

Illumination Engineering and Electric Utility Services
Prof. N. K. Kishore
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur
Lecture No. # 16
Sports Lighting

Come to this course on illumination engineering and electric utility services. Today we take up lesson 16, lesson 16 is titled sports lighting. The instructional objectives for this lesson are list the factors responsible for sport lighting, list the categories of users concerned with sport lighting, state the grouping of games according to CIE.

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The slide features the Indian Institute of Technology, Kharagpur logo and name at the top. Below this, the title 'Instructional objectives' is displayed in yellow. A list of three objectives follows in white text on a dark blue background.

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Instructional objectives

1. List the factors responsible for sport lighting?
2. List the categories of users concerned with sport lighting.
3. State the grouping of games according to CIE.

Having studied the various aspects of requirements for artificial illumination the categories of lamps the processes that are responsible for use in lamps and the components that form a lighting system the ways to measure, category and standardize these aspects. We went on to look at various ways of taking care of interior lighting in the last lecture. So it's time we have a look at exterior lighting and one of the ways, most important issues as far as exterior lighting comes is the sport lighting.

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The slide features the IIT Kharagpur logo and name at the top. The title 'Sports Lighting' is in yellow. The main text is in white on a dark blue background, listing four user groups for sports facility lighting.

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Sports Lighting

Lighting for sports facility looks for comfort of four user groups:

1. Players
2. Officials
3. Spectators and
4. Media.

The sports lighting for say is a lighting for the sports facilities and it addresses the visual comfort or the ability of viewing the game, playing the game, accessing the game for user groups which are four in type they are players, officials players who play officials who basically access the game, spectators who come to watch the game and last but not least the media because today in fact the game being played in one place is allowed to be seen all over the world, so these are the issues. So we have whenever need to light a sports facility which is ex, it could be interior it could be exterior but predominantly you could call it as exterior thing has four user groups. That is players, spectators, officials and the media.

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The slide features the IIT Kharagpur logo and name at the top. The title 'Sports Lighting' is in yellow. The main text is in white on a dark blue background, detailing requirements for players and spectators.

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Sports Lighting

- Players and officials – should see clearly in the play area to produce best possible results
- Spectators – should follow the performance of the players. In addition to play area surroundings need to be illuminated. Lighting should be such that it enables safe entry and exit. With increasing crowd level safety becomes more and more important.

Players and officials they are basically confined to the area or the play arena so that the play results in good results. Now playing could be fundamentally for a recreational purposes for the player himself and the other thing is the entertaining for the spectators. Spectators need to follow the game they need to follow the performance of the game and therefore and should be able to move around the arena where they are located. So coming to the point of view of lighting for the purpose of spectators, the play area surrounding also needs to be illuminated. Considering that large number of people may be entering and exiting over these areas, the safe entry and exit is to be ensured when the levels are chosen for the spectator region and this becomes more and more as the crowd level increases. Safety is safety requirements start increasing with the increase in the crowd level.

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The tv and film that is the media requirement and they are expected to provide conditions suitable for good reproduction of colour and the recommendations for these lighting are incorporated in CIE recommendation number 83. This looks at the picture quality from two angles, one the picture view from a close up of a player and the ability of spectators to views, watch the game. And an important issue that needs to be maintained is that these lighting scheme should have a back up supply to produce continuous transmission for the media.

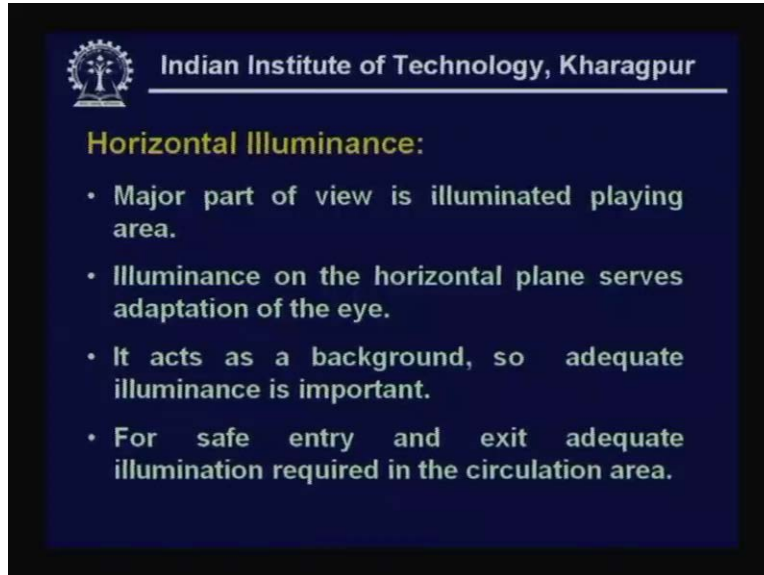
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The criteria therefore relevant for sports lighting are one, the horizontal illuminance which is normally the horizontal illuminations are the lux levels on the play area. The vertical illuminance obviously we are looking at the movement of the players, the play object typically a ball and therefore the illuminance levels in the vertical plane become important and illuminance uniformity because the uniformity of illuminance enables us to clearly distinguish which player is involved where the action is taking place. And just as any lighting installation glare restrictions must be there.

The modeling and shadows in fact shadows are the only way to get good perspective of the depth of any object, a three dimension object therefore modeling and shadow become important and needless to mention in fact although the spectator viewing may not very much depend on colour appearance in rendering but from the media point of view and the pictures are transmitted for the tv and film it becomes very important. So we have horizontal illuminance, vertical illuminance, the uniformity of illuminance, glare restriction, modeling and shadow requirement plus colour rendering appearance as important indices are factors that need to be considered in lighting a sports installation.

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Horizontal Illuminance:

- Major part of view is illuminated playing area.
- Illuminance on the horizontal plane serves adaptation of the eye.
- It acts as a background, so adequate illuminance is important.
- For safe entry and exit adequate illumination required in the circulation area.

The horizontal illuminance is responsible because this in fact enables the illumination of major portion of the play area that is the, if you talking of a football game in the football field. Similarly this is responsible for serving the adaptation of the eye, so illuminance once illuminance in the horizontal plane is maintained as required in fact it is found that it takes care of the illuminance requirements in the other planes too. Now this the illumination in fact acts as a background and this needs to be adequate and it's highly important that horizontal illuminance is maintained.

Now the circulation area as already checked in the spectator zone adjoining the play area is necessary from the point of view of safe entry and exit, you need to have adequate illumination. In this levels may be lower than what is required in the play area but there is some minimum levels required to enable safe entry and exit.

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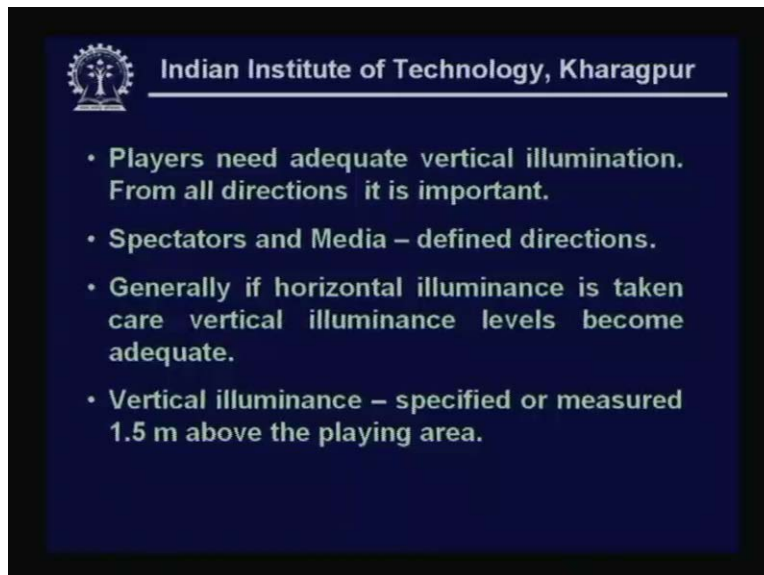
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Vertical Illuminance:

- Sufficient contrast across a players body essential for the identification of the player.
- Possible only if sufficient vertical illumination is there.
- Vertical illuminance be adequate.
- Characterized by both magnitude and direction.

The vertical illuminance should be such that it produces adequate contrast over the player's body this is necessary for the identification of the player. In fact from the spectator view point of the identity of the player gives more pleasure or entertainment value to the game and therefore it's necessary. Now this can happen only if you have sufficient vertical illumination and therefore vertical illuminance must be adequate and that becomes the most second important factor and from the point of view of the vertical illuminance both magnitude and direction becomes very very critical.

