The Risk of Occupational Safety and Health in Shipbuilding Industry in Turkey

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Abstract: - Shipbuilding industry is one of the oldest and the heaviest production industries all over the world. There are several production processes which result in hazardous waste and pollutants to the environmental safety and health. With over 40 shipyards, Tuzla Bay is one of the areas with highest density of industrial establishments in Istanbul. Ship building and ship repair industry is known as a heavy industrial zone. Production processes are variable and complicated. During this study, all processes are investigated in detail and all wastes and residues are described with effects to workers health and safety. In this paper, the actual data of accidents and illnesses from Turkish production industry, shipyard industry and a spotted shipyard are given in details to see the current status. Turkish shipyards should get environmental protection and workers safety and health issues together under ISO 9000, ISO 14000 and OHSAS 18000 all together.

Key-Words: - Shipyard worker, hazardous pollutant, occupational safety, occupational health, human exposure

1 Introduction

There is a major manpower requirement to process production in shipyard industry under hard working conditions with hazardous material. Most of the processes such as welding, painting, blasting, fiberglass production has direct effect on workers health, i.e. exposure to volatile organic compounds (VOCs), fumes resulting from burning through base metal and from burning the interior and exterior coatings, as well as a significant generation of NO_x gases during welding and cutting processes that are often left in place can cause acute and chronic health problems.

Production processes of shipyards may be discussed in two main categories: New shipbuilding and ship

repair industry. Production methods of these two divisions are similar. New ship construction and ship repairing involve the usage of several processes. Some of these processes surface preparation, painting and coating, solvent cleaning, degreasing, welding, machining and metalworking and fiberglass manufacturing. Ship repairing generally includes all ship conversions, overhauls, maintenance programs, major damage repairs, and minor equipment repairs. Raw material inputs to the shipbuilding and repair industry are primarily steel and other metals, paints and solvents, blasting abrasives, and lubrication and cutting oils. In addition, a variety of chemicals, such as solvent degreasers, acid and alkaline cleaners, and plating solutions containing heavy metal and cyanide ions, are used for surface preparation and finishing. Pollutants and wastes generated include volatile organic compounds (VOCs), chromium, hexavalent chromium, styrene, manganese, nickel, lead, tin, zinc, etc. as hazardous air pollutants (HAPs), particulate matters (PMs), waste solvents, oils and resins, metal bearing sludge and wastewater, waste paint, waste paint chips, and spent abrasives. [1]

In recent years some researchers have focused on health of shipyard workers related to working conditions. These researchers studied mostly on the effects of the process outcomes such as welding fumes and asbestos on human respiratory system in detail and their impact to worker mortality [2-9]. There are some additional studies on environmental effects such as noise, dust, VOCs, on shipyard workers health [10-14].

2 Basic Shipyard Processes

2.1 Surface Preparation Processes Wastes and Affects on Worker Health

Surface preparation is an important step in the shipbuilding industry. Common surface preparation methods adopted by the shipyards are dry abrasive blasting, wet abrasive blasting, hydroblasting, thermal stripping, chemical stripping and mechanical stripping. Material inputs used for preparing surfaces include, abrasive materials such as steel shot or grit, glass, garnet, copper, or coal slag; cleaning water, detergents, and chemical paint strippers (e.g., methylene chloride-based solutions, caustic solutions, and solvents). In the case of hydroblasting only water and occasionally rust inhibitors are required. Air emissions from surface preparation operations include particulate emissions of blasting abrasives and paint chips [15].

Potential exposure to dust and air contaminants is the primary health hazard associated with abrasive blasting. Abrasive blasting can generate large quantities of dust that can contain high levels of toxic air contaminants. Table 1 summarizes hazards of air contaminants associated with abrasive blasting in shipyards [1].

Table 1 Hazards of Air Contaminants Associated with Abrasive Blasting in Shipyards [16]

