Critical evaluation of monitors for HD

There is much misinformation and occasional deliberate blurring of the factors which go to make up the necessary feature set required for viewing of critical images within the professional monitoring arena. This is an attempt at an unbiased discussion of some of these, and takes the point of view of a comparison between the recent, acknowledged standard within the London production and Post Production community – Sony's D24 CRT, and more recent LCD offerings such as the Cinemáge from Cine-tal.

1) Screen size
   the Sony CRT has a nominal size of 24 inches but, for picture tubes, this relates to the diagonal dimension from corner to corner, measured from rim band to rim band. This results in a viewing diagonal of approximately 22 _ inches for 16:9 viewing.
   For a 1920 x 1200 LCD, the active video area is 1920 x 1080 lines. If the panel is a 24 inch, this gives a viewing area diagonal of just over 23 inches. It is up to the manufacturer what they do with the excess lines available. Some merely blank this off whilst others, Cine-tal included, use the spare 120 lines for the display of useful information related to the image input and for menu options.
   Some 1920 x 1200 panels have a diagonal of 23 inches (LG Philips panels for example). This gives a viewing area almost identical to the CRT

2) Screen resolution
   A 24 inch Grade 1 CRT is able to resolve luminance changes up to a frequency of about 18MHz. To demonstrate this, feed the input with a 0~30MHz linear sweep from a test pattern generator. Moire effects and cross colour will be noticeable about 2/3 of the way along the sweep. Feed this same signal into a 1920 x 1200 LCD, and the aliasing effects are visible only from about 24~25MHz upwards. Thus horizontally, a LCD can resolve an extra 6 or 7 MHz of signal bandwidth. This allows greater image clarity, but also can make low level noise, or film grain if viewing scanned images, seem more noticeable and with sharper edges. It was always there, but never resolved before!
   In terms of vertical resolution, a well set up 24 inch CRT can resolve about 900 to 950 lines in a dim environment (see screen brightness below) whilst a LCD will show all 1080 lines. This is an increase of about 15 to 20% in resolution, again highly useful for making decisions about critical focus.

3) Screen Brightness
   It is traditional in London to have the peak brightness of a 24 inch CRT set to a maximum of between 25 to 35 foot lamberts (FL). There were practical reasons for this – in the dark this is a comfortable peak level that prevents image burn onto the retina and some engineers believe that their CRT's will last longer if driven at lower brightness levels.
   However, there is also an underlying reason: it is not possible to turn the brightness up

any higher without the excess beam current being drawn causing a droop in the accelerating EHT that propels the scanning electron beam to the front faceplate. As this EHT droops, so does the related focus voltage, resulting in the images going soft. This results in the operator being forced to work in a dimly lit environment, since a CRT offers maximum perceived contrast ratio when there is no external light (see Black levels, below) and is unable to be turned up to compete with “normal” room lighting.

LCD’s, on the other hand, suffer from none of these disadvantages. They can be turned up at will, and the perceived contrast ratio is improved whilst being viewed in a brighter environment. This allows editing and grading decisions to be made in conditions more closely matching those of an “average” home viewing environment. Even in a Cinema, the viewing environment is much less dark than it used to be, with recent health and safety legislation mandating enough ambient lighting for customers to be able to see their way to a safety exit, plus the exit signs being permanently illuminated. As a final note, traditional cinema screens using film projectors tend to have a peak brightness of about 16 to 20FL, but the newer Digital Projectors can illuminate up to 30FL.

4) Black level

a CRT can be extinguished to black. That is, the electron beam can be completely shut off, with no light being emitted by the phosphors. Almost all LCD monitors use some kind of polarised backlighting system and rely on a twisting of a liquid crystal within each pixel to choke off the light passing through it. Panel manufacturers have got very good at managing this polarising twist, but it is still never perfect. Thus, in the dark, it is possible to perceive some residual light leakage from behind the screen even if the input is set to complete cut off. However, unlike a CRT, the moment there is some ambient lighting present, the LCD absorbs incident light rather than reflecting it back from the faceplate. Thus, as ambient lighting levels are increased, the observer’s pupils tend to contract, making black levels appear darker, and the light leakage from the LCD is not noticeable. Indeed, the perceived contrast ratio at higher ambient lighting levels is much greater and could be considered to allow for a more natural working environment if editing or grading for a TV deliverable.

Beware “dynamic backlighting”!! Here, manufacturers offer a system of manipulating the intensity of the backlight source to suit the average brightness of pixels within the bounds of the area illuminated by each, individual backlight source. This can give enhanced headline figures for contrast ratio, but at the expense of uneven backlighting or varying black levels.

