NHS
Purchasing and Supply Agency

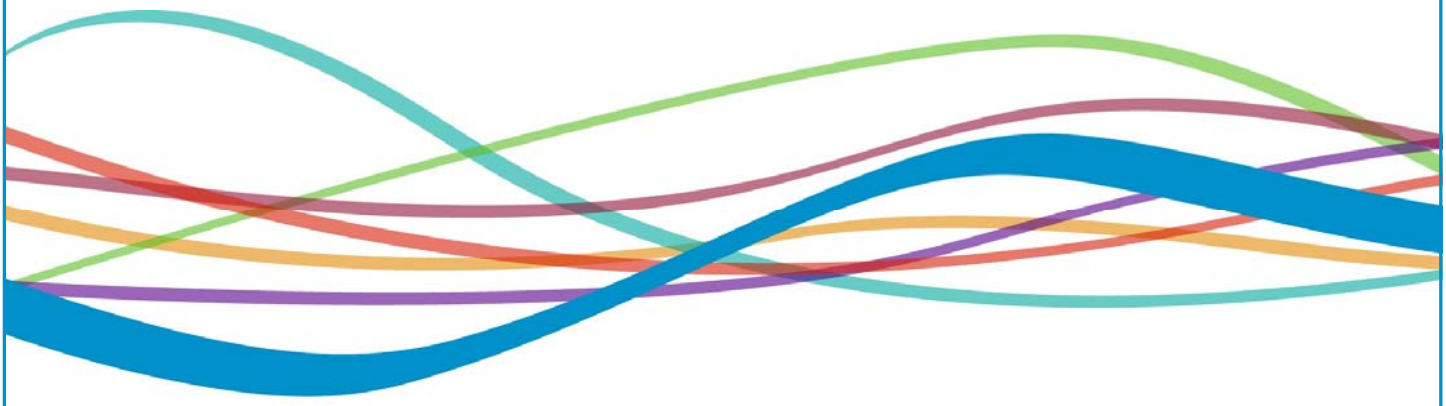
Centre for Evidence-based Purchasing

Evaluation report

Eizo RadiForce G33-N 3MP greyscale flat panel liquid crystal display (LCD)

CEP 07003

August 2007



Informing procurement - Encouraging innovation

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The Eizo RadiForce G33-N 3MP greyscale flat panel liquid crystal display (LCD) is one of a number of competing electronic display products on the UK market. It utilises a thin film transistor (TFT) active matrix liquid crystal display (AMLCD) with a three megapixel (3 MP) display matrix.

Field of use

With continuing investment in digital technologies for diagnostic imaging in the NHS, it has become increasingly common for clinicians to view medical images on electronic display devices, rather than X-ray film. This has many advantages, not least the cost savings in not printing film and managing its storage. Advances in the technology employed in electronic display devices for medical applications have resulted in cathode ray tube (CRT) displays nearing obsolescence, with liquid crystal displays (LCD) now the market leaders. Display devices purchased for use in medical imaging should be fit for the specific intended purpose, whether this is for review of images, or for primary diagnosis. Further, the minimum specification of display required depends on the source modality of the images to be viewed. Primary diagnosis of mammography images will require higher specification displays than will primary diagnosis of magnetic resonance imaging (MRI) images.

The Eizo RadiForce G33-N is intended for use in diagnostic medical imaging for primary reporting of monochrome images. Applications of the product include: computed radiography (CR), direct digital radiography (DDR), computed tomography (CT), MRI and angiography. It is not intended for the diagnostic interpretation of mammography images, for which higher resolution displays are recommended.

National guidance

Guidelines on the specification of display devices for particular uses have been produced by the Royal College of Radiologists (RCR) UK PACS & Teleradiology Group and these should be referred to when making purchasing decisions.

Purchasing guidance

NHS Connecting for Health (CfH) is tasked with delivering the National Programme for IT (NPfIT), which is intended to create a coherent IT infrastructure across the NHS. This infrastructure will include picture archiving and communications systems (PACS), key components of which are display devices. The NPfIT is being delivered throughout England within five regions, each working with a single local service provider (LSP). Display devices should be available to purchase through the NPfIT via the LSP's product catalogue. However, not all commercially available display devices will necessarily be included in each LSP's catalogue, since each LSP tends to conduct their own checks and balances, as such items directly affect their service level agreements (SLAs). It is not compulsory to purchase products from the LSP catalogue and purchasers are free to source display devices in whichever way is most convenient and economic for them.

