WHITE PAPER

Image 'brightness' and contrast.

Using a plasma screen, an LCD screen or a projector?

"How bright does my screen need to be?"

"...and what is 'brightness' anyway?"

"What contrast does my screen need to have?"

"...what is contrast, and how do I apply it in real life?"

A white paper giving a simple overview and guidelines to help specify screens. Primarily focused on projected images, the paper is also relevant to plasma and LCD flat panel displays.

For more detailed papers and Excel calculators, please refer to the Projected Image Quality section at www.rearpro.com/downloads.

'Brightness' – the problem word

'Brightness' is a ***problem word***, used in most descriptions of image quality. Often, if an image looks bad we will say that it's not 'bright', when it merely ***lacks contrast***. So what does 'brightness' actually mean? ***Brightness*** actually describes how we ***experience*** light and not 'how it is'.

If we are going to describe light and 'brightness' properly, there are two essential terms: ***luminance*** and ***illuminance***.

- ***Luminance*** is the light we see: reflected or radiating from objects.
    - Measured in ***candela per square metre*** (cd/m^2 and the same as '***nit***').
- ***Illuminance*** is light we can't see directly – it is so-called ***ambient light***, light passing through air, actually invisible until it reflects off an object (which we then see as luminance).
    - Measured in ***lux*** (*lx* or lm/m^2).

Our eyes are exposed to such dramatic changes in light levels (far greater than a million to one) that our optical systems have to protect them. We can read newspaper headlines by the light of a full moon, which might be 0.2 lux of illuminance. Yet we can also read outside in direct sunshine, in more than 100,000 lux. So our eyes constantly adjust – our irises contract and expand – to maintain vision consistently, protecting against damage to the retina at the back of the eye. (That reflex to look away from bright lights is important!) *Right away we can understand why a screen that looks so bright in a showroom can be barely visible in a shop window!*

So we only normally register differences in light levels when they ***double or halve***. This is called a ***logarithmic*** response (rather like ***decibels***, because we experience sound in a similar way). *Again, we can immediately see that merely doubling the luminance of your projector or display panel will not have as dramatic effect as we'd wish (apart from the price!).*

So ***how bright should my image be?*** We can see that this will vary, depending on ambient light in the specific location. Think about this: passive objects like paper are forms of dynamic display; as the light level varies, the 'brightness' (i.e. luminance) varies too. It's always a

product of ambient light levels; a perpetual adjustment. So white paper can be a useful benchmark:

- *Matt white paper has a gain of approx 1 (**gain is a metric for reflectance**: a gain of 2 equals twice the reflectance of gain 1, and so on).*
- *For every 100 lux of ambient light falling on a surface with a gain of 1, it will generate approx 32 nit (cd/m2) of luminance ('brightness').*
    - *In a meeting room, you might see 500 lux, so the paper will show approx 160 nit; in a shopping mall there might be 2000 lux illuminance, so the paper would show approx 640 nit. And so on.*
- *Put this formula into an Excel sheet to **make the calculation yourself**, where A is the ambient light (illuminance) in lux, and B is the gain of the reference surface (e.g. white paper)*

  =(A/3.14)*B
- *In general terms, your display should be **no more than three times brighter** (or three times less bright) than your reference material. For dynamic displays, there's an obvious impact benefit in being at the upper end of the scale.*

In ***working environments*** such as meeting rooms, images can be ***too bright***. You can design ***eye strain*** into a system if users' eyes are perpetually adjusting too much between a bright screen and other darker objects and people. Think of reading a brochure: you see great contrast and definition, not brightness – thus you can read comfortably for extended periods.

A word of ***warning***. Although 'brightness' is an essential system parameter, it's just part of the story. It's quite possible for an image to be very bright (i.e. have high luminance levels), but for it to appear dim, or washed out. So there must be some qualitative aspect that makes a difference – and, yes, this is normally ***contrast***.

Contrast – the key to image quality.

Contrast refers to the ***difference*** between ***black*** and ***white*** levels in images, whether on a flat panel display or a projection screen. Without good contrast, images appear to lack 'brightness', colour and definition.

The image contrast ratio refers to the difference between the luminance of the white part of an image, divided by the black part. So if the white part is one hundred times brighter than the black part, it will be 100:1, and so on.

