HFE Countermeasures to reduce visual problems during LED displays inspection

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Abstract

Electronic outdoor and indoor signs are part of the latest technology for advertising. However, latest trend includes electronics road signs, electronics gaming, and electronics marketing to mention a few. These electronics sings makes businesses possible to communicate with customers in real time basis. The quality of the LED display is very critical as these visual systems convey messages. The purpose of this project is to provide HFE countermeasures during inspection of the LED displays.

HFE Countermeasures to Reduce Visual Problems during LED Displays Inspection

At Adaptive Micro Systems LLC, LED inspection process is very critical in our quality process. Adaptive designs, develops, and manufacture LED displays for indoor and outdoor products. This project deal specifically with the 1146, an OEM product we manufacture for a customer that provides gaming for casinos. The LED (Light Emitting Diode) in this display is a combination of red, green, and blue color (RGB). A pixel is a combination of two or three LED's. These LED's are very bright. The 1146 are designed to be viewed at a 3 to 4 feet distance. Currently, inspectors set the display in test mode where all LED's are lighted displaying red, green, blue, and white color (combination of RGB colors) one at a time. During this test, the inspector looks for dim lights, LED out, etc. This type of inspection is repetitive throughout the day, which causes inspectors to experience eyestrain, eye confusion, watery eyes, blurred, or double vision. Thus, the importance of helping inspectors to reduce visual problems during LED display inspection, increase their visual acuity, and improve their inspection process performance.

Customer

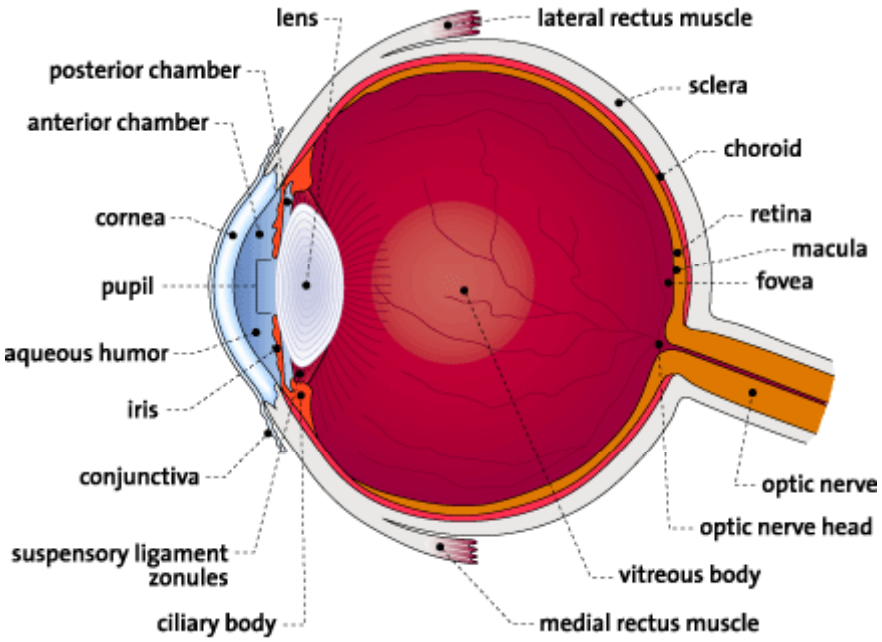
Our customer, WMS, is a major supplier of gaming products for casinos. When they receive our product, they perform incoming inspection. Currently, we are experiencing a very high rate of returns of the 1146's. During my investigation, I found that most of the rejects were due to blotchy displays. Blotchy display is mostly noticeable in the blue and white color. Our eyes can see the difference in intensity from one LED to another, thus the term "blotchy". Blotchy display is not considered a defect, as this is part of the LED characteristic caused by the difference of light intensity. However, our customer was not satisfied. Employees seemed to establish their own methods of achieving job requirements, such as creating their own standards to meet what they interpreted as the customer requirements. As one can imagine, the results weren't always what the customer wanted. This method also caused major rework when problems were caught in the plant. The company, at least, undertook "official" inspection of critical items, such as welds. Occasionally, there was a procedure for the workers to follow, though it was usually informal and relayed by word of mouth.[1] In this case, operators were doing LED inspection as trained by word of mouth as I could not find any documentation specifically for LED inspection.