Contaminant	**Potential Health Hazards**
Aluminum	Respiratory irritation.
Arsenic(metal)	skin, lung and possibly lymphatic cancers and lead to peripheral neuropathy and vascular disease
Cadmium	degeneration of the renal tubules (kidney damage) manifested by increased protein in the urine; increased blood pressure contributing to hypertension; obstructive lung diseases like chronic bronchitis, pulmonary fibrosis and emphysema; and increase the risk of lung and prostate cancer.
Chromium (VI)	Lung cancer and asthma, damage nasal tissue and cause allergic dermatitis with skin contact.
Cobalt	Chronic lung inflammation and pulmonary fibrosis, increase the risk of lung cancer, and cause allergic contact dermatitis with skin contact.
Copper	Respiratory irritation.
Iron	siderosis (mildly fibrotic lung disease)
Lead	subclinical and clinical peripheral neuropathy [muscle weakness, pain, and paralysis of extremities], disruption of hemesynthesis and anemia, loss of kidney function, increased blood pressure, nephropathy, reduced sperm count and male sterility, and increase the risk of cancer.
Manganese	Subclinical/clinical manganism, a 'Parkinson's -like' movement disorder manifested by reduced reaction time, loss of steadiness, walking difficulties, and emotional instability.
Nickel	Lung and nasal cancers, asthma and allergic dermatitis with skin contact.
Crystalline Silica	Chronic lung disease, silicosis, and increase the risk of lung cancer.
Tin(organic)	Headaches and subclinical neurological disturbances.
Titanium	Lung inflammation and pulmonary fibrosis.
Zinc and Copper	Metal fume fever (acute 'pneumonia-like' symptoms).

2.2 Painting Processes Wastes and Affects on Worker Health

Painting is a major process in shipyards which provides corrosion protection and/or improves appearance of the substrate, and is generally distributed throughout the yard. Painting activity can be divided into two major categories, painting and equipment cleaning, both of which result in emissions of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) [1].

Painting wastes are believed to be the largest category of hazardous wastes produced in a shipyard. In a typical shipyard it may account for more than half of the hazardous wastes produced. This may include leftover paint, overspray, paint that is no longer usable, rags, and other materials contaminated with paint. In many cases the amount of paint can be reduced through the use of improved equipment, alternative coatings, and good operating practices. Equipment cleaning also generates hazardous waste in the form of solvents, thinners, and acids. Painting activity involves significant air emissions. Volatile organic compounds and hazardous pollutants result from painting operations that are of concern [15].

The nature of shipbuilding and repair requires several types of paints to be used for a variety of applications. Paint types range from water-based coatings to high-performance epoxy coatings. Antifouling paints are used to prevent the growth of marine organisms. Copper-based and tributyltin (TBT)-based paints are widely used as antifouling paints, though TBT may only be used on vessels longer than 25 m and with regulatory authority approval. Most of these toxic agents are heavy metals or organometallic compounds, such as cuprous oxide, lead oxide, and tributyl tin compounds [17].

Employees exposed to methylene chloride are at increased risk of developing cancer, adverse effects on the heart, central nervous system and liver, and skin or eye irritation. Exposure may occur through inhalation, by absorption through the skin, or through contact with the skin. [18].

Organic solvents are useful to dissolve and disperse lubicants, oils, waxes, paints, varnishes, rubber and so on, and are widely used in many industrial processes. Most of them are also recognized as extremely hazardous chemicals and some of them might cause Alzheimer's disease, leukoencephalopathy, multiple sclerosis, neurobehavioral disorders etc. Solvent vapors comprised of VOCs and HAPs are significant pollutant outputs of cleaning and degreasing operations. Both halogenated and nonhalogenated solvents are used, and mixtures of different solvents are common. Typical cleaning and degreasing solvents include mineral spirits, aromatic hydrocarbons (e.g., xylenes, toluene, etc.), aliphatic hydrocarbons, ketones, esters, alcohols, glycol ethers, phenols, turpentine, and various halogenated solvents (e.g., trichloroethylene, 1,1,1-trichloroethane, perchloroethylene, etc.) [1].

2.3 Welding Processes Wastes and Affects on Worker Health

Various types of welding processes are used to join the different types of metals used in the construction of ships. Fusion welding, in particular, is performed at almost all locations in the shipyard. An important factor in welding processes is shielding. In most welding processes, this shielding is accomplished by addition of a flux, a gas, or a combination of the two. The waste generally depends on the methods and magnitude of welding employed. The waste generated by welding of thin metals by any method is the used diluted acids. The wastewater is sent for on-site/off-site treatment and other wastes such as slag are disposed as solid wastes. Welding rod stubs, wire stubs contaminated with flux and welding wire spools are the solid wastes that come from these activities. Welding fumes and particulate emissions are the potential air emissions from these operations [15].

