ISSN 0554-6397
UDK 504.05:504.42:629.54:629.129(495)
PREGLEDNI RAD (*Review*)
Primljeno (*Received*): 02/2004.

Dr. **D. Papaioannou** (PhD), Assistant Professor
Department of Economic and Regional Development
Panteion University, Athens Greece
13-15 Dioharous str., Athens 16121

Environmental implications, related to the shipbuilding and ship repairing activity in Greece

Abstract

It is widely accepted that excessive urbanization, concluded into intense industrial activities near residential districts, with unpleasant effects to the citizens health. Furthermore, shipbuilding and ship repairing consists one of the polluting industrial activities in the country – and more precisely concerning the widely capital region – in spite of the recession that has come to the last years, it remains as a source of pollution and environmental implications, in general.
A brief analysis of the environmental implications, accruing the shipbuilding and ship repairing activity, along with the presentation and analysis of the production phases and the procedures related to the above, can be identified as the main target of the present research. While at the same time, ways and methods of pollution containment that reflect the Greek practices and reality, are being proposed as a conclusion.

Key words: shipbuilding, marine environment protection, shiprepairing zone of Perama

1. Shipbuilding and ship repairing units in Greece

The shipyards of Skaramanga and Eleusinas, in the wider capital region, along with the shipyard of Neorio in Syros and the one of Aulidas in Halkida are concerned to be the bigger and most organized in the country[1].

Moreover, across the Piraeus until the Perama coast, the shipbuilding and ship repairing zone of Piraeus – Drapetsona – Keratsini – Perama is placed, where dozens of small careening wharfs and bigger units with mostly ship repairing activities, are placed.

[1] Vlachos G.P. (2002), Shipbuilding Economics and Strategy, J&J Hellas, Piraeus 2002, pp 64-75

In spite of the deep recession that the activities of the pre-mentioned businesses are going through the recent years, in time to time they have exceeded fifty percent of the total ship repairing work in the country, due to the fact of the great repairing and building experience and know-how that the above workshops hold, operating in the particular region[2].

In addition to the pre-mentioned, it must be pointed out that until 1985, approximately 15.000 permanent employees were operating in the shipyards of the pre-said region and 20.000 to 30.000 employees in collateral small industries in Piraeus. Nowadays, no more than 4.500 to 5.000 employees are being involved in the entirety of shipbuilding and ship repairing activities.

2. Presentation of the shipbuilding and ship repairing activities

The shipbuilding and ship repairing hold several common procedures. Additionally, both of them apply similar practices, procedures, and facilities and rely on the same support installations[3]. Furthermore, shipbuilding as much as ship repairing, demand high level specialized operations, due to the fact that most of the particular procedures – mainly in the ship repairing – present low automation capability. Each of the above activities, require excellent planning, mechanic and inter-stage communication. Moreover, shipbuilding is a more demanding procedure. In general, prerequisites much higher organizational standards due to high numbers of workforce, workload, high range of parts and high communication complexity – e.g. designs and production plans – that surround the workflow of the shipbuilding process.

2.1 Categorization of shipbuilding and ship repairing facilities

The shipbuilding and ship repairing facilities usually consist of elongated arrangements, are being placed in that way, in order to facilitate the smooth parts and material-flow through stages. While keeping in mind that most of the shipyards were built in the previous decades, changes in their formation were being established gradually, corresponding to the various technological evolutions, demand for new and different vessel types and the availability of land and docks. Considering the above, it can be said that a standard shipyard formation cannot be identified. On the other hand, there are a number of common facilities in most of large shipyards and naval establishments. The pre-mentioned facilities include:

---

[2] Vlachos G. P. (1996), 'Study on the Specific Policies of the Greek Shipbuilding and Shiprepairing Industry', Industrial Chamber of Piraeus, Greece

[3] Vlachos G. P., Tzannatos E., (1996), 'Shiprepairs in the Eastern Mediterranean and the case of Greece', The Cyprus Journal of Science and Technology, Vol.1, pp. 32-47, Cyprus

1. Floating and/dry docks
2. Shipbuilding piers
3. Docks and anchorages
4. Workshops/Laboratories

Floating docks are floating vessels that hold the ability to submerse in order to lift the ships out of the water surface. These are usually being used for ship repairing, but in many times also for shipbuilding operations.