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- Players need adequate vertical illumination. From all directions it is important.
- Spectators and Media – defined directions.
- Generally if horizontal illuminance is taken care vertical illuminance levels become adequate.
- Vertical illuminance – specified or measured 1.5 m above the playing area.

From the point of view of players, the vertical illuminance must be important or adequate from all directions whereas from the point of view of spectators and media, media here we mean television or film how do they pick? They pick through set of cameras, the location of cameras and therefore there is defined direction. So what do we mean, the vertical illuminance requirements for the players themselves could be in all directions so that they are able to really see the movement of the player and the object whereas spectators since they are located in a particular stand or cameras for the media which are located at a specific place, a defined direction is there. But it's observed that if horizontal illuminance on the play area is taken care, the vertical illuminance levels become adequate considering the recommended practices of mounting the lamps as is the practice as for the CIE recommendations.

So what it means? Yes, horizontal illuminance no doubt plays as a background but vertical illuminance is necessary from the point of view of a good game and if horizontal illuminance is taken care vertical illuminance levels becomes equally adequate. The specifications or the measurements for vertical illuminance are usually done at a height of 1.5 meters from the play area. So this is about 1.5 meters above the ground, the vertical illuminance levels are specified.

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Apart from player recognition and picture quality, the vertical illuminance aids observing the movement of ball by the players as well as spectators, that I have been saying that the vertical illuminance is required for the movement of players, recognition of players as well as the movement of the ball. Spectators stands are also part of the environment and they also need to have equally adequate vertical illuminance.

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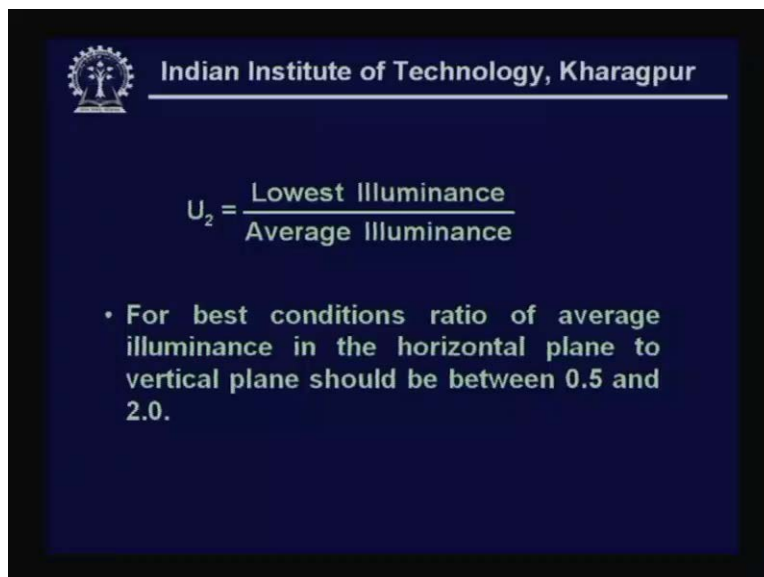
Illuminance Uniformity:

- Good illuminance is important in both the horizontal and vertical planes.
- Does away need for continuous adjustment of cameras.
- Uniformity is expressed by

$$U_1 = \frac{\text{Lowest Illuminance}}{\text{Highest Illuminance}}$$

Now what is illuminance uniformity? In fact we said the third important factor is the illuminance uniformity. We had said horizontal illuminance plus vertical illuminance are required no doubt. Now the good illuminance levels in both horizontal and vertical planes are required and once you have good levels maintained and uniformity maintained then there is no need of adjustment of cameras continuously which is necessary for the media. Now by definition we have two indices for uniformity, we talk of uniformity indices for both horizontal illuminance as well as vertical illuminance. The uniformity index one use of one is defined as the ratio of lowest illuminance in the area to the highest illuminance. So there are two uniformity indices U_1 and U_2 , the first one being the ratio of lowest illuminance to highest illuminance.

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$$U_2 = \frac{\text{Lowest Illuminance}}{\text{Average Illuminance}}$$

- For best conditions ratio of average illuminance in the horizontal plane to vertical plane should be between 0.5 and 2.0.

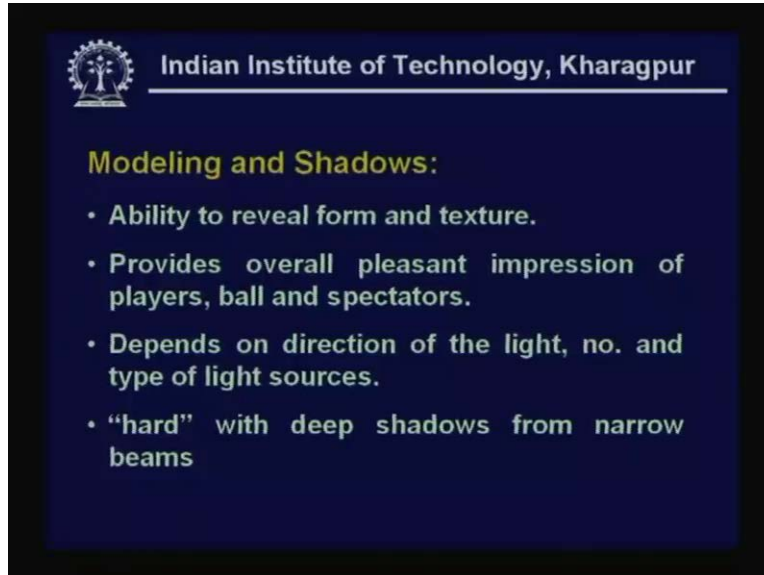
The second one which we call U_2 is the lowest illuminance to the average illuminance. These are the two indices and it is observed that from the point of view of visual comfort and satisfaction of the four user groups namely players, officials, spectators and media, the ratio of average illuminance in the horizontal plane to vertical plane be kept between 0.5 and 0.2. This is the illuminance levels, average illuminance levels in the two planes.

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Now if we talk of glare by definition we had already looked at in a detailed manner in the lecture of glare. The disturbing brightness in the field of view is what we called glare and when it enters or it's near we call it glare. And this can be eliminated by an appropriate choice; if they are mounted well above and from suitably aimed this can be minimized. So having covered the factors horizontal illuminance, vertical illuminance then the illuminance uniformity which indices, glare, the next important factor is the modeling and shadow.

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The slide features the IIT Kharagpur logo and name at the top. The main title is 'Modeling and Shadows:'. Below it, there is a bulleted list of four points.

- Ability to reveal form and texture.
- Provides overall pleasant impression of players, ball and spectators.
- Depends on direction of the light, no. and type of light sources.
- “hard” with deep shadows from narrow beams

The modeling and shadow enables us to reveal complete form of texture and gives an overall impression of players, ball, ball I am calling it ball here but then if it is a badminton if it is a shuttle badminton it will be the shuttle, the object that is being played. And this very much depends on the direction of light and depending on the number and type of light sources with hard shadows are formed from narrow beams, hard deep shadows are formed from narrow beams whereas flat shadows with less lighting from a luminous siding.

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- “flat” – shadow less lighting from luminous siding.
- These are extremes and not desirable.
- Later improved by few spotlights.
- Good quality pictures on TV require good modeling.
- In order to limit shadows – 60% light must come from main camera side and 40% from opposite side.

So these are the two extreme forms of shadow formation. So you have hard deep shadows from a narrow beam and from a large luminous site, side lighting of low lighting levels you have flat. So

one aims to have shadows between the two and often shadows are improved by providing few spot lights. And this is more important from the point of view of observing pictures in tv for the media requirement, it becomes very important than the player. Now in order to have shadows kept under control or good modeling, the main camera should allow about 60% of the light to come and 40% from the opposite side that way it enables good quality modeling, this is the about modeling.

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The slide features the IIT Kharagpur logo and name at the top. The main content is titled 'Color Appearance and Color Rendering:' and includes two bullet points. Below this, it states 'Color has two distinct aspects' and lists two sub-points: 'i. Color appearance of the light – color impression of the total environment – due to the lamp.' and 'ii. Color rendering of the light – ability to reproduce color of an object faithfully'.

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Color Appearance and Color Rendering:

- Good color perception is very important.
- Some color distortion acceptable.