Welding is a common and a highly skilled occupational specialty. Welding processes involve inhalation exposures, which may lead to acute or chronic respiratory disease. The primary source of inhaled particulate material in most welding processes is a consumable electrode of filler metal, which is partially vaporized. Metal fume is formed when vaporized metal condenses in air as metal oxide particles. These particles are particularly hazardous component of welding fumes because they are small enough to deposit in the terminal bronchioles and alveoli, distal to mucociliary cleaning mechanisms. Welding has been associated with many respiratory problems, which vary from acute or chronic respiratory symptoms, such as malaise, cough, dyspnea, chronic bronchitis, interstitial lung disease, pneumonitis, asthma, pneumoconiosis, and lung cancer [19].

Hexavalent chromium has been designated as a priority pollutant due to its ability to cause genetic mutations and cancer. Various studies have reported a greater incidence of lung cancer in chromate workers than in other industrial workers. However, it may take around 15-20 years for the lung cancer to develop, so the disease may not immediately appear after exposure [1].

3 Current Situations of Tuzla Shipyards

Within the integration process with the European Union, workers health and safety problems should be the area for solution production. Current researches show three workers are injured each second all over the world, lose their life each three minutes due to work accidents or occupational disease. Even only these numbers reflect

the importance of the global workers health and safety issues. International Labor Organization (ILO) reports loss of 1.2 million workers annually due to work accidents and occupational disease. There are 250 million people affected from work accidents and 160 million people affected from hazards of occupational diseases [20].

The capacity usage of Turkish shipyards was around 15% between 1982 and 2000 but with the world's high demand from 2002, capacity usage and the quantities increased to their top level. From 2003, world shipbuilding industry has achieved an increase of 89% while the Turkish shipbuilding industry has achieved a 360% enlargement. Fig. 1 shows number of shipyards in Tuzla area.

There is a huge increase on employment of shipyard industry in last 5 years. There is an expected amount of 111.000 employees in this industry in 2013.

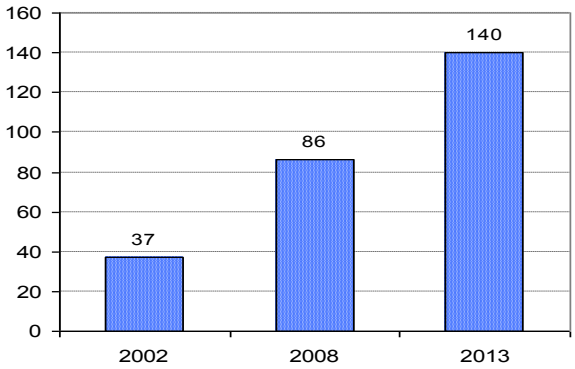

Figure 1 number of shipyards in Tuzla area

There are still 100.000 current employments in subcontracting companies. Fig. 2 shows employment in Tuzla shipyards (2002-2008 May).

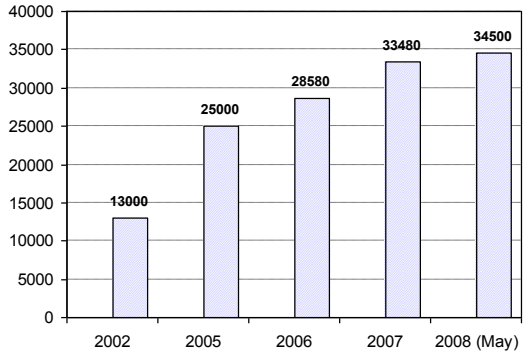

Figure 2 employments in Tuzla Area (2002-2008)

There are 979.122 m^2 open and 300.592 m^2 covered area with a total amount of 1.279.714 m^2 for 46 shipyards in Tuzla shipyards area in Istanbul. But when compared to South Korea who is the third biggest shipyard industry all over the world, the smallest area for a shipyard is 500.000 m^2. Due to insufficient and narrow working areas, increasing amount of workers without organizing the working areas, the organization of work areas with preventive methods for workers health and safety are becoming difficult and risky working conditions. Table 2 shows breakdown of the accidents with loss of life [20].

Table 2 Breakdown of the Accidents with Loss of Life

Year	Loss of life
2000	4
2001	1
2002	5
2003	3
2004	6
2005	7
2006	10
2007	12
2008	14
TOTAL	**62**

