

4. Screens, Specifications and Sightlines

4.1 Introduction

Design Goals

Screen based presentations are crucial part of modern teaching and learning practice. The content displayed can vary between:

- PowerPoint presentations
- videos and cinema,
- websites of all kinds
- spread sheets
- detailed, graphs, charts plans and illustrations
- fine text from books, magazines and websites
- scientific data and visualisations
- and much more

Specifying Presentation Screens and Ceiling Heights

To enable the detailed content to be read by all the audience the display screen(s) must be of sufficient size in proportion to the distance of the furthest audience member.

Consequently the determination of the screen size must not be an arbitrary decision, but rather a result of the strict application of the viewing distance rules below. Stated as a simple "rule of thumb", the aim is to make the screen large enough for those in the back row to read the 10pt body text of a standard website, but not so large as to overwhelm the closest viewer.

Unless designed to be fit for purpose, the ceiling heights the presentation spaces of modern buildings can be insufficient to allow appropriately sized screens. Such low height spaces put their original purpose at risk by making presentations hard to see or by limiting class size. A simple rule to remember is that if the room is longer than 7.5 m then the ceiling height must be greater than 2.7m to provide acceptable screen viewing.

Audience Area and Angles of View

The acceptable area for audience placement in front of a screen is determined by the horizontal and vertical angle of view as well as the distance to the display for the closest and furthest viewers. These factors must also be determined by the application of the following rules and not be defined in an ad-hoc manner.

Multiple Screens

In many educational organisations the presentation of two independent images is now a standard requirement for medium to large presentation spaces. Independent dual screens/displays allow educators to present complementary information. For example: a PowerPoint presentation on one screen and live notation on a visualiser on the other.

Screen Aspect Ratio

Wide screen and high definition has been the standard for video and television in Australia since 2001 and most modern laptops have a wide screen display.

AETM recommends projection in either the 16:9 or 16:10 ratio as this better matches modern film and television programming and compliments the output of wide screen laptops and material such as spread sheets.

Partial Conformity

The AETM recognises that site conditions, Heritage considerations, and other factors sometimes cause difficulty with full compliance to all of the rules for screens listed below, especially during refurbishment projects.

Compliance is often most difficult for those audience members seated closest to the screens. Teaching spaces typically fill from the back, with front rows more likely to be empty. Consequently if compromise regarding a rule is unavoidable, then it is preferable that the rules compromised relate to viewing angles (which will primarily affect the closest viewers) rather than the maximum viewing distance versus display size rule (Rule 1). Agreement in writing for any compromise must be obtained from the AV designer and the AV staff representative of the institution.

To remain in compliance with the AETM Design Guidelines no more than 10% of the seats in any teaching space can fall outside any rule.

4.2 Rules for Screen Size and Sightlines

Rule 1: Screen Height and Maximum Viewing Distance

The height of the projection screen or flat panel display shall be no less than the distance from the centre of the screen to furthest audience member divided by 5.3

Background to Rule 1

The calculation of the minimum allowable screen height or conversely the maximum allowable viewing distance for a given screen height, depends on the nature of the material displayed and the intent of the viewer. The AETM recognises two applicable standards and provide guidelines that take account of both.

Internationally, the ICIA standards specify three types of viewing tasks. In the context of tertiary instruction, where students are required to pay close attention to screen images and (often) take notes, two of these are generally applicable:

- Detailed Viewing Tasks (e.g. note taking from text based slides)
- Inspection Viewing Tasks (e.g. viewing graphic material such as complex mathematical equations, engineering drawings or medical slides containing specific detail such as x-rays)

ICIA recommendations for Detailed Viewing Tasks (text based) are:

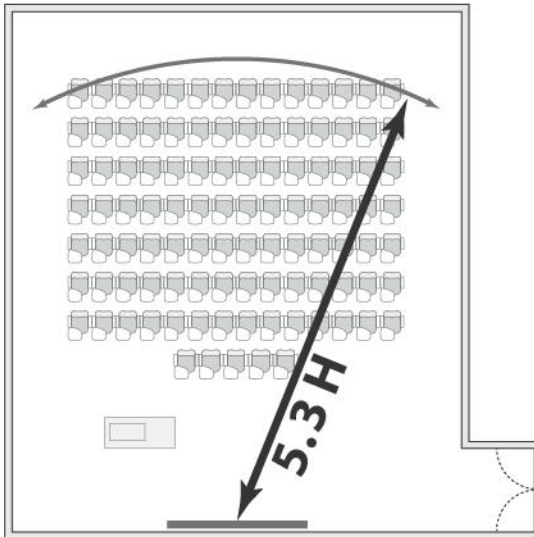
The height of the projection screen or flat panel display shall be no less than the distance to furthest audience member divided by 6.

ICIA recommendations for Inspection Viewing Tasks (detailed graphics) are:

The height of the projection screen or flat panel display shall be no less than the distance to furthest audience member divided by 4.

Individual institutions sometimes provide in-house standards that provide for some spaces to conform to the ICIA recommendations for Detailed Viewing Tasks and define a viewing ratio of 6:1 for appropriate spaces. Sometimes a ratio of 4:1 as per the stricter ICIA recommendations for detailed graphics will be defined for specialist classrooms (especially in disciplines such as Medicine and Engineering).

The resolution of the projector or display must also be considered when determining the appropriate sizing ratio to be used. For example a high definition WUXGA projector (1920 x 1200 pixels) requires a screen substantially larger than one used with XGA or WXGA projectors if the readability of text and detailed images is to be maintained. When using high definition displays or projectors with a vertical resolution of 1080 pixels or more, the use of the AETM recommended screen sizing ratio below should be treated as an absolute minimum and consideration should be given to more stringent ratios.



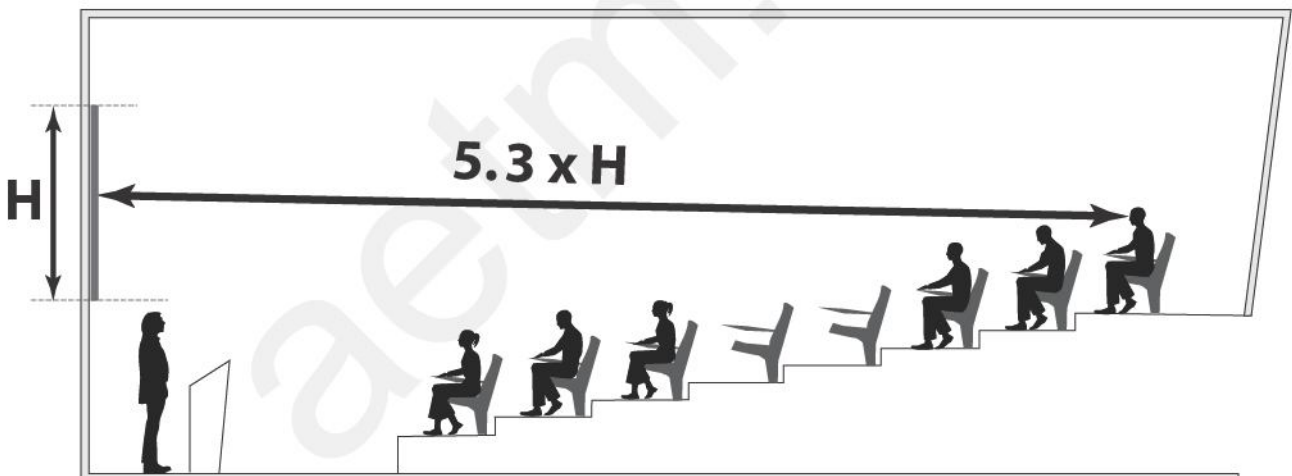
Recognising that most classrooms and lecture theatres are general purpose and may cater for both kinds of tasks, AETM recommends that:

*The **height** of the projection screen or flat panel display shall be no less than the distance from the centre of the screen to furthest audience member divided by 5.3.*

Application of Rule 1

Where “H” is equal to the height of the projection screen, the furthest viewer must be seated no more than a distance equal to $5.3 \times H$ from the centre of the screen.

Conversely, for a given distance from the centre of the screen to the furthest seating position, the screen height must be at least equal to that distance divided by 5.3.



The table opposite indicates examples of maximum distances serviced by standard, commonly available 16:10 screen sizes. “Maximum Viewing Distance” is the distance to the furthest audience member measured in metres (to nearest 10 cm).

Notes: standard sizes are often specified in imperial measure.

Maximum Viewing Distances 16:10 Screens

Diagonal Inches (mm)	Width (viewable area in mm)	Height (viewable area in mm)	ICIA Detailed Viewing H x 6	ICIA Inspection Viewing H x 4	AETM Recommended H x 5.3
84 (2130)	1810	1131	6.8 m	4.5 m	6.0 m
96 (2440)	2070	1294	7.8 m	5.2 m	6.9 m
100 (2540)	2155	1347	8.1 m	5.4 m	7.1 m
120 (3050)	2585	1616	9.7 m	6.5 m	8.6 m
130 (3300)	2880	1800	10.8 m	7.2 m	9.5 m
150 (3810)	3230	2019	12.1 m	8.1 m	10.7 m
200 (5000)	4300	2700	16.2 m	10.8 m	14.3 m
300 (7600)	6450	4000	24.0 m	16.0 m	21.2 m

The table below is provided as a “quick reference” to illustrate the increasing height requirements as the floor space becomes larger. The ceiling height at the point where the screen is fixed must be no less than in the table below.

Notes: If bulkheads, air conditioning ducts, beams or other ceiling obstructions are present at the point where the screen is to be fixed, the clear space under the obstruction is to be considered as the ceiling height available. Ceiling fans or suspended lights must also be taken into account when calculating the clear space available for the screen. It is recommended that such obstructions be avoided wherever possible during the development of the architectural design.

Ceiling height calculations based on 5.3 ratio, 1.2m off floor and projection screen case under the ceiling

Distance to Furthest Audience Member	Required Ceiling Height (m)
<7.5m	2.7
7.6 - 8m	2.8
8.1 - 8.5m	2.9
8.6 - 9.1m	3.0
9.2 - 9.6m	3.1
9.7m - 10.1m	3.2
10.8 - 11.2m	3.4
11.8 - 12.2	3.6
12.9 - 13.3m	3.8
13.9 - 14.4m	4.0
For every 475mm extra distance add 100mm ceiling height	

Rule 2: Maximum Horizontal Viewing Angle

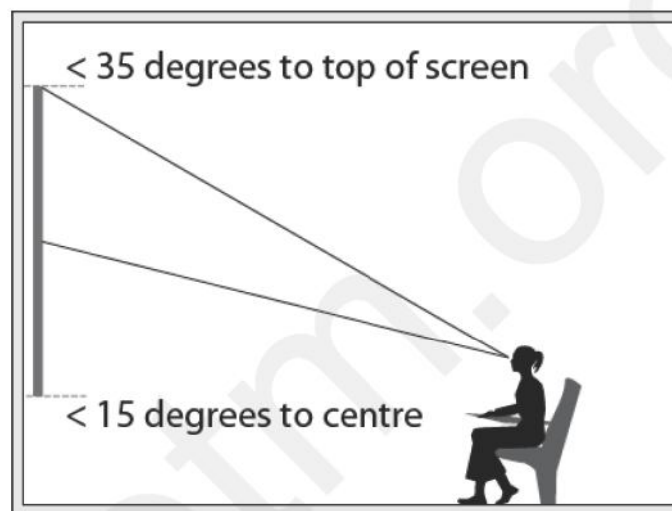
The maximum horizontal viewing angle shall be 45 degrees from the centre line of the screen.