Here are some quick facts to digest:

- With projectors, the projected contrast ratio will be different to the image contrast ratio.
    - When there is any ambient light at all, the image contrast will be less than the 'pure' projector (or flat panel) contrast
- Confusingly, there are two ways contrast is measured:
    - Contrast ratios in brochures use the so-called ***'on/off' method***. It's a ***sequential*** test: measure a full white field, then measure a full black field. This has limited use for product comparison, and is no use for image quality assessment. You will see figures of quoted in excess of 1000:1. No wonder men are reputed to think size is everything...
    - What you really want to know is what white and black levels you can achieve on the same image, when displaying a real source. This is done by using ***ANSI methodology*** (adjust a warmed up projector to a test grey scale pattern via an external source, then display and measure a sixteen panel ***black and white checker board pattern***). Most projectors measure at ***less than 100:1*** on this test; at time of writing the author has seldom personally tested anything above 200:1.

So what about some ***real life*** contrast ratios? Let's use the typical example of a projector on a normal white front projection screen. No matter what the projector contrast ratio is, in a typical meeting room you'll only measure ***typically*** between ***2:1*** and ***10:1***!

- Here's a typical real life situation:
    - We have a room with 200 lux ambient light falling on the screen
    - The screen is 80" (diagonal, meaning 64" wide x 48" high, 4:3 aspect ratio)
    - It has a gain of 1 (i.e. typical matt white screen).

    - The projector has 2500 ANSI lumens and 100:1 ANSI contrast ratio.
- In this case, the ***image contrast ratio*** will be ***6.9:1***.
    - Even if the projector had 10,000:1 contrast, the number goes up to 7.3 : 1

What does this mean?

- Projector contrast ratio is always higher than its resultant image contrast
- With normal front projection screens under any kind of ambient light, the image contrast is entirely a product of that ambient light.

There are three possible ways to change this situation:

- Control the level and direction of ambient light. If this isn't possible, then...
- Use an **optical** (i.e. lensed) ***front projection*** screen such as dnp Supernova or Sony ChromaVue
- Use ***optical rear projection screens*** such as dnp New Wide Angle (and other dnp optical screens) or Draper Diamond Screen.

Ambient light doesn't just kill projected images, it affects plasma and LCD panels too. Glass, whether as an LCD panel front or shop window, acts like a mirror at certain angles – so spotlights or even the sun can create ***reflections*** many times ***brighter than the display*** itself.

Here are some some ***benchmarks*** for ***real life contrast ratios***, gained from recent committee work:

- From ***5:1*** a normal ***PowerPoint*** show can be viewed
- From ***10:1*** a ***photo*** or complex spreadsheet can be viewed
- From ***20:1 all images will look good***
- ***Optical rear projection*** can produce up to ***200:1***
- Some ***LCD*** and ***plasma*** panels claim even ***higher*** ANSI contrast ratios
- Most projectors have less than 100:1 contrast ratios
- Therefore, aim for at least 20:1 image contrast ratio; never accept less than 10:1.

There's a ***subjective*** element to contrast too. Images lacking contrast appear to have reduced brightness, poor sharpness and low definition – effectively reducing the quality you paid for! Choose a technology or display that can handle the type and level of ambient light for the ***specific location***.

CONCLUSION

Think of displays like TVs or plasmas or projection as replicating a painting. They are machines that organise and deliver light to the eye, by means of radiation and reflection. Going back to basics gives us all the clues we need to decide how bright our displays or screens need to be.

Specifying the 'brightness' of an image or display requires more than wetting a finger and estimating. But it's easy to do, as I hope this document proves.

Buy a meter! You can buy an illuminance (i.e. lux) meter for less than £100. Carry one around and use it. It will make also make you look cool and clever – just what clients want! (A biro and clipboard are optional extras, but less cool.)

Image contrast in practice is inextricably linked to ambient light. Ambient light has to be understood and compensated for.

Understanding how we see helps our knowledge of how subjective image quality can be. This paper can help you understand the principles. In practice you need to set users' expectation levels, and there is only one of doing this. So, despite the feasibility of using science to specify and measure, in all cases it's essential to do tests of proposed equipment on location, or realistic equivalent.

If you are interested in this subject and want to learn more, then you can download a complete best practice paper and Excel calculators to help specify and measure systems from www.rearpro.com/downloads.

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