Dry docks are rectangular constructed bays connected with the sea and allow the ship to come in and out of it. When the ships enter the dry dock area float, as there is still water inside it. Then, watertight doors close in the back of the dry dock and allow most of the water to being taken out to the sea, with the use of adequate water pumping systems. Usually, dry docks have an inclined base so that the remaining water can be driven through appropriate canals, which are connected with a network of smaller water pumps, in order for the last remaining quantity of water being taken out.

2.2 Shipbuilding and ship repairing procedures

Most of the shipbuilding constructions are being made, using area orientation methods, as it happens in the Hull Block Construction Method (HBCM). Through HBCMethod, the ship's frame is been visualized in a number of divided sections. The determination of the hull holds a great importance in the ship's construction the efficiency. Consequently, the pre-mentioned sections are being carefully designed, in order to minimize the workload and any possible planning drawbacks, being avoided. Continuously, the above sections are been constructed and fit to each other, into five main construction phases.

The first phase concerns the acquisition and the handling of the raw materials as long as the construction of the basic parts, from them.

The second phase involves the joining of the basic parts into assembling segments.

The third phase has to do with the fitting of the assembling segments into a preconstruction kit, which is being permanent assembled during the fourth phase, in order for the main sections to be created. These sections involve three dimension main parts of the ship and concern the largest parts to be assembled away of the shipbuilding site.

The fifth phase incorporates the actual building of the ship, by fitting together the various pre-determined sections.

The ending of the shipbuilding occurs when the equipment of the ship (outfitting), takes place.

On the other hand, ship repairing incorporates surveys, conversions, repairing of extensive damages and the fixing of secondary ship equipment. Even if specialized ship repairing methods differ from each other, many of the functions are similar to

those of shipbuilding. Of course, the ship repairing functions are of lesser degree and are being fulfilled in lesser time rates.

The typical maintenance and repairing activities, include:

Sandblast as long as painting of keel, hull superstructures, holds and the decks of the ships.

Extensive rebuilding/reconstruction and the fitting of machinery like diesel engines, turbines, generators, pumps e.t.c.

Surveys, maintenance and systems installation.

Replacement and new systems installation, like navigation, combat, communication and upgrade pilots' network.

Repairs concerning the propeller and rudder, changes and alignments into the default settings.

Creation of additional space, with cuttings of the existing steel structure and adding of new partitions, in order for the new engines to be installed.

3. Naval yard pollution and its consequences to the sea environment

The existence of the two larger naval yards in the gulf of Salamina as long as the neighboring to the wider shipbuilding industry, add to the already heavy polluted environment in the gulf of Eleusina.

Especially, the gulf of Eleusina is heavy polluted and eutrophicated. Moreover, during the summer months, the stratification of the water does occur and the content of oxygen below 15 meters is zeroing, which creates extreme conditions for the existence of underwater sea life. A typical example of the above concerns the area of Eutaxia (depth 33 meters) where during the summer period, in the bottom of the sea large amounts of ammonia are being released (due to luck of oxygen). The eutrophication is being developed, mostly it the areas of Aspropyrgo and Nea Peramo. The problem continues to exist in the bottom of the sea, where the improvement is more difficult. The bottom sediment contains large contents of organic carbon, phosphate, nitrogen, heavy metals and oils. The fact that higher concentrations of heavy metals are being found in the front of the two larger naval yards (Eleusinas and Skaramanga), the presence of chromium in Saint George's stream mouth (due to up stream) tanneries and the oily compound remnants, in the front of two oil refineries are characteristic examples. In general, along the coasts greater contents of metals in the floating particles as long as the diluted metals and metals in the sediments do developed. Additionally, the existed naval yards in the area of Thriasion Plain, constitute a great source of pollution due to oil remnants.