Notes: The legibility of text and images will be too compromised at greater angles.
For wide spaces repeater screens may be an option.

Rule 3: Maximum Vertical Viewing Angle

The maximum vertical viewing angle shall be no more than (plus or minus) 15 degrees to the centre of the image, measured from perpendicular at seated eye height (1270mm AFFL) from the front row centre seat. For tight spaces, this rule may be relaxed to a maximum angle of 35 degrees to the TOP of screen.

Notes: The rule aims to prevent neck and eye strain for audience members.

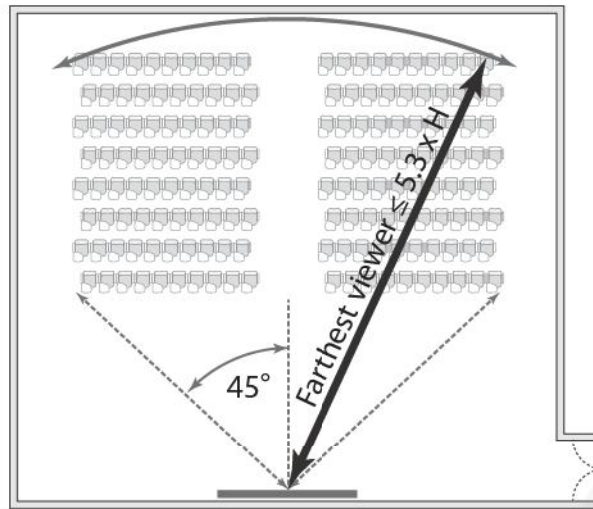


Rule 4: Screen Bottom Edge Minimum Distance from the Floor

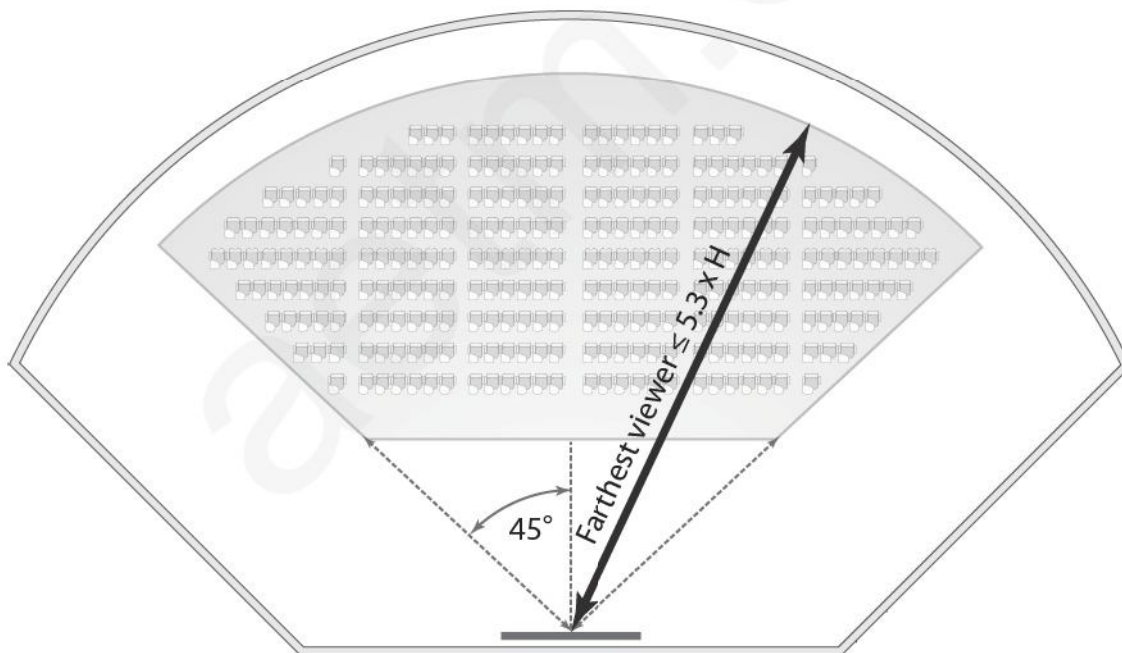
For flat floor venues with an unobstructed view the screen shall be positioned so that the bottom edge of the viewable area is no less than 1.2m above the floor.

Notes: The preferred height is 1.35m or more. In tiered venues the height may be lowered marginally to suit, however the decision on the screen position must take into account the potential issue of glare in the presenter's eyes from the projector. In labs or other spaces where there are obstructions, the screen must be positioned to allow for a clear view over or around the obstructions while at the same time staying taking into account the maximum viewing angles.

Illustrations



Shows the floor plan of a rectangular lecture theatre which meets the requirements for viewing angles and distances.
H = screen height.



Shows the floor plan of an auditorium style lecture theatre which meets the requirements for viewing angles and distances.
H = screen height.

4.3 Recommendations for Screens

Viewing Conditions for Dual or Multiple Screens

Where a teaching space is fitted with more than one screen, the rules should be applied for each screen to ensure that, where different information is to be displayed on each screen, the viewing area falls within the maximum distances and within acceptable angle of view for both screens. This involves calculating distances and angles for viewer to "worst case" screen.

On the advice of the institution and in the case where identical information is displayed on all screens, the calculations may be made for "best case".

Recommendations for Dual Projection/Display

Dual projection is recommended by AETM as best practice for presenting educational material on screen. Dual projection is adopted by most educational institutions for lecture theatres and larger presentation spaces. The benefits are:

- Ability to present complimentary and/or comparative material simultaneously
- The ability for most presentations to continue should a lamp or projector fail
- Improved sightlines for audience members on the sides (when showing the same image on both projectors)
- Better support for video conference applications

Recommendations for Screen Aspect Ratio

A projection area or screen with a 16:10 (width to height) ratio is recommended for lecture theatres.

This is ideal for the typical display ratio adopted by most wide screen PCs and laptops and also suits modern film and television programming presented in 16:9 ratio.

When direct view monitors are used, AETM recommends the use of monitors with a 16:10 aspect ratio where available; however 16:9 (typically the standard aspect ratio for larger monitors) is also acceptable.

Recommendations for Projector Placement

Vertical Position

The height that a projector is positioned is dependent on a number of factors. Each projector has different optical characteristics and a manufacturer's recommended vertical position in relation to a given screen size. To ensure a high quality image the projector must be installed in the manufacturer's recommended vertical position. Higher quality installation grade projectors often include a lens shift function that allows a range of vertical positions to be used. In all cases the projector must be installed horizontally level. Commonly the highest position that a projector with lens shift can achieve is level with the top of the screen image area. The use of electronic keystone correction to correct the optical aberrations caused by the incorrect placement of a projector is generally unacceptable since even small amounts of electronic keystone degrades the clarity of the image.

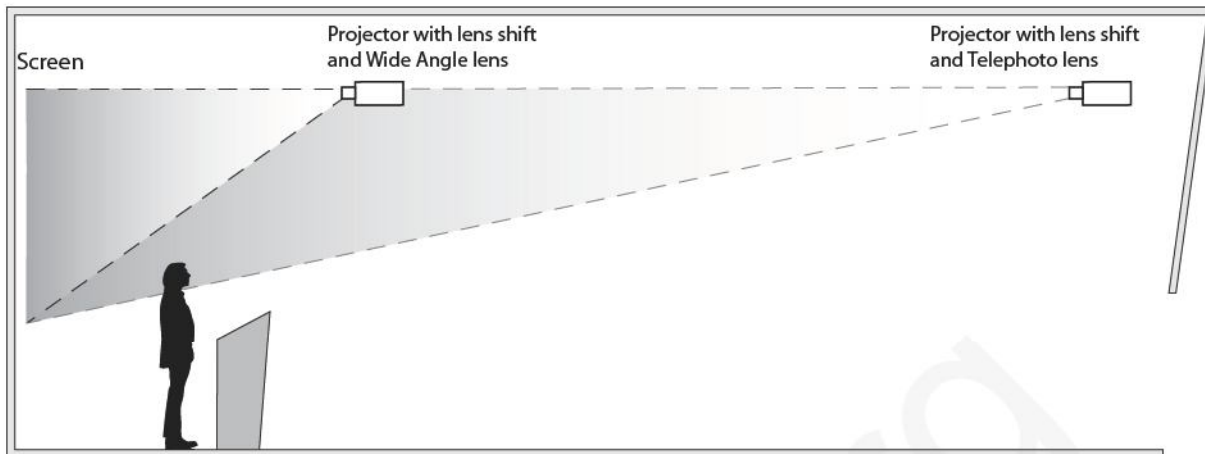
Horizontal Position

The decision on the placement of the projector is also influenced by a number of considerations:

- Ease of maintenance,
- Projector noise intrusion
- The presenter's workable area in front of the screen free from projector glare.
- The additional cost of telephoto or short throw (wide angle lenses)
- Security concerns

Where the venue is equipped with a projection booth, the maintenance, security and noise benefits of placing the projector(s) there are considerable.

The ability of the presenters to walk in front of the screen without contending with the glare from the projector in their faces is also an important factor to be considered with possible OH&S implications. The closer a projector is to the screen the steeper the angle of light and the more glare free work area is created. See the illustration below:



This issue becomes even more critical for interactive whiteboard applications. Consequently a range of ultra-short throw projectors are available that overcome the problem.

However short throw technology is only suitable for a screen with a gain of 1 or less. Where gain is a factor (for example in rear projection) screen manufacturers³ recommend that the projector be placed at a distance of greater than 1.6 x screen width (16:10) to avoid excessive angles of incidence which will cause brightness issues at the edges of the picture.

4.4 Image Quality and Lighting

Contrast Ratio Standard for Projected Images

(See also section 5.4 Ratio of Projected Versus Ambient or "Spilled" Light)

Standards Compliance

To provide acceptable legibility for projected images, the contrast ratio (the difference between peak white and "black" in the projected picture) must fall within defined minimum limits. The contrast ratio achievable in a teaching space depends upon the brightness of the projected image (the "peak white") and crucially upon the amount of ambient light falling on the projection surface (which determines the "black" or minimum level).