5) Contrast ratio

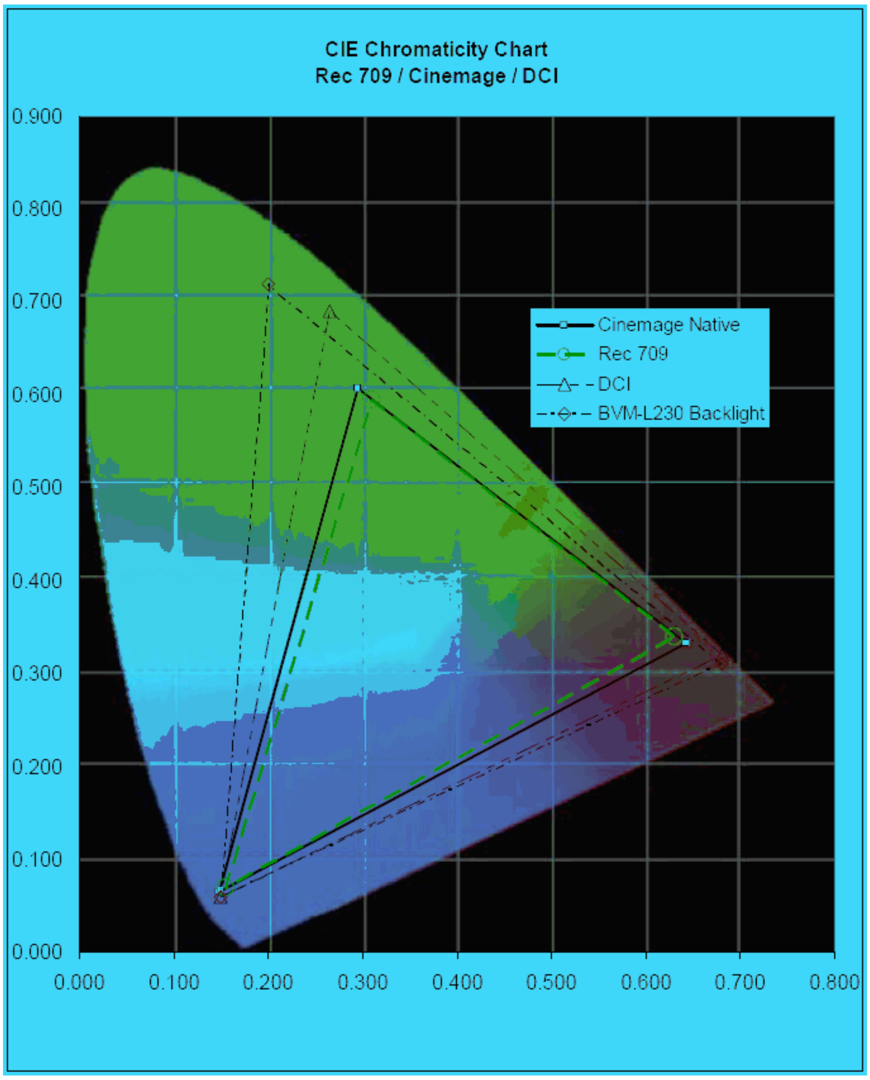
is the ratio of luminance between the brightest white that can be produced and the darkest black that can be produced. According to Poynton, [1] a well projected cinema film has a contrast ratio of about 100:1, whilst the average contrast ratio of a TV (CRT) screen in a living room ranges from about 30:1 to 70:1. The human eye can operate from bright sunlight to faint night vision – a contrast range of 10Million :1 or more than 23.5 stops! But this range is not all visible at once – the iris and the chemical sensors take this down to a manageable contrast ratio of between 75:1 and 500:1 (depending on who you listen to, and how old you are!)

The contrast ratio of a well aligned CRT can be up to 6000:1, whilst for a typical LCD is between 500:1 and 900:1. However, to a human observer the perception of black can only ever be as black as the screen surface. Thus, 1 lit candle in the average living room renders any improvement in contrast ratio over 500:1 unnoticeable since a) it reduces the eye's low light accommodation and b) the light reflects off the screen surface, raising the perceived level of black.

6) Viewing angle
this is the Achilles heel of LCD technology. There is no denying that any LCD monitor will exhibit some shift in either colorimetry, black level or both as you move from side to side. This does not occur with a CRT, and therefore in big "hero" grading suites where three of four people might be in attendance, it is necessary to very carefully consider if an LCD is suitable. This is purely a matter of personal choice. Some monitors have better viewing angle than others. The terms 160 degrees, or 178 degrees have very little bearing on the real world of critical, professional viewing; a monitor is either good enough or it isn't, but to maximise the viewing angle make sure you are viewing at an axis perpendicular to the monitor in the vertical direction, since the viewing angle of most modern LCD's is more critical vertically than horizontally.

