Technical white paper

HP Healthcare Edition Displays: Image deviation over time

January 2017

Table of contents

Introduction

The HP HC240 and HP HC270 Healthcare Edition displays are clinical review displays that are factory calibrated to conform to DICOM Part 14 GSDF (grayscale display function) specifications. As clinical review displays, there are no governmental or agency requirements that these displays conform to the DICOM Part 14 GSDF. Healthcare professionals, however, do want to be able to view accurate medical imaging on them for wet reads, collaboration, and consultation, and feel confident that they are viewing the imaging with the same grayscale values as those viewed by the radiologist or diagnostician who made the diagnosis[1].

The HP HC240 and HP HC270 displays contain a high-performance scaler chipset with an integrated color management pipeline. This allows HP to store look-up tables (LUTs) in the display that are used to change the grayscale response of the display. The HP HC240 and HP HC270 utilize 12-bit LUTs to ensure GSDF accuracy.

How DICOM GSDF factory calibration is performed

Prior to factory calibration, the display is warmed up for a minimum of thirty minutes to ensure that the display backlight is stable. The display is then placed in a dark light-controlled booth and a high-performance colorimeter (Konica Minolta CA-310) is positioned in front of the display. Custom calibration software is then used to do the following:

- Measure the display response across all three (R, G, B) signal channels at multiple grayscale levels.
- Measure the display peak luminance and iterate to the desired target value of 250 cd/m².

Once the measurements are completed, LUTs are then calculated to modify the display's native grayscale response to match the expected DICOM GSDF response. A target white point of D65 (6504° K) is also applied and the grayscale is tone neutralized relative to the D65 white point.

These LUTs are then uploaded into non-volatile memory within the display.

Important
DICOM GSDF calculation is made using a 0.0 cd/m² ambient light compensation. When validating the HP HC240 or HP HC270 calibration, please set the ambient light compensation in your conformance software to 0.0 cd/m²

LCD display performance over time

When considering the performance of a LCD display over time, there are two different factors that should be considered: liquid crystal (LC) voltage response and backlight LED and phosphor ageing.

Liquid crystal voltage response

Grayscale values are generated by a LCD panel by applying a specific voltage to the LC material. Different voltages will result in different levels of gray generated. These voltages are characterized during the development of the LC material. The response of the LC material to these voltages has been found by the display industry to be extremely stable. This means that as a LCD panel ages, the grayscale value generated by the application of specific voltage to the LC material in a display "pixel" does not change as the LC material ages.

This means that the grayscale performance (relative grayscale values as a percentage of the peak – or full open – state of the LC material) does not change over time and the input of a specific grayscale value will result in the display of that value for the life of the LC material.

Backlight LED and phosphor ageing

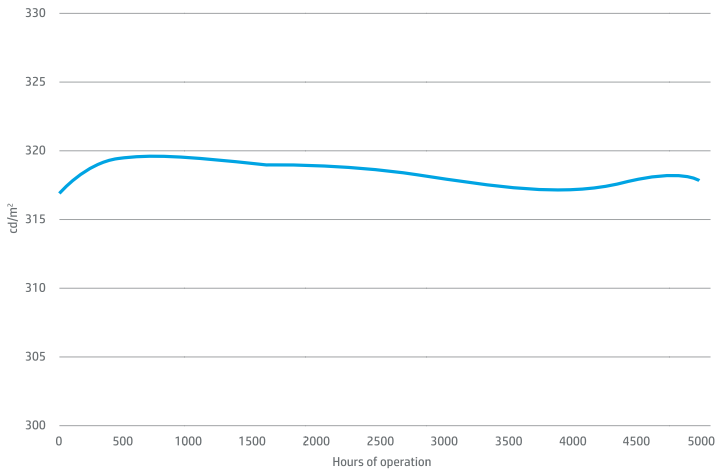
As LC material used in computer displays is transmissive, backlight illumination must be applied behind the LC material in order for an image to be visible to the naked eye. While backlights can be built using a wide range of illumination materials, the HP HC240 and HP HC270 backlights generate light using a "white LED" package, which is actually a combination of narrow bandwidth blue LEDs and wide bandwidth yellow phosphors.

Over time, the efficiency of these "white" LEDs degrade, resulting in a reduction in illumination. A typical modern white LED package loses half of its illuminance after approximately 30,000 hours of use. In addition, the efficiency of the blue LEDs and yellow phosphors degrade at slightly different rates. This results in a gradual color shift over time along the blue-yellow axis.

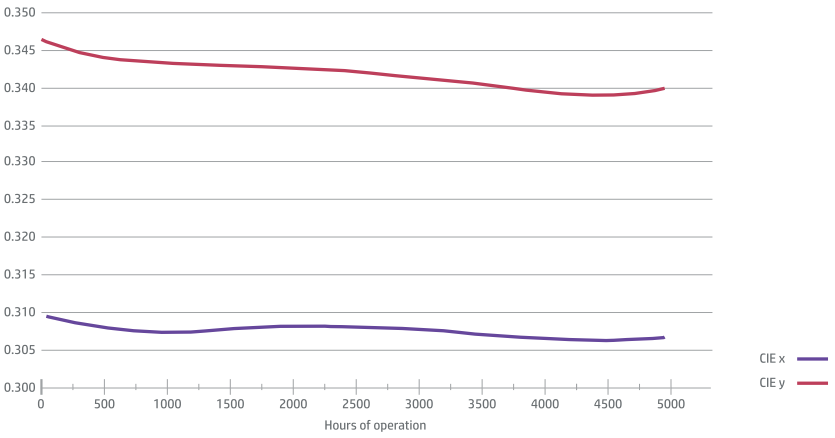
The net result of this is that a LED-backlit LCD such as used in the HP HC240 and HP HC270 will get gradually dimmer over time and the white point will gradually shift towards blue (along the blue-yellow axis). It should be noted that this ageing is not linear and the amount of dimming and color shift will change, over time.

The following two plots show the real-time ageing data of a typical high-performance display of the type used in the HP HC240 and HP HC270 over 5000 hours.

Luminance variation over time



White point variation over time (CIE xy)



The white point variation is shown as a change in the CIE xy coordinate values of the white point over time. As both x and y reduce over time, the resultant white point shifts to towards blue.

DICOM GSDF calibration accuracy over time

DICOM Part 14 (PS3.14) specifies a grayscale display function (response curve). It does not provide any guidance regarding the color performance of a display. Quoting from PS3.14, "PS3.14 does not specify functions for display of color images, as the specified function is limited to the display of grayscale images. Color Display Systems may be calibrated to the Grayscale Standard Display Function for the purpose of displaying grayscale images. Color images, whether associated with an ICC Profile or not, may be displayed on standardized grayscale displays, but there are no normative requirements for the display of the luminance information in a color image using the GSDF." (DICOM PS3.14 2016e, page 13).

Due to the long-term stability of the liquid crystal voltage response, the DICOM grayscale display function should maintain internal accuracy over the life of the display. While it is also true that the front-of-screen luminance will gradually dim and the white point will gradually shift towards blue, neither of these are part of the PS3.14 spec, and therefore for clinical review displays they can be considered relatively insignificant.

Note that, since the peak luminance will reduce over time, when using DICOM conformance software to measure the display performance, the peak luminance target should be set to the measured peak luminance in the conformance software.

[1] The HP HC240 and HP HC270 are not intended for primary image interpretation or diagnostic use.

4AA6-9344ENW, January 2017