AETM endorses the ANSI/ICIA published specification regarding contrast ratios in projected images:

ANSI/INFOCOMM 3M-2011: Projected Image System Contrast Ratio

To comply with the AETM Design Guidelines, in spaces that use projected images the AV Designer and Lighting Designer must design AV systems and lighting systems to meet the ANSI/INFOCOMM 3M-2011 Projected Image System Contrast Ratio standard. Copies of the standard are available for purchase from: <http://webstore.ansi.org/RecordDetail.aspx?sku=ANSI/INFOCOMM+3M-2011>

³ April 2007 Da-Lite Screen Company Angles of reflection V1 Issue 2

Application of the ANSI/INFOCOMM 3M-2011 Standard in Learning Environments.

In teaching space design, and in particular in lighting design, ambient light from all sources must be controlled so that the following minimum recommendations regarding contrast ratio are achievable at the any point on the image area. Measurement must be according to the procedure outlined in the ANSI/ Infocomm standard referred to above.

Projected Contrast Ratios		
Projection Type	Examples	Minimum Contrast Ratio
Text and Numerals	Bullet point text, documents, spread sheets, charts and graphs	7:1
Pictorial	Black and white or colour photographs, artwork, illustrations	15:1
Motion Pictures	Film, video, or television programs	80:1 (best practice) 50:1 (minimum acceptable for classroom viewing)

Table 4-1

In lecture theatres and other tertiary education presentation spaces the standard lighting pre-set for projected presentations also provides workable levels of light for student note taking. This pre-set would correspond with the 7:1 contrast ratio target. Commonly the next lighting pre-set in a lecture theatre provides lower light levels in the space. The purpose of this pre-set is to provide the best quality of image possible while still accommodating note taking by students. The 15:1 contrast ratio target is appropriate for this pre-set. The final pre-set in a theatre is usually reserved for the presentation of cinema or similar material. A 50:1 contrast ratio target is appropriate for these purposes in an educational environment.

The ANSI/INFOCOMM standard for contrast ratios may on occasions be difficult to achieve while at the same time providing sufficient light to illuminate the presenter and the students' writing surfaces, however it is essential that it is achieved. All uncontrolled light that reflects off surfaces can be detrimental. Light coloured floor coverings and furniture near the projection screens should be avoided as much as possible since they will reflect significant amounts of light from the spot and stage lights onto the screens.

Recommendations for Minimum Projector Brightness

Large venues require large screens, which in turn require powerful projectors. For example, using the inverse square law we know that a screen twice the width requires a projector 4 times as powerful to achieve the same brightness on the screen. ANSI lumens is a measure of light emitted by a projector and Lux is a measure of light falling on a given area.

A common target for projection is 500 Lux for any given screen size. This target is usually achievable for small to mid-sized venues; however this is progressively more difficult to achieve in large venues without the use of expensive cinema grade projectors. For large venues a more achievable and affordable target for large venues is 300 Lux, however this reduced target will only comply with the ANSI contrast ratio standard if the lighting is carefully designed to significantly restrict ambient or spilled light falling on the projection screen(s).

The AETM recommends that for all spaces of more than 100 seat capacity the following process occur at the commencement of the detailed design phase:

- The AV Designer provides to the Lighting Designer for sign off the calculated LUX values for the proposed projection screen and projectors solution.
- The Lighting Designer provides for sign off by the AV designer the results of a computer lighting model of the proposed lighting design that confirms the achievement of the 7:1, 15:1 and 50:1 contrast targets mandated by the ANSI standard for contrast ratios.

As a general reference the table below provides a guide to the recommended minimum projector light output

Recommended Minimum Projector Light Output			
Screen Size (Diagonal)	Screen Width	Screen Height	Projector ANSI Lumens
100" (250cm)	2.15m	1.35m	3000
120" (330cm)	2.6m	1.6m	4000
150" (380cm)	3.2m	2.0m	5000
200" (500cm)	4.3m	2.7m	7000
>200" (500cm)	>4.3m	>4.3m	Specialist Hi Power

Based on standard (imperial measure) screen sizes – metric equivalents are approximate

Projection Surfaces

Projection should ideally be onto matt white, purpose manufactured projection screen material with a gain of 1.0. (Gain is a measure of screen surface reflectivity). Screens may be fixed or retractable. Where high gain or rear projection screen material is used, the manufacturer's recommendations regarding optimum viewing angle must be followed.

Walls as Screens

Walls are acceptable as projection surfaces so long as they are painted flat (matt) white and are uniformly flat and perpendicular to the projector and the audience. Special paint is available for projection walls and may be specified by the standards of individual institutions.

Whiteboard and Writable Surfaces

Whiteboards are generally not suitable for use as projection screen surfaces as the shiny surface causes unacceptable glare and hot-spotting. Where whiteboard surfaces are used in special circumstances (for example in interactive whiteboard installations) the projector used should be of the ultra-short throw type so that most glare is reflected away from the audience area.

Glass writing surfaces are not suitable as projection screens.

Recommendations for Flat Screen Technology

The cost of flat screen display technology has reduced significantly and for small venues and especially small video conference venues, it is now the recommended display technology.

The selection and placement of flat screen displays must be governed by the same size and sight lines rules as for projection screens (refer Section 0). Therefore a display of around 165cm (65") diagonal will service a room of around 4.5m in length.

Recommendations for Video Conference Venues

The display technology in video conference venues is often required to perform the dual function of both video conference calls and presentations and should be sized using the guidelines above.

The cameras used to capture videoconference images require higher lighting levels than generally needed for note-taking in lecture theatres and seminar rooms. Generally flat panel displays (such as LCD panels) are much better at coping with high levels of ambient light. Accordingly, large flat panel displays are the recommended technology for small and medium sized videoconference venues.

Further information on videoconferencing may be found in later sections of these guidelines including Section 5.18.

5. Lighting Design for Teaching Spaces

5.1 Standards Compliance

Lighting must meet the requirements of Australian and New Zealand Standards - AS/NZS 1680 for Lighting (as amended) and the relevant government building codes. In particular lighting must conform to the relevant sections of:

AS/NZS 1680.2.1:2008 (as amended) Interior and workplace lighting - Specific applications - Circulation spaces and other general areas

AS/NZS 1680.2.2:2008 (as amended)

Interior and workplace lighting - Specific applications - Office and screen-based tasks

AS/NZS 1680.2.3:2008 (as amended)

Interior and workplace lighting - Specific applications - Educational and training facilities

Note that it is common for individual Universities to have their own specifications in conjunction with these standards and advice should be sought from relevant personnel.

5.2 Introduction

The presentation of PowerPoint slides, websites and other visual material is an essential part of modern teaching and learning and the clarity of these images is critical to the successful use of the venue. Poor lighting design can ruin the effectiveness of projected presentations making them “washed out” and hard to read. Consequently, the importance of lighting design in all presentation and teaching spaces cannot be over-emphasized.

Design Goals

In the majority of teaching spaces, the lighting design must have the following objectives:

- Control all ambient light to allow the required contrast in projected images
- Provide note taking light and if required task lighting for students
- Properly illuminate the presenter wherever they are in the presentation area
- Properly illuminate any demonstration and presenter work spaces

Selection of Light Fittings

The legibility of projected images is totally dependent on the careful selection, arrangement and control of light fittings. It is essential to select fittings which provide a high degree of directional control. Lighting divided into zones; dimming (or at least selective switching); directional ambient and task lighting; spot lights; and easy to use control systems are the tools required to achieve effective lighting in presentation and teaching spaces.

During a presentation different lighting settings may be required in rapid succession. It is essential that the lights used be capable of being switched on and off (or dimmed) quickly. Lighting which requires long delays between extinguishment and re-strike, or fittings which take more than 10 seconds to achieve maximum brightness are not suitable for general purpose teaching spaces.

Control

Presenters need access to flexible but easy-to-use lighting controls located at the presentation position. Best practice involves the integration of lighting control with the AV control system. In larger spaces this is an essential requirement.

5.3 Lighting Zones and Circuits

Small to mid-sized teaching and presentation spaces with projection

For small to mid-sized teaching and presentation spaces with projection three lighting circuits* are the minimum that shall be provided to allow sufficient zone control of lighting. Each of the circuits should preferably be controlled by a separate dimmer or by a relay controlled contactor if this is not possible.

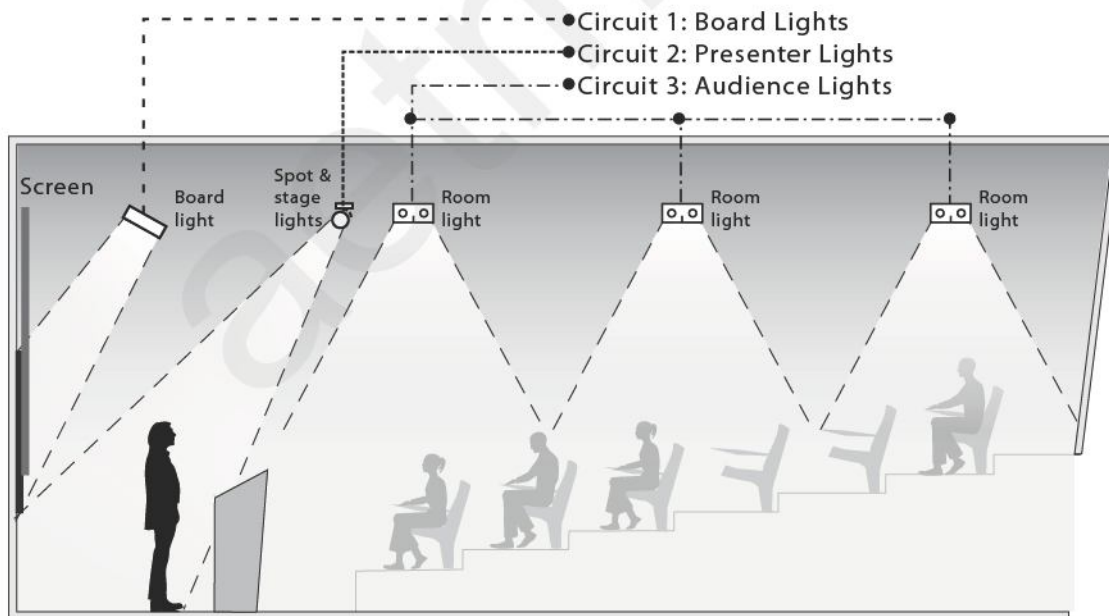
Provide separate light fittings and switching circuits for:

1. Front lights that spill directly on the screen (including board lights)
2. Directional task/spot lighting to illuminate the presenter at the lectern or presentation position without spill on the screen.
3. Audience area room lights

*Other zones/circuits may be used if required, and these should be switched or dimmed separately.