7) Colour calibration
In critical grading applications there are two questions that need to be answered – is the monitor capable of being calibrated to REC709? is the monitor capable of being calibrated so it looks like our existing monitors?
These are not necessarily the same thing. In most monitors, including CRT's, you can adjust the lowlights (bias) and highlights (gain) and not much more. In an older CRT, where the RGB guns might have drifted in linearity and the phosphor might have aged, this could mean that low light and highlight are correct, but all the mid ranges are undetermined. However, if a colourist has spent years looking at this monitor, and instinctively knows exactly where the colours will map for a film out it might be desirable to be able to achieve that set up on a LCD. There is only one LCD monitor that can answer yes to both of the questions above, the Cinemáge from Cine-tal. It has a built in calibration and profiling system co-developed with the engineers from Gretag Macbeth. Almost any calibration is possible, with full control over brightness, contrast, gamma, x,y coordinates at multiple points up the display curve.

8) Colour gamut
The key question to ask here is – does the monitor cover the required gamut and if its gamut is wider, is there a way to either manage the colorimetry such that it only displays the necessary subset of needed colours, or allow the identification of any colours outside of the regular gamut standard that would be impossible on regular monitors. The most preferential way of managing this is by the use of Look Up Tables, giving the ability to map input colour co-ordinates onto a chosen display colour space such as REC 709 (the HD standard).



This diagram shows the native colour gamut of a Cine-tal monitor against DCI, REC709 and the published spec for Sony's new BVM-L230 monitor. As can be seen, both monitors encompass REC709, and whilst the Sony has a wider colour gamut neither cover DCI completely. The Cine-tal supports open source 1D and 3D LUT's for colour management, allowing a huge variety of colour space mappings and/or "previsualization looks "to be created by the end user and out of gamut colours to be indicated, whilst the Sony has closed source 3D LUT capability used solely for the management of calibration

9) 8 bit or 10 bit?
   Until recently 8 bit LCD panels were the maximum bit depth resolution available. With the advent of 10 bit panels, there is considerable interest to see if this results in a better image. For an 8 bit panel the final image quality, in terms of bit depth, depends on maintaining full bit depth resolution internally during the signal processing followed by optimization algorithms used to apply dynamic re-sampling to the signal fed to the panel during the 10 bit to 8 bit conversion. Independent, side by side viewing tests indicate that there is very little perceivable difference between the images displayed on 8 bit versus 10 bit panels if this re-sampling is successfully optimized.

10) Other display tools
   There are an increasing variety of display tools built into high spec broadcast and grading monitors, which may or may not be useful to the end user depending on the circumstances of use. These can include:

   a. 1D LUTS – available as an input conversion tool, these can be very useful for applying a de-log or de-gamma curve to images captured on the latest generation of HD cameras or Telecine systems. Many cameras now allow the creation and application of custom gamma curves for optimization of the dynamic capture range. A 1D input LUT can allow this curve to be "de-gamma'd " for image interrogation or correction

   b. Framestore – the ability to capture full bit resolution images can be very useful. Clients can take away stills from work-in-progress grading or effects sessions; DoP's, continuity, make up, etc can take stills from live feeds on location

   c. 3D LUTs – the ability to implement pre-visualization 3D LUT's can be very useful on location for DoP's who wish to optimize and/or manage colorimetry. Even better since simple tools exist to allow the dynamic creation of 3D LUT's for basic, on-set grading!

   d. Flexible routing – gives the ability to apply 1D or 3D LUTs to the screen image, whilst by pass routing the LUT engine for the loop through, or the ability to apply the internal 3D LUT engine to the loop-through signal whilst keeping the screen image raw....

   e. Cage and mask generation – some monitors support multiple, pre-determined cages and or masks for safe titles and safe area. Even better if user defined cages can be accurately created and stored!

   f. Image calibration and measurement – a well defined monitor calibration and probe system should also have the ability to measure and profile other displays

   g. Waveform and vectorscope – for use on cluttered desks or on location, the ability to implement 10 bit, single link or dual link 4:4:4 waveform and vectorscopes can be advantageous

h. Network interface and TCP-IP routing – offers the ability to use the monitor as a network device, with the control and use of any or all of the inbuilt tools described above. Gives the ability to save frame grabs to a network address or import/export frames and/or LUTs via the TCP-IP interface to any other device on the net. Can dramatically shorten the time taken on set to view graded dailies – send a still directly from the monitor to a grading suite, and minutes later the colourist can send back a 3D LUT with primary grading decisions embedded.

i. Internal test pattern generator – useful as a test and diagnostic tool, especially if it contains a good selection of SMPTE test patterns

References and further reading.

Gamma, brightness, contrast and colour:
Find much useful information on http://www.poynton.com/Poynton-color.html

Lots of information about colour science:
http://www.efg2.com/Lab/Library/Color/Science.htm

White paper: Colour Management for film:

http://cinespace.risingsunresearch.com/docs/ColourManagement.pdf

For an interesting and readable paper on Colour Spaces, try the following link:
www.filmlight.ltd.uk/pdf/technicalnotes/FL-TL-TN-0139-StdColourSpaces.pdf