Projection

▶ Foreword

This module, **Projection**, is part of the **Architecture** chapter of the document, **A Best Practices Guide** published by the **European Digital Cinema Forum**. It should be read in conjunction with other modules and chapters of the complete guide and in particular the modules on **Image** and also in compliance with all valid regulations, especially aspects regarding security, emergency, and accessibility. The aim of this module is, however, to give architects, cinema owners/managers and other people who are involved in the process of planning and designing cinemas some help in the design process. Very special thanks are owed to Rolv Gjestland who has kindly donated much of his text to this guide from his book, **How to design a Cinema auditorium**, for which we are eternally grateful.

Editor and project lead	Julian Pinn.
Principal author	Rolv Gjestland.
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▶ Why this is important

There are laws of nature that cannot be changed like rules of optics, anthropometry etc; not all seats can be perfect; and a complete black room might not look so nice. Designing a cinema auditorium always includes a lot of compromises and this module—and the wider chapter on Architecture—aims to help the reader optimise their investment towards making the best compromises and, therefore, making good cinema auditoriums where the audience can get many good movie experiences.

▶ Projector placement

▶ Isolation

Digital cinema projectors make some noise, in the range of 40-50 dB @ 1m for laser projectors, mainly caused by fans and must therefore be physical isolated from the auditorium. The temperature must be within an acceptable range, typically in the range of 10-35°C for laser projectors. If the air gets too hot, the lamp/laser life will be reduced, and the projector may shut down.

Large xenon lamp projectors will need external exhaust ducting with an airflow of 800-1000 m³ per hour. Check with the installer for cooling requirements.
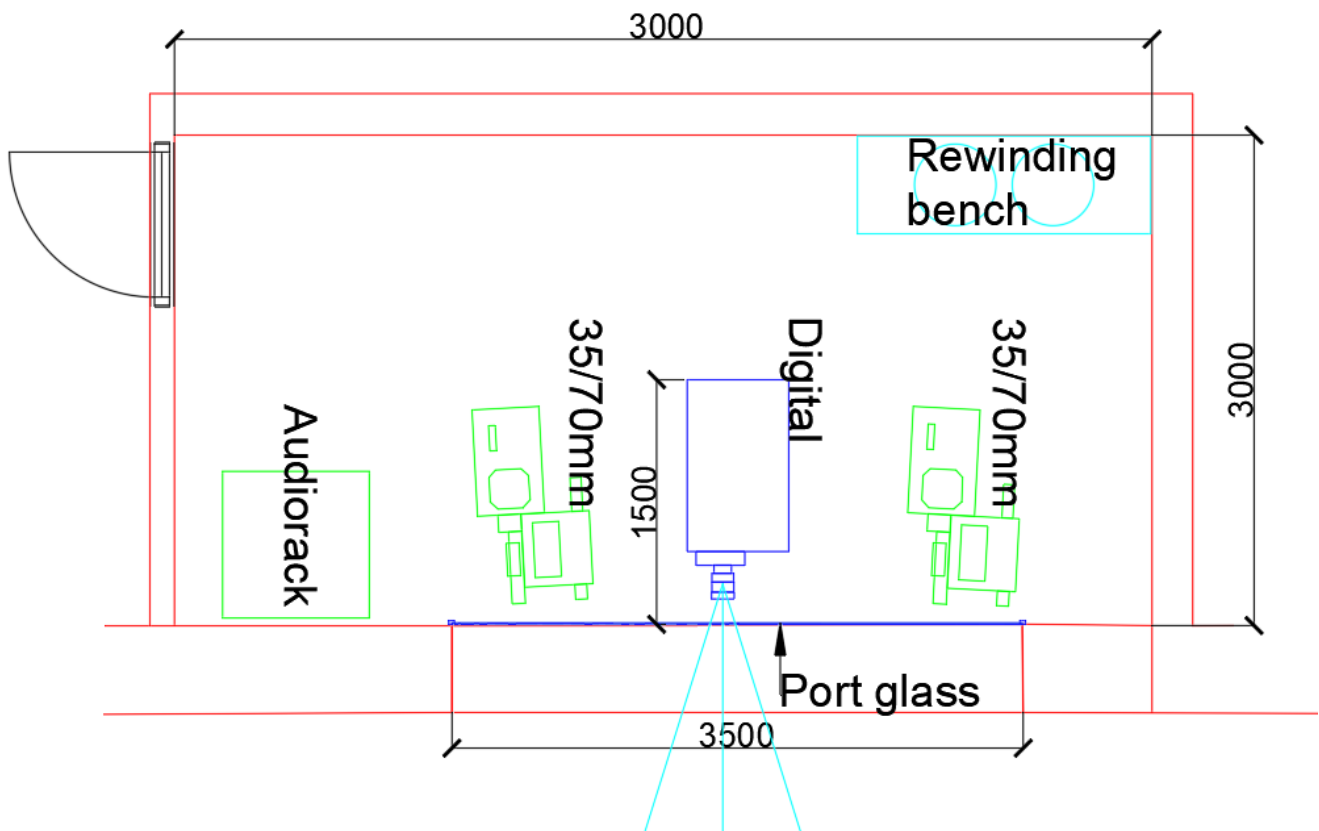
Projection

