Illumination Levels Evaluation in a Wiring System Company in Hermosillo, Sonora.

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Abstract

The purpose of this paper is to analyze the employees' illumination exposure levels of a wiring system manufacturing company located Norwest of Mexico, to evaluate and compare them with certain standards included in the current Mexican regulations.

Due to the double working shift of the company, measurements were taken at different hours, as demanded by section A.2.1 of the Illumination norm NOM 025-STPS-2008. The measurement points were selected according to the needs and characteristics of each workstation.

Research results concluded that some previously identified zones as conflict points have an inadequate illumination based on NOM 025-STPS-2008 standard, due to higher illumination levels, while other zones presented lower levels.

Having a deficient working environment illumination may have harmful effects in the employees' health such as blurred vision, headaches and/or general fatigue.

Key words: Illumination, industrial safety, lux

Resumen

El propósito del presente artículo es analizar los niveles de iluminación a los que encuentra expuesto el personal que laboran en una empresa manufacturera de arneses electrónicos del noroeste de México, con el fin de evaluar y comparar con ciertos estándares incluidos en las normativas vigentes.

En este análisis se realizó de acuerdo a los lineamientos presentados en el apartado A.2.1 de la NOM 025-STPS-2008 – Iluminación, y en cuanto a los puntos de medición, fueron seleccionados en función a las necesidades y características de cada centro de trabajo.

Los resultados generados en la investigación nos dan a conocer que en algunas de las zonas identificadas por recorridos previos, como puntos de conflicto, presentan una iluminación inadecuada, ya que sus niveles se encuentran con una iluminación superior a lo que la NOM 025-STPS-2008 considera es el estándar de la operación que en esa zona se realiza, mientras que otras se encuentran debajo del nivel que deberían presentar.

El contar con una iluminación deficiente, pone de manifiesto que el ambiente laboral que se presenta en las zonas de estudio, puede afectar la salud de los trabajadores con distintos efectos como trastornos visuales, cefalalgias y/o fatiga general.

Palabras clave: Iluminación, seguridad industrial, lux

1. INTRODUCTION

Rea, (1993) defines illumination as a radiant energy capable of exiting the retina and creating a visual sensation. Illumination is a crucial part in information gathering because more than 80% of the information received by people is through a visual sense. Sight has two basic mechanisms called accommodation and adaptation; while accommodation allows focusing sight at a specific point depending on the distance, interest and needs of the operator, adaptation makes possible to adjust sight sensibility to the existing level of illumination (Wolska 2003).

> "Occupants on those buildings with efficient lighting installations had positive perceptions of the lighting quality (Moore, Carter and Slater, 2003)."

The weak point of sight appears when it is necessary to observe very near small details with a low illumination level; in this circumstances mistakes increase, visual and mental fatigue may present, which is why determining the correct illumination levels for these tasks becomes fundamental. Illumination conformity should be at least 0.7 in a working area and 0.5 in the working environment (CIE 2001).

Illumination: is the relation of incident luminous in a surface by unit area, expressed in lux. One lux is the illumination produced by a lumen uniformly distributed over a square meter.