Analysis

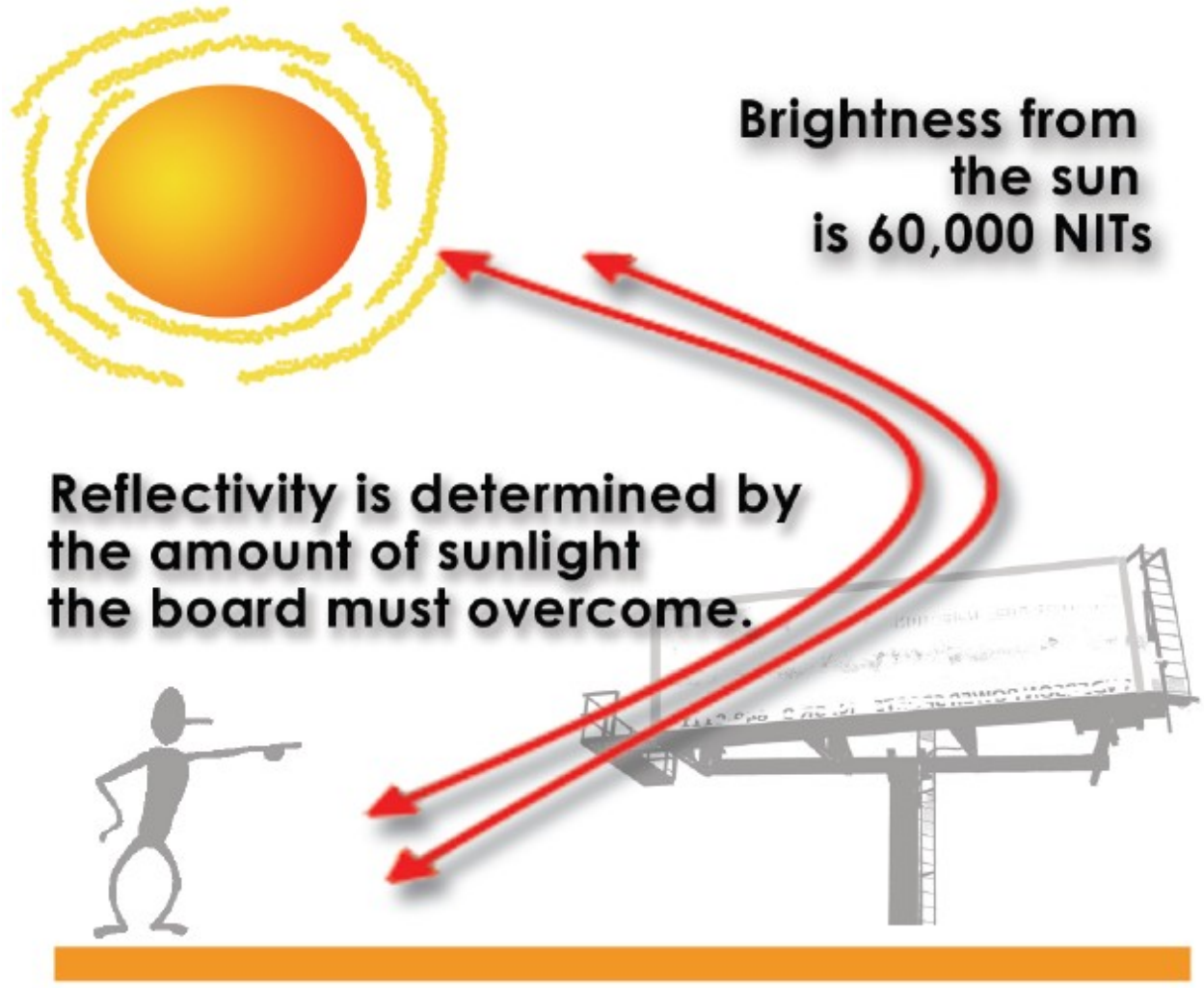
Inspectors Eyes

Inspector's eyes are vital for the LED display inspection. In order to understand how inspectors impact Adaptive Micro Systems LLC quality, we need to understand how human eyes work. The eye is like a camera. Light comes in through the cornea, a clear cover that is like the glass of a camera's aperture. The amount of light coming in is controlled by the pupil, an opening that opens and closes a little like a camera shutter.