▶ **Projection booth (room)**

With digital cinema projection systems, there is no need for a traditional projection booth, like in the old days with 35mm projectors. A separate projection room still have some advantages.

▶ Access to the equipment is easy and can be done during the show, avoiding cancellations.

▶ Easy access for service and maintenance.

▶ Storage for spare parts, like lamps, filters etc.

▶ Fuse box for each auditorium, easily available and accessible.

▶ Space for processors, servers, amplifiers, light control etc.

▶ Possibilities for manual operation in case of errors, or if the auditorium will be used for special screenings, events, conferences etc.

If the auditorium is planned for 35 and/or 70mm film projection in addition to digital cinema, it is necessary to have projection room. Usually the digital projector will be placed between the two analogue projectors. In addition, there must be access to each projector for operation and service.

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▶ Projection cabinet

The projector can be installed in a cabinet behind the auditorium, above the ceiling in the corridor behind the auditorium or on the rear wall inside the auditorium. The cabinets must be designed for access to the projector, for quick fix of problems during a show as well as repairs
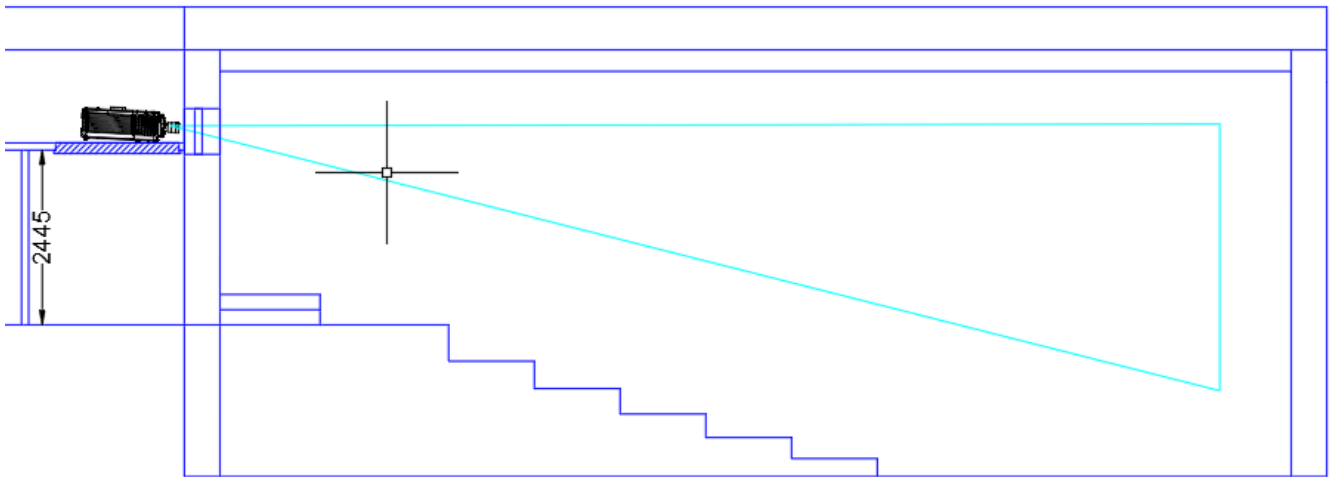
and maintenance. It must meet requirements for sound isolation and temperature control inside, and necessary cooling. Fire regulations may also apply.