Color has two distinct aspects

- i. Color appearance of the light – color impression of the total environment – due to the lamp.
- ii. Color rendering of the light – ability to reproduce color of an object faithfully

And we said colour appearance and colour rendering though may not be necessary in the field for the spectators and the players, it's very much necessary for the media point and its very important to have a very good colour perception. May be a little colour distortion is acceptable and this has two distinct aspects, one, the colour impression of the total environment which we call the colour appearance of the light which is mainly due to the types of lamps that are used. Indecently one must mention here that the types of lamps which are used these days are based on metal halide lamps. The other is the colour rendering, the ability to faithfully reproduce the object colour. In fact this is one way of assessing or the radiation from the lamp source, we have already seen colour rendering index or colour CRI.

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- Depends on spectral energy distribution of light emitted.
- Color appearance obtained from color temperature varying between 2000 (warmer) to 6000 (cooler) K.
- Color rendering specified by CRI or Ra. Maximum possible being 100, comparable to day light situation. Higher the Ra more agreeable is the environment.

Now this very much depends on the spectral energy distribution of the light that is emitted and the colour appearance varies obtained from colour temperatures which are varying between 2000 to 6000 where 2000 correlates to a warm colour, 6000 corresponds to a cooler colour in degree Kelvin and remember this was the temperature, colour temperature mentioned for the good quality radiator which if maintained at that temperature gives similar colour. Colour rendering as already mentioned in an earlier lecture is specified by colour rendering index or CRI or abbreviated as Ra. The maximum possible which it may attain is around 100 which is on a basis of comparison to a day light situation, higher the Ra more agreeable is the environment this is the thing.

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Sport	Level of Activity	E (lux)	U_1	U_2	R_a	T_k	Group
Athletics							
Indoor	t/r	200	0.3	0.5	65	2000	A
	Ca	300	0.4	0.5	65	4000	
	Cp	500	0.5	0.7	65	4000	
Outdoor							
Outdoor	t/r	100	0.2	0.3	20	2000	
	Ca	200	0.2	0.3	20	2000	
	Cp	400	0.3	0.5	65	4000	

Now here is a table which gives us the typical illuminance levels that is and we have the first column mentions the sport, it is incidentally the sport covered here in this table is athletics. The two categories indoor athletics and outdoor athletics have been shown. The level of activity is been categorized into three categories, one t/r tournament, amateur or the creational. Second one is C sub a, C sub p which corresponds to competition in nature for national and international. See the national would mean the coverage requirement would be over certain region whereas international would mean much larger region then the lux levels are mentioned. For indoor athletics we find it varies from 200 lux for the creational game to about 500 for international competition. And the uniformity indices U_1 U_2 are specified which vary from 0.3 to 0.5 and the colour temperature is varying from 2000 to 4000 degree, 4000 k and the Ra is around 65.


Now, if you come to the outdoor we find the lux levels required are less and even the uniformity indices U_1 U_2 are lower compared to the indoor levels. However we find for an international coverage either indoor or outdoor, the colour rendering index and the colour temperature are similar. We also find another grouping mentioned in the last column which is mentioned as A, this grouping is according to CIA is dependent on the action of the moved game. Now this faster the game is, the higher is the grouping level. Incidentally the games are grouped into three groups A B C depending on the speed. A corresponds to slow speed high object more games, the object being smaller the group level goes higher that is moves like for instance a table tennis would which has got a fast game with small ball will come under group C.

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Sport		Level of Activity	E (lux)	U_1	U_2	R_a	T_k	Group
Badminton		t/r	300	0.4	0.6	65	4000	B
		Ca	600	0.5	0.7	65	4000	
		Cp	800	0.5	0.7	65	4000	

Coming to badminton we find the levels are higher than those we saw in case of athletics. For a simple reason the game speed also increases and the object size also comes down and you can very well see the, what was between 100 to 500 lux in case of a indoor athletics has increased to about 300 to 800 lux. These are as per the CIE recommendation but from the colour rendering point of view, the colour temperature requirement and colour rendering are more or less around 65 and 4000 degree K.

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Sport	Level of Activity	E (lux)	U_1	U_2	R_a	T_k	Group	
Basket Ball	Indoor	t/r	300	0.4	0.6	65	4000	B
		Ca	400	0.5	0.7	65	4000	
		Cp	600	0.5	0.7	65	4000	
Outdoor	t/r	100	0.2	0.3	60	2000		
	Ca	200	0.3	0.4	60	2000		

Coming to the basketball, again here which is again a group B game you can see the indoor levels are between 300 to 600 and the outdoor are between 100 to 200 lux and obviously the outdoor level recommendations are mentioned only for a national level competition. We find the colour temperature requirements are only up to about 2000 K and the uniformity indices as one can see are going as high as 0.5 to 0.5, 0.7 for U_1 U_2 in case of a international level game in most of these games. Going further we go to the group C game.

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Sport	Level of Activity	E (lux)	U_1	U_2	R_a	T_k	Group	
Cricket	Infield	t/r/Ca	750	0.5	0.7	65	4000	C
		Cp	1500	0.7	0.8	65	4000	
Outfield	t/r/Ca	500	0.4	0.5	65	4000		
	Cp	1000	0.5	0.6	65	4000		

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As I said group A is a slow game, group B is faster and group C is really fast. We have here cricket which is divided from the requirements of the illuminance levels in to two areas that is


the infield where the main zone outfield the exterior and we find the lux level requirements are really high going from 750 to 1500 for the infield and 500 to 1000 lux for outfield and you can also see that the uniformity indices are higher going up to 0.7, 0.8 for the infield and 0.5, 0.6 for the outfield. The colour rendering colour temperature more or less remain in the same level. We may observe as we go along that these colour rendering and colour temperature requirements become more stringent for the media requirement not as though as much for the normal lighting Next we have here the data for football.

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Sport		Level of Activity	E (lux)	U_1	U_2	R_a	T_k	Group
Football								
Indoor	t/r		300	0.4	0.6	65	4000	B
	Ca		600	0.5	0.7	65	4000	
	Cp		800	0.5	0.7	65	4000	
Outdoor	t/r		100	0.4	0.6	65	4000	
	Ca		200	0.5	0.7	65	4000	
	Cp		500	0.5	0.7	65	4000	

Once again considering both indoor and outdoor, as can be seen indoor is varying from 300 to 800 lux and obviously this a group B game unlike cricket which was a group C which is a faster game with the smaller object size whereas the object size in case of a football is bigger and one could clearly see the outdoor illumination level requirements are lower compared to the indoor level and the colour rendering and colour temperature for the source requirements remain optimally around 65 and 4000 K.

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Sport	Level of Activity	E (lux)	U_1	U_2	R_a	T_k	Group
Table Tennis							
	t/r	300	0.4	0.6	60	4000	C
	Ca	400	0.5	0.7	60	4000	
	Cp	600	0.5	0.7	60	4000	

The really fast game we do find is the table tennis high speed game but one may say the levels appear to be low but remember the area required to be illuminated is smaller and as one may have observed the mounting height is also much lower in this case for table tennis and therefore these levels appear to be adequate between 300 to 600 lux.

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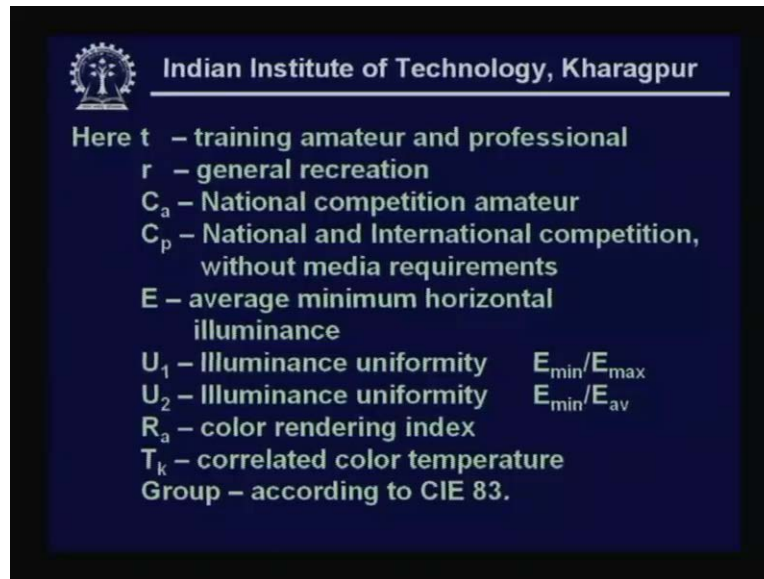
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Sport	Level of Activity	E (lux)	U_1	U_2	R_a	T_k	Group
Tennis Indoor							
	t/r	500	0.4	0.6	65	4000	B
	Ca	750	0.4	0.6	65	4000	
	Cp	1000	0.4	0.6	65	4000	
Tennis Outdoor							
	t/r	250	0.4	0.6	60	2000	
	Ca	500	0.4	0.6	65	4000	
	Cp	750	0.4	0.6	65	4000	

Now the tennis which is again categorized as indoor tennis and outdoor tennis, one could see the levels mentioned in this tables one finds that the levels for indoor tennis vary from 500 to 1000 lux.

