Video Projection Formulas Guide

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I'm frequently asked to explain how much 'horsepower' (brightness) a projector needs to have in order to make the image on a screen look good. In a moment, I will give some formulas that are very necessary in determining projector brightness and screen size. However, two 'red flags' popped into my head.

First, it's a bit technical, and some will not understand the concept.

Second, while the formulas are not a big secret, they are a necessary part of how I make a living as a consultant. However, I can honestly say that MOST firms that I've run across do not perform all of the math required to make the estimates for screens and projectors as accurate as possible. How do MOST do it? They guess.

Trust me, I'm about to get to the formulas, but this is important.

Most A/V firms 'guess' in that they have done several (if not dozens) of installations. Some of these individuals have developed an 'eye' for guessing approximate values. Some are even very good at this, and, to be honest and try to sound humble, I usually am very close by guessing myself.

But how much money is being invested here? Is that money worth a good 'guess-timate', or is it worth an accurate, calculated proposal? I prefer the latter.

So, here are the basic math formulas necessary:

Determine screen placement
Sightlines are paramount in determining screen location. Make sure everyone (especially those far away) have a clear, unobstructed view of the screen. In some cases, more than one screen is required.

I won't go into screen viewing angels, as this has a lot to do with screen gain (or lack thereof) and front vs. rear, but keep in mind that anything beyond 45 degrees (horizontal or vertical) will fatigue the eye.

Determine screen orientation (front or rear)
Rear is always best, but requires space behind the screen that is essentially useless for anything EXCEPT the projector (and possibly a mirror). This means you need to have the space necessary, the lens capable of projecting a short throw will still filling the screen and the correct projector positioning for maximizing the light path to the viewers. There are several variables that are used to calculate the correct orientation placement, and cannot easily be done with a simple formula.

Determine screen size
Measure the distance from the screen to the furthest seat in line-of-sight. If the majority of the content is video, divide that number (the distance) by 8. This will yield the screen height. Remember that this is just one of many possible formats that will determine which number to achieve the screen height.

Next, measure the distance from the screen to the closest audience seat that is in line-of-sight to that screen. The screen should be no taller than twice that distance. Example - 6' tall = 12' away for closest viewer. This isn't always possible, but it is preferable. Remember, the furthest viewers take priority, as it is better for the screen to be "too big" for those close than "too small" for those in the back.

The screen height will be the same if the aspect ratio is 4:3 or 16:9 as only the width is different (if done correctly, anyway). This is not the same as "letterboxing" a 4:3 image, so make sure you're either using 4:3 or 16:9 – not letterbox.

Determine square footage of the screen surface
Take the screen height (in feet) and multiply it by the screen width (in feet). Ex. 6' x 8' = 48 sq. ft.

Multiply the square footage of the screen by 20 (ANSI says 18 + or – 2, so we use 20).
Example - 20 (ANSI lumens per sq. ft. minimum) multiplied by 48 (sq. ft.) = 960 projected lumens.

960 lumens isn't hard to find in a projector by today's standards. But before you get too excited, remember that ANSI specifies that 18 (+ or - 2) is the acceptable number. This is assuming NO light is hitting the screen. Pitch black area. Dark. No light. Nada.

Our next measurement is at the screen area itself - the amount of foot-candles of light striking the screen surface from lights, windows, etcetera using a light meter.

Let's assume we measure 8 foot-candles striking the screen surface. We now take our number (8) and multiply it by 5 (our next formula). The answer? 40, of course.

THAT (40) is the number we must now reach to have adequate lumens being projected onto the screen surface. In other words, we must project at least 40 lumens per square foot onto the screen to over come 8 foot candles of light on a 6' x 8' screen.

So, going back to our first example, we have 48 sq. ft. of screen area. We multiply 48 by the new 40 lumens per sq. ft. number to get 1,920 lumens.

Therefore, assuming no screen gain, we will need nearly 2,000 lumens projected onto the screen surface from the projector *in order to overcome ambient light*.

Contrast Ratio
Here's another item to think about: contrast ratio. In a pitch-black room, lower contrast ratios are not nearly as important. But in a lit room, the better the contrast of the projector, the better the image will be. Contrast, in layman's terms, is how black the blacks are in comparison to how white the whites are. We call this *contrast ratio*.

Contrast ratios are normally listed (if at all) in one of two ways on a projector spec sheet: ANSI contrast and ON/OFF contrast. The number to pay attention to is ANSI contrast.

I'll give another example to help illustrate contrast ratio.

Let's say you have two projectors: Projector A is 2000 lumens with a 150:1 ANSI contrast ratio. Projector B is a 1400 lumen projector with a 500:1 ANSI contrast ratio. We'll also say they are using the exact same lenses projected onto the exact same size screens, side by side in a well lit room.

For an easy simulation, let's also assume the screens are the 4' x 6'. Now, which image will appear brighter?

If you said Projector A, you're wrong.

You see, the human eye *perceives* brightness in comparison to something dark. Therefore, because Projector B had a much greater contrast ratio, the whites would *seem* brighter next to those blacks. To our eye, Projector B would seem brighter.

Keeping it simple
Beyond this, it gets quite complicated, and I probably have lost 85% of the readers four paragraphs ago anyway. In fact, there's *much more* to it than what I've typed here. My goal is to educated churches on the basic information so that they can make better display technology decisions. Therefore, I'm wrapping this up.

If you need more help than is provided in this short Video Projection Formulas Guide, then you really need to hire a consultant or design/build firm.

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