Advisol
Advanced Visual Solutions

Technical Memo: Light intensity budget for 3D cinemas

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Measuring perceived brightness in projection displays

The perceived brightness magnitude of a projected image is determined by the projector light output, the optical gain of the screen, and the image area. There are two common units for measuring perceived brightness: Footlambert and Nit. These two units are related as follows:

1 Footlambert = 3.426 Nit

The SMPTE 196M standard recommends brightness between 12 to 22 Footlamberts for cinema displays. Typically, 16 Footlamberts (55 Nits) is considered as a nominal brightness design goal for cinema display.

Display	Brightness (Nits)
Cinema	55
CRT TV	170
LCD TV	400
Plasma	600

Table 1: Typical brightness levels in common displays

Required projector output for cinema display

The relation between the projected image brightness in nits and the projector output (in Lumens) is given by

$$B = G\frac{P}{\pi A}$$

Equation 1

Symbol	Meaning	Typical value and units
B	Perceived image brightness	55 Nits
G	Screen optical gain	1
π	Mathematical constant	3.14
A	Image area	Square meters
P	Projector light output	Lumen

Table 2: Symbols and values for Equation 1

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Inverting Equation 1 for the projector light output *P* and inserting the typical values for the parameters as shown in Table 1, we get

$$P_c \approx 170 \cdot A$$

Equation 2

In Equation 2 the projector output P_c is measured in lumens, and the image area *A* in square meters.

Required projector output for 3D cinema display

In 3D cinema, Equation 2 must be amended to take into account the effect of the polarizing components:

$$B = e_E e_P G \frac{P_{3D}}{\pi A}$$

Equation 3

where e_E and e_P are the transmissions of the eyewear and the projector polarizers respectively. The various symbols that appear in Equation 3 are explained in Table 1.

Symbol	Meaning	Typical value and units
B	Perceived image brightness	55 Nits
e_E	Eyewear polarizer transmission	0.8
e_P	Projector polarizer transmission	0.4
G	Screen optical gain	1.5
π	Mathematical constant	3.14
A	Image area	Square meters
P	Projector light output	Lumen

Table 3 Symbols and values for Equation 3

Inverting Equation 3 for the projector output *P*, and using typical values for the other parameters, we obtain the following relation:

$$P_{3D} \approx 360 \cdot A$$

Equation 4

Silver screens have high peak gain, typically in the range of 2.0 to 2.8. For deriving Equation 4 we took a value of 1.5 for the screen gain, even though the typical gain is higher. Using the peak silver screen gain for the calculation of projected image brightness leads to an over-optimistic estimate, because most viewers do not fully benefit from the peak gain reflection lobe.

If one uses StereoPol™ filters instead, the transmission of the projector polarizer increases from 0.4 to 0.65. The corresponding output-area relation becomes

$$P_{3D,SP} \approx 220 \cdot A$$

Equation 5

The projector outputs required to meet the SMPTE nominal standard for a modest cinema screen area of 30 m^2 are shown in Table 4.

Application	Required projector output (Lumen)	Applicable equation
2D cinema	5,100	Equation 2
3D cinema	10,800	Equation 4
3D cinema with StereoPol™ polarizers	6,600	Equation 5

Table 4: Required projector outputs for cinema applications