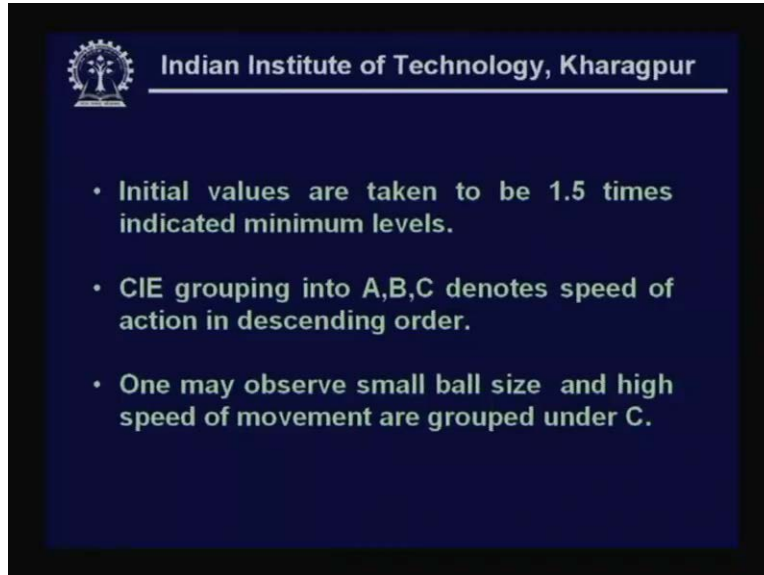
It's a group B game, outdoor is varying from 250 to 750 and more or less around 0.4 to 0.6 uniformity indices appear to be all right and most of these we have seen as per the recommendations a Ra of 65 and colour temperature 4000 appears to be adequate.

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As already mentioned in all these tables t was referring to training amateur or professional requirement, r for general recreation. As already said C_a corresponds to national competition, amateur competition and C_p is national or international competition without media requirements and the lux levels which have been mentioned we have been talking about say 100 lux, 300 lux, 700 lux, 1500 lux all these was the average minimum horizontal illuminance. Illuminance uniformity U₁ as defined as E minimum by E maximum, illuminance uniformity index U₂ as the E minimum by E average. Ra of course colour rendering index, T_k is the correlated colour temperature and the grouping was there as per CIE A B C, A will corresponding to slow speed games, B moderate and C corresponding to very fast games.

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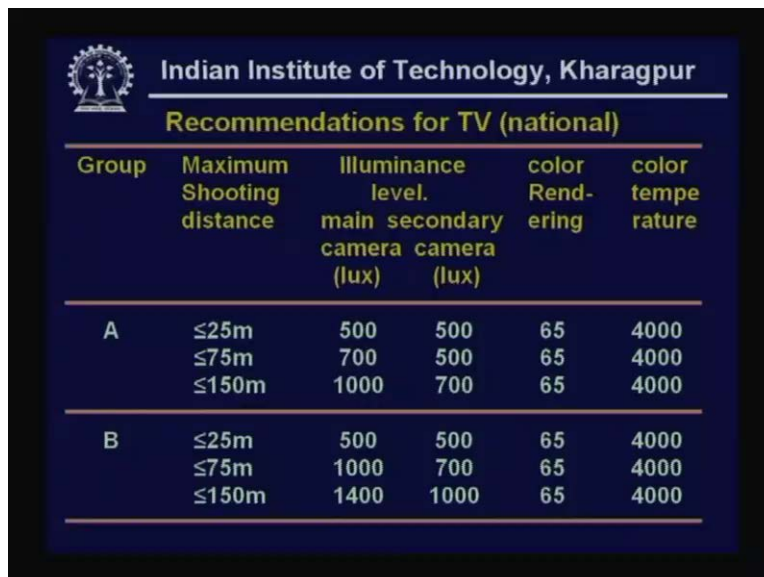


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- Initial values are taken to be 1.5 times indicated minimum levels.
- CIE grouping into A,B,C denotes speed of action in descending order.
- One may observe small ball size and high speed of movement are grouped under C.

Now from the point of view of using, these are average minimum levels indicated. So in designing one takes initial levels which are 1.5 times that of those indicated minimum levels. So we have already seen that CIE grouping denotes speed of action in descending order A B C. One may observe small ball size and high speed of movement are grouped under category C. Now this table here talks about the recommendations for media.

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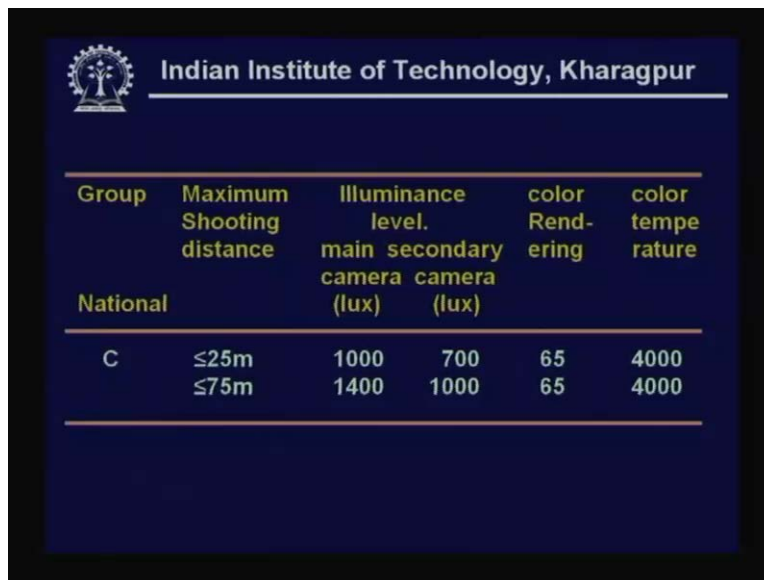
Recommendations for TV (national)

Group	Maximum Shooting distance	Illuminance level.		color Rendering	color temperature
		main camera (lux)	secondary camera (lux)		
A	≤25m	500	500	65	4000
	≤75m	700	500	65	4000
	≤150m	1000	700	65	4000
B	≤25m	500	500	65	4000
	≤75m	1000	700	65	4000
	≤150m	1400	1000	65	4000

What one could see is this is for a national coverage. From the point of view of media coverage we have three categories, one, the national coverage, the other international coverage then the upcoming high definition television coverage. You can see this is categorized in terms of the

grouping of the games A B C. The maximum shooting distance is been taken as the one of the criteria with illuminance levels in lux for the main camera and secondary camera. As can be seen, the three distances chosen 25 meters, 75 meters, 150 meters. For the group A we find for the lux levels for the main camera vary from 500 to 1000 whereas for the secondary camera they vary from 500 to 700, that is the main camera lux level requirements are much higher. When you move on from group A to group B, these levels have increased further from 500, 700, 1000 to 500, 1000 and 1400, the three distances that are been considered are 25 meters, 75 meters and 150 meters. As can be seen the colour rendering is uniformly around 65 with 4000 as the colour correlated temperature.


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Group	Maximum Shooting distance	Illuminance level.		color Rend-ering	color tempe rature
		main camera (lux)	secondary camera (lux)		
National					
C	≤25m	1000	700	65	4000
	≤75m	1400	1000	65	4000

Coming to the category C, group C with shooting distances maintained between 25 meters and 75 meters, the recommended levels are 1000 and 1400. So, as the speed of the game goes higher the required levels are higher as is being the earlier case.