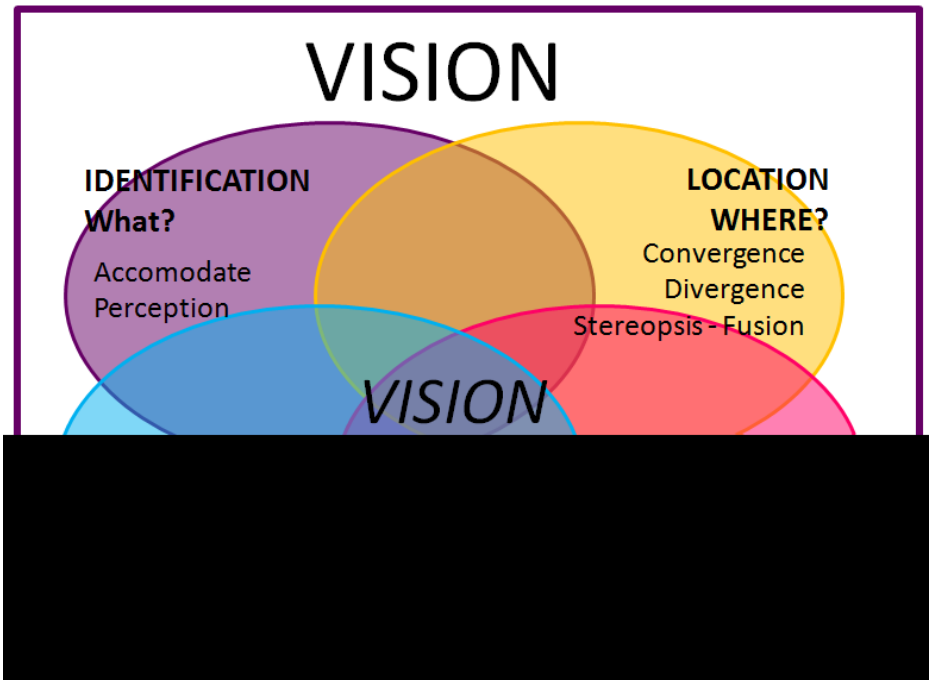


Figure 1

NOM-025-STPS-1999 establishes the illumination characteristics in the workplace, so that it will not represent a health risk for the workers while conducting their activities. Therefore it expresses a number of requirements that employers must meet in order to provide a comfortable working area.

1. Illumination Levels

Minimum illumination levels to be presented in a working area, for each type of visual task are established in table 1.

Also, the reflection factor of surfaces situated inside the normal visual field generally has the following values according to the official Mexican standards:

Table 1

Table 2

NIVELES MÁXIMOS PERMISIBLES DEL FACTOR DE REFLEXIÓN

CONCEPTO	NIVELES MÁXIMOS PERMISIBLES DE REFLEXIÓN K_f
TECHOS	90 %
PAREDES	60 %
PLANO DE TRABAJO	50 %
SUELOS	50 %

Luminance and brightness distribution in the visual field should be as homogeneous as possible, because the eye must adapt according to the illumination intensity and it may produce fatigue and damage in the visual perception if done very often.

Brightness uniformity is practically impossible to achieve. Therefore, considering three areas in the visual field (center of the working area, immediate surroundings and mediate surroundings) the differences between the brightness of the three areas should not be higher than the ratio 10:3:1 or vice versa 1:3:10..

When illumination is artificial, generally white light is recommended, or the most similar to day light (more precisly noon); thus, in addition of being the healthiest, the objets will be seen in thier true colors.

Interest in natural illumination has increased recently. This interest its not due to quality, but rather the wellness it provides. But as natural illumination levels are not uniform, an artificial illumination system is required. The most common illumination systems are the following:

1. *Uniform general illumination.* In this system, sources of light are uniformly distributed regardless job locations.
2. *General illumination and localized support illumination.* It is a system that tries to strengthen the general illumination scheme by placing lamps in working surfaces.

Wolska (2003) expresses that interior environment illumination has to satisfy the following needs:

- Contribute on creating a safe working environment.
- Helps realize visual aids
- Create a proper visual environment.

The creation of a safe working environment has to be top on the list of priorities and, in general, security is raised by making dangers clearly visible. The order of the other two priorities will greatly depend of the interior working environment. Task performance can be improved by making every detail easier to see, while creating appropriate visual environments varying illumination emphasis according to objects and existent surfaces inside the working environment.

1. METHODOLOGY: EVALUATING ILLUMINATION LEVELS – FOAM AREA

An illumination evaluation study of a wiring system company in Hernosillo, Sonora was performed. This study was conducted on October 12 and 22, 2010 and was authorized by the industrial safety engineer.

The principal activity of the company is to ensemble wiring systems. La principal actividad de la empresa es el ensamblado de arneses electrónicos. The company is interested in determining if its illumination is a risk factor for the health of the workers while performing their activities.