Executive summary

As of 1st April 2007, accountability for the delivery of the NPfIT has been transferred to Strategic Health Authorities (SHAs) as part of the NPfIT Local Ownership Programme (NLOP). Therefore, in the first instance, you may have to go to your local SHA for assistance and advice with the procurement of your display devices as part of the NPfIT.

Evaluation method

The evaluation methods were based on the American Association of Physicists in Medicine (AAPM) On-line Report No. 03 “Assessment of Display Performance for Medical Imaging Systems” (April 2005). Measurements were made of: geometric distortion, luminance response, luminance stability, luminance uniformity, variation of luminance with viewing angle, contrast resolution and spatial resolution. The display was evaluated in combination with a Matrox MED3MP-DVI 3MP graphics card and BIOS 1.1 – 17 EC display driver package, recommended by Eizo as being appropriate for use with this type of display and together with the display, loaned by them for the period of the evaluation. The display was evaluated in a darkroom. No attempt was made to distinguish between the performance of the display and that of the supplied graphics controller card.

CEP verdict

The measured performance of the Eizo RadiForce G33-N indicates that it is suitable for use in diagnostic medical imaging for primary reporting of monochrome images. The display has a high contrast ratio, little luminance variation across the display and good luminance stability over time. As expected of liquid crystal display (LCD) technology, there is no geometric distortion in the displayed image.

Introduction

With the advent of digital imaging systems, it has become increasingly common to view medical images on electronic display devices rather than film. This has many advantages, not least the cost-saving involved in not printing film and managing its storage.

Liquid crystal displays (LCDs) offer a number of advantages over the cathode ray tube (CRT) displays that they increasingly replace in medical imaging. LCDs are not affected by screen flicker, geometric distortion or focus problems, all of which commonly afflict CRTs. Furthermore, they take up much less space and consume less power. They do however have some minor disadvantages compared with CRTs, including a relatively low maximum viewing angle (affecting the number of people who can reliably view an image on the same screen), lower refresh rate (which can cause blur on fast-moving images), and lower contrast. However, these shortcomings are becoming less significant as LCD technology matures.

Guidelines on the specification of display devices for particular uses have been produced by the Royal College of Radiologists (RCR) UK PACS & Teleradiology Group and these should be referred to when making purchasing decisions.

Displays used for primary reporting should be calibrated to the digital imaging and communications in medicine (DICOM) Part 14 Greyscale Standard Display Function. Many current LCD devices on the UK market allow for automated calibration to the DICOM curve and some devices can send results of their self-calibration over a network for remote quality assurance. The Eizo RadiForce G33-N, as supplied, did not have any self-calibration facilities. The Eizo RadiForce G33 (not tested here) does include self-calibration facilities.

The evaluation methods were based on the American Association of Physicists in Medicine (AAPM) On-line Report No. 03 “Assessment of Display Performance for Medical Imaging Systems” (April 2005). The display was evaluated in a darkroom. No attempt was made to distinguish between the performance of the display and that of the supplied graphics controller card.

Product description

The Eizo RadiForce G33-N greyscale flat-panel liquid crystal display utilises a thin film transistor (TFT) active matrix liquid crystal display (AMLCD) with a three megapixel (3 MP) display matrix and uses the Quad eXtended Graphics Array (QXGA) display standard. The stand allows adjustment of height and tilt and rotation between portrait and landscape orientation.

Display supplied

Eizo Nanao RadiForce G33-N 3 megapixel display, serial number 10012095.

Graphics card supplied

Matrox MED3MP-DVI, serial number BB96759.

Display driver package

Graphics BIOS 1.1 – 17 EC.

The Matrox “PowerDesk” software provides features additional to the standard Microsoft Windows display control, including the ability to adjust screen orientation, the option to use one display or multiple displays and choice of display mode (stretched or independent, i.e. whether an image can spread over multiple screens or fill one screen at most).