▶ Boothless projection

With digital projectors, there is very little need for manually operation. Still there is need for access to change lamps in xenon projectors, filters etc, and on rare occasions, if something needs to be fixed or adjusted on the projector during a show. To save space the projectors can be mounted inside the auditorium, in a box mounted on the rear wall, above the audience, or in a box mounted in the ceiling.

If the projector box is located above the rear part of the auditorium or if the projector is in a box in the ceiling, there are some issues to consider (see also illustrations below that compare booth and boothless arrangements):

- ▶ The distance from projector to screen will be shorter. That will decrease the projection ratio (shorter focal length), decreasing the depth of focus, and may reduce the picture sharpness.

- ▶ Shorter projection throw will increase the projection distortion (see "projection angle" chapter below).

- ▶ The height under the projector box must meet the requirements for minimum passage height. Projection from the ceiling will therefore usually have larger projection angle than a projector behind the last row.

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▶ The need for clearance under the box may limit the last row level and may reduce the sightline clearance.

▶ Having a large box inside the room, will have a negative influence on the acoustics, especially if the auditorium has an immersive audio system.

▶ If the projector is hanging from the ceiling and there is a minor problem with the projector during a show, the audience must leave the room before the problem can be fixed, and the show might be cancelled.

▶ The projector box must be soundproof, to eliminate noise from the projector in the auditorium, and it must have quiet air supply. This can be difficult (and expensive) to achieve.

