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**Risk Assessment Case Study:
A Wiring Harness Assembly Line**

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Abstract

The competitiveness of companies is affected by the quality, the cost and the customer preferences for their products. To ensure this, risks affecting the production and employees being the most important production factor should be determined, classified and protected. The purpose is to avoid the adverse effects of work accidents and occupational diseases on employees, employers and companies. In the case of a disability or death, these effects can be psychological pressure, the psycho-social effect of losing personnel and loss of reputation and confidence. According to the International Labour Organization (ILO), the cost of work accidents and occupational diseases is 4% of the Gross Domestic Product (GDP) in less industrialized countries. In Turkey, according to the Turkish Statistical Institute data of 2015, GDP is 443,189 million Turkish Liras. Considering the ILO criteria for Turkey, the total cost of work accidents and occupational diseases is calculated to be 17 billion Turkish Liras (4% of GDP). It is necessary to minimize work accidents to reduce the cost in terms of the national economy. In this study, a health and safety risk assessment activity in a company that assembles automobile wiring harness systems was conducted. The purpose was to reduce losses, to increase employee performance and to ensure productivity by avoiding the possible risks. In the risk assessment, several high risks were identified. In order to achieve the purpose of avoiding these risks, a new assembly line design that can be adjusted according to height and reaching distance of each employee was introduced and presented.

Keywords: Assembly line design, Occupational health and safety, Risk assessment, Wiring harness assembly.

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Introduction

Nowadays companies prefer to detect possible problems through continuous improvement studies because these problems increase cost, reduce quality or negatively affect employee performance and thus production. Any improvement with a proactive approach that is made in these processes is important for the company. For the improvement studies to be made in the processes, the processes should be analyzed and examined in terms of both productivity and ergonomics. For this purpose; because the performance of employees affects the quality of product or service and production per unit time, losses resulting from the factors that create risks in terms of employees, workplace and environment should be evaluated. After these evaluations necessary measures can be taken and a safe work environment can be created.

In this study, a risk assessment activity was conducted in wiring the harness assembly line of a company that produces wiring harnesses for the automotive industry. Factors that could pose a risk on the line were identified and by evaluating the results of risk assessment some preventive measures were proposed to reduce and eliminate risks. Work accidents and occupational diseases were intended to be minimized by the implementation of these measures. Thus the aim was to eliminate the impact of labour losses on the production.

Occupational Health and Safety

The concept of occupational health and safety involves systematic studies conducted for the elimination of health problems and occupational hazards faced by employees because of some factors in the working environment. Occupational health and safety considers both human and machinery failures that can have an impact upon human life and therefore worker safety [1, 2, 3]. In accordance with the objectives of ergonomics, occupational health and safety can be considered to be the relationship between work and people and people and their work [4].

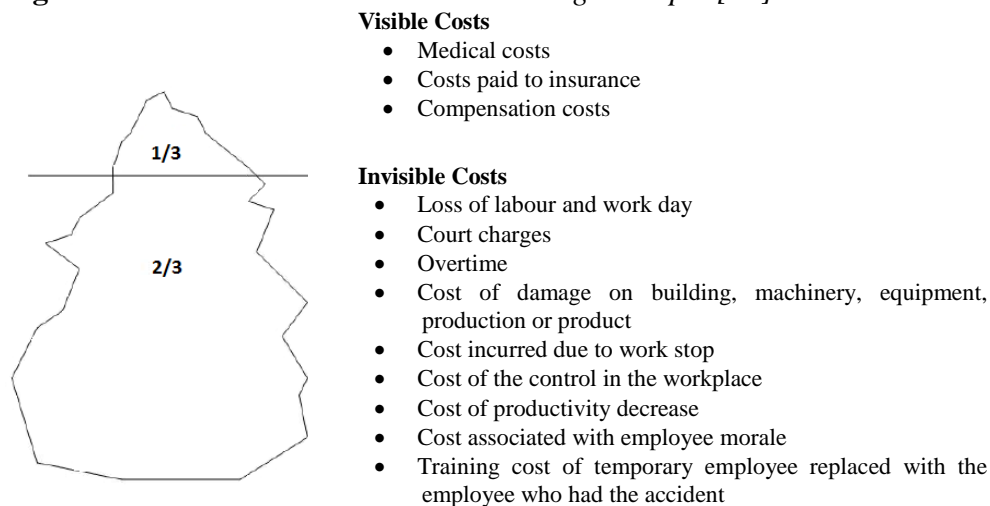
The WHO describes health as not only the absence of disease and disability but also complete physical, mental and social wellbeing [5].