Figure 1. Eizo RadiForce G33-N 3 MP display

Product specifications

Table 1. Eizo G33-N specifications (from manufacturer's literature)

Dimensions	
Screen size	318 x 423.9 mm (W x H) (portrait mode)
Height (with stand)	515.5 - 597.5 mm (portrait mode)
Width	368 mm
Depth	209 mm
Viewable image	529 mm (20.8”)
Weight	10.0 kg
Power supply	120 / 200 - 240 VAC +/- 10% 50 / 60 Hz 1.0 - 0.8 / 0.5 - 0.4 A
Power consumption	
Minimum	90 W
Maximum	100 W (with USB hub)
Power saving mode	< 3 W (USB hub not connected)
Operating conditions	
Temperature	0 - 35 °C
Humidity	30 - 80 % relative, non-condensing
Pressure	70 - 106 kPa
Resolution	
Native resolution	1536 x 2048 pixels
Pixel size	Not quoted
Pixel spacing	0.207 x 0.207 mm
Response time	50 ms
Scan frequency	
Horizontal scan	31 - 100 kHz
Vertical scan	48 - 71.5 Hz
Dot clock	165 MHz (max)

Evaluation method

The evaluation methods were based on the American Association of Physicists in Medicine (AAPM) On-line Report No. 03 “Assessment of Display Performance for Medical Imaging Systems” (April 2005). The display was evaluated in a darkroom. No attempt was made to distinguish between the performance of the display and that of the supplied graphics controller card. The device was tested for geometric distortion, luminance response, luminance stability and uniformity, variation of luminance with viewing angle, contrast resolution and spatial resolution.

The supplied device was tested attached to a Dell Dimension 8100 PC (Pentium 4, 1.5 GHz; 256 MB RAM; 74.5 GB HDD) owned by PACSnet, running Windows 2000 Professional v5.00.2195 SP 3.

Geometric distortion

In an LCD, pixel positions are fixed and are determined by the position of the individual cells. Therefore, in a properly designed and manufactured display, there should be no geometric distortion apparent. If images are rescaled for display, this may introduce minor distortion.

To establish that there was no geometric distortion, a test pattern of squares (AAPM TG18-QC) was displayed at 1:1 display pixel: image pixel and the size of the squares in the test image measured.

One square:	21 mm x 21 mm
Two squares:	42 mm x 42 mm
Four squares:	84 mm x 84 mm

There was no measurable geometric distortion in the displayed test image. No distortion was seen in any other test images used during the evaluation.

Display reflections

No formal measurement of the reflectance of the display screen was performed. Subjectively, the display reflectance was similar to that of other displays in its class.

Luminance response

No calibration software was supplied with the display. However, a number of options were available via the display's firmware. These were a choice of 'curve' and a choice of maximum luminance.

'Curve' options were:

1-DICOM

2-NATIVE

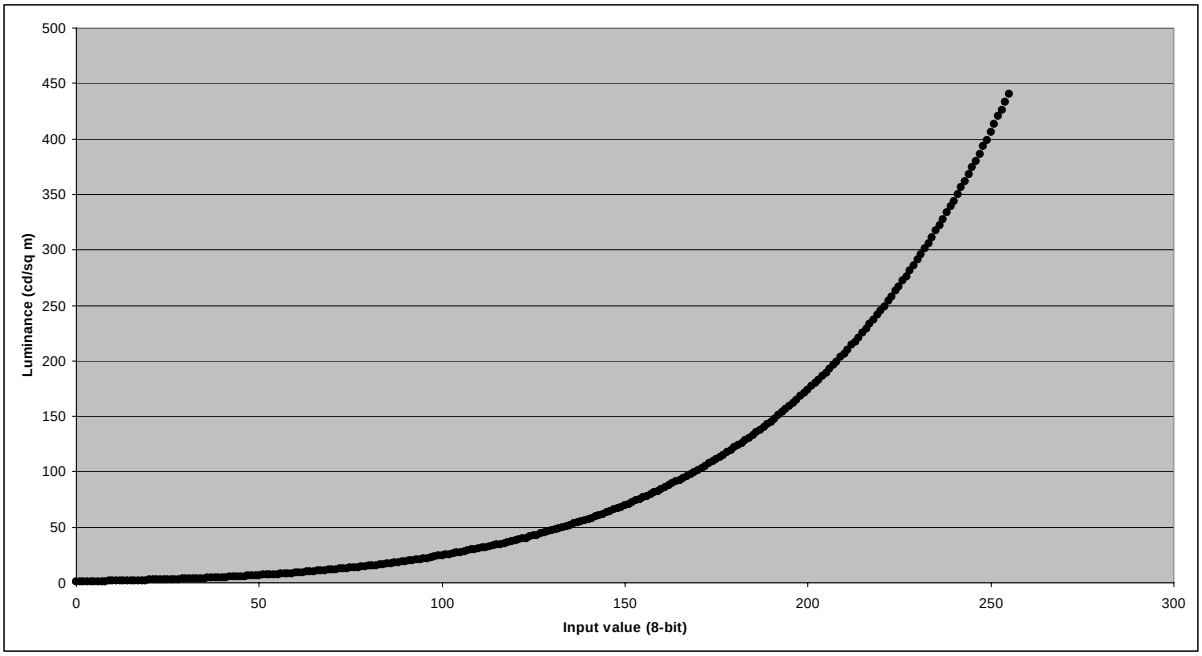
3-CAL

Maximum luminance could be adjusted in a range from '0 %' to '120 %' in 1 % steps.