Moreover, the luck of organized statistical recordings, as long as annually renewed measurements, adds to the luck of data, concerning the kind, the amount and the production source of wastes. In the following table 1, limited data that Greek Ministry of Environment holds are being presented.

3.1 Polluting Activities, involved in Shipbuilding and Ship Repairing Facilities

Main activities polluting the environment[4], are the followings:

Table 1: Waste Amounts and Processes of Naval Yards[5]

Waste	Processes	Solid and material waste amounts (tons)		
		1998	1999	2000
Oil wastes from the ballast and slops processing	Occasional wastes from special designed spaces from company's area. Storage for passing vessels to oil refineries	1 000	1 000	2 163
Wastes from metallic surfaces cleaning and used sand-blast material	Recycling or adding to the cement industry	16 500	13 781	6 231
TOTAL		17 500	14 781	8 394

Source: Greek Ministry of Environment, Solid Waste Department

3.1.1 Cleaning and de-greasing

The cleaning of metallic parts and de-greasing using dissolvent, consists a very common activity in the shipbuilding and ship repairing industry. Typical processes here are cold cleaning or steam de-greasing. The cold cleaning is an operation, during which the solvent is being used under room temperature and the actual surfaces are being sunk in the solvent tank[6]. During steam de-greasing, the actual surfaces are being cleaned by hot steam and solvents.

3.1.2 Preparation for Painting

A strong correlation does exist, between a successful coating of the metallic surface and the high quality of its preparation. The surface preparation process, involves the removing of rust, metal oxides, old coatings and greases. Moreover, depending on the state of the surface, various processes are being used, as:

---

[4] Joseph Angelo, Scott Newsham (US Coast Guard, ISO/TC8/SC2, Marine Environment Discussion, 2002

[5] Hellenic Ministry for the Environment, Physical Planning and Public Works (Solid Waste Department)

[6] Vlachos G.P, & Emm. Nikolaidis (2002) *"Policy and Measures for the Confrontation of Social Cost Stemming from the Operation of Shipbuilding Companies",* First Scientific Conference on Oceanographical Aspects for a Sustainable Mediterranean, 27-29/09/2002, Piraeus, Greece

- Cleaning by dissolvent, detergents and steam
- Sandblast
- Treatment by stand tools
- Sandblast and Water-blast or shot - blasting
- Chemical cleaning

3.1.3 Paints of Metallic Parts

The maintenance of the ships structural integrity as much as their parts proper operation is the main target of the colour-coating or tar-coating. Painting and coating processes take place in almost every site of the shipyard. The different types of paints and coatings are applied from water solvent materials, to high endurance chemical compounds. The particular type of materials used in a surface treatment depends on the specific environmental type that it is to be exposed.

The paint consists on three main components: the colour, the binding solvent and the actual solvent. Colours include materials as zinc oxide, carbon, carbon-tar, lead, aluminum and zinc dust. The solvents are added in order to dilute the paints so that to be able to cover completely the surface before they get dry. Typical examples of solvents are the acetone, xylole, toluene and other organics, whereas in some cases water is the appropriate solvent.

Protective paints are used in order to prevent the development of sea organisms in the hull of the ships. Materials based on copper and tri-butyl-tin are commonly used, due to the fact that they release small amounts of toxic substances that prevent the development of sea organisms on the ship's keel. Anti erosive paints are based on vinyl, enamel or much modern chemical coating compounds. The first are used in unprocessed steel foils or surfaces as the "primers" i.e. as adherents between the surfaces treated.

The two in use painting methods are airtight spraying and thermal spraying, both of them using the compressed air. Furthermore, the thermal spraying involves zinc or aluminum coating on the coated steel for long-term anti erosion[7].