Directional lighting of the presentation area is a strongly recommended feature for even small venues. Without it, the presenter will either be in the dark while presenting or will they will turn on the board lights thereby "washing out" the projected presentation.

The Graphic below illustrates a typical three circuit layout consisting of separate lighting instruments and control circuits for Board lights, Presenter illumination and audience (note taking) lights. Note that in small rooms, even if specific board lights are not used, it may be necessary to isolate the lighting nearest the screen surface so that it may be switched off during projection without affecting the note taking lights over the general audience area. Presenter lighting should be angled horizontally and or vertically by between 45 and 60 degrees to avoid dazzling the presenter and to enable them to maintain eye contact with the audience.



Typical Three Circuit Lighting Scheme

Lecture theatres and larger presentation spaces with projection

For lecture theatres and larger presentation spaces multiple lighting circuits shall be provided to allow sufficient zone control of lighting. In addition to the three zone scheme used in smaller teaching spaces it is usual to provide more sophisticated control over the audience area and the presentation area. All zones must be under the control of the presenter via dimmers with the exception of Exit, stair tread and safety lights (which may be required to be always on).

Provide separate light fittings and switching circuits for:

- Board lights (as required)
- Directional front stage area lighting, either spot lighting with cutters/barn doors or other forms of directional lighting that do not spill on to the screen(s). The stage lighting shall be broken into multiple zones for large venues (e.g. Stage Left, Centre and Right).
- Lectern/presentation point focused spot lights with cutters/barn doors to ensure no spill on to the screen(s).
- A minimum of 3 audience lighting zones (e.g. front, middle, back)
- Aisle lights
- Safety lights
- Other zones/circuits as required (e.g. for demonstration or performance spaces)

5.4 Ratio of Projected Versus Ambient or “Spilled” Light

(See also 4.4 Contrast Ratio above)

As discussed already, the clarity of projected images relies on a sufficient contrast ratio between the light from the projector and the ambient or spilled light falling on the projection screen. AETM endorses the ANSI/ICIA published specification regarding contrast ratios in projected images (ANSI/INFOCOMM 3M-2011: Projected Image System Contrast Ratio). As these standards apply to the tertiary environment, we can identify three situations:

- a. Projection of Text and Graphics (e.g. PowerPoint Slides or Visualiser) where it is expected that reasonable ambient light levels are provided for note taking
- b. Projection of detailed photographic images (including medical images and x-rays) where note taking is secondary to a full contrast ratio projected image which allows for the reproduction of detail in the darkest areas of the picture.
- c. Projection of moving images (Film and Video) where note taking is secondary to a full contrast ratio projected image which allows for the appreciation of detail in both the brightest and darkest scenes in the presentation.

It is the responsibility of the lighting designer, working with the audiovisual design consultant, to ensure that ambient light from all sources is sufficiently controlled so that the minimum recommendations regarding contrast ratio are achievable at the any point on the image area. (See Table 4 1: Projected Contrast Ratios (page 20)). Measurement must be according to the procedure outlined in the ANSI/Infocomm standard 3M-2011. If this is not achieved the imaged will be “washed out” and be hard to read.

Control of ambient and spilled light falling on the projection screen is essential in all spaces with projection, but it is absolutely critical in larger venues. Large venues require large screens which in turn require powerful projectors. For example, using the inverse square law we know that a screen twice the width requires a projector 4 times as powerful to achieve the same brightness on the screen. In general, the audiovisual designer will declare the target illumination the projector is able to achieve given the screen size.

Compared with classroom situations described above, the projected light reflected off the screen will often be substantially reduced in these larger venues. Therefore to retain a sufficient contrast ratio between projected and ambient light the ambient light falling on the screen the lighting designer must take particular care with the directional control of light fittings and the control of external ambient light sources such as daylight.

Light coloured floor coverings and furniture near the projection screens should be avoided as much as possible since they will reflect significant amounts of light from the spot and stage lights onto the screens.

5.5 Target Light Levels

Actual lighting levels in practice will be set by reference to: first, Australian Standards (where appropriate) and secondly, to the requirements and standards set by the individual institution concerned. Where no institutional standards exist, this section will provide guidance as to typical situations found in undertaking the lighting design for a larger multi-purpose lecture theatre.

For a typical lecture theatre, four lighting examples are defined:

- a) Board Lighting or Demonstrations (also used as Entry/Exit lighting without board lights). This is often defined as Preset 1 or Full lighting. Board lights to be separately controllable.
- b) Text and Graphics Projection. Often Preset 2, this is the most commonly used state.
- c) Pictorial or Detailed Projection. Preset 3, this is as for 2 but with reduced audience light
- d) Cinema Projection. Preset 4, Projection takes precedence, plus safety lighting, with note-taking light only implemented if achievable without excessive spill.

In addition, the following measurement points are defined:

- At the surface of each student writing surface (horizontal plane)
- In the presentation area (horizontal and vertical planes)
- On the whiteboard writing surface where fitted (vertical plane)
- Spill and ambient light on the projection surface (vertical plane)
- Stair treads and safety lighting

Definitions:

"ANSI Lumens" – measure of light output of a projector

"LUX" is a measure of the light falling on a given area.

"Screen Gain" is how much light a surface reflects (1=100%)

Assumptions:

Target Projected Lux = 500+

Screen Gain = 1

Example A: Whiteboard / Blackboard or Demonstration Mode

Intent:

The lighting (and external light control) must be capable of providing suitable light levels at student writing surfaces to facilitate detailed note taking while simultaneously providing good visibility of notations being made on the whiteboard and/or of the presenter undertaking a physical demonstration in the presentation area together with a safe level of access light. Projection is generally not required in this mode so there is no specification for contrast ratio on the screen.

Design Lighting Levels

- Note taking light in student seating area shall be capable of producing between 150 (minimum) and 320 maintained lux (preferred) measured on the horizontal surface of each student writing bench.
- Separately controllable illumination of presenter to a minimum of 150 lux measured in a horizontal plane and a minimum of 50 lux in the vertical plane within the defined presentation area. Where frontal lighting is used it should be placed as close as practical to 45 degrees elevation and 45 horizontally degrees from a line perpendicular to the screen to avoid undue glare in the presenter's field of view.
- Separately controllable illumination of the whiteboard or blackboard area. Lighting to be as even as possible across the surface and should not vary by more than a ratio of 3:1 from brightest to darkest point within the board area with board lights, presenter lights and note taking lights all ON at nominal levels. Lighting must not produce glare or hot spots on the surface of the whiteboard. The average level of illumination on the board with the board lights ON should be 300 lux.
- While the amount of spill light on the screen from all sources is not defined in this mode, if there is a requirement for projection to be simultaneous with board or demonstration lighting, then spill light on the screen shall be limited so that a contrast ratio of 7:1 is achieved between the level of white illumination produced by the projector across the entire screen surface and the level of ambient light incident on the screen.
- Stair treads: refer to applicable Australian standard or local specification

Example B: Text and Graphics Projection Mode (with note taking)

Intent:

The lighting (and external light control) must be capable of providing suitable light levels at student writing surfaces to facilitate detailed note taking while simultaneously providing good visibility of the presenter, a safe level of access light and adequate (7:1) contrast ratio on the screen.

Design Lighting Levels

- Note taking light in student seating area shall be capable of producing 150 maintained lux measured on the horizontal surface of each student writing bench and shall have dimming control allowing adjustment down to 10% of full brightness with no noticeable flicker. This lighting source must be controlled to minimise spill onto the projection surface (see below).
- Separately controllable illumination of presenter to a minimum of 150 maintained lux measured in a horizontal plane and a minimum of 50 maintained lux in the vertical plane within the defined presentation area. Where frontal lighting is used it should be placed at angles of between 45 and 60 degrees elevation and 45 and 60 degrees horizontally from a line perpendicular to the screen to avoid undue glare in the presenter's field of view.
- Whiteboard surface illumination is not required in this mode.
- Spill light from all sources to be limited so that when note taking light of 150 lux is achieved in the audience area, a contrast ratio of 7:1 is achieved between the level of white illumination

produced by the projector across the entire screen surface and the level of ambient light incident on the screen.

The specific expected white level from the projector should be confirmed prior to lighting design. However, as an example, where 500 lux is achieved as projected peak white, spill light from all sources must be <72 lux at any point within the image area of the screen.

- Stair treads: refer to applicable Australian standard or local specification

Example C: Pictorial Content or Detailed Projection Mode (with note taking)

Intent:

The lighting (and external light control) must be capable of providing suitable light levels at student writing surfaces to facilitate note taking while simultaneously providing good visibility of the presenter, a safe level of access light and adequate (15:1) contrast ratio on the screen.

Design Lighting Levels

- Note taking light in student seating area shall be capable of producing 50 maintained lux measured on the horizontal surface of each student writing bench and shall have dimming control allowing adjustment down to 10% of full brightness with no noticeable flicker. This lighting source must be controlled to minimise spill onto the projection surface (see below).
- Separately controllable illumination of presenter to a minimum of 50 maintained lux measured in a horizontal plane and a minimum of 25 maintained lux in the vertical plane within the defined presentation area. Where frontal lighting is used it should be placed at angles of between 45 and 60 degrees elevation and 45 and 60 degrees horizontally from a line perpendicular to the screen to avoid undue glare in the presenter's field of view.
- Whiteboard surface illumination is not required in this mode.
- Spill light from all sources to be limited so that when note taking light of 50 lux is achieved in the audience area, a contrast ratio of 15:1 is achieved between the level of white illumination produced by the projector across the entire screen surface and the level of ambient light incident on the screen. The specific expected white level from the projector should be confirmed prior to lighting design. However, as an example, where 500 lux is achieved as projected peak white, spill light from all sources must be <35 lux at any point within the image area of the screen.
- Stair treads: refer to applicable Australian standard or local specification

Example D: Cinema Projection Mode

Intent:

The lighting (and external light control) must be capable of providing adequate (50:1) contrast ratio on the screen, along with a safe level of access light and (if possible) suitable light levels at student writing surfaces to facilitate less comprehensive note taking.

Design Lighting Levels

- Spill light from all sources to be limited so that a contrast ratio of 50:1 is achieved between the level

of white illumination produced by the projector across the entire screen surface and the level of ambient light incident on the screen.

- The specific expected white level from the projector should be confirmed prior to lighting design. However, as an example, where 500 lux is achieved as projected peak white, spill light from all sources must be <10 lux at any point within the image area of the screen.
- Where practical, note taking light in student seating area shall be capable of producing up to 50 lux measured on the horizontal surface of each student writing bench and shall have dimming control allowing adjustment down to 0% of full brightness with no noticeable flicker. Where note taking light cannot be achieved without compromise to the amount of spill light on the screen, then note taking light is to be reduced or eliminated
- Presenter illumination is not required in this mode.
- Whiteboard surface illumination is not required in this mode.
- Stair treads: refer to applicable Australian standard or local specification

The table below provides an example of the indicative maximum ambient/spilled light limits for different screen sizes. In all cases, the actual contrast ratio shall take precedence.