The device was supplied set to the DICOM curve and with a luminance setting of 72%. These settings gave appropriate values for the expected use of this display (i.e. a maximum luminance of 450 cd m-2) and were therefore used for the majority of the tests.

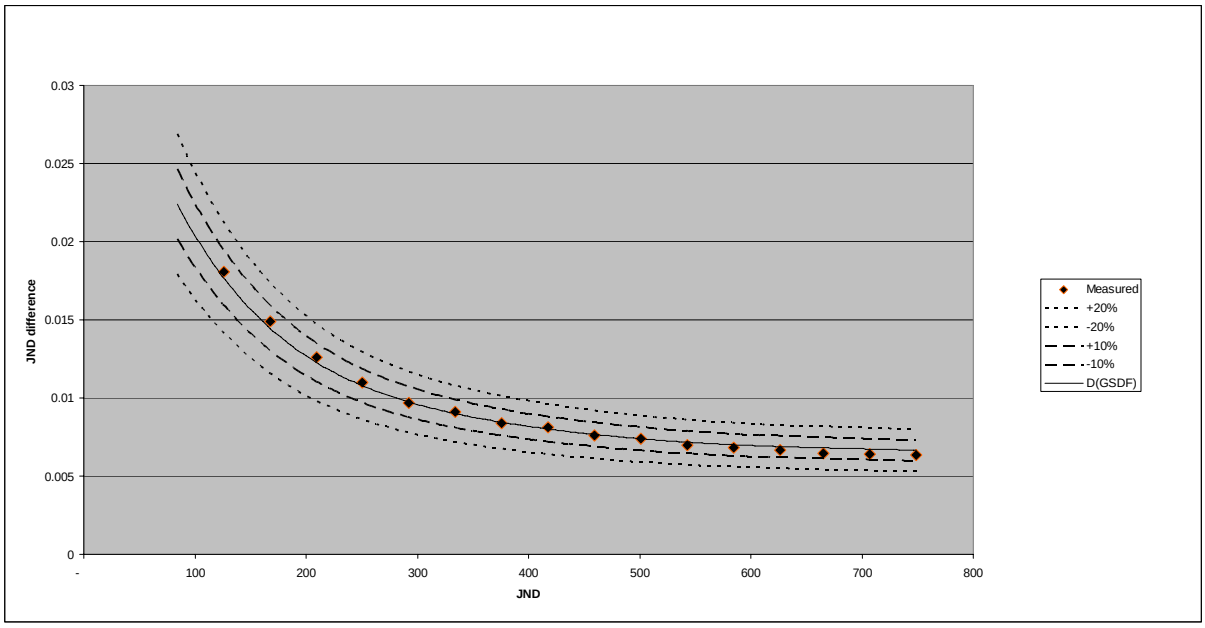
To check the response of the display to changes in input values, the display's luminance was measured across the available range of input values. Results of the measurements are shown in figure 2.

Figure 2. Luminance response to varying input value



To check conformance with the DICOM Greyscale Display Function (GSDF), a number of points were measured for contrast difference and compared to the contrast difference specified by the DICOM GSDF. The results of this test are shown in figure 3, which also shows the target values, together with 10% and 20% variation curves. The graph shows that the measured values are well within the 10% variation curve.

Figure 3. DICOM conformance



Luminance uniformity

An LCD panel may not be uniformly illuminated by the backlight, resulting in uneven intensity and shading over the screen. The screen glass itself may also contribute to non-uniformity in the displayed image.