3.1.4 Vessel Construction with the use of Fiberglass

Many small and medium sized shipyards construct or repair fiber glass boats and ships or produce fiberglass parts for steel ships. The process involves the combination of polymerized resins with endurance additives for fiberglass. The resins are being polymerized with the help of appropriate solvent or by the use of hardening agent. After the resin is hardened, it has more endurance than synthetic plastic without strengthening but it cannot be softened again and reshaped. Knitting fiber of glass type constitutes

[7] United Nations Environment Programme: Intergovernmental Negotiating Committee for an International Legally Binding Instrument For Implementing International Action On Certain Persistent Organic Pollutants, Bonn, 20-25 March 2000

the actual fiberglass matter. The composition percentage of the endurance matter in the fiberglass varies from 25 percent to 60 percent.

The standard types in use for the resins are polyester, oxide and phenol. The appropriate type of resin to be used in a particular procedure depends of the final product special features. The resin is being delivered in liquid form and might also contain a solvent. Its preparation involves the mixing with solvent, catalysts, colour and other additives. The dissolvent usually is acetones and methanol. The catalysts usually are amines, anidrites and concentrates of aldehydes. Gelatin is a painted polyester resin or a polyester paint with resin as its main substitute, and holds a 35 percent in styrene, which applies in the cast and on the surface with the use of air spraying or airtight spraying. Then, the dissolvent is being mixture with the resin, in a different phase and being mangled by hand, in order for the polyester resin to be temperature stabilized.

3.1.5 Scrapping

After the completion of ship's life cycle, scrapping yards undertake the partitioning of metallic surfaces and the final de-building of the metallic frame. Due to the fact that nowhere in the world are established fully organized scrapping yards residues of the process as metallic parts and organic matter can easily access the soil and sea environment.

3.1.6 Operational Emissions

Operational emissions involve discharging of various materials – organics or not – that enter the sea environment surrounding the shipbuilding and repairing facilities. Operational emissions are usually due to the lack of sufficient waste collecting systems. The operational waste includes a variety of cases due to different production methods and environmental impact for constitute the heaviest pollution category, of the ship building and repairing activity.

3.2 Pollution of the Sea Environment

Steel and other metals, paints, solvents as much as means of grinding and sandblast residues, are strongly related to the raw materials used by the shipbuilding and repairing industry[8]. A large variety of chemicals for the preparation and finishing of the surfaces are in use, such as the de-greasing solvents, acid and alkaline cleaning agents, metal covering solutions. Furthermore, vapor organic compositions, particles,

[8] IMO, Marine Environment Protection Committee, 44th session, 6-13/3/2000, discussion paper on marine environment protection

lubricants solutions and resins waste, metal containing sludge, paint color or polishing residues are considered to be the usual pollutants[9].

3.2.1 Surface Preparation

The incoming material consists on: polishing parts (steel specks, small spheres of lead, pyrite minerals, carbon and copper rust), cleaning solvents, paint removal dissolvent and caustic cleaning solutions.

The air borne compounds involve: particles (i.e metals, paint, polishings, etc), volatile organics (VOCs) from the cleaning solvents and paint removers.

The liquid wastes are: paint remnants, cleaning and paint removal solvents, hold and hull tank lubricant remnants.

The solid wastes are: paint remnants (mixed with metals cleaning solvents and three-butilic tin), used polishing agents, surface dirt and hold remnants.

3.2.2 Surface plating and finishing

The incoming material concern: metal, salts cyanate solutions, cleaning water, acid and caustic solutions and rust impediments.

The air borne compounds involve: metal clouds and smokes, and volatile organic compounds (VOCs) from the dissolvents.

The liquid waste are: cleaning water, containing metal salts, cyanates, acids, alkalis, organic and solvents contaminants.

The solid wastes are: liquid waste treatment sediments used up metal salts and cyanates and cleaning tanks remnants.