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Group	Maximum Shooting distance	Uniformity vertical		color Rendering	color temperature
		U_1	U_2		
National					
A	$\leq 25m$	0.4	0.5	65	4000
	$\leq 75m$	0.4	0.5	65	4000
	$\leq 150m$	0.5	0.6	65	4000
B	$\leq 25m$	0.5	0.6	65	4000
	$\leq 75m$	0.5	0.6	65	4000
	$\leq 150m$	0.6	0.7	65	4000
C	$\leq 25m$	0.5	0.6	65	4000
	$\leq 75m$	0.6	0.7	65	4000

This table in fact shows the second important index that is necessary from the point of view of sport lighting that is the uniformity index, this is giving the uniformity index indices U_1 U_2 . What was U_1 ? U_1 was the minimum illuminance to the maximum illuminance whereas U_2 was minimum to the average. So, for different distances of camera, for different categories of the games seen as you can see for group A you vertically U_1 is minimum recommended is around 0.4 which becomes 0.5 when you move on to 150 meter camera distance was which again in the U_2 varies from 0.5 to 0.6 as the speed of the game increases, we find this goes on to 0.6, 0.7.

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Group	Maximum Shooting distance	Uniformity Horizontal		color Rendering	color temperature
		U_1	U_2		
National					
A	$\leq 25m$	0.3	0.5	65	4000
	$\leq 75m$	0.3	0.5	65	4000
	$\leq 150m$	0.4	0.6	65	4000
B	$\leq 25m$	0.3	0.5	65	4000
	$\leq 75m$	0.3	0.5	65	4000
	$\leq 150m$	0.4	0.6	65	4000
C	$\leq 25m$	0.4	0.6	65	4000
	$\leq 75m$	0.4	0.6	65	4000

If you take the horizontal indices they vary from 0.3 to 0.4 for group A which becomes 0.4 to 0.6. So, the previous table had given us the recommended levels for the uniformity indices in the vertical plane, this table has given us uniformity indices in the horizontal table. So we have been looking at the illuminance requirements from the point of view of a national tv coverage. You have seen the, and observe we have talked about the uniformity indices in the vertical plane but we have not mentioned the levels because recall that if horizontal illuminance levels are taken care vertical illuminance levels automatically get taken care. The table here talks about the requirements for tv coverage on an international level.

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Group	Maximum Shooting distance	Illuminance level.		color Rendering	color temperature
		main camera (lux)	secondary camera (lux)		
International					
A	≤25m	700	500	65	4000
	≤75m	1000	700	65	4000
	≤150m	1400	1000	65	4000
B	≤25m	1000	700	65	4000
	≤75m	1400	1000	65	4000
	≤150m	1750	1250	65	4000

As you can see levels are much higher because the colour, it becomes more important to get better quality pictures and therefore one could see that you have higher lux levels this lists for group A and group B for different camera distances. The horizontal illuminance levels specified average illuminance minimum average illuminance levels for both main camera and secondary camera. So far what do we find? We find the colour rendering index Ra and colour, colour temperature are adequate around 65 and 4000.

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Group	Maximum Shooting distance	Illuminance level.		color Rendering	color temperature
		main camera (lux)	secondary camera (lux)		
International					
C	≤25m	1400	1000	65	4000
	≤75m	1750	1250	65	4000

This shows for group C as has been in the previous instance, this is going higher and higher as the speed of the game increases.

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Group	Maximum Shooting distance	Uniformity vertical		color Rendering	color temperature
		U ₁	U ₂		
International					
A	≤25m	0.4	0.5	65	4000
	≤75m	0.5	0.6	65	4000
	≤150m	0.5	0.6	65	4000
B	≤25m	0.5	0.6	65	4000
	≤75m	0.6	0.7	65	4000
	≤150m	0.6	0.7	65	4000
C	≤25m	0.6	0.7	65	4000
	≤75m	0.7	0.8	65	4000

This is the uniformity indices which are somewhat similar to what we found in case of a national thing. Obviously uniformity indices do not change so much but the levels of illuminance required levels are increasing. So you have for group A going from 0.4 to 0.5 for U₁ and 0.5 to 0.6 for U₂ and for group C going up to 0.7 for U₁ and 0.8 for U₂.

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Group	Maximum Shooting distance	Uniformity Horizontal		color Rendering	color temperature
		U_1	U_2		
International					
A	$\leq 25m$	0.3	0.5	65	4000
	$\leq 75m$	0.3	0.5	65	4000
	$\leq 150m$	0.4	0.6	65	4000
B	$\leq 25m$	0.3	0.5	65	4000
	$\leq 75m$	0.4	0.6	65	4000
	$\leq 150m$	0.4	0.6	65	4000
C	$\leq 25m$	0.4	0.6	65	4000
	$\leq 75m$	0.5	0.7	65	4000

Then similarly one finds the uniformity indices in the horizontal plane which are similar to what we saw in the case of a national tv. So you, what do we have? We have three categories of games depending on the speed as per the CIE recommendations A B C and each of these having for three different camera distances.

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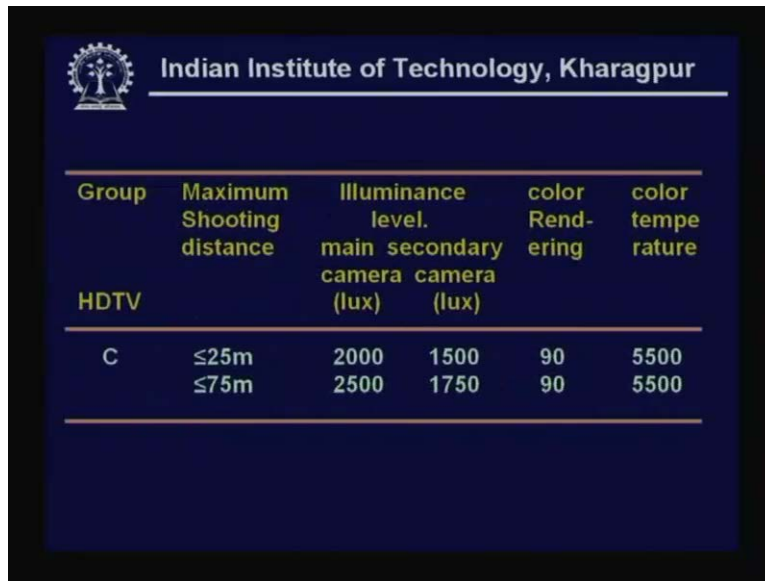
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Group	Maximum Shooting distance	Illuminance level.		color Rendering	color temperature
		main camera (lux)	secondary camera (lux)		
HDTV					
A	$\leq 25m$	1000	700	90	5500
	$\leq 75m$	1500	1000	90	5500
	$\leq 150m$	2000	1500	90	5500
B	$\leq 25m$	1500	1000	90	5500
	$\leq 75m$	2000	1500	90	5500
	$\leq 150m$	2500	1750	90	5500

Now coming to the upcoming high definition television requirements, we find the lux levels are really high. There is not only increase in the lux levels but there is stringent requirement on the colour rendering which has now expected to be around 90 with the colour correlated temperature of around 5500.

Observe even for group A games, the requirement of the lux has gone up from a minimum of 1000 for 25 meters shooting distance to 2000 for 1750 meters shooting distance which becomes higher up to 2500 for group B and even for a secondary camera which is around 1750 which is much higher than what it was in case of a national or international tv coverage even for group C games.

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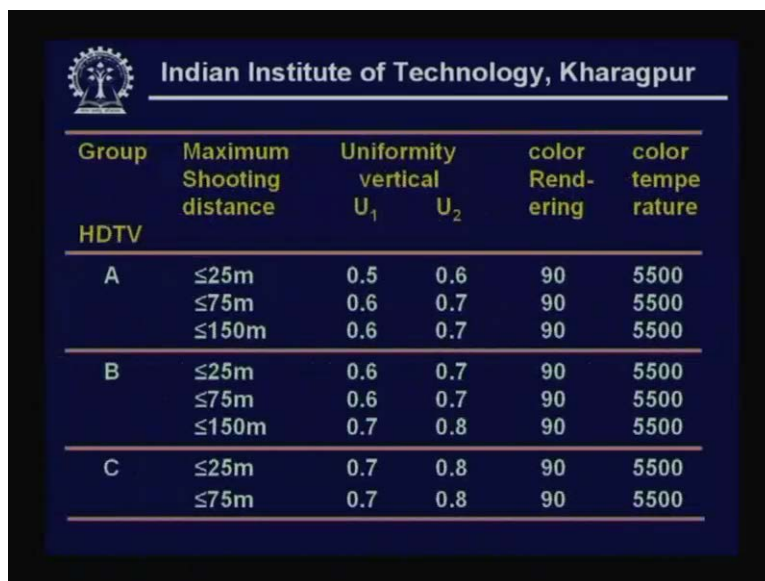


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Group	Maximum Shooting distance	Illuminance level.		color Rendering	color temperature
		main camera (lux)	secondary camera (lux)		
HDTV					
C	≤25m	2000	1500	90	5500
	≤75m	2500	1750	90	5500

Here, so the lux levels required go higher up to about 2500 lux and the colour rendering goes to 90 at 5500 degree colour correlated temperature. The uniformity indices are shown in this table.