Some Common Scenarios							
Room Type	Screen Size	Projector ANSI Lumens	Non-Std Lens	Typical Projected LUX	Max Ambient Light on Screen (lux)		
					Text	Photo	Movie
Meeting room	100"	3000	no	600	85	40	12
Small Seminar room	115"	3000	no	450	65	30	9
Large Seminar room < 11m	130"	4000	no	575	82	38	11
Lecture Theatre >11m	150"	5000	yes	465	66	31	9
Auditorium	200"	7500	yes	385	55	26	8

This is a guide only – actual figures may vary depending lens type, illumination source and other factors.

Design Modelling

All lighting designs should be computer modelled during the design stage to ensure that the light falling on the projection screen does not exceed these limits. If the design does not meet these standards then the specification of new light fittings and light placement will be required prior to the issue of the tender.

5.6 Light Fitting Selection

Light fittings with good directional control are required to eliminate glare and unwanted lighting spill on projection screens. The closer the lights are to the projection screens the more important this requirement becomes.

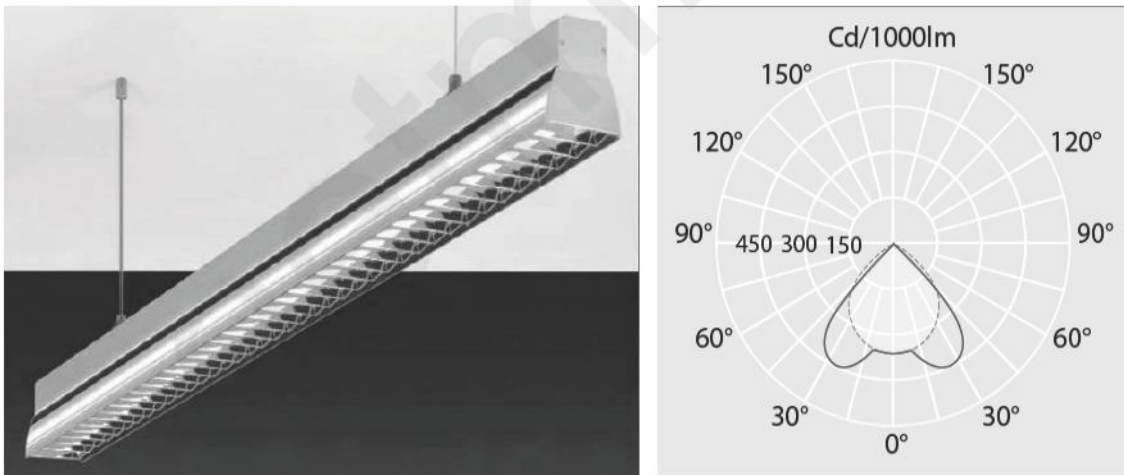
Light fittings without horizontal shielding and louvers, or light fittings that bounce light off ceilings or other surfaces do not provide sufficient directional control and are not suitable for spaces with projection. Low brightness non-reflective louvers are preferred.

During a presentation different lighting settings may be required in rapid succession. It is essential that the lights used be capable of being switched on and off (or dimmed) quickly. Lighting which requires long delays between extinguishment and re-strike, or fittings which take more than 10 seconds to achieve maximum brightness are not suitable for general purpose teaching spaces

General Light Fittings Compatible with Projection

To achieve low levels of ambient light spill onto projection surfaces, light fittings must be of a glare free design with direct light distribution only (i.e. no upward incident light) and have reflectors with **cut-off or shielding angles of 50 degrees** or less in the direction of the screen(s). Recessed lights with non-reflective louvers or suspended lights with sufficient side shielding reflectors and non-reflective louvers are usually suitable.

Examples of light fittings with sufficient light cut off or shielding



Shown above is a louvered fluorescent fitting suitable for use in rooms with projection along with a typical dispersion pattern

In addition to the requirements for general room lighting, fluorescent light fittings that are not turned off during projection must be equipped with low spill reflectors/louvers. Highly reflective louvers are not suitable as they reflect light horizontally.

Task lights and spotlights that are not turned off during projection must also have either internal cutters or external barn doors to enable illumination of people near the screen, while preventing direct light falling on the screen.



This Philips Selecon PL1 LED Luminaire, is a modern LED Spotlight light fitting which provides the beam control needed for presenter lighting without excessive spill while significantly reducing the impact of our activities on the environment.

Image supplied courtesy of Philips Selecon.

5.7 Light Fitting Placement

The placement of lights in relation to the projection screen(s) is another critical aspect of lighting design for teaching and presentation spaces.

Near the projection screens, house lights, stage lights and lectern spotlights must all be carefully positioned to avoid spill on the screen taking into account their beam cut-off/shielding angles. This should be confirmed in the computer modelling during the design stage and not left until the lights are installed. Care must also be taken when placing spotlights to that the body of the spotlight does impede the data projector's beam.

The vertical positioning of stage lights and lectern spotlights is often a difficult balance between sufficient light on the presenter's face and glare in their eyes. A commonly agreed balance is to position these lights between approximately 45 degrees and 60 degrees above horizontal from the presenter's eye-line.

Board lights should be set back from the boards a sufficient distance to allow even coverage.

5.8 Control of External Ambient Light from Windows and Skylights

In the architectural design of teaching spaces with projection systems, special consideration should be given to the control of natural ambient light by limiting use of windows or skylights. Where windows or skylights are present, use of curtains or blinds or louvers to control ambient light will be required. Motorised blinds or louvers controlled by the AV system are preferable.

For videoconference rooms complete control of sunlight is essential. Even small gaps in curtains can severely reduce the quality of the image captured by the camera. (See also 5.18 *Special requirements for Video Conference spaces*)

Notes: Light from all external sources should be excluded or controlled such as to allow the attainment of the standards above with respect to spill on the projection screen at any time of day and at any time of the year.

5.9 Dimming

Any space where the basic functionality involves presentation technology should have lighting dimmers installed. Dimming provides a finer control of the presentation environment and can optimise the performance of other components. In large spaces, dimming can also result in more efficient use of energy. The space should have functionally different areas allocated to discrete circuits on the dimming system. In some instances a rough dimming effect can be achieved by selective switching of fluorescent tubes in light fittings, however proper dimming remains the preferred method.

Dimming must only be achieved using appropriate dimming technology to suit the installed light fittings. Care should be taken to ensure that no flicker, audible noise, electronic interference or other undesirable artefact is evident throughout the dimming range.

5.10 User Controls

Lighting system should be able to be operated in either of two modes:

- Standalone - using lighting wall panel(s)
- Controlled - by the AV control system

Wall mounted lighting control panels (or "Entry/Exit" switches which bring up the appropriate lighting mode) must be placed near entrances in accordance with applicable regulatory requirements and building standards. When the venue has a Bio box additional lighting controls should be installed there as well.

Presenters need quick access to lighting controls located at the lectern/presentation position, consequently lighting control must also be available via the AV control system. In larger spaces this is an essential requirement.

5.11 House Lights

House lighting shall be directional in nature, dimmable, low spill, low glare, even and reasonably shadow-free providing approximately 320 lux falling on audience horizontal reading surfaces when operated at 100%. Currently fluorescent lighting is the most suitable for this purpose when combined with suitable low glare/spill fittings.

Lighting shall be arranged in enough zones to enable sufficient control of lighting for various projection needs and evenness lighting of the audience areas in tiered venues where the rear lights are much closer to the audience than at the front.

Fluorescent light fittings shall be of 'rapid-start' energy efficient type with a minimum of flicker and audible noise. They shall meet the stringent low glare and spill requirements described in the previous section - 5.6 *Light Fitting Selection*

Lights shall be spaced so there is significant overlap of beam patterns (so a lamp failure does not create an unusable dark zone).

5.12 Board Lights

Whiteboard lights are essential for the visibility of the whiteboard. Light levels falling on the board must at least match the levels on the reading surfaces of the audience section. Fluorescent lighting provides the most even source, however effective fittings with louvers will be required if the intention is to light banks of boards separately.

A common mistake is to mount the light directly above the board. This approach will result in a hotspot at the top of the board and ineffective lighting towards the bottom. A more successful approach is to position an asymmetric “wall washer” light fitting some distance out from the boards and to have its light angled across the full height of the board. There is a range of specific fixtures for this purpose.

Lighting must be as even as possible across the surface and should not vary by more than a ratio of 3:1 from brightest to darkest point within the board area with board lights, presenter lights and note taking lights all ON at nominal levels. The average level of illumination on the board with the board lights ON should be 300 lux. Board lighting must be separately controllable.

5.13 “Stage” Area Lights

Whether to illuminate presenters as they move around the room or for a table of speakers at a conference, ‘Stage Lighting’ provides a means of illuminating the required presentation area while avoiding washing out the projected images. Good stage lighting can help to reduce the occurrence of presenters turning on the board lights while projecting simply to get enough light to read their notes.

“Stage” lights must be dimmable narrow-beam directional lights with excellent control of spill. They should include devices such as barn doors or cutters to accurately shape the light beam to avoid spill on the projection screen while at the same time lighting as much of the area in front of the screen as possible. For smaller venues the principle of providing lighting with strong spill control near the screen is just as valid. In this context it may be achieved with a series of small down lights or directional fluorescent lights with highly effective louvers.

5.14 Presenter Spotlights

In lecture theatres and large venues a minimum of two narrow-beam focussing spotlights shall be installed to light the presenter at the lectern. The spotlights shall have full beam control (zoom, focus and cutters or barn doors) to adjust the light coverage and minimise spill onto the screens. Care shall be taken to avoid reflections off the lectern surfaces. For large venues theatrical spotlights are suitable.

In smaller venues a range of cost effective low voltage fittings can be used. A compact fluorescent asymmetric wall washer recessed in the ceiling can also be effective as long as care is taken to position it well and direct its beam well clear of the projection screen.

5.15 Aisle Lights

When installed, aisle lighting must meet the relevant building codes in terms of edge and step definition. The selected aisle light fittings must emit no, or minimal spill onto projection screens. A range of LED based lights are available that provide both edge definition and tread illumination.

5.16 Exit Lights

Special consideration should be given to the type and location of exit lights in lecture theatres and performance venues. Exit lights can have a detrimental effect on projection quality by producing an unacceptable level of ambient light.

5.17 Bio Box Lights

Many large lecture theatres are equipped with a bio box or projection booth. A bio box should have dimmable general room lighting and another circuit with highly directional down lights operable independently or the venues lighting control system.

5.18 Special Requirements for Video Conference Spaces

Video conference venues are in effect small television studios and require additional care and consideration in lighting design. It is important to minimize shadows, eliminate glare, avoid reflective surfaces and to create an evenly lit environment.