1. Illumination Areas Recognition

To identify working areas, the visual tasks associated to each work and identify working areas with a illumination deficiency or excess of illumination that may cause glare, a tour through the entire company was made and the worker reports were considered.

To determine the areas and the visual tasks of each job, the following information was gathered:

1. Work areas, illumination system (number and distribution of luminaries), machinery and equipment distributions;

2. Lamps characteristics;

3. Description of the illuminated area: color and types of surfaces.
   The interior of the company is painted white with blue details.

4. Description of the visual task and working areas;
   The area with the highest illumination is the quality inspection area, mostly where the accessories dimensions are checked. Each station counts with illumination above each working area.

   The conveyor area also counts with illumination on each working station but not as intense as the quality inspection area. The riveting area was another well illuminated.

   The opportunity areas detected where the Foam area and an area from segment 2 where different process take place, such as inspection, kitting, conveyor, meshing and electric testing.

5. Work job description that require localized illumination, and the authorization for taking pictures of the areas where localized illumination was required, areas like quality inspection and conveyor. This request was authorized by the Industrial Safety and Hygiene Coordinator.

6. The information about perception of illumination conditions from the workers to the employers. Employees from areas detected were surveyed. After making a preliminary survey to identify key points to consider as the Mexican Official Standard NOM-025-STPS-2008 establishes, it was decide to analyze the foam area and the meshing area.

1. Illumination Levels Evaluation – Foam Area

Before measurements were taken, it was reported that the fluorescent lamps had been turned on for more than 45 minutes to allow the light flow to stabilize. It was also reported that the ventilation systems were operating normally. Because natural light has a direct influence on the illumination levels in this areas, 3 measurements were taken in each point or determined zone distributed during the work shift (7:00 – 17:00 hrs):

1. The first measurements were taken at 8:00 am
2. The second measurements were at 12:00 pm

3. The third measurements were taken at 4:00 pm

According to the establishments on NOM-025-STPS-2008, the area index (1) for the foam area was obtained and the area was divided in equally size parts.

$$IC = \frac{(x)(y)}{h\,(x+y)} = \frac{(34)(8)}{4(34+8)} = 1.619 \quad (1)$$

IC = area index

x, y = area dimensions (length and width), in meters

h = height from the working surface to the luminaries, in meters.

A preliminary recon study was made to determine the principal points to study as established in the Official Mexican Norm NOM-025-STPS-2008, finding 10 sampling points and covering the minimum required by the norm with an area index 1 < IC < 2.

Eight zones where identified were the visual task was of moderate distinction (machinery work), with a minimum of 300 luxes specification required. Two zones were identified as circulation zones or hallways with a minimum of 100 luxes specification required

Measurements were taken in the area with the highest concentration of workers, which did not coincide with focal luminary points. At least one measurement was taken in each work surface placing the luxometer 30 cm. above it to avoid projecting shadows or reflecting additional light over the luxometer.

2.3 Equipment

For this study, a Testo 540, Testo AG, luxometer was used.

2.4 Reflection Factor Evaluation

The reflection factor measurements were taken for each working surface and walls in contact with the study area. To determine the reflection factor, the first measurement (E1) was made with the luxometer's photocell facing the surface, at a distance of 10 cm. until the luxometer displayed a constant reading;

The second measurement (E2), was made with the photocell facing the opposite direction and supported on the surface, to measure the incident light.

The reflection factor (2) of the surface can be determined by the following equation:

$$\boldsymbol{Kf = \frac{E_1}{E_2}\ 100} \qquad (2)$$

3. RESULTS

Table 3 presents the results of illumination levels and the reflection factor (kf) found in the same locations measured, there are also the minimum standard of illumination. The values of levels of illumination and reflection factor are an average of several readings taken at each point (three data each, three times in one turn.) It also shows the difference between the observed and dictated by the standard. As all the lighting is fluorescent product.