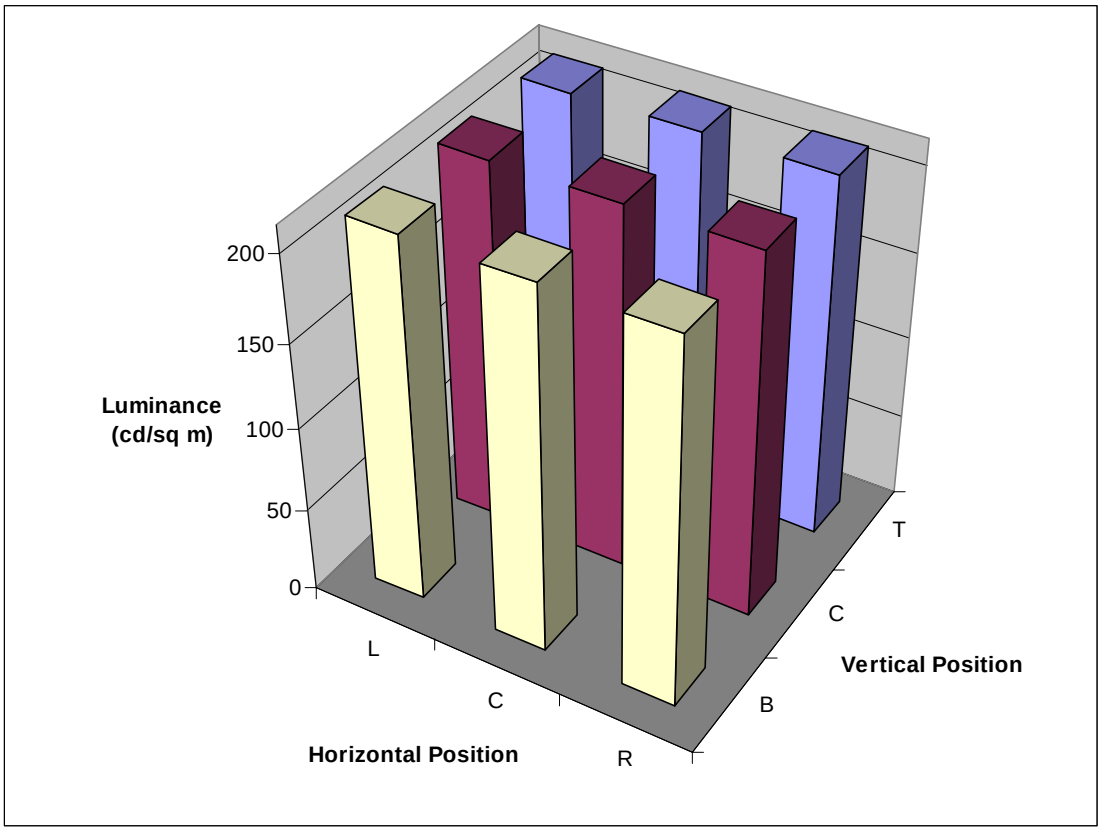
Luminance uniformity was measured by displaying a plain white image over the entire screen and making measurements of the luminance at 9 points over the screen, in a 3 x 3 matrix.

Mean results of these measurements (in cd m^{-2}) using the Eizo luminance probe were:

419	426	425
429	432	442
407	417	418

These results are illustrated in figure 4.

Figure 4. Luminance uniformity measured using the Eizo luminance probe



The AAPM TG18 Display Assessment protocol states that the maximum luminance variation should be less than 30%, this luminance variation being calculated by the formula:

$L_{var} = 200 * (L_{max} – L_{min})/(L_{max} + L_{min})$.

In the above case, the maximum variation is

$L_{var} = 200 * (442 – 407)/(442+407) = 4.1$ %

The luminance variation over the display screen falls below the upper limit of 30% recommended by the AAPM and is therefore acceptable.