The best general lighting for videoconferencing is diffuse fluorescent. However even fluorescent lights will cause unattractive shadows around the eyes of participants if placed directly overhead. When carefully placed fluorescent asymmetrical wall washer light fittings can provide an even light at a 45 degree angle that reduces eye shadowing. Small spotlights carefully applied can provide pleasant shaping and highlights to the participant's faces. For consistency of colour and skin tone reproduction by the camera use lights of the same colour temperature (e. g. 4000 Kelvin) and ensure illumination of participants' faces at around 500 lux.

Ideally, the room should not have any exterior windows. If it does, they need to be fully covered with curtains or blinds. Even a small chink of sunlight in the background can cause problems for the camera. Backgrounds and table tops should not be too dark or too light as this can cause difficulty with camera auto-iris control. Mid tones and moderate lighting levels on background walls will give the best results. Avoid patterned or woven fabrics and finishes on walls as these can produce moiré patterns or strobing effects when the camera is moved.

5.19 Occupancy Sensing

Occupancy or motion sensing is a common feature of modern lighting systems. It enables significant energy savings by shutting down services when the space is unoccupied for defined periods of time. Occupancy sensors should be installed as part of all new lighting systems. The output of the occupancy sensors should be available to the control system and in many cases will also provide input to the BMS system. This can allow for energy management of both AV equipment and lighting in the space.

To avoid unwanted AV system shutdowns during longer sessions where people may be stationary for extended periods of time (for example during examinations), the sensor technology must be capable of detecting the presence of stationary occupants and not just those traversing the space.

5.20 Integration with AV Control Systems

The dimmer network must have either a serial or IP interface and be connected to the AV control system via either serial or IP network cabling.

The AV control system must be programmed to provide quick access to lighting presets and user accessible slider/fader controls for spot and stage lights. The AV control system can also automate some functions, such as dimming board lights or closing motorised blinds when projection is selected.

Lighting levels shall be fully and continuously controllable from 100% light output to less than 2%. Control function (i.e. control input versus light output) shall be approximately linear.

No occupancy time out and user initiated lighting and AV system shut down routines must be programmed. The desired lighting and AV system actions at each stage of the routine should be documented and agreed upon by stakeholders.

5.21 Fire, Emergency, Mechanical Services (A/C) and BMS integration

Where required the AV and lighting system shall be installed and programmed to accept signals from the buildings emergency warning system (EWIS). An emergency signal to the system should trigger the actions determined by regulation e.g.: turning on the lights, muting sound systems other than warning announcements etc.

In many cases it is desirable to connect the room control system to the Building Management System (BMS). This allows the room automation to send signals to the air conditioning regarding lighting states and room occupancy.

5.22 Dimmer Location

Dimmers should be located in positions that facilitate easy access. They should not be located in ceiling cavities or in false floors. Within the cupboard dimmers must be mounted at a height which allows ready access for a standing technician, without using a ladder or having to crouch or kneel down. The operation of the dimmers must not cause electronic magnetic or any other kind of interference with other systems within the room or in the vicinity.

In venues with a bio box the dimmer(s) shall be installed in or near the bio box to facilitate control wiring and adjustment.

6. Acoustics in Teaching Spaces

Section 7 Audio Replay systems and Public Address should read in conjunction with this section.

Standards

Australian standards referenced in this section are:

- AS/NZS 2107:2000 Acoustics – Recommended design sound levels and reverberation times for building interiors;
- AS/NZS ISO 717.1:2004 Acoustics – Rating of sound insulation in buildings and of building elements. Part 1: Airborne sound insulation

Overview

Acoustics that support intelligible communication with all participants are fundamental to successful teaching in any room. "Technology cannot (on its own) solve the problems of reverberation, background noise and echo, which detrimentally effect so many cognitive environments. It is therefore important to ensure that the technology investment is complimented by sympathetic building and space preparation. The best technology in the world cannot deliver on its potential without appropriate support from the built environment"⁴.

Special consideration must be given to the design of teaching spaces with regards to acoustic performance. The ultimate measure of acoustics in a teaching space must be the Speech Transmission Index (STI). Best practice teaching spaces should achieve a rating of "excellent" (STI between 0.75 and 1.0⁵) and AETM recommends a minimum standard of STI no less than "good" (0.6 – 0.75).

To achieve high speech intelligibility the teaching space must be constructed in such a way as to control the reverberation and echo internally and provide isolation from all noises sources. The signal (amplified or un-amplified speech) to noise (all other sound) ratios at the listener position should be better than 25 dB to optimise intelligibility. Rear and side wall reflections should be minimised by appropriate acoustic treatment. The overall acoustic treatment should ensure short reverberation times.

AETM recommends that professional advice from an Acoustic Consultant should be sought to design and detail the acoustic treatment required to achieve the required acoustic performance of teaching venues. The information in this chapter is provided only as guide to the design considerations needed.

Ambient Sound Levels & Reverberation Times

The ultimate utility and function of teaching areas is highly dependent on the control of external and internal noise. Choice of layout, construction, materials and finish should be carefully guided by the need to provide spaces with acceptable acoustic performance for the required use. Particular care should be given to the selection and detailing of walls, windows, doors and ceilings. Special treatment may be required in the vicinity of high noise zones such as plant rooms. In general, the recommended Design Sound Levels and Reverberation Times for Building Interiors set out in AS2107 must be adopted.

⁴ Andrew Calov Presentation & Teaching Facilities 2009: AVS Engineering Brief pp1

⁵ There are two scales in common use to measure Speech intelligibility: STI and CIS (Common Intelligibility Scale). Values in this chapter are specified using the STI scale

The level of ambient sound from air-conditioning, ventilating and other mechanical equipment, traffic noise and any other intrusive noise, must be neither so high that it is objectionable nor so low that the resulting quiet causes intruding speech and other activity noise to be objectionable. The level of noise and recommended reverberation times are described here by the Noise Rating & RT60, as defined by Australian Standard AS 2107-2000.

Type of Space: Educational Buildings	Ambient Noise Level		Typical Reverb Time (*RT60 varies with room volume)
	Best Practice	Minimum Standard	
Lecture rooms up to 50 seats	30 dB(A)	35 dB(A)	0.7 – 1.0*
Lecture theatres - without speech reinforcement	30 dB(A)	35 dB(A)	0.7 – 1.0*
Lecture theatres - with speech reinforcement	35 dB(A)	45 dB(A)	0.7 – 1.0*
Computer Rooms - Teaching	40 dB(A)	45 dB(A)	0.4 – 0.6
Conference Rooms	35 dB(A)	40 dB(A)	0.6 – 0.7

Permissible Noise Levels & Recommended Reverberation Times

Ambient noise and room reverberation times are two important measures of acoustic performance and key indicators of the intelligibility of speech communication in a room. However, there are other potential acoustic performance issues that should be reviewed and addressed by the Acoustic Consultant. The consultant will consider room size, shape and location of fixtures as aspects of the design that may give rise to issues of: echoes or late arriving reflections; standing waves with resultant nodes and antinodes in the lower frequencies; and focussed reflections.

Intelligibility

Speech Intelligibility is quantified by the 'Speech Transmission Index'⁶ or STI. An STI value between 0.6–0.75 is considered good, while a value between 0.75–1.0 is rated as excellent. Teaching spaces in general should achieve a rating in the "excellent" range, however for large multi-purpose auditoria, or for other open plan teaching spaces such as collaborative teaching and learning spaces an STI that measures in the "good" (>0.60) range is acceptable.

Choice and positioning of microphones (and hence teaching lecterns) in rooms is assisted by an understanding of the acoustic energy levels throughout the space. The selection of speaker type and installed position will govern the achievable SPL levels at the listener position.

⁶ Don Davis & Eugene Patronis, Jr: *Sound System Engineering 3rd Ed: p213 Measuring Intelligibility*

A number of software packages are available to acoustically model spaces and determine likely sound pressure levels at key points within the space. Based on this analysis, microphone / speaker requirements can be reviewed and, if required, changed to improve performance.

Refurbishment of existing teaching spaces poses significant challenges as to what can be done to improve acoustic performance, particularly in older buildings where spaces may be heritage listed, limiting the scope for structural change. In particularly challenging circumstances, consideration should be given to steerable line array speakers to enable a more directional, focussed sound field over the listening area. Steerable beam arrays provide fine electronic control of the energy distribution which assists in reducing the reverberant field by minimising reflections from surrounding hard surfaces.

Mechanical Services & Air Delivery

Noise from mechanical services is one of the most common causes of degraded function in presentation and learning spaces. Key points are:

- Lecture Theatres require high capacity air handling systems, which should typically operate at low velocity to minimise noise.
- Low velocity modes invariably require larger and longer diffusers, bigger ducts etc. This can present an acoustical and architectural challenge if not carefully planned at an early stage.
- Air handling systems with local Fan Coil Units (FCU) mounted within the room ceiling space are a potential risk to achieving the required Noise Rating (NR). Such units are best relocated if practical to outside the room envelope or otherwise fully enclosed in an acoustically rated compartment designed to achieve a reduction in FCU noise to below the room Noise Rating.
- Project engineers need to take all steps to eliminate low frequency noise from mechanical plant compressors, and to minimise the wide band noise generated by faster air flow in ducts and through diffusers. Vibration transmitted into the building from FCUs and other installed mechanical equipment must not cause sound levels to exceed the requirements for Lecture Theatres NR 30 and Seminar Rooms NR30 within the band (63 to 8000 Hz).

Cinema

Spaces designed for cinema presentations should aim to satisfy acoustic design criteria provided and licensed by Dolby and THX companies. Refer also to INTERNATIONAL STANDARD ISO 22234:2005 Cinematography - Relative and absolute sound pressure levels for motion-picture multi-channel sound systems - Measurement methods and levels applicable to analog photographic film audio, digital photographic film audio and D-cinema audio.

7. Audio Replay systems and Public Address

7.1 Standards and Legislation

Audio systems and equipment shall comply with performance and installation standards defined by:

- AS/NZS 60065:2003 & Amendment No. 1 (January 2008) Audio, video and similar electronic apparatus—Safety requirements;
- ANSI/INFOCOMM 1M-2009 Audio Coverage Uniformity in Enclosed Listener Areas
- AS 60118.4-2007 Hearing aids - Magnetic field strength in audio-frequency induction loops for hearing aid purposes.

In Australia, requirements for the fitment of Hearing Augmentation systems are covered by the Disability (Access to Premises — Buildings) Standards 2010.

