

Introduction

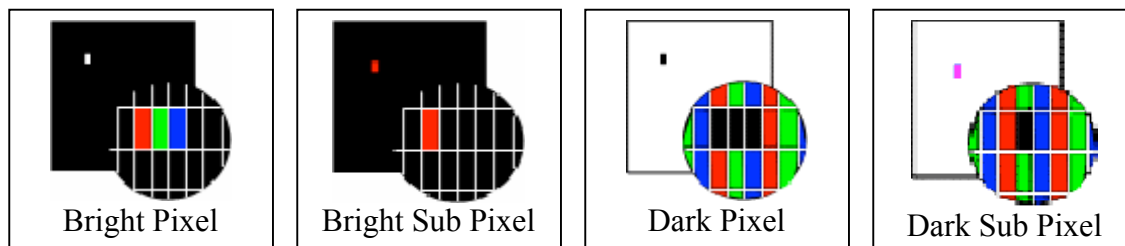
LCD displays are made up of a large number of pixels, and each pixel comprises three sub-pixels of Red, Green, and Blue. Each sub-pixel is individually addressed to control its state, thus forming the image.



A typical LCD display incorporates millions of transistors to drive the individual sub-pixel cells. Due to limitations inherent in the manufacturing process, a small proportion of defects inevitably occur in the formation of the transistors and cells, resulting in imperfections in the LCD image.

Such pixel defects fall into two broad categories, known as Bright Defects and Dark Defects. As the names imply, Bright Defect pixels or sub-pixels always remain lighted, while dark defect pixels or sub-pixels never turn on. Generally, Dark Defects are less noticeable than are Bright Defects. The visibility of such defects is strongly dependent upon the image displayed.

Pixel Defect Examples



New pixel defects rarely develop after initial manufacture.

These faults cannot be repaired. Instead, LCD panels are graded as to quality, and are selected and priced accordingly.

ISO 13406

ISO 13406 is an international manufacturing standard which addresses LCD display image quality. Pixel defects are among the quality issues defined.

Pixel defects may be classified as:

- Pixel always illuminated
- Pixel never illuminated
- Sub-pixel error (R, G or B malfunction)

The highest-level ISO quality standard is ISO 13406-1. This standard allows no pixel defects (as determined by their method). Only a small portion of very high-resolution LCD panels can meet this requirement, and for economic reasons, it is generally reserved for only the most critical applications.

For high quality display applications, LCD units must meet ISO 13406-2*. This standard permits a small maximum number of defects, based on the number of physical pixels on the display (native resolution).

Subjective tests have shown that viewers are unlikely to notice a small number of discrete defects scattered across a display. In the special cases of solid color images, including black screen and white screen, pixel defects are easier to spot. Clusters of defects are also more noticeable. A cluster is defined as a number of defects within any 5 x 5 pixel block.

Based on this data, ISO 13406-2 defines acceptable limits for pixel defects in high-quality displays as follows:

ISO 13406-2 PIXEL FAULT TABLES

Limit: 2 full-pixel malfunctions per million pixels

Native Resolution	Number of Pixels (millions)	Allowable Defects
600 x 480	0.31	1
800 x 600	0.48	1
1024 x 768	0.79	2
1280 x 1024	1.31	3
1600 x 1200	1.92	4
2048 x 1536	3.15	6
2048 x 2048	4.19	8
2560 x 2048	5.20	10

ISO 13406-2 PIXEL FAULT TABLES cont.

Limit: 5 Sub-pixel malfunctions per million pixels

Native Resolution	Number of Pixels (millions)	Allowable Defects
600 x 480	0.31	2
800 x 600	0.48	2
1024 x 768	0.79	4
1280 x 1024	1.31	7
1600 x 1200	1.92	10
2048 x 1536	3.15	16
2048 x 2048	4.19	20
2560 x 2048	5.20	26

Limit: 1 full-pixel malfunction or 2 sub-pixel malfunctions within a 5x5 pixel block (cluster), with 2 clusters permitted per million pixels

Native Resolution	Number of Pixels (millions)	Allowable Cluster Defects
600 x 480	0.31	1
800 x 600	0.48	1
1024 x 768	0.79	2
1280 x 1024	1.31	3
1600 x 1200	1.92	4
2048 x 1536	3.15	6
2048 x 2048	4.19	8
2560 x 2048	5.20	10

CCC's Pixel Policy

Each LCD Panel is evaluated against ISO 13406 standards and the following additional criteria when viewed from a normal viewing distance of 50cm (16 inches), with the panel displaying in its native resolution. Thus, any of the following conditions will disqualify the unit from sale.

- The allowable pixel or cluster count is exceeded (per LCD size)
- 2/3rds of the allowable defects are bright non-performing pixels appearing as a red, green, blue, yellow, cyan, magenta, or white dot on a black background, or
- 2/3rds of the allowable defects are dark non-performing pixels appearing as a black dot on a bright or white background or,
- 2 non-performing pixels of any kind located less than 10 mm from each other.