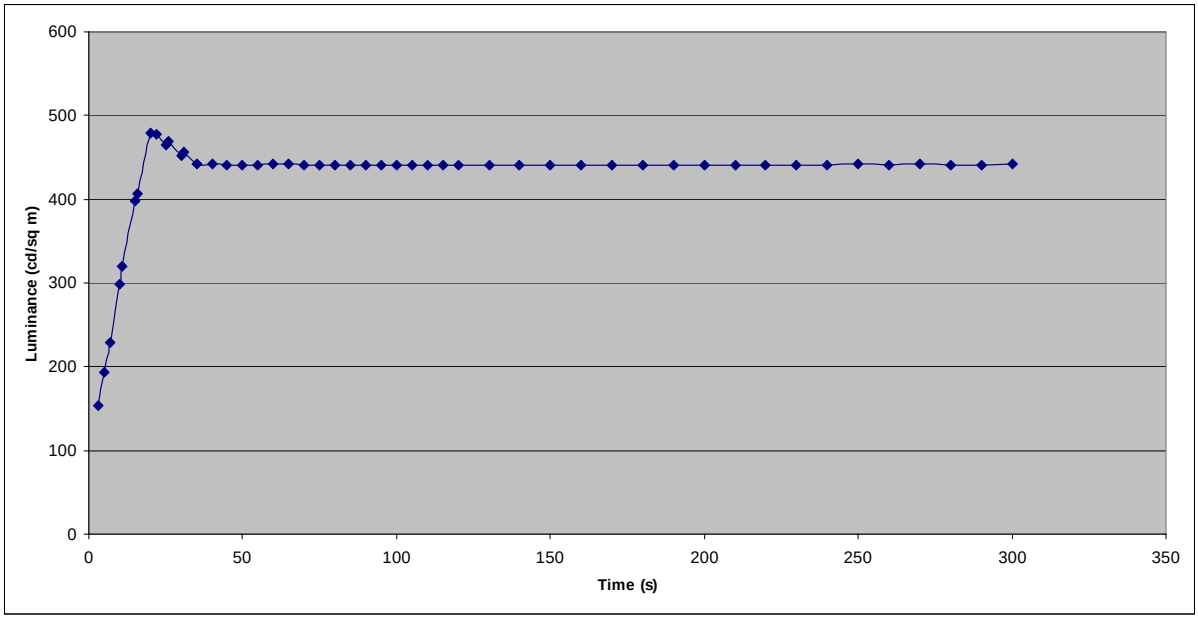
Luminance stability

The stability of the luminance of the display was measured, both short-term luminance changes following switching on the device and longer-term drift over several hours.

Luminance changes following switching on the device

To measure the luminance changes following switching on the device (the “warm-up” time), the system was set up to display a white square at peak luminance at the centre of the display. After leaving the display switched off overnight, the display was then powered on and luminance readings taken every few seconds until the display luminance had stabilised. Results are shown in figure 5. This shows the luminance of the device for the first 300 seconds (5 minutes) following switch-on.

Figure 5. Warm-up time



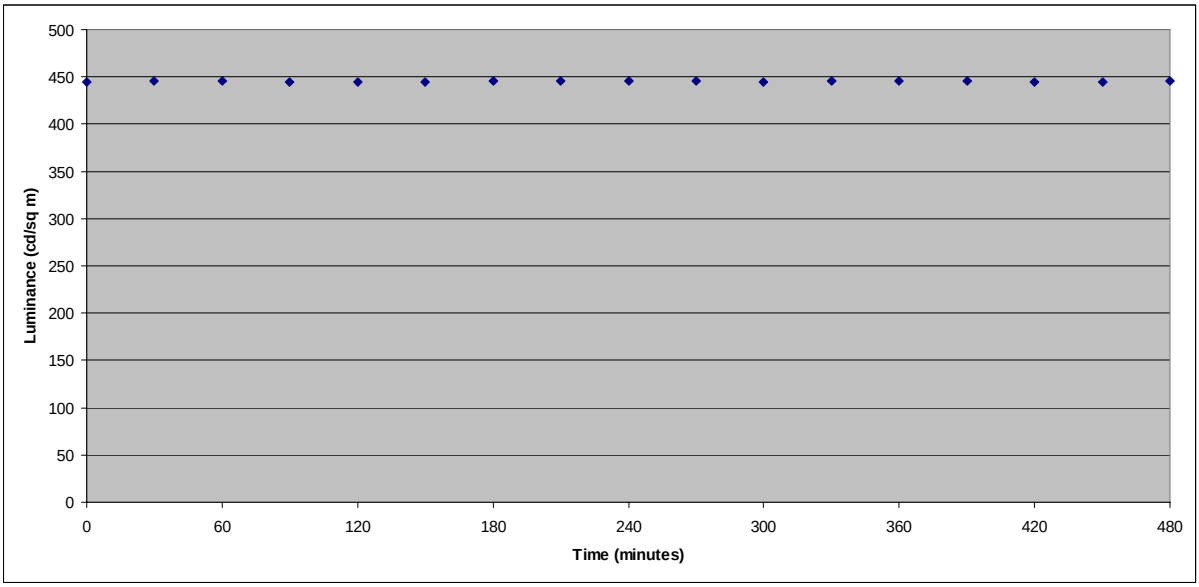
The display reached its target luminance and remained there after less than one minute. In normal use, this would be well within the time required to start up the base PC and for the user to log in.

Luminance drift

To measure any drift in luminance, the display was switched on and a test image displayed in the same manner as for the warm-up measurements above. Measurements were taken for a significantly longer period of 480 minutes (8 hours, approximately one working day) and the results are shown in figure 6

.

Figure 6. Luminance stability



There was no significant drift in the peak luminance value over the measurement period.