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Group	Maximum Shooting distance	Uniformity vertical		color Rendering	color temperature
		U ₁	U ₂		
HDTV					
A	≤25m	0.5	0.6	90	5500
	≤75m	0.6	0.7	90	5500
	≤150m	0.6	0.7	90	5500
B	≤25m	0.6	0.7	90	5500
	≤75m	0.6	0.7	90	5500
	≤150m	0.7	0.8	90	5500
C	≤25m	0.7	0.8	90	5500
	≤75m	0.7	0.8	90	5500

Obviously uniformity indices really do not change much whether it is national or international tv or a high definition television. As you can see it's similarly for group A, it varies from 0.5 to 0.6 for U_1 and 0.6 to 0.7 for U_2 and group C remains at 0.7 and 0.8 for U_1 and U_2 , this is in the vertical plane.

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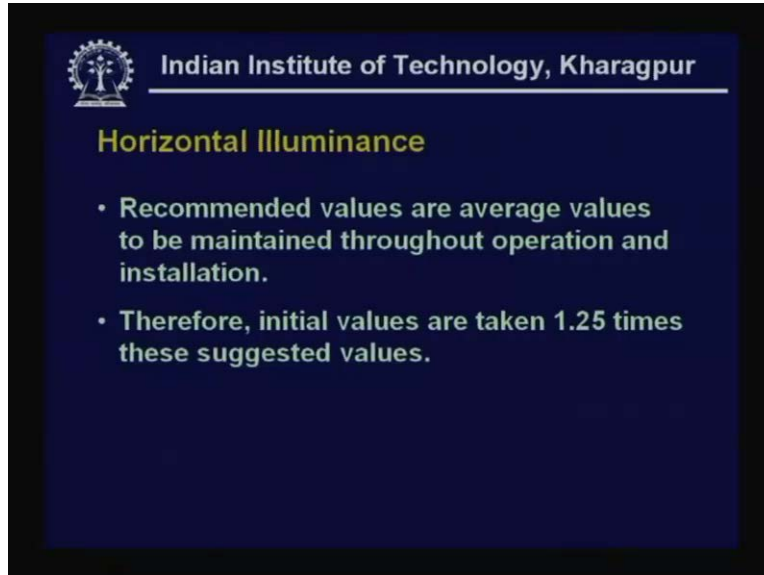



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Group	Maximum Shooting distance	Uniformity Horizontal		color Rendering	color temperature
		U_1	U_2		
HDTV					
A	$\leq 25m$	0.5	0.6	90	5500
	$\leq 75m$	0.6	0.7	90	5500
	$\leq 150m$	0.6	0.7	90	5500
B	$\leq 25m$	0.6	0.7	90	5500
	$\leq 75m$	0.7	0.8	90	5500
	$\leq 150m$	0.7	0.8	90	5500
C	$\leq 25m$	0.7	0.8	90	5500
	$\leq 75m$	0.7	0.8	90	5500

However observe the uniformity indices in the horizontal plane have changed from what it was in case of a national tv and international tv coverage where it is used to be around 0.3, 0.4 for U_1 and 0.4, 0.5 for U_2 it has increased to 0.6, 0.7 for even group A games and it remains at 0.7, 0.8 for group C games. So, we find that from the requirements of the HD tv, we have higher colour temperature requirement and higher colour rendering requirement.

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Horizontal Illuminance

- Recommended values are average values to be maintained throughout operation and installation.
- Therefore, initial values are taken 1.25 times these suggested values.

The one important issue that needs to be stressed is the horizontal illuminance values which are recommended are average values which need to be kept throughout the operation and installation and therefore its always suggested that at least 1.25 times these values are chosen initially.

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Vertical Illuminance

- Such that camera operators have free choice of camera angle.
- These levels are specified at a height of 1.5m above the playing area.

Illuminance Uniformity

- Stringent for TV or media.
- Human eye is less sensitive.
- Levels of uniformity higher for TV.

The vertical illuminance if kept properly enables the media operators to have there proper free choice of the camera angle, they can locate the camera appropriately. Now the levels specified are at 1.5 meters above the play arena. The illuminance uniformity we have seen has varied from 0.3 to 0.6. We saw it was higher for high definition television or HD tv requirement than normal

sport requirement or even national, international tv coverage. So it is stringent for tv or media. The human eye doesn't really bother so much, uniformity levels are higher for tv.

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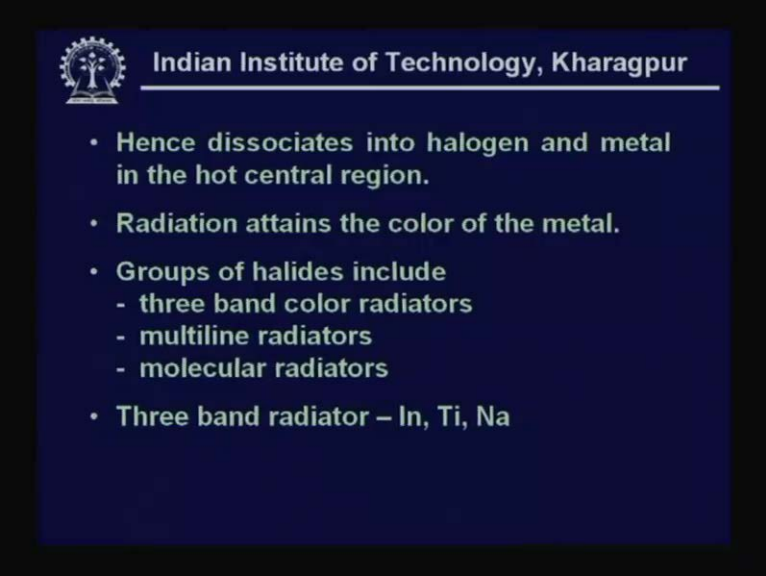
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Metal Halide Lamps

- Most sports installations employ metal halide lamps.
- They are similar to high pressure mercury lamps.
- It contains number of metal halides in addition to mercury.
- Halides are partly vaporized when normal operating temperature is reached.

Now as already mentioned most of these lighting installations employ the metal halide lamps. The most sports installations employ metal halide lamps. What do they work on? They are in fact nothing but high pressure mercury lamps, we have said high pressure mercury lamps radiate give rise to the radiation as a band radiation and therefore colour rendering is poor. The number of metal halides are added in addition to the mercury vapor to improve the colour, colour rendering.

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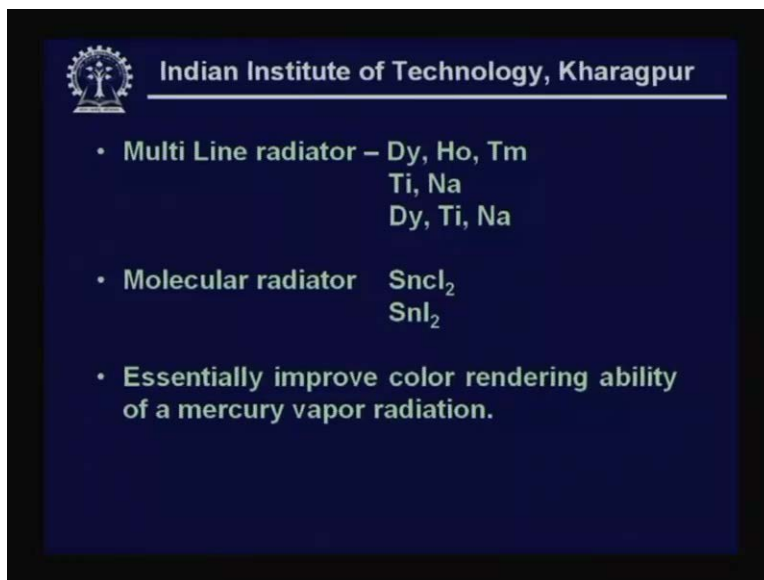


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- Hence dissociates into halogen and metal in the hot central region.
- Radiation attains the color of the metal.
- Groups of halides include
 - three band color radiators
 - multiline radiators
 - molecular radiators
- Three band radiator – In, Ti, Na

Then what happens? By addition of these, these halides are partly vaporized and because of which they dissociate into halogen and metal in the central region where it is core which is hot and therefore the radiation attains the colour pertaining to the metal. So the groups of halides that are included they are categorized as three band colour radiators which could correspond to three primary colours, multiline radiators or molecular radiators. The three band radiators normally employed are indium, titanium and sodium based halides.