Table 3

Area	Visual task	Data number	Luxes	Minimum Standard	Deference	% of reflection
1	*MDD1*	3	442	300	142	13

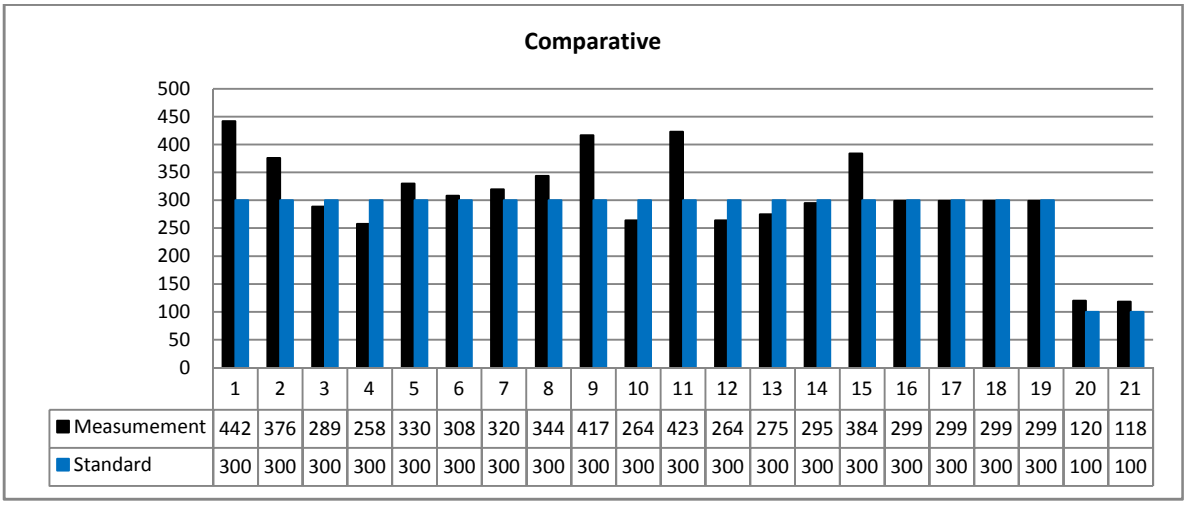
1 MDD: Moderate distinction details: Machine Work

2	*MDD*	3	376	300	76	7
3	*MDD*	3	289	300	-11	9
4	*MDD*	3	258	300	-42	11
5	*MDD*	3	330	300	30	9
6	*MDD*	3	308	300	8	8
7	*MDD*	3	320	300	20	11
8	*MDD*	3	344	300	44	8
9	*MDD*	3	417	300	117	46
10	*MDD*	3	264	300	-36	48
11	*MDD*	3	423	300	123	43
12	*MDD*	3	264	300	-36	18
13	*MDD*	3	275	300	-25	20
14	*MDD*	3	295	300	-5	16
15	*MDD*	3	384	300	84	7
16	*MDD*	3	299	300	-1	48
17	*MDD*	3	299	300	-1	46
18	*MDD*	3	299	300	-1	48
19	*MDD*	3	299	300	-1	45
20	*CAH2*	3	120	100	20	N/A
21	*MDD*	3	118	100	18	N/A

Below is a comparison between the levels set by the standard and those observed in the measurements:

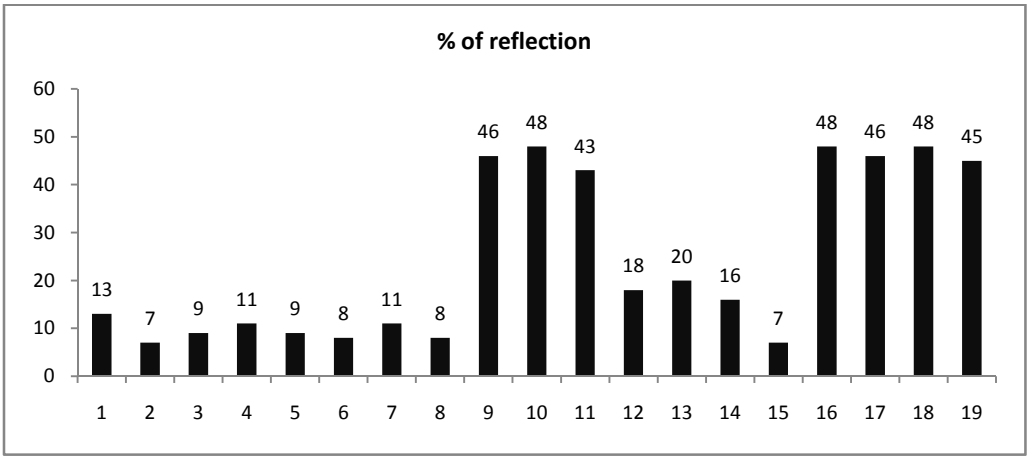
Figure 2

2 CAH: Circulation area and hallway



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Measumement	442	376	289	258	330	308	320	344	417	264	423	264	275	295	384	299	299	299	299	120	118
Standard	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	100	100

Figure 3



The second part of the lighting study was conducted in the area of meshing of a plant, carrying out the study in two of the assemblies, one on a conveyor with capacity for twelve boards and one for one with up to eight boards, two with their knitted, inspections and areas of stationary conveyor.

4. METHODOLOGY: ILLUMINATION LEVELS EVALUATION - GILL NET AREA

Before the measurements, we were informed that fluorescent lamps were more than

45 minutes of burning to allow the flow of light is stabilized. We were also informed that the ventilation systems were operating normally. Because it does influence the natural light in the installation, 3 measurements were made in each specific zone or point spread over the work shift (7:00 - 17:00 hrs)

1. The first readings were taken at 8:00 am
2. A reading taken at 12:00 pm
3. The third reading took place at 4:00 pm

According to the provisions of NOM-025-STPS-2008, we obtained the area index (3) for the area of netting and divided the work area in areas of the same size.

$$IC = \frac{(x)(y)}{h\,(x+y)} = \frac{(30)(10)}{4(30+10)} = 1.875 \quad (3)$$

IC = index of the area.

x, y = area dimensions (length and width) in meters.

h = height of the luminaire on the work surface, in meters.

In the plant we carried out a preliminary survey to identify key points to consider as the Mexican Official Standard NOM-025-STPS-2008, finding 10 points of sampling.
The number of areas to be evaluated in this study were those referred to in the preceding paragraph, so that covers the minimum required by the regulations that are 9, the area index 1 <CI <2.

We identified four areas where lighting is required for distinguishing moderate required details, average work machine, and six areas where it has a simple inspection, in both visual tasks, the minimum is 300 light lux.

Measurement was performed in the area with the highest concentration of workers, which did not coincide with the focal points of the fixtures. Had at least one measurement at each level of work placing the light meter to 30 cm of the plane to not cast shadows or reflect additional light on the light meter.

4.1 Equipment

For this study we used a light meter mark Testo 540, Testo AG, Germany.

4.2 Evaluation of the Reflection Factor

It makes measuring the reflection factor for each level of work and the walls were in contact with them. To determine the degree of reflection, it made a first measurement (E1), with the light meter photocell positioned facing the surface, at a distance of 10 cm, until the reading remains constant;

The second measurement (E2), is made with the photocell facing in the opposite direction and supported on the surface, to measure the incident light.

The reflection factor of the surface (4) is determined by the following equation:

$$\boldsymbol{Kf = \frac{E_1}{E_2}\ 100} \qquad (4)$$

5. RESULTS

According to the Norms of the Ministry of Labor minimum lighting values for different tasks within the factory are set out in Table 1. Table 4 presents the results of lighting levels and the reflection factor (kf) found in the same locations measured, there are also the minimum standard of illumination. The values of levels of illumination and reflection factor are an average of several readings taken at each point (three readings each, three times in one turn.) It also shows the difference between the observed and dictated by the standard. As all the lighting is fluorescent product.