3.1 The Risk of Occupational Safety in Shipbuilding Industry in Turkey

Surface preparation operations present a significant risk for skin, eye, and respiratory exposure to toxic and corrosive chemicals, as well as risk of burns, cuts, and lacerations. Abrasive blasting produces noise levels that can cause permanent hearing loss in unprotected employees and others close to the blasting process. Injuries can be very serious and include loss of sight and body parts (e.g., fingers and hands). Abrasive blasting operators are exposed to hand-arm vibration from the force of the abrasive moving through the blast hose. If exposure to vibration continues, skin necrosis and gangrene can occur. Chemical paint strippers and removers used for surface preparation include corrosive acids, (e.g., hydrochloric and phosphoric), alkalis (e.g., sodium hydroxide/lye), chlorinated hydrocarbons (e.g., trichloroethane) and carcinogens (e.g., methylene chloride). These chemicals may present severe eye, skin and respiratory exposure hazards. Toxic vapors or corrosive mists produced by chemical paint and preservative removers may present significant health hazards including oxygen-deficient atmospheres. When used in confined or enclosed spaces these agents produce vapors that are often heavier than air. This can cause displacement of air, reducing oxygen levels, which may be fatal. Toxic and corrosive paint strippers and removers can harm employees' eyes and/or skin [18].

Fall hazards are a leading cause of shipyard fatalities [21]. Shipyard employees are often required to work in dangerous environments that may include fall hazards. Accidents involving elevation equipment such as ladders and scaffolds are often serious, even fatal. Environmental hazards include temperature, humidity, and air movement within the work area. Heat related illnesses includes heat stress, heat stroke heat cramps

dehydration. Cold related illnesses includes hypothermia and frost bite the potential for electrical shock hazards is greater in shipbuilding and repair than in other industries, since workers have to stand on metal decks and often work in a wet environment.

Surface coating applications may release large quantities of these materials into the air, causing possible fire and explosion hazards as well as toxic inhalation and skin absorption hazards. Fire and explosion hazards associated with paint and coating applications depend upon the flashpoint and volatility of the substance. Lower flashpoint liquids (less than 80º F) present greater hazards and require additional controls. Toxic vapors and mists from paints and paint solvents may present significant health hazards due to inhalation during painting operations. Employees working with paint or paint solvents containing toxic or corrosive materials are at risk if skin or eye contact occurs [18].

Analyze of the work load in shipyard shows 80% of the workers are subcontracted from third party companies. High amount of subcontractor limits the possibility of necessary organization and precautions for the workers health and safety issues and threats the continuation of the current actions. Working in open areas under cold and hot weather, rain, wind and similar bad weather conditions can cause dangerous working conditions (physical reasons) for accidents and loss of work motivation resulting with hazardous behaviors (personal reasons). When taken into consideration, 34% of these accidents are due to fall down from high working zones, preventive actions for these work conditions have not been effective, working platforms and areas are not designed with necessary preventive methods protective equipments together with the missing obligatory usage of safety belt for high work zones.

Shipyard educational plans should be created and followed. Shipyard visitors should be informed and trained about the risks and work health and safety data. All shipyards should have trained work safety personnel to prevent and intervene work accident and fire cases. There is not enough data for recording minor accidents and injuries in Turkey. In most of the shipyards in Turkey, there is not enough work safety understanding and a management system for improvement of the current knowledge [20]. Fig.3 The work accident distribution according to 2006 statistical data of Turkish Social Security Department demonstrate the biggest share as “Metal Industry” which includes the shipyard industry

Table 3Risk of Occupational Safety in Shipbuilding Industry in Turkey [21]

Transportation, lifting, warehousing	Fall or crash due to not completing the periodical maintenance of transport equipments.
Grinding	Eye damage due to metal burr from grinding, high volume effect on worker, sparks from grinding can cause fire, grinding stone explosion risk.
Blasting	Not wearing necessary protection for blasting, to breathe the dust and gas from blasting
Bending	Bending material can damage the worker, disimportance of worker during bending process, manual material movement risks.
Assembly	To hold material on crane during assembly and risk of crane malfunction, not to use correct material for scaffold during assembly, fall down from high assembly areas, to have welding fume in segregated areas.

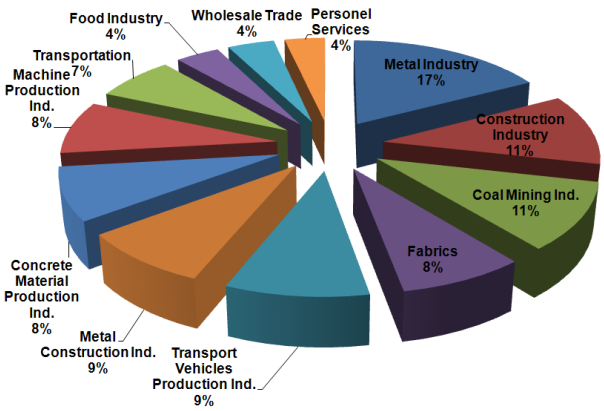

Figure 3- Work accident distribution according to 2006 statistical data of Turkish Social Security Department

As can be seen in Fig.4 the distribution of accidental injuries on Body between 1982-2000 in Turkish Shipyard Industry shows the biggest shares of accidents are related to hand injuries with 41%.