▶ If the auditorium has a room in room construction, to improve the sound isolation, the weight of the cabinet with projector might be a challenge.
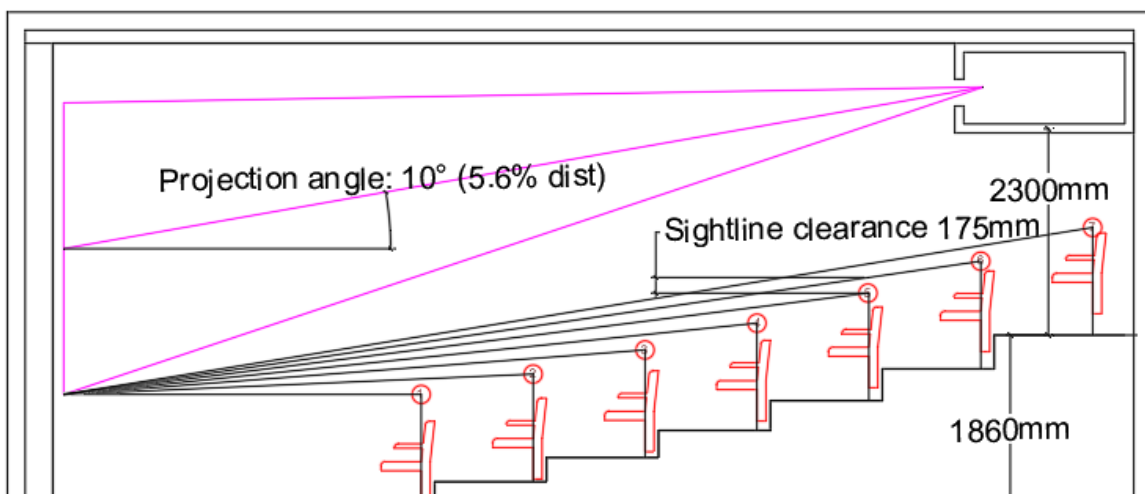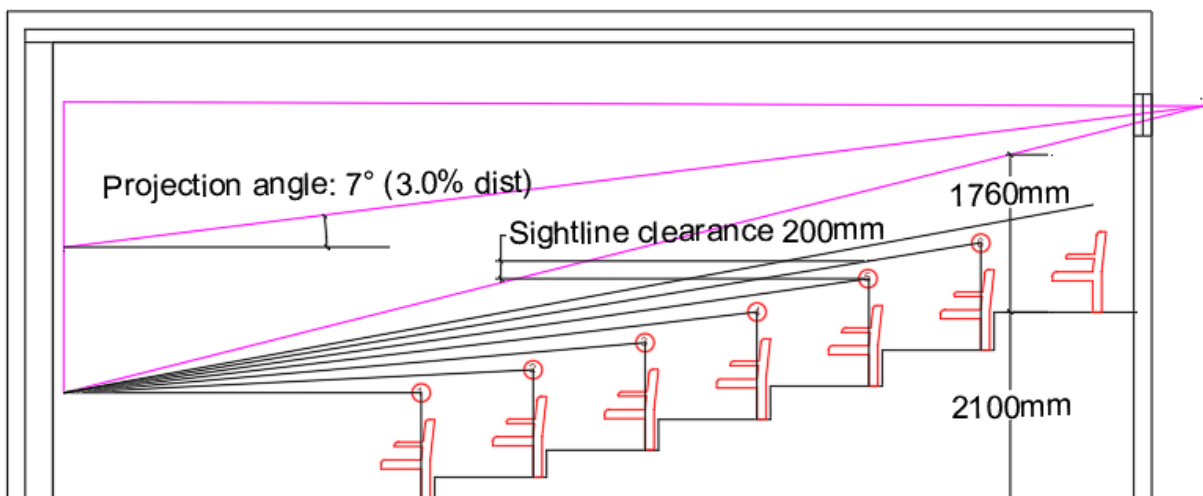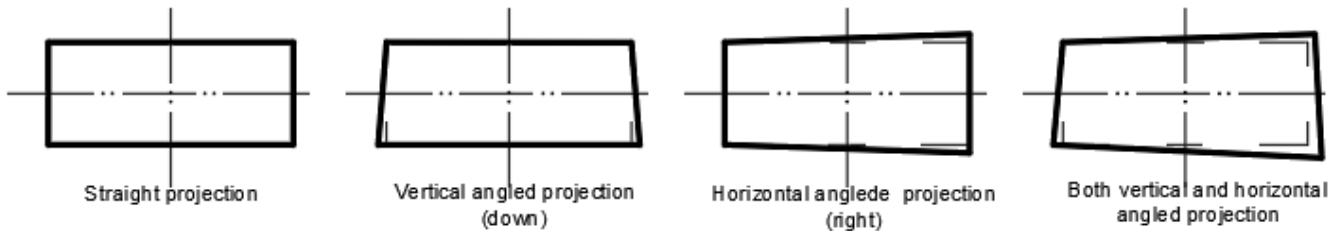
▶ Projection angle

▶ Definition

The projection angle is the angle between the projection axis, from the lens to the screen centre and a perpendicular to the screen. It has a vertical and a horizontal component.


| Straight projection | Vertical angled projection (down) | Horizontal anglede projection (right) | Both vertical and horizontal angled projection |

▶ Distortion

The distortion increases with the projection angle and with the ratio between the picture size and the projection throw (distance from lens to screen). Larger screens make the projection angle more critical.

