

# Work Environment and Health Effects of Operators at Light-on-Test Process in TFT-LCD Plants

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**Abstract.** TFT-LCD (thin film transistor liquid crystal display) industries have been grown-up in Taiwan. Many workers are at light-on test workstations in TFT-LCD factories. At the light-on test station, the operator has been exposed to the lower ambient illumination (105.10 lx) for a long time (12hour/1day). There are few researches discussed about health effect of workers of TFT-LCD workers. The aim of this research is to measure the illumination of the light-on test station and to collect the work environmental data for exposure assessment. The work environment information of test workstations has been measured such as ambient illumination and illumination of the five types of test color of LCD (red, green, blue, white, gray), visual angle, and visual distance between worker and LCD test board. The results shows that: 1) the light-on test was a long-term operation of lower ambient illumination (4.00 lx to 105.1 lx) and shorter visual distance (28.04 cm to 34.43cm); 2) the means of illumination of LCD board of different test color are 10.90 lx in red, 41.20 lx in green, 18.00 lx in blue, 67.30lx in white, and 13.80 in gray. Light-on test is a task of low ambient illumination, short visual distance and long-term job in TFT-LCD factories. Some workers complained about visual fatigues. Under this working environment, the more working duration workers have the more visual discomfort they complain. Some administration controls have been suggested such as more time of rest, lubrication of eyes by appropriate solution and job rotation.

**Keywords:** work environment, Light-on-test, TFT-LCD, health effects.

## 1 Introduction

The TFT-LCD (thin film transistor-liquid crystal display) industry has been quickly rising in Taiwan. Moreover, the Taiwan's global market share of LCD panels has reached about 36% in 2003, which made Taiwan the second leading panel producer, next only to the South Korea<sup>1</sup>. The manufacturing of TFT-LCD includes array process (array), panel process (cell) and module assembly process (module). The manufacturers exercise stringent quality assurance and quality control measures, and

the careful inspection of panels plays a very important role in the whole manufacturing process to ensure a high yield rate of products and reduce the costs,. Panels with defects or imperfections can be picked up through strict inspections and then repaired or recycled. Methods of inspecting the panels include: optics instrumental examination, electric instrumental examination, and eyes check<sup>2-4</sup>. The eye check (light-on test) is to inspect panel's defects by human eyes. In general, it includes the gross inspection of the panel first, which is followed by inspection of the surface of panel, modules, and the panel's picture display quality by microscopy.

The light-on test is a key of quality control steps during the panel process and module assembly in the manufacturing of TFT-LCD. The test is performed by human eyes, and workers, mostly women, generally carry out the task in a dark environment, which may cause eye strain and even lead to poor eyesight, throughout the shift with limited resting time<sup>5-6</sup>. At the light-on test station, the operator has been exposed to the lower ambient illumination (105.10 lx) for long time (12hour/1day). There are few researches discussing about health effect of workers of TFT-LCD factories. The aim of this research is to measure the illumination of the light-on test station and to collect the work environmental data for exposure assessment.

Moreover, to make sure high quality and high yield, the TFT-LCD industry places most manufacturing processes in "clean rooms." In clean rooms, the dust particles in the air are controlled to extremely low levels, and the temperature and the humidity are maintained at relatively lower levels in comparison with the general ambient environment in Taiwan. In addition, to prevent the contamination of dusts, clean room workers have to put on special clothing covering the whole body from head to toes<sup>5</sup>. Many operators have complained about eye disorders such as dryness and soreness, but the ophthalmic effects of working in such strictly controlled environments are not clear. To evaluate whether the clean room workers performing light-on tests have a high risk of developing tear secretion dysfunction and eye symptoms, we conducted a study in a TFT-LCD company in Taiwan.

## 2 Methods

We recruited workers engaged in light-on tests in the company during their periodical health examination. In addition to a questionnaire survey of demographic characteristics and ophthalmic symptoms, we evaluated the tear secretion function using the Schirmer's lacrimal basal secretion test. The work environment information of test workstations has been measured such as ambient illumination and illumination of the five types of test color of LCD (red, green, blue, white, gray), visual angle, and visual distance between worker and LCD test board.

## 3 Results and Discussion

The white and gray are the original colors or background lights of LCD boards. Operators need to turn on the different colors of LCD to examine the errors or problems on the boards. Meanwhile, the ambient illuminations of the workstations are very low. Table 1 shows the ambient illumination levels of workstations. In LCD

area, the ambient illumination is the lowest (mean = 4.00Lux, SD=0.00Lux). In LCD area, the ambient illumination is very low (mean = 5.5Lux, SD=3.7Lux). The Table 2 shows the operators' visual angles and distance of workstations. The range of mean operators' visual angles is from 18.50 to 26.98 degrees. The range of mean operators' visual distance is from 28.04 to 35.53 cm. The different colors of Liquid Crystal illumine different illuminations levels. In table 3, the means of illuminations levels are 10.90lux in red, 41.20lux in green and 18.00lux in blue at LCD test stations, and 36.49lux in green, 53.35lux in green, and 36.22lux in blue at LCM workstations.