Table 4

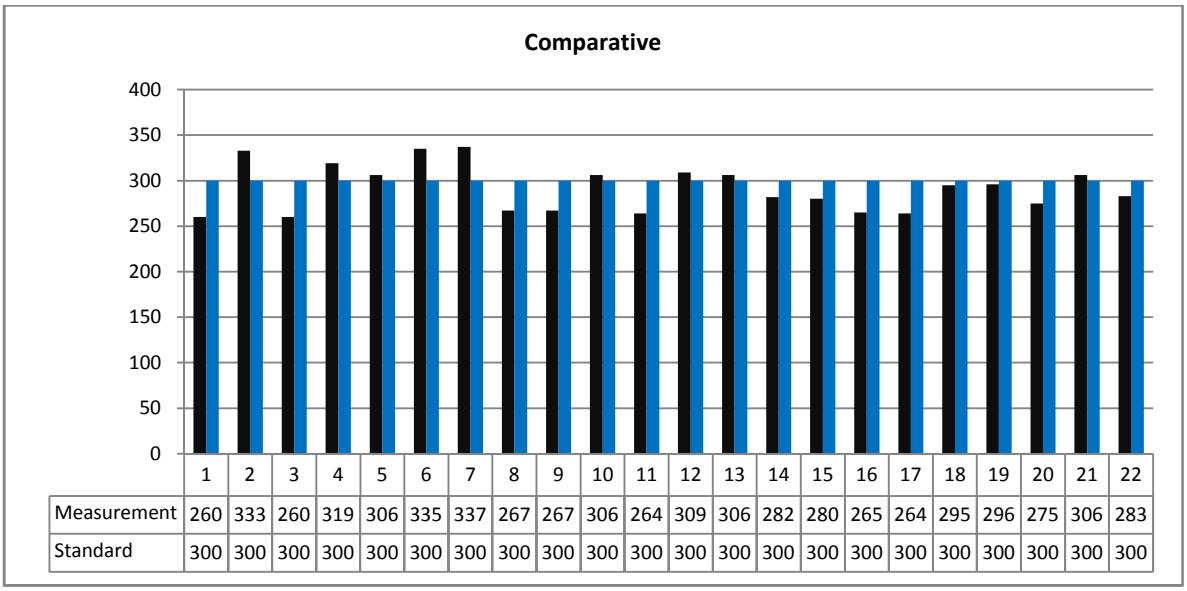
Area	Visual task	Data numb	Luxes	Minimum	Deferenc	% of reflectio

		er		Standard	e	n
1	*MDD*	3	260	300	-40	17
2	*MDD*	3	333	300	33	31
3	*MDD*	3	260	300	-40	33
3	*MDD*	3	319	300	19	20
3	*MDD*	3	306	300	6	13
3	*MDD*	3	335	300	35	23
4	*MDD*	3	337	300	37	32
4	*MDD*	3	267	300	-33	11
4	*MDD*	3	267	300	-33	24
4	*MDD*	3	306	300	6	22
5	*MDD, simple inspection.*	3	264	300	-36	22
5	*MDD, simple inspection..*	3	309	300	9	33
5	*MDD, simple inspection.*	3	306	300	6	23
5	*MDD, simple inspection.*	3	282	300	-18	30
6	*MDD, simple inspection.*	3	280	300	-20	14
6	*MDD, simple inspection.*	3	265	300	-35	15
6	*MDD, simple inspection.*	3	264	300	-36	18
6	*MDD, simple inspection.*	3	295	300	-5	34
7	*MDD, simple inspection.*	3	296	300	-4	18
8	*MDD, simple inspection.*	3	275	300	-25	22
9	*MDD, simple inspection.*	3	306	300	6	35