Fig.5 shows the distribution of the accident’s statistical data for the “Shipyard A” in 2006 in Tuzla Bay area, Turkey. The leading cause for the accidents is “Fell off” as shown. Also “Fell Off” and “Traumas” are seen constantly on each month’s statistics. These are the results of high level working conditions and using cutting and drilling tools.

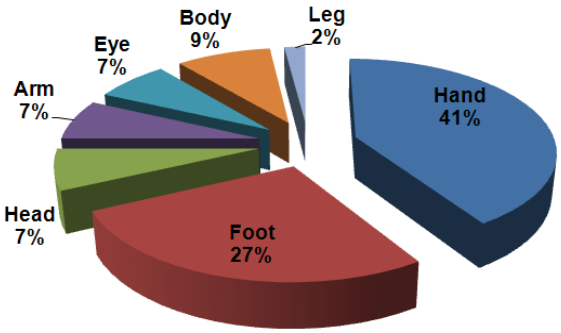

Figure 4- The distribution of accidental injuries on body between 1982-2000 years in Turkish Shipyard Industry

As shown from Fig.6 April 2006 accident distribution data for "Shipyard A". The biggest share is 29% from fell off accidents

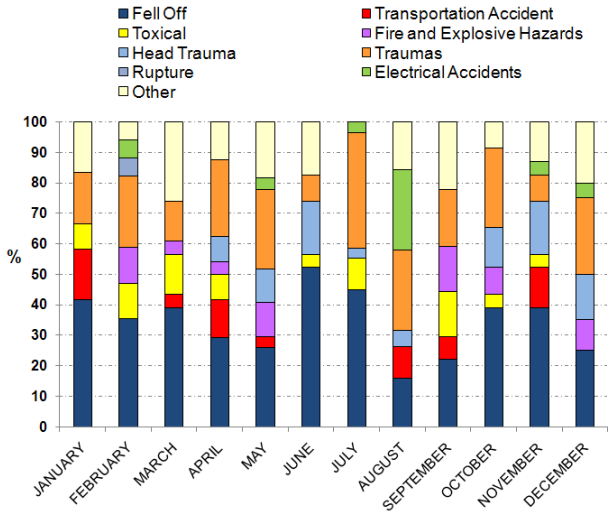

Figure 5- Accident statistical of the "Shipyard A" in 2006 in Tuzla Bay

Fig.7 shows the distribution of the accident's statistical data for the "Shipyard A" in 2009 in Tuzla Bay area, Turkey. As shown from Fig.8 April 2009 accident distribution data for "Shipyard A".

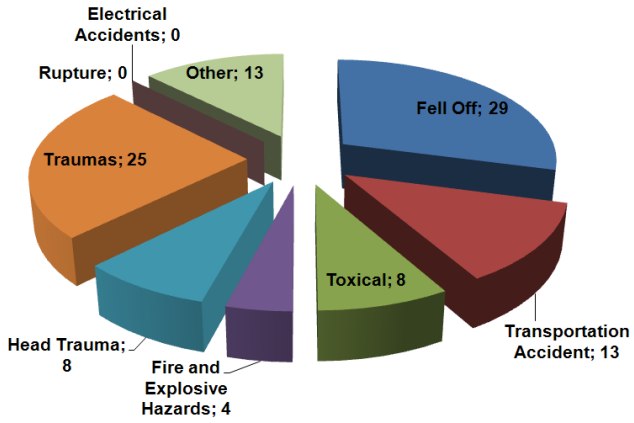

Figure 6-April 2006 accident distribution data for "shipyard A".