The light focuses on the retina, a series of light-sensitive cells lining the back of the eye. The retina acts like camera film, reacting to the incoming light and sending a record of it via the optic nerve to the brain. Other parts of the eye support the main activity of sight: Some carry fluids (such as tears and blood) to lubricate or nourish the eye. Others are muscles that allow the eye to move. Some parts protect the eye from injury (such as the lids and the epithelium of the cornea). And some are messengers, sending sensory information to the brain (such as the pain-sensing nerves in the cornea and the optic nerve behind the retina).[2]



Next, is understanding how the LED display works in the real work since there are other factors that affect not only the LED display itself, but the human eye as well. A digital display's reflectivity is every bit as important to viewing as its brightness.
Consider that the sun's brightness (when viewed directly) is measured at approximately 60,000 NITs (a "NIT" is the amount of candela emitted in 1 square meter at the source of the light). If too much light were reflected, the reflected sunlight would completely overwhelm and wash out any LED display if brightness were the only factor involved. That's why all digital display manufacturers make an attempt to reduce reflectivity in order to improve viewing contrast.[3]



Last but not least, is to understand how human eye interact with the LED display. Currently, Adaptive Micro Systems LLC rely on operators eyes for visual inspection of the LED display. One of the weakest links in establishing a quality control system is the lack of information about the efficiency of the visual inspector. Every component in the processing system has a characteristic reliability and an inherent variation due to the many factors that affect a component's reliability. The human inspector is one of the components of the system. The human, like the other components, has less than perfect reliability and there are many factors that affect his reliability in a visual inspection situation.[4] Thus, keeping in mind that human inspector is not going to be 100% effective, we can surely improve the current inspection process by understanding what the inspector see and what he perceives when inspecting the LED displays.

Inspectors Training

After investigating how the inspectors were trained I found the following HFE issues that needed to be addressed.

1. Inspectors have no formal training on how to inspect LED displays
2. Inspectors trained by word of mouth
3. Inspectors did not have clear understanding of what is and/or what is not acceptable
4. No documented procedure for LED displays inspection either in production or QA department

Documents and Procedures

1. No documented procedure for LED display inspection available in production
2. No documented procedure in QA department
3. No pictures of what is acceptable and what is not

Work Area

1. Lightning area too bright for LED display inspection purpose. Lightning need to be measured with light meter.
2. Workbench and chair acceptable, however, no pre-defined setting for the LED display inspection

In order to get it started, I submitted an internal 8D CAR (Corrective Action Report).
Table 1
This 8D CAR report identify four items for root cause of HFE issues to LED display inspection:

1. No visual inspection procedure
2. Operators do not have pre-defined workbench to perform visual inspection (lightning, seating distance/angle)
3. Operators do not know what is acceptable or what is not.
4. Operators complain on visual confusion
5. Operators use of sunglasses

Table 1

8D Form

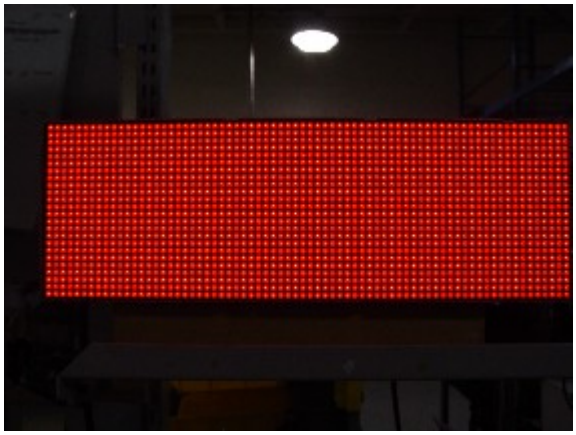
Project Title: 1146800301LF WMS Display Incoming Inspection				
Problem Statement: LED Display Visual Inspection				
D1 Establish Team & Goal	**D3 Contain Symptom**	**D4 Find/Verify Root Cause**	**D5 Choose/Verify Corrective Action**	**D6 Implement & Verify Corrective Action**
QA & Optical Team to determine why are we getting blotchy display as one of the highest RMA defects from our customer WMS	1. RMA to cycle units in burning chamber to ensure no defective pixel. 2. QA to do visual inspection and determine what is acceptable and what is not on case-to-case basis until a decision is made.	1. No visual inspection procedure 2. Operators do not have pre-defined workbench to perform visual inspection (lightning, seating, distance/angle) 3. Operators do not know what is acceptable or what is not 4. Operators complain of visual confusion.	1. Write visual inspection procedure 2. Acceptable workbench set up 3. Train operators on go/no go criteria	TBD
D2 Describe				
1. Blotchy displays per customer complaint				
2. WMS incoming inspection does not correlate with AMSI inspection				