Contrast ratio

The contrast ratio was measured using the method described by the American National Standards Institute (ANSI). This requires the display of a 4 x 4 “checkerboard” pattern, with eight areas at peak white and eight areas at black. The luminance of each of these areas is measured and the luminance ratio is calculated by dividing the mean luminance of the white areas by the mean luminance of the black areas. The display is masked, apart from an aperture for the area being measured, during this test in order to reduce the effect of scattered light on the measurements.

Results:

Mean white luminance: 423.4 cd m^{-2}

Mean black luminance: 0.854 cd m^{-2}

Calculated contrast ratio: 496

The calculated value for the contrast ratio exceeds the minimum value of 400 recommended by the AAPM and is therefore acceptable.

Spatial resolution

The resolution of an LCD display is fixed at the time of manufacture. At the native resolution of the panel, the resolution is exact. Should it be required to display images at different resolutions, the image data will need to be rescaled before display. This rescaling can introduce distortion in the displayed image.

The display resolution was evaluated using the AAPM TG18 test image. As expected, the limiting factor for the resolution was the size of the pixels. With test images displayed at 1:1 image pixel: display pixel (i.e. at 1536 x 2048 pixels image size) there was no loss of spatial resolution.

Display noise

Display noise was not measured but appeared to be minimal.

Angular dependency of luminance

The apparent brightness of displays can vary considerably with viewing angle. This is especially true for LCD flat-panel displays. This variation of luminance can affect not only the perceived brightness of the displayed image, but also its contrast. The same image viewed from different angles can convey quite different information. LCD devices should be viewed from directly in front of the display.

Figure 7 shows the variation of peak luminance as viewing angle varies, with the display in the portrait orientation. There is a decline in luminance as viewing angle increases.

Figure 7. Variation of luminance with viewing angle

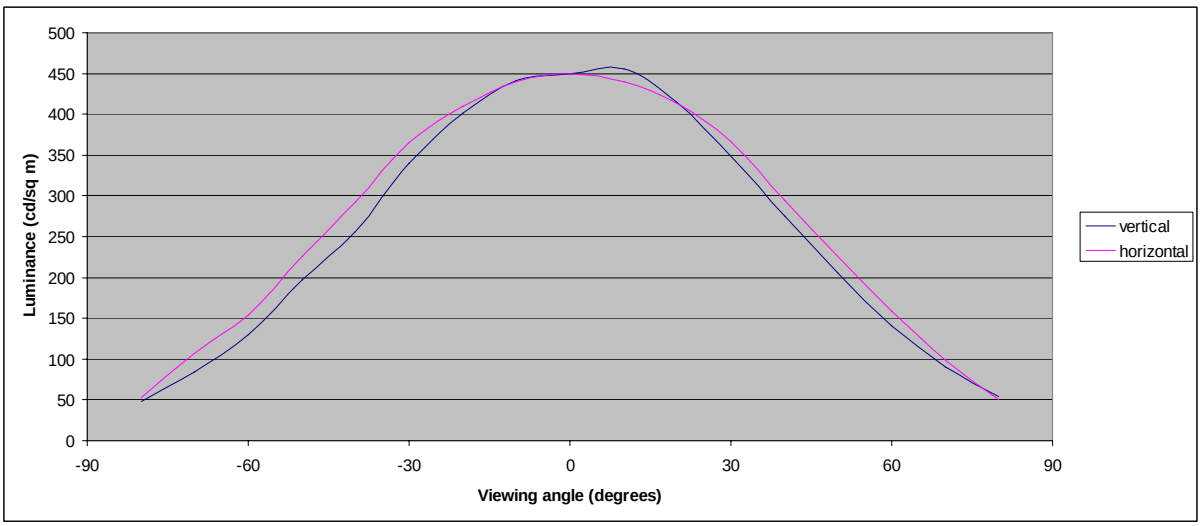
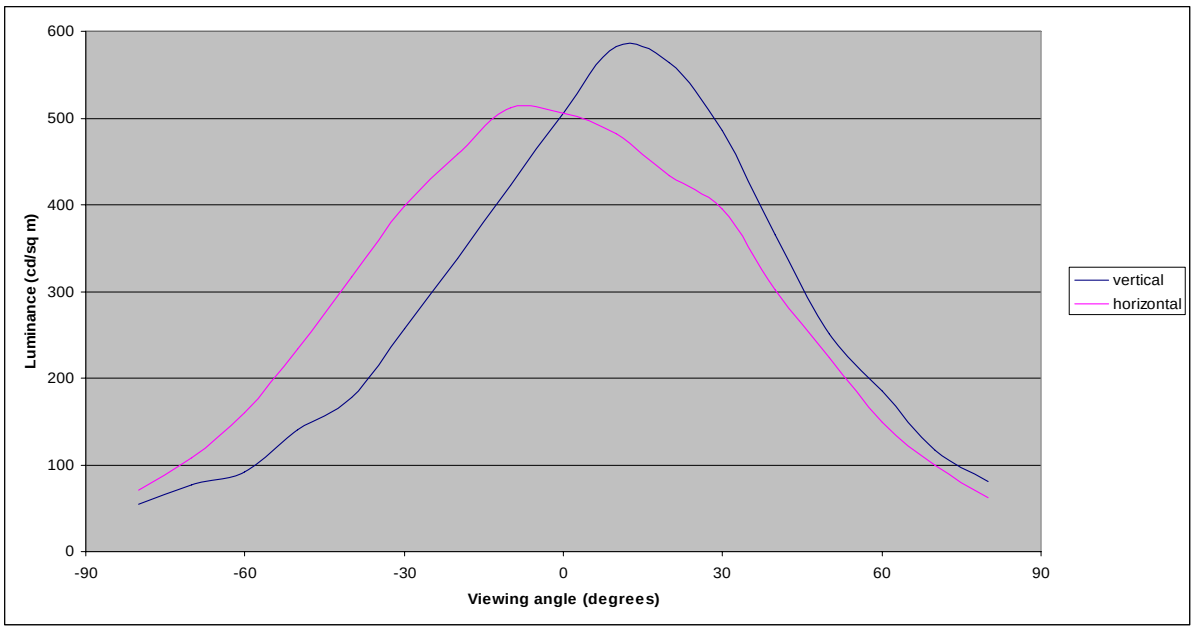