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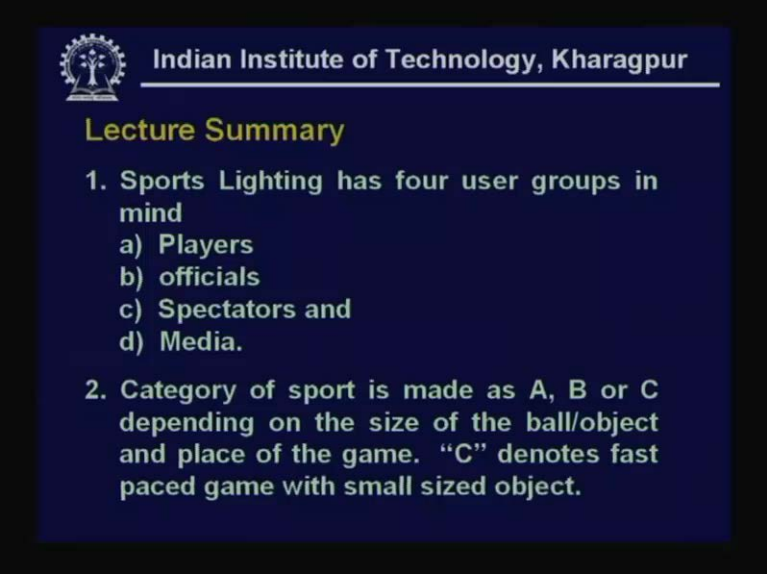


The slide features the IIT Kharagpur logo and name at the top. Below, it lists three categories of radiators with their respective chemical symbols:

- Multi Line radiator – Dy, Ho, Tm
Ti, Na
Dy, Ti, Na
- Molecular radiator SnCl₂
SnI₂
- Essentially improve color rendering ability of a mercury vapor radiation.

Multiline radiators are deuterium, hafnium, atomium, titanium, sodium etc. The molecular radiators come under the category of stannic chloride and stannic iodide arsenite, these are the things and the main use of these halides is in improving the colour rendering ability of mercury vapor radiation.

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The slide features the IIT Kharagpur logo and name at the top. Below this, the title 'Lecture Summary' is displayed in yellow. The main content consists of two numbered points in white text on a dark blue background. Point 1 lists four user groups: players, officials, spectators, and media. Point 2 explains the categorization of sports into A, B, or C based on the size of the ball/object and the game's pace, with 'C' specifically denoting fast-paced games with small objects.

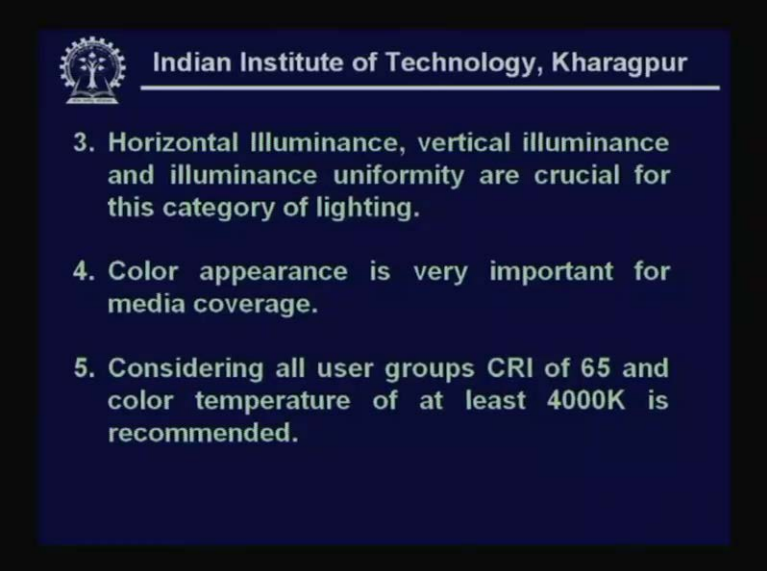
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Lecture Summary

1. Sports Lighting has four user groups in mind
 - a) Players
 - b) officials
 - c) Spectators and
 - d) Media.
2. Category of sport is made as A, B or C depending on the size of the ball/object and place of the game. "C" denotes fast paced game with small sized object.

In total the lecture summary could be the sports lighting addresses four user groups in its minds, they are players, officials, spectators and the media. Category of sport is made category or grouping of the sport is made as A B or C according to CIE depending on the object or the ball that is being used for the game and place of the game. Here, C corresponding to the fast paced game with small size object and A corresponding to a large size object with slow paced that is athletics have been grouped under group A whereas tennis was group under C and badminton was grouped under B.

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This slide continues the lecture summary with three more points in white text on a dark blue background. Point 3 emphasizes the importance of horizontal, vertical, and uniform illuminance. Point 4 notes that color appearance is crucial for media coverage. Point 5 provides technical specifications, recommending a CRI of 65 and a color temperature of at least 4000K.

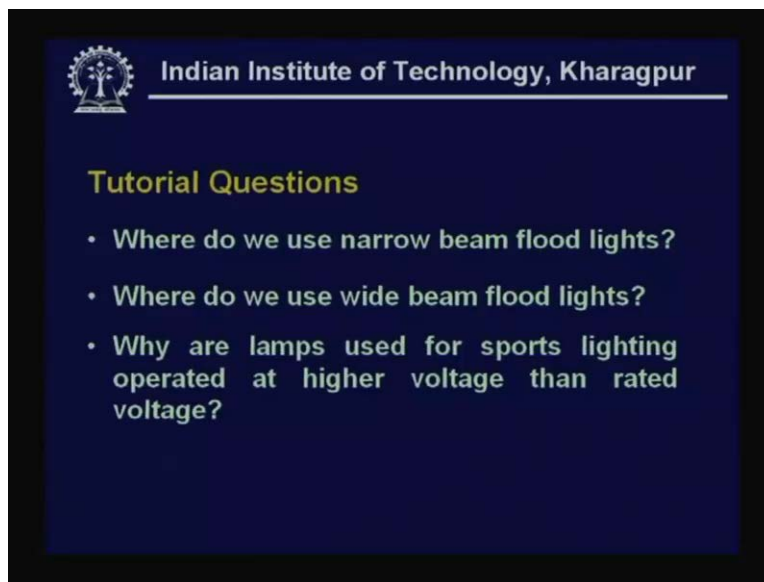
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3. Horizontal Illuminance, vertical illuminance and illuminance uniformity are crucial for this category of lighting.
4. Color appearance is very important for media coverage.
5. Considering all user groups CRI of 65 and color temperature of at least 4000K is recommended.

Horizontal illuminance, vertical illuminance and the illuminance uniformity are quite important for this kind of a lighting. And in fact we have had a look at various recommended levels according to CIE for the sports lighting for from all these angles. The first set of tables were corresponding to the players and spectators along with officials. Players they need to play and they need to observe the game, spectators enjoy and the officials have to access the game then we had requirements from the media categorized as from three different angles national, international tv coverage and high definition television coverage. Colour appearance is important for media coverage. From all user groups we find a CRI of 65 and colour temperature of 4000 K is recommended.

However a caution is to be added here that for the high definition television requirements, this two values have recommended are much higher. CRI becomes 90 and colour temperature of 5500 is recommended for high definition television, for most other things its okay.