HFE Countermeasure

Inspectors Re-Training

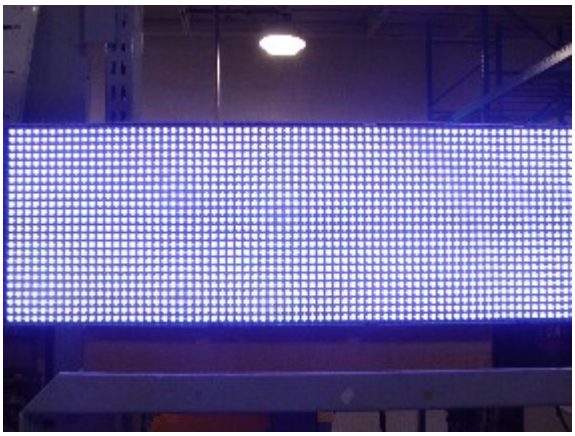
Our main asset for visual inspection is the operator. They do have to use their eyes to inspect for LED display quality. Therefore, we have to re-train them. “Whether they are integrated into the manufacturing operation and used as in-process inspection systems, or used as post-process inspection systems, vision systems aim to identify process problems quickly so that corrections can be made. The systems' primary advantage is their consistency in performing the inspection task.” (Alexander Kolchinsky, Vision Systems: Seen the Light). Thus, training operator for identifying non-conformance display quality is the key to perform the inspection task. Below are pictures of the 1146’s display in test mode. These pictures represent “acceptable” displays. After this, I developed document and procedure on workbench set up, what is acceptable and what is not.

Green LED



Red LED

Blue LED



White

Process and Procedures

The following is the workbench set-up to improve operator inspection performance:

(Click to view workbench set up & inspection movie)

1. Display is placed on the top shelf of the workbench. This is approximately 57" from the floor.
2. Operator sits down on the chair and inspect unit at 3' distance.
3. Operator eye sight is a 45° in reference to the LED display
4. Do not use workbench overhead fluorescent light. This will help maintain a 0.60-lux, which is acceptable for this type of inspection.

The following is inspection criteria for inspector to decide what is and what is not acceptable:

1. Some blue dim light is acceptable as long as they do not form a row or column
2. Some discoloration in white is acceptable as long as they do not form a column or row
3. Random dim light is acceptable

Example of blotchy display: Notice a horizontal line across the display.

Evaluation of HFE Countermeasures vs. Quality

After implementing the above-mentioned HFE countermeasures, I evaluated the new inspection process for effectiveness. Talking with the operators, they reported that their vision was not confused. They could "see" what was acceptable and what is not because this was already identified in the procedure. Actual pictures of acceptable display and non- acceptable display were also provided. Their inspection process became smoother. They no longer complained of eye confusion or eyestrain. Also, inspection pass rate increased from 89% to 98%, which is very good considering the difficulty of this type of inspection.

Conclusion

In conclusion, inspector re-training, update of documents and procedures, and updated set up of the inspection area has improved Adaptive Micro Systems LLC quality. The inspection process of the LED displays is more enjoyable for the inspector. Pictures of product acceptability has "eliminated the guesswork from quality issue".[5]
The bottom line for any company is that it should never forget that quality assurance activities are critical to its product's—and hence the company's—viability, now and in the future.[5] Hence not only we do have a happy customer with the end product,Figure 1 but also a happy employer.

Figure 1

Adaptive Micro Systems LLC 1146's Display

Adaptive Micro Systems LLC 1146's display in a customer end product for casino

References

1. www.qualityprogress.com
2. http://www.allaboutvision.com/resources/anatomy.htm
3. www.adaptivedisplays.com
4. An Analysis of Human Reliability Measures in Visual Inspection: Steven L. Johnson, Douglas J. Funke
5. Quality in the first person: Darrick Dean