While occupational health includes rules needed for a healthy environment, occupational safety mostly discusses the technical standards to eliminate danger to life and the physical integrity of employees [6].

By placing sufficient importance on occupational health and safety practices, labor and work time losses that occur as a result of occupational diseases and work accidents will be reduced. So operating profit and productivity can be increased by preventing the undesirable costs of these losses [7, 8]. Work accidents have a negative effect on the employee, employer and national economy, both materially and spiritually. From the employee's point of view; these effects include treatment costs of the employee and loss of wages for the period that the employee cannot work.

In addition, future wage losses if the accident or illness has prevented normal work in the occupation of the employee and prevented the possibilities of promotion, and psychological problems to be experienced by the employee and his/her family are in question [9]. For the employer; compensation paid to the injured employee or to the relatives of the employees who died after the accident, court costs for filed lawsuits, interruption of production in case of employee's inability to work etc. can be regarded as losses to be incurred [10]. Besides the visible costs such as medical, insurance and compensation costs etc. there are also the invisible costs such as labour and work day loss, overtime, cost of damage on building, machinery, equipment or product which will be incurred in case of occupational accidents (Figure 1). As in the iceberg example, the costs remaining at the water surface are known however the majority of the costs remain under the water.

Figure 1. Work Accident Costs – The Iceberg Example [11]

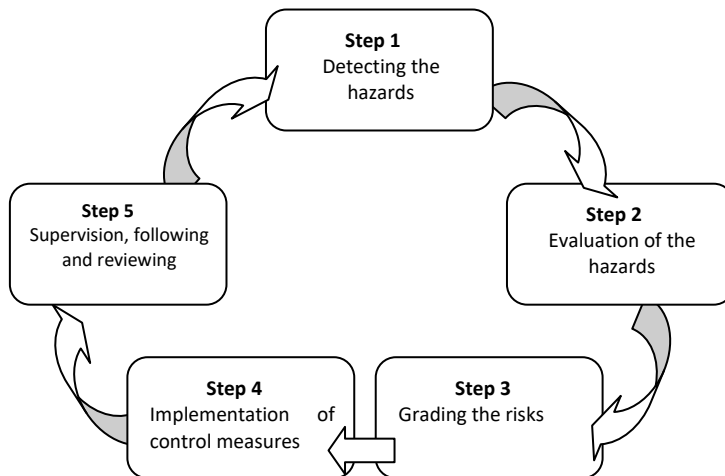


Occupational Health and Safety Risk Assessment

Risk assessment comprises the studies needed to identify workplace hazards that exist or may result from external factors, to analyze the factors that cause these hazards to turn into risks, to grade the risks and to decide on the control measures [12].

Generally the risk assessment process includes five steps. First of all the hazards and risks are identified, then they are analyzed. After the risks are evaluated, they are graded as high, medium and low risk. If there are any control measures, they are implemented. Finally the measures are supervised and reviewed periodically (Figure 2).

Figure 2. Risk Assessment Implementation Steps [13]



In a risk assessment study, the significance of risks that could be dangerous for employees and production should be determined and carefully reviewed. Not all risks may need to be managed and monitoring those of lesser significance may be more efficacious and cost effective. The occurrence frequency of risks is evaluated according to Table 1 and the severities are evaluated according to Table 2.