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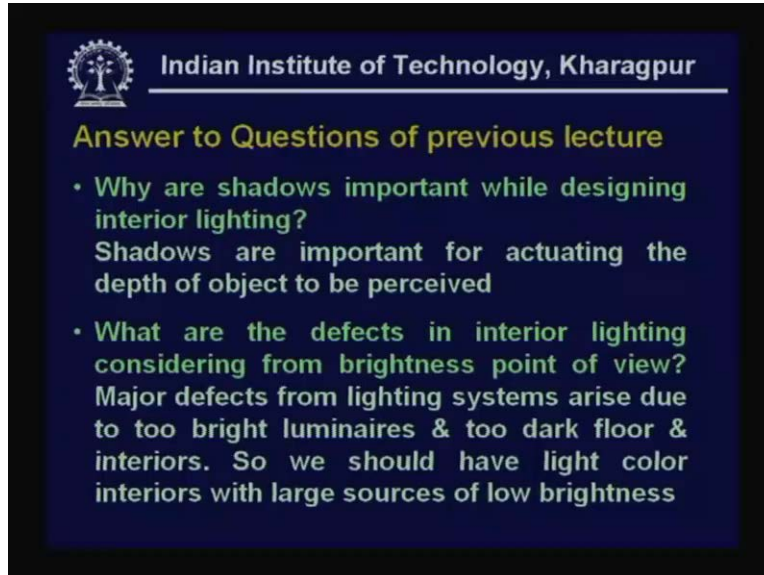
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Tutorial Questions

- Where do we use narrow beam flood lights?
- Where do we use wide beam flood lights?
- Why are lamps used for sports lighting operated at higher voltage than rated voltage?

The questions that may be taken up from this topic are where do we use narrow beam flood lights. Where do we use wide beam flood lights? Why are lamps used for sport lighting operated at higher voltage than rated voltage? Now we can take up some of the answers to the questions of the previous lecture.

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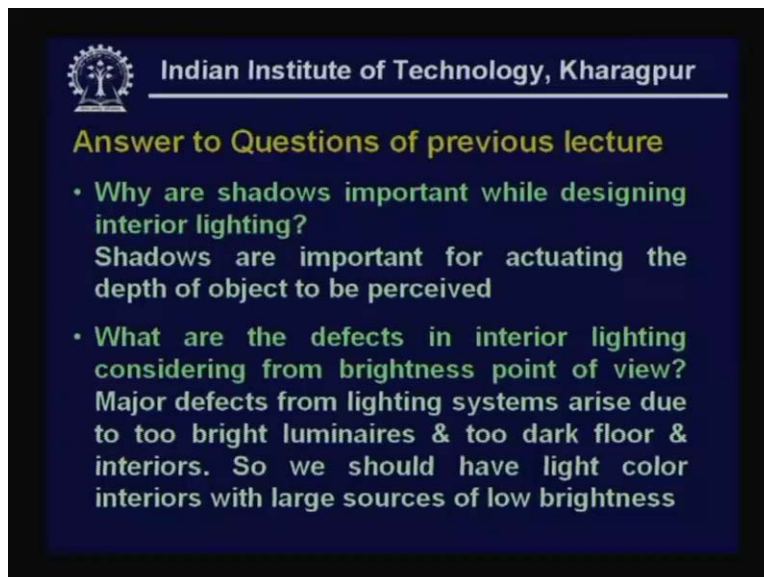
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Answer to Questions of previous lecture

- **Why are shadows important while designing interior lighting?**
Shadows are important for actuating the depth of object to be perceived
- **What are the defects in interior lighting considering from brightness point of view?**
Major defects from lighting systems arise due to too bright luminaires & too dark floor & interiors. So we should have light color interiors with large sources of low brightness

What are factors which need to be considered while designing interior lighting? The factors that need to be considered while designing interior lighting are purpose of lighting or the intention or the service for which the lighting is providing the class of interiors, the luminaires suited and the effect of the colour. Obviously deflection from ceilings, walls and floor needs to be taken in to account.

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Answer to Questions of previous lecture

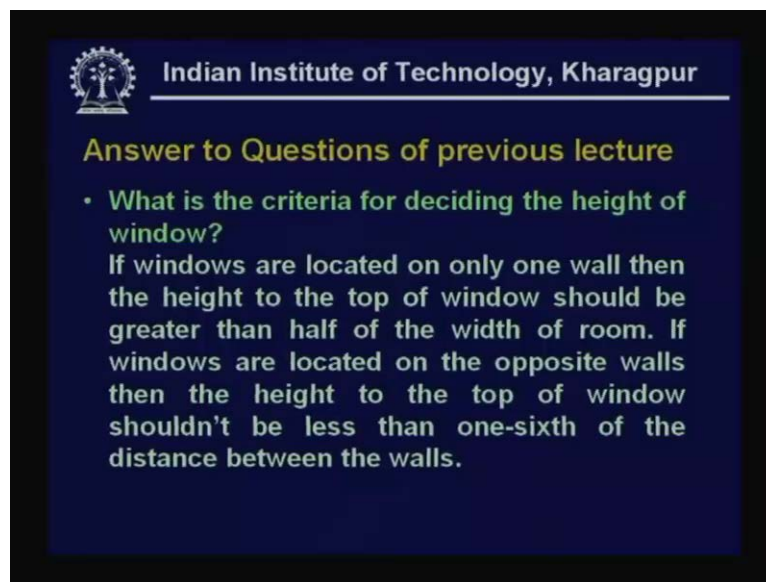
- **Why are shadows important while designing interior lighting?**
Shadows are important for actuating the depth of object to be perceived
- **What are the defects in interior lighting considering from brightness point of view?**
Major defects from lighting systems arise due to too bright luminaires & too dark floor & interiors. So we should have light color interiors with large sources of low brightness

Why are shadows important while designing interior lighting? Not only in interior lighting shadows are important in fact for actuating depth of object to be perceived. In fact even in today's lecture, we said one of the crucial factors in sport lighting is modeling and shadows and

depending on the nature of the light one may have hard shadows or a fast faint shadows. We said that we need not have extremes, we should have something in between and they are necessary for the observers to be able to perceive the depth of the object. What are the defects in interior lighting considering from brightness point of view? Major defects in lighting system arise due to too bright luminaire, too dark floor and interiors.

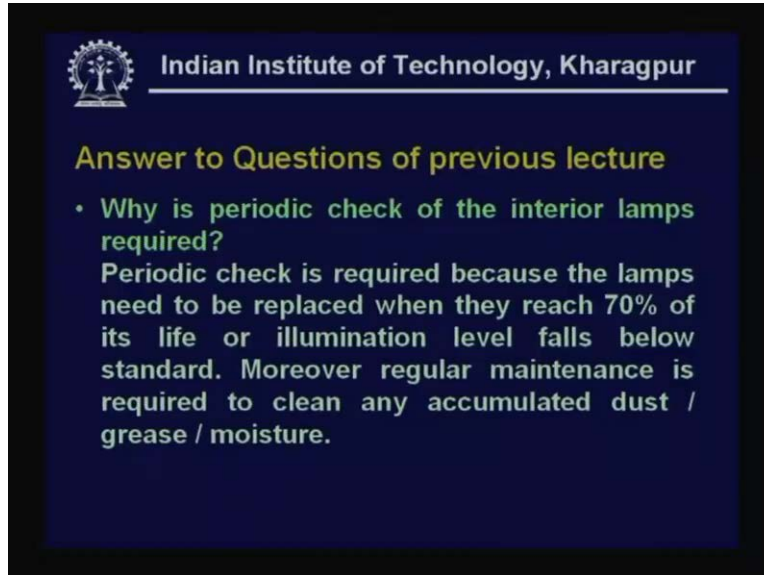
So in fact we did mention in the lecture that there is certain ratio which needs to be maintained between the darkest object to the light brightest object in a room between 1:3:10 in order to avoid such. So we have light coloured interiors with large sources of low brightness, this takes care of such defects.

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What is the criteria for deciding the height of a window? Now windows are necessary to enable the natural light to be percolate and that's how we are able to decide whether to have artificial lighting. So windows if they are located on the one wall, the height to the top of the window should be greater than half the width of the room. On the other hand if they are located on both the walls then the height to the top should not be less than one sixth of the distance between the walls. The idea is that average illuminance level to interior depth of the room is maintained.

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Answer to Questions of previous lecture

- **Why is periodic check of the interior lamps required?**
Periodic check is required because the lamps need to be replaced when they reach 70% of its life or illumination level falls below standard. Moreover regular maintenance is required to clean any accumulated dust / grease / moisture.

Why is periodic check of interior lamps required? Periodic check is required because the lamps need to be replaced when they reach there, when there life reduces and so whenever the life reduces by about 75% or illumination level falls below standard level it becomes necessary. So and this can be taken care through regular maintenance by cleaning the dust grease or moisture that is accumulated and often it is advised to replace in groups rather than in terms of a individual lamps large group replacement is advisable. Thank you.