3.2.3 Painting

The incoming material consists on: paints, dissolvents and water with various ad dives.

The air borne compounds involve: volatile organics (VOCs) stemming from paint solvents and equipment cleaning (hyper injection).

The liquid wastes are: equipment-cleaning water, spraying champers and drying tanks cleaning water, paint and dissolvents contaminated water.

The solid wastes are: paint and solvents remnants, filters and used equipment parts.

---

[9] Bhaskar Kura, PhD & Raghuram Tadimalla (2003), "Pollution Prevention Technologies for Shipyards", International Conference on Shipyards Pollution Proceedings, November 2003, University of New Orleans

3.2.4 Fiberglass, Constructions

The incoming material consists on: fiberglass, resins, solvents, hardening catalysts, wooden and plastic strengthening materials.

Air born emissions: volatile organics (VOCs) escaping during the construction and hardening process (e.g. styrene) as much as during the cleaning process with the use of solvents (e.g. acetone and methyl-chloride).

Liquid waste: mineral or no production of liquid waste.

Solid waste: gelatin waste, resins with solvents and used parts.

3.2.5 Mechanical and metallic procedures

Incoming material: lubricants, dissolvents.

Air borne emissions: volatile organics (VOCs) coming from the use of cleaning and de-greasing solvents.

Liquid waste: liquid waste containing solvents, lubricants and cutter's cooling liquids.

Solid waste: cutter's lubricants and metal residues.

3.2.6 Chemical Substances emissions

According to the international bibliography (American Toxic Release Inventory), 39 chemical substances are being emitted and released by shipyard plants. By them, the main part us volatile organics (VOCs) and metal waste. Furthermore, 37 percent of naval-yards' chemical emissions concern the air, water and ground. From these, 98 percent is being released in the environment. VOCs' concern the 86 percent of toxic emissions. The remaining percent, involves metal containing solid waste[10].

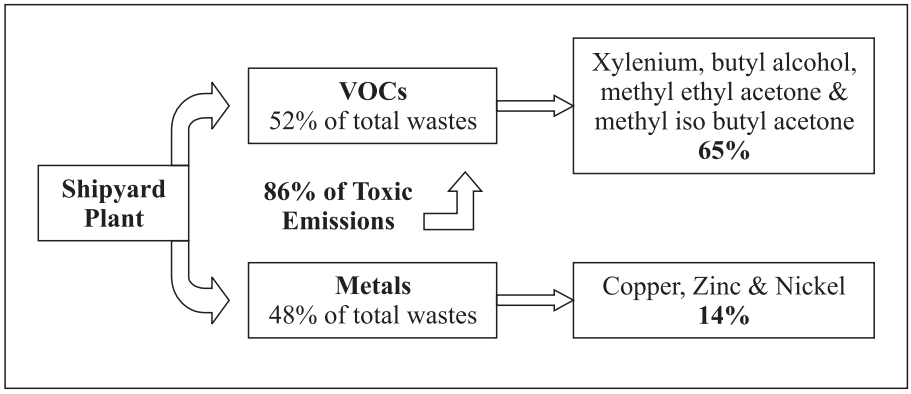
Additionally, xylenium, butyl alcohol, methyl ethyl acetone, and methyl isobutyl acetone consist 65 percent of the emissions. The pre-mentioned organic compounds can usually be found in paint dilution and metallic part and equipment cleaning as much as de-greasing solvents that are widely in use concerning the particular industry. Moreover, styrene consist 4 percent of the emissions produced. Finally, copper, zinc and nickel holding waste, constitute 14 percent of the total.

The above pollutants are emitted during metal plating processes as escaping pollution substitutes as much as escaping polluted sand, during sandblast procedures (Table 2).

---

[10] Water Environment Federation, 1991, *Design of Municipal Wastewater Treatment Plants, Volume 1*, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, Water Environment Federation, Alexandria, Virginia.