Table 1. The Occurrence Frequency of Risks

POSSIBILITY/FREQUENCY	CRITERION	SCORE
Very Small	Yearly	1
Small	Quarterly	2
Medium	Monthly	3
High	Weekly	4
Very High	Every Day	5

Table 2. The Severities of Risks

SEVERITY/EFFECT	CRITERION	SCORE
Very Light	No loss of work hours, requiring first aid	1
Light	No loss of work hours, requiring first aid	2
Middle	Slight injury, requiring treatment	3
Serious	Death, serious injury, occupational disease	4
Very Serious	Multiple death, permanent incapacity	5

Significance of risk is calculated using the equation “Significance of Risk = Frequency of Risk × Severity of Risk”. Risks are considered as high, medium and low risk according to their importance (Table 3).

Table 3. *Categories according to Significance of Risk*

SIGNIFICANCE	RISK	ACTION
25,20,16,15	High	Risks need to be studied on immediately
12,10,9,8	Medium	Risks need intervention as soon as possible
6,5,4,3,2,1	Low	Risks may not require immediate measure

By identifying the risks that should be given priority according to their significance, loss of time spent on low level risks will be prevented. Suggestions that provide elimination of significant risks or reduction of their impact are offered and these suggestions are audited. Assessments made periodically should be reviewed again and to ensure a truly healthy and safe working environment it should be followed whether the suggested measures are implemented or not [11].

When the working conditions and the environment become free of risks from the point of employees and production; the job satisfaction of employees will increase. The motivation arising with this satisfaction, will have a positive contribution on employee performance. This positive reflection will increase production rate and decrease errors and losses which may result from poor working conditions. By improving the working conditions, the risk of work accidents and occupational diseases will be minimized. Thus, loss of labor and its cost will decrease and a safe working environment will be formed [13, 14, 15, 16].

Thus the continuity of companies in the market and the sustainability of production will be ensured and the losses caused by work accidents and occupational diseases will be reduced.

Case Study

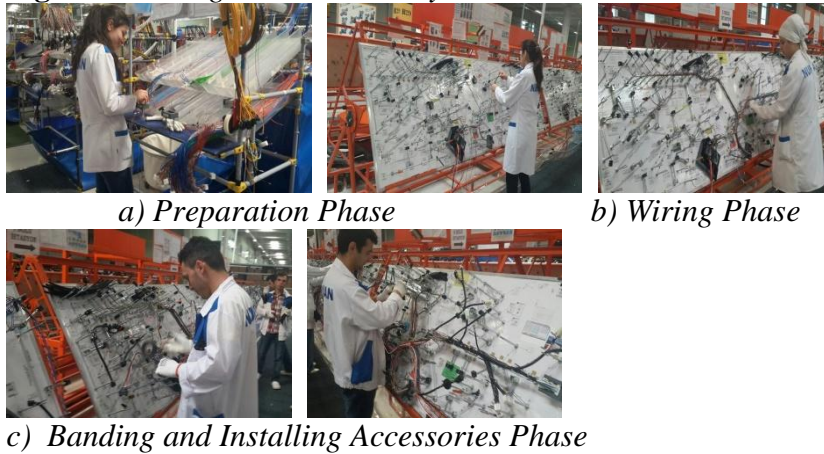
This study was conducted in Nursan Wiring Harness Inc. located in Tavşanlı Organized Industrial Zone. The company produces electrical equipment and battery cables for vehicles like passenger cars, commercial vehicles and trucks. It is built on a 60,000 m² land with 27,000 m² of indoor space.

The study was conducted on the wiring harness conveyor line in the company. The aim was to determine the situations that can cause work accidents and occupational diseases or pose a risk for employees and then to take measures to eliminate these situations. Thus a safe and comfortable working environment for employees will be created.