Figure 8 shows the variation of contrast ratio as viewing angle varies, with the display in the portrait orientation. Again, it can be seen that there is a decline in luminance as viewing angle increases.

Figure 8. Variation of contrast ratio with viewing angle



The decline in luminance with viewing angle in both portrait and landscape orientation is due to the structure of the display screen, in particular the properties of the polarisers used on the liquid crystal cells and the length of the light path taken through the cells, both of which vary with the angle of incidence of the light passing through. Slightly different effects are seen as screen orientation changes due to the shape of the liquid crystal cells, which are not square in this device. This is typical for this type of display.

Electronic cross-talk

Electronic cross-talk is the effect of signal on one channel affecting the signal on a nearby channel. In a display, this can mean the luminance of one pixel being affected by signal intended for another pixel.

There was no effect from cross-talk apparent on a visual inspection of the displayed image.

Pixel defects

LCDs can have “stuck” pixels, i.e. pixels which are permanently ‘on’ or ‘off’. Some pixels may be improperly connected to adjoining pixels, rows or columns.

There were no pixel defects apparent on visual inspection of the display.

NHS Connecting for Health and the National Programme for IT (NPfIT)

NHS Connecting for Health (CfH) is tasked with delivering the National Programme for IT (NPfIT), which is intended to create a coherent IT infrastructure across the NHS. This infrastructure will include picture archiving and communications systems (PACS), key components of which are display devices. The NPfIT is being delivered throughout England within five regions, each working with a single local service provider (LSP). Display devices should be available to purchase through the NPfIT via the LSP's product catalogue. However, not all commercially available display devices will necessarily be included in each LSP's catalogue, since each LSP tends to conduct their own checks and balances, as such items directly affect their service level agreements (SLAs). It is not compulsory to purchase products from the LSP catalogue and purchasers are free to source display devices in whichever way is most convenient and economic for them.

Accountability for the delivery of the NPfIT was transferred on 1 April 2007 to the Strategic Health Authorities (SHAs) as part of the NPfIT Local Ownership Programme (NLOP). CfH is working closely with the 10 SHAs in ensuring activities with LSPs continue effectively have established three geographic areas linking the LSPs and SHAs together;

- North, Midlands and East Programme for IT (NMEPfIT) with six SHAs and Computer Sciences Corporation (CSC) as the LSP;
- London Programme for IT (LPfIT) with one SHA and BT as the LSP
- Southern Programme for IT (SPfIT) with three SHAs and Fujitsu as the LSP.

Prospective purchasers of display devices and related products might wish to seek guidance from their local SHAs on their available options.

Acknowledgements

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Eizo RadiForce G-33N 3MP greyscale flat panel liquid crystal display (LCD)

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