Vertical projection distortion: $\% Keystone = \frac{H}{P} \times \tan \delta_v \times 100\%$

Horizontal projection distortion: $\% Keystone = \frac{W}{P} \times \tan \delta_h \times 100\%$

Where:
δ = Projection angle
P = Projection throw
H = Max picture height
W = Max picture width
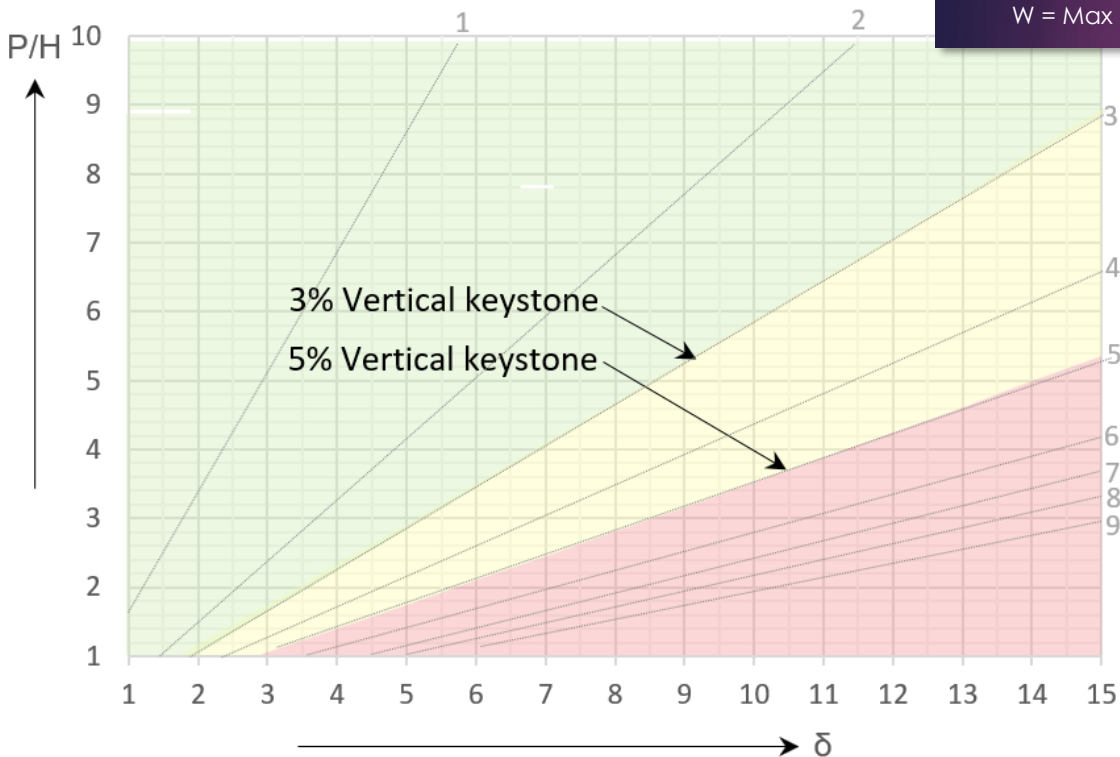
For good projection, the keystone should be less than 3%. Up to 5% is acceptable.

▶ Lens shift

Digital cinema projector lenses usually have a lens shift functionality to reduce vertical and/or horizontal keystone. To do this, the lens is adjusted horizontal or vertical relative to the optical axis. This will move the projected image sideways or vertical without changing the image geometry.

Even minor adjustments will have a negative influence on the picture quality. The limits for lens shift will vary with type of lens and projector. Consult the manufacturer or installer for advice.
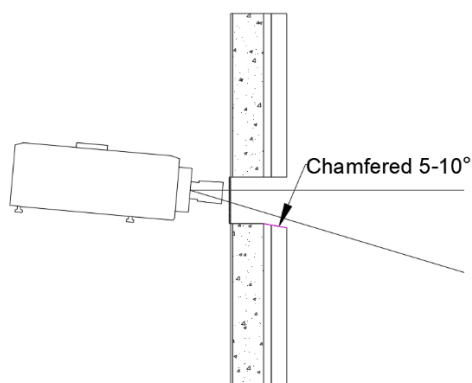
▶ Porthole

▶ Purpose

The main purpose of the porthole glass, between the projector and the auditorium, is to prevent noise leaking from the projection room/cabinet. If the projector is in a different fire cell than the auditorium, the porthole must also meet requirements for fire protection.

