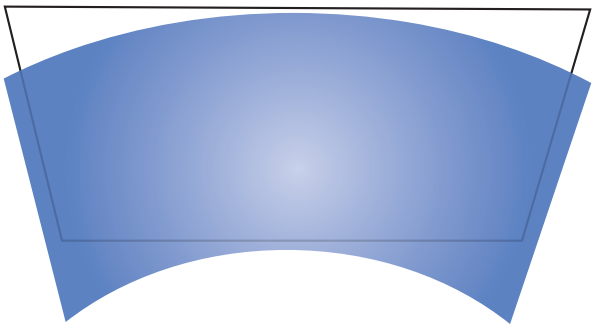
Talking dirty on curves

by Tom Bert, Senior Product Manager, Barco

In this article we'll discuss the impact and importance of choosing the right cinema screen by zooming in on two parameters that are not directly linked to the screen material, but do have a big effect on the perceived image quality.

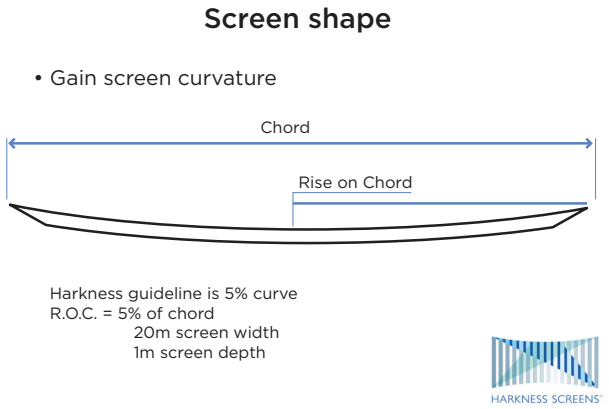
Curved screens

The first parameter is the **screen curvature**. This is a property that is sometimes applied when installing screens and their frame: not a flat surface that's parallel to the wall; but making screens – gently – curved so that the left and right edges come off the wall.



The reason why this is done is related to the fact that the **theoretical screen gain only applies when looking perpendicular at the screen**. The theory of half-gain angle explained how the perceived luminance drops as you see the screen under larger angles. These viewing angles increase as you sit further to the edges of the auditorium, or as you look at the edges of the screen. By bringing the edges inward, you reduce the largest angles. It's like creating a more immersed environment, where both the center of the screen and the outer parts are perceived under the similar angles.

The amount of curvature is typically quantified with the **chord depth** that measures the distance between the sides of the screens and the wall. You can **relate the absolute chord depth to the screen width**, to come to a **relative curvature in %.** The illustration below (courtesy of Harkness screens) explains how this metric works. Here, 'chord depth' is called 'rise on chord':



Looking at it from a pure luminance viewpoint, curving your screen is effective: by reducing the maximum viewing angles, you reduce luminance drop at the edges. Not only per user, but also globally more light is reflected into the auditorium.

However, there is a downside to all this. The first one comes from the fact that a curved screen is only seen as a rectangle when looking at it from a height that matches the screen center height. The moment you're seeing it from a lower or higher position, you can notice a distortion. This applies to the audience – the top or bottom of the image will not be a straight line – as well as to the projector. Indeed, the projector also 'sees' the screen under an angle – typically the porthole is just below the ceiling height. The light coming out of the lens is a perfect rectangle; which can be distorted when falling onto the curved screen surface. Straight lines in the image will become curved as well. In "normal" video content and on screens with a small chord depth, this is almost unperceivable. The effect can however be very visible on straight structures like subtitles, or when the screen is curved excessively. The rule of thumb is that **chord depth should be ≤5%.**

Another drawback is the impact on **perceived contrast ratio**. Contrast ratio defines the difference between the brightest white and the darkest black. It's defined by the properties of the projector, but also by the auditorium ambient and the on-screen content. This is how **screen curvature** comes into play: it's one of the ambient parameters that influences how light is managed and impacts perceived contrast. By curving the screen, you do not only reduce the angles towards the audience, but also between different zones of the screens. By bringing the sides forward, you are kind of 'folding' the screen together. This means that for all light bouncing off one side, a larger fraction will fall onto the other side. That leaking light is added to the intended luminance and has a negative effect on contrast ratio.

Screen aging

Another topic that impacts image quality through screen performance is screen aging. This covers all **degradation of or on the screen surface**: dust, dirt, scratches, grease etc. The effect is smallest in controlled environments with clean air and/or where air flow is minimized. Avoiding the audience touching the screen also helps preventing damage. The perceivability is typically small, except for cases where the degradation creates non-uniformity (the human eye is very susceptible to non-uniformities); or where the silver screen material degrades the 3D performance.

On 3D content, an important quality metric is cross talk: light reaching the wrong eye. On silver screens, screen aging can impact crosstalk and lead to visibly blurry edges in 3D. This effect does not play on 3D systems that work on white screens.

Epilog

Curved screens are not limited to cinema or even projection. You've probably already noticed that shops are also offering curved LCD or OLED TVs. Here the proposed customer value comes from a more immersive viewing experience: the viewer is more surrounded by the image. The history behind these curved direct-view TVs in the home is quite remarkable... at least, that's what I'm told.

When the first large-size OLED TVs where produced, the large glass plates where the material is deposited on, came out of the production line slightly bended... unintended. This was a consequence of the processing material and the fact that a large glass plate carried at its side, has a natural tendency to bend in the middle. Turning a problem into an opportunity, some clever marketing guys decided to promote these 'curved TVs' as the next big thing... and the rest is history. (If someone with more insights in large-size flat panel TV manufacturing would like to comment on the correctness of this story: please feel free to do so).

About the author

Tom Bert is a senior member of the Product Management team in Barco's Entertainment division; he is responsible for the digital cinema servers and projectors. Tom joined Barco in 2006 as Research Engineer for Barco's Technology Center. In 2009, he joined the Product Management team in the Digital Cinema division. Since 2015, Tom has been actively working on digital cinema servers and projectors and he has been promoted to Sr. Product Manager. Based in Belgium, Tom has international experience in display technology. He holds a PhD degree in Engineering from Ghent University.