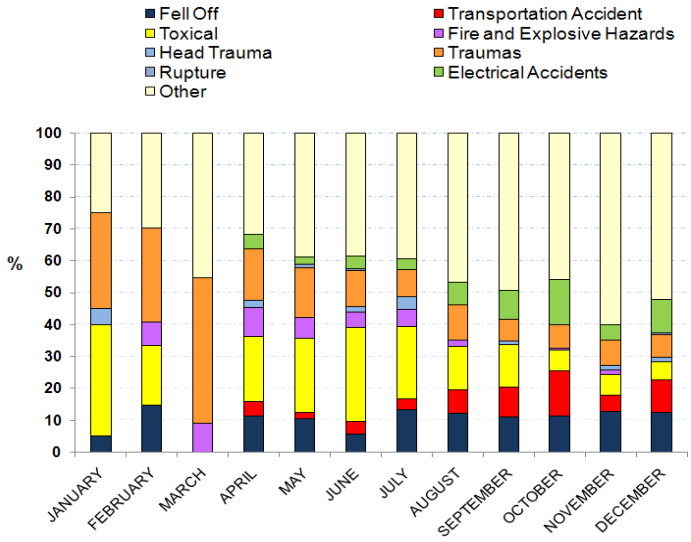

Figure 7 Accident statistical of the "Shipyard A" in 2009 in Tuzla Bay

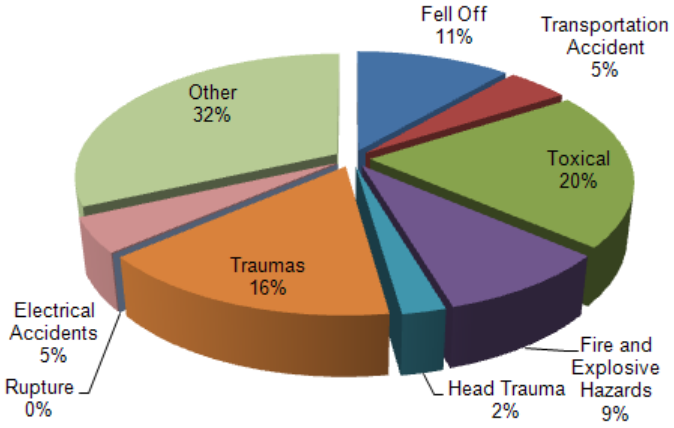

Figure 8-April 2009 accident distribution data for "Shipyard A".

In this study, statistical data during 2006-2009 for shipyard "A" are compared. Investigations done in 2007 show several rearrangements had been placed due to occupational accidents in 2006. In 2006, "fell off" had the highest rate among accident causes. Shipyard A modified scaffoldings to a standard and safer condition as a precaution. Furthermore, Personal Protective Equipments (PPE), safety belt and helmet, for high elevations workers are brought as obligation. As a result, decrease in the rate of accidents related to fell off is observed from data investigated for year 2009. Moreover, due to the precautions taken, trauma rate which was very high during 2006 and up until the beginning of 2009 is reduced significantly. Due to precautions taken for fire safety, decrease in rate of accidents investigated under fire and explosive hazards is observed. Comparison of April 2006 and April 2009, showed traumas and fell off rates decreased, but toxical rate increased with respect to 2006. In year 2009, action for wearing appropriate PPEs and ventilating the painting, blasting and welding spaces are started. As a conclusion, it is observed for the

shipyard A that the rate of accidents ending up with death with respect to year 2006 has been decreased, improvement efforts since 2006 have been accomplished substantially and gradually targets have been reached.

4 Conclusion

The improvement of the production processes in Turkish shipyards is mandatory to have the work health and culture in the industry. The employers are informed about these improvements but willing to spread these to a wide time period. Industrial employers, shipyard workers and engineers have to be on the same side for work health and safety issues and hand sample applications for improvement [21-22].

Ship building and ship repair industry is known as a heavy industrial zone. Production processes are variable and complicated. During this study, all processes are investigated in detail and all wastes and residues are described with effects to workers health. After these studies, workers can be called as they have risk of health and safety. This can be avoided by using necessary protection equipment and organizing legal controls to from the source of the risk.

Protective equipments have to be defined with national and international standards. Current cases in EU and USA have to be investigated and common standards have to be created. Employers and the employees have to be well trained about work health and safety. Workers have to be periodically checked by health departments.

All people (workers, temporary workers, subcontractors, customers and visitors) affected from a service of a company, including safety and health factors are described in OHSAS 18000. This Project consists of the analysis of the risks in the area and processes and to avoid the risk and dangers before occurring. This system is named as Work Health and Safety Management System. The aims of the system are;

- To protect the workers from the effects of the risks listed in processes and to motivate the workers.
- To minimize the work accidents and industrial illnesses not to cause manpower loose in the industry
- To protect the company from risk of fire, explosion, and machinery break downs with protective controls.
- To cover the national and international requirements of the laws and standards.

Turkish shipyards should get environmental protection and workers safety and health issues together under ISO 9000, ISO 14000 and OHSAS 18001 all together.

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