▶ Size

The porthole must be large enough for projection in any possible format, and if necessary, have additional width to allow viewing the screen through the window, next to the projector.

Chamfered 5-10°

If the wall between the projector and the auditorium is thick, the porthole must be larger, and chamfering the bottom edge of the opening on the auditorium side can be a solution (see illustration).

Internal height of a porthole is usually around 400mm, and the width around 600mm. If observing the screen through the glass a necessary addition, increase the width to 1000 or 1200mm.

For dual projection systems, it is common to stack the projectors. In such cases the porthole height must be larger. Check with the projector manufacturer what size is recommended.

For special auditoriums there might be additional projectors, for example two 35 mm, or combined 35 / 70 mm projectors. Place them symmetrical on the screen centre axis, with the digital cinema projector on the centre axis, and with enough space between each of them for operation and service.

Do not make the porthole larger than necessary, because the surface will act as an acoustical reflector in the auditorium and can also be source for stray light on the screen.

▶ **Horizontal position**

Sideways, the projection lens should be on the screen centre axis. If there are more than one projector, with one main projector, place the main projector on the screen centre axis, and the other projector on the left side (if possible).

▶ **Vertical position / clearance under projection beam**

There are different factors that decide the porthole's vertical position:

▶ The projection angle must not be too big (see "Projection Angle" above)

▶ There might be limitations given by the level and height of the projection room/cabinet.

▶ There must be enough clearance under the projection beam on the row in front of the projector (usually last row) to avoid seated people intentionally or accidentally making shadows on the screen. One can expect people to bow their heads when passing the beam. Measured in the front of the row in front of the projector, 1700 mm clearance is acceptable. If critical, the clearance can be reduced to 1600mm.
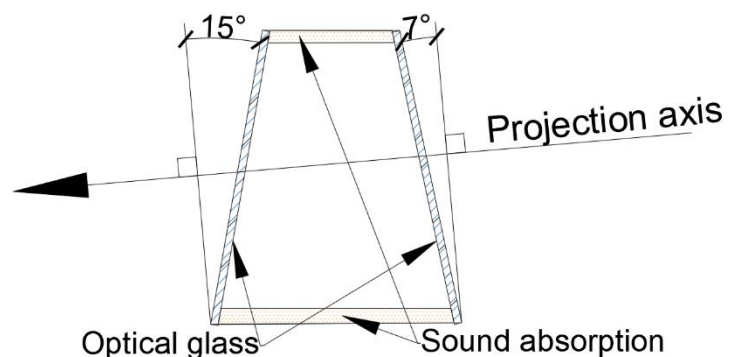
▶ **Glass**

▶ **Optical requirements**

Use anti-glare and anti-reflective coated optical glass that transmits 98-99% of the light. Angle the glass surface relative to the projection axis for best results.

▶ **Sound isolation**

A thicker glass will give better sound isolation. If a single glass is used, the thickness should be 8-10mm, and carefully mounted to make it as soundproof as possible.

For best result, use double glass. To avoid internal reflections between the glasses being visible on the screen, Dolby has recommended a solution where the first glass (closest to the lens) is angled 7° and the second -15° relative to the projection axis (see illustration to the right).

Use sound absorbing material in top and bottom between the glasses. For best acoustically performance the two glasses should have slightly different thickness.

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▶ **Fire protection**

If the projector is in a different fire compartment than the auditorium, the projection window must be fire resistant. There are two ways to achieve that:

▶ Using a fireproof glass mounted in a fireproof framing system. Use tempered fireproof, anti-reflective coated glass, like Schott Pyran (AR), with acceptable optical properties for 2D projection. For 3D using polarization, the glass will partly depolarize the light and increase the ghosting and is not recommended.

▶ For better performance, and if polarized 3D projection might be used, use anti-glare and anti-reflective coated optical glass, and complete the window with a fire door or curtain that is activated and protects the window in case of fire. Similar to what was done in the old days when nitrate film was still used.

▶ **Your notes**

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