10	*MDD, simple inspection.*	3	283	300	-17	34

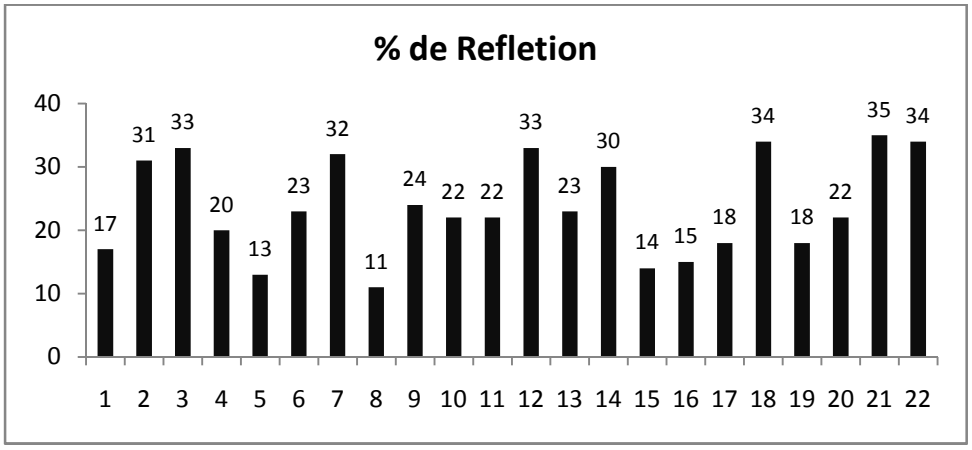
Below is a comparison between the levels set by the standard and those observed in the measurements:

Figure 4



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Measurement	260	333	260	319	306	335	337	267	267	306	264	309	306	282	280	265	264	295	296	275	306	283
Standard	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

Figure 5



6. CONCLUSIONS

Based on the results of the analysis to the company, shows the light levels in a number of workstations are inadequate. The levels measured in some specific areas do not meet the national standard recommendations, with the NOM-025-STPS-2008. This situation shows that the work environment can be characterized as extreme and dangerous working conditions. Poor lighting can affect the health of workers with different effects such as blurred vision, headaches and / or general fatigue. The appropriate level of lux for tasks that require moderate distinction details, simple assembly and simple inspection is 300 lux. It proposes the implementation of a plan to protect staff and adequate lighting levels for the work done on the basis of NOM-025-STPS-2008.

7. RECOMMENDATIONS

Obviously the lighting in some areas of work investigated lack of adequate lighting on the basis of NOM-025-STPS-2008. However, it is possible to implement a series of measures that help to correct the lighting level. Here are some recommendations that can be considered basic:

1. Maintain the luminaries;

1. Maintenance should consider the following aspects:
    1. Cleaning of luminaires;
    2. Ventilation of the luminaries;
    3. The replacement of the lights when they stop working, or after the expiration of the predetermined number of operating hours set by the manufacturer;
2. Modify the lighting system or its distribution.
3. Install additional lighting or localized.
4. For this last measure of control, where more light is required, consider the following:
5. Avoid direct glare or reflection on the worker;
6. Select appropriate visual background for the activities of workers;
7. Avoid blocking the light while performing the activity,
8. Avoid areas where there are sudden changes in lighting.
9. Each of these measures should be appropriately tailored to the specific situation of the organization.

8. GENERAL CONCLUSION

In conclusion refers to the importance of this research as a process of improvement which show areas of opportunity within the plant. Based on the results of the analysis in the enterprise, evidence of exposure to unsafe conditions inherent in this organization, identifying areas that are outside the maximum permissible limits specified in the regulations in Mexico. Such factors beyond control, may adversely influence the health of the operator, whether short or long term.

There levels measured in specific areas identified by the evaluation, the recommendations do not meet national standard. This situation shows that the work environment, from the standpoint of the research group can be characterized as extreme and unsafe working conditions. You must have a knowledge of the current situation where these factors are involved by the worker and the staff responsible for their safety as well as negative impacts on the health of workers, which can lead to long exposures with the participation of environmental factors mentioned above. This knowledge can develop measures to counter the impact that may arise in the health of operators in the future.

In the present investigation procedures to counter facing unsafe working conditions and these are based on current regulations issued by the Ministry of Labour and Social

Welfare (STPS), with the objective of maintaining a standard that allows workers to work in a safe environment and free to present health risks thereof. The company intends to follow up and make a management plan to keep running the mitigation measures proposed here.

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