**Table 1.** Illumination of the workstations

Location of workstation (Number)	Local illumination (LUX)Mean (SD)	Ambient Illumination (LUX) Mean (SD)
LCD (43)	5.50(3.70)	4.00(0.00)
LCM –LOT (28)	639.80(70.02)	32.00(16.12)
LCM –PCBI (15)	106.00(11.66)	119(17.49)
LCM –C test (55)	93.63(33.45)	146.38(33.56)
Sub-summary (98)	161.44(84.28)	129.76(48.46)
Total (141)	130.86(76.29)	105.10(66.50)

**Table 2.** Operators' visual angles and distance of the workstations

Location of workstation (Number)	Operators' visual angles (degree) Mean (SD)	Operators' visual distance (Cm) Mean (SD)
LCD (43)	22.12(1.05)	34.51(1.52)
LCM –LOT (28)	18.50(4.32)	28.04(7.72)
LCM –PCBI (15)	26.93(8.79)	42.13(5.89)
LCM –C test (55)	24.75(5.41)	35.53(5.3.)
Sub-summary (98)	22.30(6.52)	34.40(7.71)
Total (141)	22.94(5.48)	34.43(6.47)

But, at workstations in LCM-PCBI area, the illuminations levels of colors from LCD boards have not been measured.

In table 4, the means of illuminations levels are 67.30lux in white and 13.80lux in gray at LCD test stations; and 36.49lux in green, 53.35lux in green, and the means of illuminations levels are 83.71lux in white and 41.32lux in gray at LCM workstations.

All the 319 qualified workers agreed to participate in this study, and they were all females working by 4-shift rotations. The average age was 24.15 years old (standard deviation [SD] =3.78), and the average employment duration was 13.63 months (SD = 5.65). Among the 11 ophthalmic symptoms evaluated, eye dryness was the most prevalent (prevalence = 43.3%). In addition, the prevalence of tear secretion dysfunction was 40.1% (128 cases), and contact lens users had a relative risk of 1.73 (95% confidence interval = 1.02—2.94) in comparison with non-contact lens users. Comparing the Schirmer's test results of those who also participated in the screening in the previous year, we found 40 of the 156 participants (17.2%) with normal test

results in the previous year turned abnormal in 2001. In contrast, only 21 of the 76 participants (9.1%) with abnormal test results in the previous year turned normal, and the difference was statistically significant ( $p = 0.02$  for McNemar's test).

**Table 3.** Lamination level of red, green & blue colors from LCD board

Location of workstation (Number)	Lamination level of red	Lamination level of green	Lamination level of blue
LCD (43)	10.90 (2.60)	41.20 (10.21)	18.00 (5.29)
LCM –LOT (28)	10.80 (3.56)	21.00 (6.71)	8.80 (4.09)
LCM–PCBI (15)	-----	-----	-----
LCM–C test (55)	40.50 (13.62)	58.41 (20.82)	40.50 (15.81)
Sub-summary (98)	36.49 (16.35)	53.35 (23.35)	36.22 (18.38)
Total (141)	31.04 (17.96)	50.77 (21.75)	34.34 (18.07)

**Table 4.** Lamination level of white & gray colors from LCD board

Location of workstation (Number)	Lamination level of white	Lamination level of gray
LCD (43)	67.30(22.27)	13.80(3.39)
LCM –LOT (28)	57.20(23.91)	16.20(7.60)
LCM –PCBI (15)	129.20(38.66)	-----
LCM –C test (55)	80.75(35.66)	45.25(16.16)
Sub-summary (98)	83.71(38.72)	41.32(18.24)
Total (141)	80.56(36.54)	35.47(19.81)

## 4 Conclusion

The results shows that: The light-on test was a long -duration operation with lower ambient illumination (4.00 lux to 105.1 lux) and shorter visual distance (28.04 cm to 34.43cm); 2) the means of illumination of LCD board of different test color are 10.90 lux in red, 41.20 lux in green, Eighteen lux in blue, 67.30lux in white, and Thirteen and eight tenths lux in gray. Light-on test is a task with low ambient illumination, short visual distance and long duration in TFT-LCD factories. Some of the workers complained about visual fatigues. Under this working environment, the more working duration it is, the more visual discomfort the workers complain about. Some administration controls have been suggested, such as more time of rest, lubricating eyes with appropriate solution and job rotation.

The prevalence of tear secretion dysfunction in woman workers engaged in light-on tests is high and increases with the duration of employment. The use of contact lens may further increase the risk.

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