[http://www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrument1.nsf/0/943923505EFF5F51CA2576E40008FFF9/\\$file/F2010L00668.pdf](http://www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrument1.nsf/0/943923505EFF5F51CA2576E40008FFF9/$file/F2010L00668.pdf)

7.2 System Functionality

A purpose designed audio system for teaching spaces should be installed to provide the following functionality:

- Voice reinforcement (Public Address): as a guideline LTSMG Report (UK) suggest rooms above 50 seating capacity should be considered for voice reinforcement;
- High fidelity replay of program sources
- Assistive listening / hearing augmentation
- Recording (where required)

Overview of key components

Audio system components for a teaching room of 50+ students will, as a minimum, comprise:

- One or more high quality speakers installed so as to provide uniform sound coverage of the listener area;
- Lectern microphone and provision for additional microphones to be connected;
- Radio microphone (where specified);
- Audio mixer to enable signal routing, level control, limiting/compression and equalisation of signals from microphones and line level audio replay equipment. The audio mixer will provide phantom power to microphones, interface to the lecture theatre control system and provide sufficient outputs for power amplifiers and recording devices;
- High quality audio power amplifiers with overload protection;
- Fit for purpose induction loop amplifier and room coil (AS 60118.4-2007) or other suitable assistive hearing technology: consistent with the practices/policies of the University's special needs program. Other hearing augmentation technologies include infrared and RF systems

Large (>150 seats) or special purpose venues will have additional requirements, particular where the venue is used for cinema studies, remote lecture telecasts/webcasts, or other theatrical activities. Audio Visual representatives of the University are to be consulted on special purpose requirements as well as the general classroom requirements.

7.3 Design

The audio design shall ensure an electro acoustical system that is capable of producing adequate sound level with high intelligibility at the listener position, is stable under normal operating conditions, and is free from noise and distortion.

Effective design of the audio system and its components will require an understanding of the expected behaviour of sound in the room (refer Acoustics in Teaching Spaces). Acoustic modelling of the proposed space should be considered at an early stage of the project to provide valuable data for determining speaker type and quantity, placement, amplifier power, and expected performance against the guidelines. Computer modelling may be arranged through the Architectural Design Team, independent Acoustic Consultants, or Sound System Designers associated with major suppliers of professional speaker systems.

Speaker system options for teaching venues include, but are not limited to:

- Single source Line Array
- Front of House (FOH) Left-Right stereo pair
- Distributed system (ceiling or wall)
- Combination of FOH and distributed
- Dolby/THX Surround system

Loudspeaker Selection and Placement

Loudspeaker type and position shall be based on achieving an effective coverage of the listening area while optimising the 'gain before feedback' of the microphone / loudspeaker system for the nominated presentation area. A practical electro-acoustical system design for teaching spaces should be capable of delivering an SPL of 65dBA-Slow at any listener position for amplified voice and an SPL of 85dBA-Slow for program material.

The uniformity of audio coverage shall be determined by measurement and validation standard ANSI/INFOCOMM 1M-2009: Audio Coverage Uniformity in Enclosed Listener Areas to "ensure that every listener perceives approximately the same direct sound from the sound system, no matter where the listener is positioned within the specified listening area of the sound system". A conforming system shall achieve a tolerance window of 6dB within each of six ISO octave bands 250 Hz to 8 kHz when measured at the required test locations.

A combination of FOH and distributed speakers should be considered for medium to large venues to ensure all areas receive voice reinforcement which is direct, uniform in level and has high intelligibility. Electronic delay and speaker zoning should be considered where the delay between the sound arriving at the listener from the primary source and distributed speakers interact to significantly affect the intelligibility (STI) or spatial image of the sound source.

Smaller venues will require a minimum of two 'front of house' (FOH) speakers configured as a Left-Right pair for stereo imaging of program material in the primary listening area. Alternatively, a distributed ceiling speakers array may be used to provide a uniform coverage for both voice reinforcement and program content, albeit mono. Factors such as ceiling height and structure will determine the choice of speaker system.

Audio Mixer

Consideration should be given to using DSP technology for audio mixing and processing due to its inherent flexibility, cost/performance benefit and ease of external control.

The mixer shall accommodate a combination of microphone and line level sources, either as balanced or unbalanced connections. The increased use of domestic digital equipment in teaching venues requires review of practicality of connecting digital audio to audio mixers using HDMI, optical (TOSLINK) or coaxial (S/PDIF) for transfer of multichannel signals as an alternative to multiple analogue inputs.

Mixer size shall be determined by the specific requirements for microphones and replay equipment related to the use of the venue, but at least two additional inputs and outputs should be considered to enable future expansion during the operational life of the system.

Audio Inputs:

- Lectern microphones
- Radio Microphones
- Conference microphones
- Auxiliary input for Laptop Computers
- Resident computers
- CD / DVD players
- Blu-ray players
- HD/SD 'Set top box'
- Video conference CODECs
- External feeds

Audio Outputs:

- Program audio LEFT/RIGHT
 - Speech reinforcement*
 - Speech reinforcement delay channel/s*
 - Recording output
 - External feeds
- * Larger venues may require multiple channels of delay for distributed speakers to achieve uniform coverage, particular where balconies are present.

Audio equipment chain performance

System design and gain settings provide for a nominal operating level such that:

- Peak or Maximum operating level (headroom) is 10 dB above nominal operating level
- System Noise (S/N) with all inputs assigned is at least -65 dB unweighted below nominal operating level
- Total Harmonic Distortion < 0.5% at peak operating level
- System frequency response 50Hz – 18kHz +/- 2dB at nominal operating level
- Nominal operating level of the electronic chain should be +4 dBm

Power Amplifiers

High quality power amplifiers, matched to the power requirements of the loudspeakers, are required to achieve appropriate sound level to listener positions. Power rating should be such that at least 10dB headroom is available to handle peaks over the level required to achieve target SPL for program content. Consideration should be given to the location of the amplifier in relation to the heat generated and ventilation requirements as well as the likelihood of temperature impact on surrounding equipment. Speaker cabling should be run well clear of low level signal cabling to minimise the risk of interference and crosstalk.

7.4 Hearing Augmentation

In Australia, hearing augmentation/assistive listening systems are a requirement in all Class 9b buildings including (but not limited to) all spaces where a public address system is fitted.

The requirements are summarised in the Disability (Access to Premises — Buildings) Standards 2010 which form part of subsection 31 (1) of the Disability Discrimination Act 1992.

Other relevant standards and codes include:

- BCA - SECTION D - Part D3 - Access for People with Disabilities
- AS1428.5-2010 Design for access and mobility – Communication for people who are deaf or hearing impaired
- AS60118-4. – performance requirements for hearing loops

In general, a “safe” assumption is that hearing augmentation systems are required in any University space which includes an audio reproduction system.

While a number of systems are permissible under the act, including Induction Loop, IR and RF systems, individual University Audio/Visual staff and Student Disability support staff should be consulted to determine local policies before deciding the appropriate technology for particular spaces.

In University situations, classrooms are often closely adjacent and special care must be taken to ensure that the coverage fields of hearing augmentation systems do not overlap.

7.5 EWIS

Emergency evacuations systems may require room sound systems to be muted in the event of an alarm. Advice should be sought from a Fire/Electrical Engineer as to what is required of the sound system in relation to evacuation alarms/announcements.

7.6 Equipment Installation

Audio systems shall be installed in accordance with sections 2.9, 2.10, current industry best practice models (refer Infocomm AV Installation Handbook ‘The Best Practices for Quality Audiovisual Systems’) and related Australian Standards.

7.7 Grounding

Audio system noise performance may be compromised by poor management of equipment earthing. A single phase, star power earthing arrangement to the AV equipment rack or technical earth for all AV equipment within the room should be explored with the Electrical Consultant. Appropriate consultation and earthing design will minimise the potential for issues from ground loops and multiple phase connection of AV equipment. Balanced audio systems with high common mode rejection ratio (CMRR) provide maximum protection against ground loops and other sources of interference and are the preferred audio design.

7.8 Lecture Recording Systems

Lecture recording systems are fitted to lecture theatres and teaching spaces in a majority of Universities in Australia and New Zealand. These standards do not recommend a particular system, but set out general guidelines so that spaces can be adequately provisioned, either immediately or in the future, with capture systems.

Audio Recording

Where audio recording is possible under the lecture recording system in use by the institution, a line level output containing a post fader mix of all microphone and line sources should be available under the audio switching and mixing specification. This output shall be capable of supplying a balanced feed at +4dbm. If requested, an unbalanced output at -10dBm may be supplied for direct connection to the recording appliance.

Screen Capture

Where screen capture is possible under the lecture recording system in use by the institution, the video switching system shall be capable of providing an extra scaled output at XGA or WXGA resolution for each display (projector or screen) feed.

Depending on the system in use, the output may be required to be analogue (typically RGBHV) or digital (e.g. DVI or HDMI) as appropriate to the Capture Device.

Camera Provision

Where video recording is possible under the lecture recording system in use by the institution, a suitable camera mounting position shall be identified and provisioned with power, data and video tie lines. The chosen position will have an unobstructed view of the entire teaching presentation area at an angle of view no greater than 15 degrees vertically and 30 degrees horizontally.

Suitable provision should be made for lighting of the presenter area without spill onto the projection screen. (See Lighting Section 5.13, 5.14)

8. Control System Integration

AETM fully supports and recommends the use of integrated control systems for all spaces where Audio Visual systems are deployed.

The control system used should always be specified by the University Audio Visual staff and must be fully compatible with existing reporting and management systems, network standards and programming requirements.

Best Practice standards will require the control system perform the following functions:

- Functional control of all local audio visual equipment including (where relevant)
 - Power on/off
 - Functions (input switching, volume etc.)
 - Status reporting
 - Transport controls
 - Warnings (e.g. lamp hours)
- Control of remote AV systems (lecture recording, videoconferencing)
- Control of electro mechanical devices (e.g. screens, stage curtains)
- Control of lighting dimming and/or switching
- Control of lighting control devices (blinds, curtains)
- EWIS Integration
- Intelligent power management
- Automated shut down of equipment after hours or on "no signal"
- Control of air-conditioning
- Remote status reporting and error logging
- Capability for remote assistance

Minimum standard requires the control system to perform the following functions

- Functional control of all local audio visual equipment including (where relevant)
 - Power on/off
 - Functions (input switching, volume etc.)
 - Status reporting
- Control of electro mechanical devices (e.g. screens, stage curtains)
- Intelligent power management
- EWIS Integration

Functions should be automated such that a single button press to select a projection input should start the projector (and the selected source), select audio, deploy screens and blinds and adjust the lighting. Full manual over-ride should also be available, should the user wish to alter the pre-programmed lighting for example.

Best practice requires all control systems to be networked, preferably on a separate sub-net to provide enhanced security.

All touch screen designs should conform to University-wide standards to maximise usability and minimise the need for specific user training. Automation code must provide for integration with appropriate campus wide AV control management systems.

9. Whiteboards and Writing Surfaces

(Adapted from UQ Standard PF 50)

9.1 Standard Type

All writing board installations in spaces with AV and IT technology must be dust free. Whiteboards and writing surfaces using dry erase pens are suitable, however the dust from chalkboards is not compatible with electronic technology and may also have negative OH&S impacts. For these reasons chalkboards/blackboards do not comply with the AETM design guidelines.