Operations performed on the conveyor line were examined in three phases: the preparation phase, wiring phase, banding and installing accessories phase (Figure 3a-c). In the preparation phase; modules are installed in accordance with the modular schemes prepared by the project department. Some of the cables to be used in equipment are attached to the sockets. In the wiring phase; the conveyor line begins with a wiring station. Cables prepared at a preparation phase are wired according to the method

statement on the conveyor table, equipment is banded and accessories are installed.

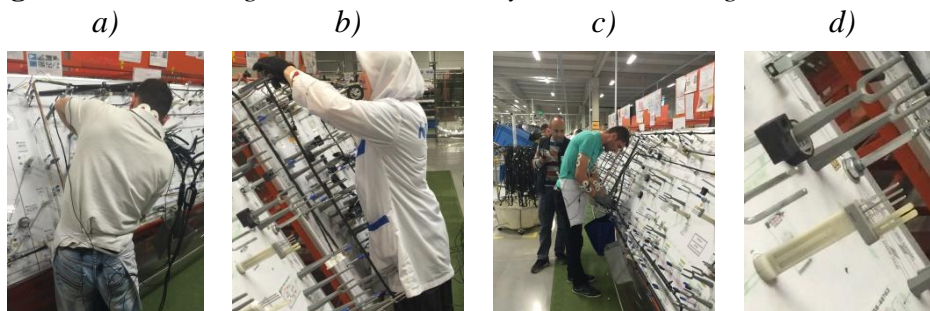
Figure 3. *Wiring Harness Conveyor Line*



Discussion

A total of six errors were encountered in the risk analysis made for the wiring harness conveyor line (Table 4). Four of these errors have a high level of risk and need to be investigated immediately. Two ergonomic situations were discovered; that the assembly panel is too high for the employees whose height is lower or the panel is too low for the employees whose height is higher and this puts them at a high level of risk. In these situations employees have to reach out or bend down while working (Figure 4.a-c) and such working postures may cause occupational diseases in the long term. Anthropometric measurements of employees were taken and these measurements were evaluated in compliance with the dimensions of the conveyor assembly panel. Women's heights varied between 161 cm and 165 cm, whilst men's heights varied between 163 cm and 181 cm on the conveyor line. The conveyor assembly panel height is 150 cm. Employees have to reach out, lean down or even rotate while working on the upper part or lower part of the panel. These actions are repeated all the time they are working and cause repetitive strains on employees.

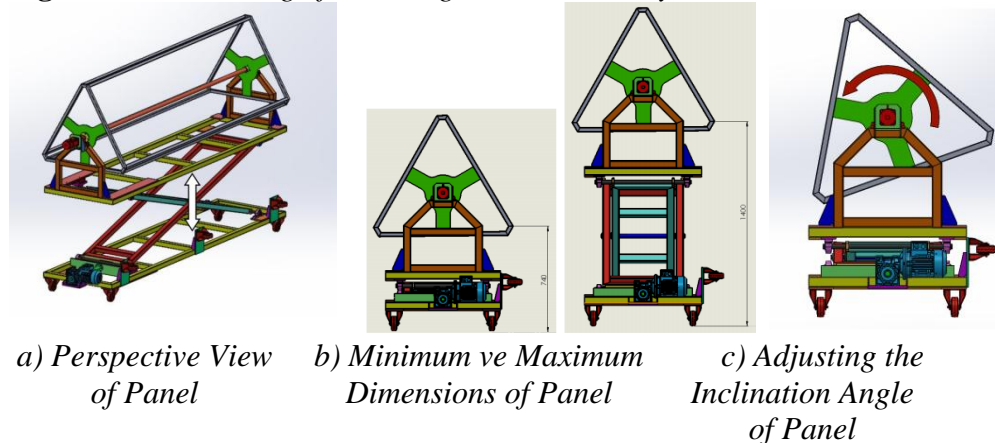
Figure 4a-c. *Working Postures on Conveyor Line* **d.** *Prongs on the Panel*



While bending down in case of carelessness, employees may hit the prongs on the panel. Because hitting the prongs may cause injury in the employee's head area, this situation has high level of risk (Figure 4.d). The probability of this risk occurring will be removed by adjusting the inclination angle of the panel.