Table 2: Shipyard Pollution Substances Breakdown



Source: Data compiled by the Author

4. Concluding comments and proposals for further research

Shipyards generate large quantities of wastes, management of which assume prime importance owing to the extent of pollution. Pollution prevention is the best sought out method for reducing pollution. Many options are available for reducing the extent of pollution from shipyard processes most of them being source reduction methods. Reuse/ recycling options have also been evaluated for reduction of emissions from processes such as painting, blasting, metal plating and surface treatment, and surface preparation. Treatment is the last step for preventing pollution of the environment. Implementation of pollution prevention technologies in shipyard could result in cost benefits, regulatory compliance, and increased public image apart from reduction in liability.

Despite the fact that the shipbuilding and ship repairing industry of Greece, is under large scale downsizing in nowadays, is being involved into various polluting, the environment, processes.

Crucial facts and especially the unquestionable one concerning the pollution coming from shipbuilding and ship repairing facilities, neighboring to the sea, which influence the ground as much as the aerial and sea environment has been extracted from the above analysis.

The detailed presentation and analysis of the various involved pollutant entering the environment, significantly supports the identification of the proper techniques, in order for each of the pollutants to be confronted separately[11].

To sum up, the above mentioned fact is being seen as of significant importance

for the pollution, due to the fact that until nowadays the only action taken against it, concerned administrative containment actions as much as economically imposition under the form of a fine. As a result of the above, was only the superficial confrontation of the pollution implications and surely did not deteriorate the phenomenon.

D. Papaioannou

Ekološke implikacije povezane sa brodograđevnom i remontnom djelatnošću u Grčkoj

Sažetak

Općenito je prihvaćena činjenica da pretjerana urbanizacija koju prati intenzivna industrijska aktivnost nadomak stambenih četvrti nepovoljno utječe na zdravlje stanovnika. Nadalje, brodograđevna i remontna industrija predstavljaju najveće industrijske zagađivače u zemlji – posebice na širem području glavnoga grada – koji i unatoč krizi kroz koju prolaze posljednjih nekoliko godina ostaju, općenito gledajući, glavni izvor zagađivanja s daljnjim ekološkim implikacijama.
Može se reći da je glavni cilj ovoga rada kratka analiza ekoloških implikacija koje potječu od brodograđevne i remontne industrije, te predstavljanje i analiza s njima povezanih proizvodnih faza i postupaka. Istodobno se u zaključku predlažu načini i metode za spriječavanje zagađivanja koji odražavaju praksu i stvarno stanje u Grčkoj.

Ključne riječi: brodogradnja, ekološka zaštita pomorskog dobra, remontna zona Perama

[11] IMO, Marine Environment Protection Committee, 49th session, Agenda item 22, 13th of August 2003, Guidelines to ship recycling and list of hazardous wastes and substances that are relevant to ship recycling

Impatto sull'ambiente dell'attività cantieristica in Grecia

Sommario

È largamente risaputo come l'eccessiva urbanizzazione che sbocca in intense attività industriali nelle vicinanze dei centri residenziali produce effetti nocivi sulla salute pubblica.
L'industria cantieristica di costruzioni navali e raddobbo è una delle attività che causa il maggior inquinamento nel paese – ed in particolare nella vasta regione della capitale – che nonostante la recessione degli ultimi anni rimane fonte d'inquinamento con effetti nocivi per l'ambiente.
Scopo precipuo dell'indagine è una breve analisi degli effetti sull'ambiente derivanti dall'attività cantieristica di costruzioni navali e di raddobbo comprendendo nell'esposizione l'analisi delle fasi produttive e i relativi procedimenti.
A conclusione si propongono le vie ed i metodi di contenimento del fenomeno che riflettono la prassi e realtà della Grecia odierna.

Parole-chiave: cantieristica, salvaguardia dell'ambiente marino, area cantieristica di Perama