While a range of surfaces, including glass are now becoming popular, the standard surface is still vitreous enamel on steel, unless otherwise specified.

9.2 Multiple Sliding Boards

Multiple sliding board systems shall be constructed so that with the bottom edge of the rear board at a height of 1.0m, the full area of all boards shall be capable of being displayed above. Multiple sliding board systems shall consist of no more than three boards.

9.3 Fixing Height

The bottom edge of the writing area shall not exceed 900mm, or be lower than 850mm from the finished floor level.

9.4 Storage for Writing Materials and Erasers

Temporary storage for board writing materials and erasers shall be provided. This shall be a shelf along the bottom edge of a fixed board or along the bottom edge of the outer board in multiple board systems or a small shelf or box to one side of the board system or lectern where a bottom-edge shelf is not appropriate. Care shall be taken to avoid sharp edges or corners on the shelf system. Any shelf attached to the bottom edge of boards must not obstruct the user when writing on the board at the lowest possible level.

9.5 Board Lighting

(see also 5.12 Board Lights)

Board lighting shall be designed so that boards are clearly legible at all audience angles of view. Board lighting should be on a separately controlled circuit. Where possible, board lighting should not spill onto the projection area in a way which will degrade the minimum available contrast ratio.

Board lighting shall provide 300 lux on the vertical plane of the board surface without creating glare for the viewers and without creating reflections that could obscure the information thereon.

9.6 Board Reflections

Room lighting and window curtains shall be arranged so that light reflected from the surface of the boards does not reach the audience and obscure the information thereon.

10. Equipment Housing and Cabling Standards for Teaching Spaces

10.1 Provision for Rack Mounted Equipment

In all spaces where audio visual equipment is to be fitted lockable, ventilated, purpose designed space must be reserved for the equipment which comprises the audio, video, control and lighting sub systems. Provision must be made for power and data access to this space and for fitment and maintenance of interconnecting signal cables.

Adequate bench space must be allowed for the fitment of control panels, preview monitors, and microphones in addition to user operated equipment such as Visualisers and graphics tablets. This space allowance should be in addition to space for lecturers to place a laptop or portable PC, lecture notes and presentation aids.

While some equipment (such as power amplifiers) are desirably located away from the teaching area because of considerations of fan noise and heat, space must be reserved close to the presentation area for the accommodation of equipment which needs to be accessed to insert media (disks, USB keys, tapes etc.) at the start of a teaching session. This may include PCs, disk players, tape players and recording devices.

Provision must be made to secure this equipment in a way which still allows access to loading slots, trays and connectors.

10.2 Access for Maintenance

Audio Visual equipment in professional use needs to be accessible for routine maintenance (such as filter cleaning) and also for emergency maintenance should failure or mis-operation occur during a teaching session.

Professional equipment typically has operational controls and mounting screws at the front, while power and signal interconnection is made at the rear. It is important therefore that provision is made for ready access to both the front and rear of equipment racks.

Where rack frames are mounted in joinery, front and rear access doors should be fitted which are lockable and wide enough to allow removal of the rack without disassembly of the rack or removal of the door.

Where racks are fitted in rooms such as Comms rooms, space must be large enough for provision to be made to access the front and rear of the rack. Comms room access doors should be lockable and wide enough to allow removal of the rack without disassembly of the rack or removal of the door.

If audio visual equipment such as projectors and speakers are to be fitted to a space with flush plasterboard ceilings, Audio Visual maintenance staff from the Institution should be consulted at DD stage to determine the type and location of access hatches required to mount and service this equipment.

10.3 Ventilation

Active equipment (including PC based equipment) generates significant heat when in operation and excessive operating temperatures dramatically affect system reliability and service life.

Racks in Joinery Units

Where active equipment is fitted to racks contained in joinery units, the space containing the joinery must be air-conditioned.

The rack space within the joinery must be ventilated with provision to suck in fresh air at the bottom and exhaust hot air at the top. Vents shall be fitted with appropriate mesh to render them vermin proof. Often, forced air ventilation is required, typically using low voltage fans which can operate at very low levels of noise. Two or more fans should be fitted if the active equipment power consumption exceeds 100 watts.

Ventilation provision should be such that the air temperature in the interior of the equipment enclosure (worst case) does not rise by more than 10 degrees Celsius above ambient.

Racks in Communications Rooms

Where active equipment is fitted to racks contained in Communications Rooms, the space containing the racks must be air-conditioned.

It is essential that any joinery, cupboards or rack enclosures are provided with ventilation slots at the bottom (to draw in fresh air) and at the top (to exhaust hot air). Ventilation slots should be covered with expanded metal mesh to render them vermin proof.

Ventilation provision should be such that the air temperature in the interior of the equipment enclosure (worst case) does not rise by more than 10 degrees Celsius above ambient.

10.4 General Provisions for Equipment

Unless required to be portable when in use, all equipment shall be firmly secured to minimise the possibility of unauthorised removal. Fastenings and supports shall be adequate to support the load applied with a safety factor of three times the actual weight.

All racks, housings and installed or bench-top equipment shall be level, plumb and square. Consideration shall be given not only to access and operational efficiency but also to overall aesthetic factors in regard to installed equipment and housings.

10.5 Cable Management Standards

Standards

Wiring materials and standards of workmanship shall fully comply with the relevant documents of Standards Australia and the International Organisation for Standardisation (ISO), including subsequent amendments applicable to any part or item forming part of the installation.

Cabling works shall also comply with any relevant requirements of the Electric Supply Authority Regulations, the Australian Communications and Media Authority, the Building Code of Australia, and the Insurance Council of Australia.

Digital Video

Computer chip makers Intel and AMD and computer manufacturers have jointly announced the end of life for analogue computer video (VGA). The announced end for VGA is 2015, however laptops are already appearing with only digital display outputs. Consequently all AV system design must now include digital video infrastructure.

Digital video potentially provides improved image quality, however to be successfully implemented it requires careful attention to cable and signal processing design and meticulous adherence to cable quality, termination, and installation standards.

Some DVI/HDMI installations have been plagued by issues related to the transmission or management of :

- EDID (Extended Display Identification Data)
- HDCP (High-bandwidth Digital Content Protection)

EDID is an electronic handshaking process where the resolution capability of the display device is communicated to the sending device. The successful transmission and management of EDID information is essential.

HDCP is a copyright protection system that is now incorporated into DVD players, Bluray players and protected computer based media content such as purchased movies. The behaviour of each HDCP protected device can vary depending on the media being viewed and the operating system of the device. In some cases the device can stop working if it detects a non-compliant device attached to the system.

The AETM strongly recommends that HDCP and EDID management be incorporated into the planning, design and installation of cabling and processing hardware.

Cable Labeling and Numbering

All connectors, patch leads, audio/video leads, controls, equipment and components, terminal blocks and equipment racks shall be permanently labelled in a format approved by the University. Abbreviations are acceptable only when shown on drawings.

All fixed labels, other than those affixed to cables, shall be permanently engraved in metal or plastic laminate.

All cable numbering and/or identification shall be performed using labels approved by the University. Labels shall be affixed at both ends of each cable. There shall be no unmarked cables at any place in the system.

The proposed cable numbering system shall be submitted to the University for approval to ensure consistency and coordination with the rest of the Campus installations.

Cable Layout and Dressing

All inter-rack and intra-rack cabling shall be neatly laced, dressed and adequately supported.

All exposed cable shall be dressed with heavy duty neoprene heat-shrink tubing

Nylon Cable Management Jacket: The AV Contractor shall organise all signal and power cables which connect equipment racks to adjacent electrical devices. These cables shall be bundled and installed within black nylon woven mesh fabric. This fabric jacket shall be manufactured for such purposes and shall be sized appropriately to the quantities and sizes of cables contained within.

All cables shall be grouped according to the signals being carried to reduce signal contamination. Separate groups shall be formed for the following:

- Power
- Control Cables
- Computer Data Cables
- Video Cables
- Audio Cables carrying signals less than -20dbm
- Audio Cables carrying signals between -20dbm and +20dbm
- Audio Cables carrying signals more than +20dbm

Each group shall be spaced at a minimum segregation of 50mm or that specified by the then current wiring regulations for that signal type (whichever is greater). In all cases, segregation will be such as to ensure no measurable induced current shall flow in the lower voltage cable as a result of its proximity to a higher voltage cable. Where cables of different signal level must cross they shall do so at an angle of 90 degrees for at least 500mm from the crossing point.

Route all cable and wiring within equipment racks and joinery according to function, separating wires of different signal levels (microphone, line level, amplifier output, AC, intercom, etc.) by as much distance as possible. Neatly arrange and bundle all cable with plastic or Velcro ties according to the requirements of the University.

As a general practice, all power cables, control cables and high level cables shall be run on the right side of an equipment rack as viewed from the rear. All other cables shall be run on the left side as viewed from the rear.

Where there are multiple adjacent equipment racks, the looming shall alternate. For example, as viewed from the rear, all power cables, control cables and high level cables shall be run on the right side. For the next rack, these shall be on the left side and the low level cables on the right. This scheme will alternate from rack to rack, ensuring maximum spacing.

Cable Termination

All cables, except high frequency cables which must be cut to an electrical length, shall be cut to the length dictated by the run. Terminal blocks, boards, strips or connectors, shall be supplied for all cables which interface with racks, cabinets, consoles or equipment modules.

Cables must be of the correct type and manufacturer provided for in the drawings and specifications unless equivalents are approved in writing by the University.

Proper circuit polarity and loud speaker wiring polarity must be observed at all times. Patch panels and connectors shall be wired as follows:

Patch Panel & Cable Wiring Guide		
Wire	Connector	Signal
Red or White	Pin#2	Hot or Positive
Black or Blue	Pin #3	Cold or Negative
Shield	Pin #1	Ground or common

No cables shall be wired with a polarity reversal between connectors at either end.

All circuits should be balanced and floating, except as noted in the specification. All system wire, except spare wire, after being cut and stripped, shall have the wire strands twisted back to their original lay and be terminated by approved soldered or mechanical means. No bare wire ends will be accepted.

Heat shrink type tubing shall be used to insulate and dress the ends of all wire and cables including a separate tube for the ground or drain wire.

All solder connections shall be made with rosin-core solder. Temperature controlled soldering irons rated at least 40 watts shall be used for all soldering work. All mechanical connections shall be made with approved crimp plugs of the correct size and type for the connection. Wire nuts are not permitted. Each connector shall be attached with the proper size controlled-duty-cycle ratcheting crimp tool which has been approved by the manufacturer of the connectors.

All use of data cabling whether used for network data or AV signal transmission must comply with the institution's data cabling standards for quality, installation and termination. To be accepted the installed cabling must pass the institution's approved testing process.

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