A survey was made to determine which parts of body the employees complain about more, and to calculate the frequency, the severity and the relevance to work of these complaints. Questions were posed to determine working postures which could create the risk of an occupational disease. When the survey was considered medium level of risk was calculated on neck, shoulder, back, upper arm, waist, lower arm, wrists, legs and foot. Complaints on these parts of body appear to be caused by reaching out, bending down or rotating during the work. A new conveyor assembly panel that would reduce or eliminate these ergonomically unsuitable working postures was designed (Figure 5.a-c).

Figure 5. Panel Design for Wiring Harness Conveyor Line



An electric shock might occur because of open spaces in the assembly of the busbar system onto the conveyor line. This has a high level of risk and needs to be investigated immediately because of the possibility of a fatal work accident. Isolation was proposed for this risk. Thus, the occurrence probability of the risk will be reduced.

Pain and wounds are experienced in the fingers because the clips inserting process is repeated too much in working hours and this is a medium level of risk. The clips inserting process is repeated depending on the current running projects. It was aimed to prevent finger injuries with gloves given to employees.

The assembly panel could fall over the employee if the conveyor chain breaks. This is a medium level of risk and requires intervention as soon as possible. It was suggested to control the chains periodically with regular maintenance and to take mechanical measures by with the purpose of avoiding the panel falling over the employee. The frequency and the severity of this risk were reduced by implementing these suggestions.

Table 4. Risk Assessment

Source of Hazard	Cause of Hazard	Hazard	Possibility	Severity	Risk	Priority Status	Measures	Possibility	Severity	Risk	Priority Status
Assembly panel	Assembly panel is too high for the employees	Occupational disease risk because of assembly panel being high	4	4	16	HIGH	Adjustable height of assembly panel according to height of employees	1	1	1	LOW
Assembly panel	Assembly panel is too low for the employees	Occupational disease risk because of assembly panel being low	4	4	16	HIGH	Adjustable height of assembly panel according to height of employees	1	1	1	LOW
Assembly panel	Panel inclination angle is not adjustable to employees	Risk of hitting the prongs on panel while bending down	3	5	15	HIGH	Reducing the bending need with adjustable height and angle of assembly panel	1	5	5	LOW
Assembly panel	The clips inserting process is repeated too much	Pain and wound in the fingers	3	3	9	MEDIUM	Giving gloves to employees	2	2	4	LOW
Conveyor line	Conveyor chain breaks	Assembly panel falling over the employee	2	4	8	MEDIUM	Controlling the chains periodically with regular maintenance	1	4	4	LOW
Conveyor line	Open spaces in the assembly of the busbar system onto the conveyor line	Electric shock on the employee	2	10	20	HIGH	Isolation	1	10	10	MEDIUM

Conclusions

In this study, a risk assessment was made by evaluating the wiring harness conveyor line in terms of occupational health and safety. Situations that could pose a risk on the conveyor line were revealed and by classifying them according to their significance some preventive measures were suggested to reduce the risk levels. Possible work accidents and occupational diseases will be avoided by the application of these measures. Also the material and spiritual losses that will occur with the formation of risks and will affect the employee, employer and the country will be minimized.

The aim of this study was to prevent the situations which may contain risks for occupational health and safety, and thereby to provide a safe working environment for the employees. The sense of belonging of the employee who feels safe and valued will increase. And the importance that this employee gives to his/her work will increase, so the performance will be affected positively. Higher production rate and efficiency will be ensured by employees whose job satisfaction is higher. It is important to make the risk assessment studies in a planned and programmed manner for the sustainability of production.

The study continued with the design of new wiring harness conveyor line which was made considering the earlier risk analysis. With the new design, the assembly panel will move down or up according to the height of different employees and will incline according to height and reaching distance of the employees. Situations with high level of risks will be eliminated and a more comfortable working environment will be created for employees with the use of the redesigned panel.

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