

# Enormous Fire at "Chyma" Bulk Chemical Terminal: Evaluation of an Incident's Management and Environmental Impact Assessment

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**Abstract**— The Industrial revolution and the advance of technology led to additional risks from serious technological accidents, known as Major Industrial Accidents. A series of such accidents that have recently taken place at European and international level and their pernicious effects on human-health, economy, environment and society as a whole, highlighted the necessity of an institutional framework to address the risks stemming from sites that use hazardous substances. A major accident occurred on the morning of July 26, 2006, at a solvent and chemicals company (Chyma S.A.) located in Lavrion, Attica, Greece, near the sea and adjacent to the premises of Public Power Corporation (P.P.C. S.A.) and chemical company DOW. In the present paper, we have analyzed the Chyma S.A. accident, its impact on human health, environment and the society of the affected area and evaluated its management. Furthermore, we have drawn conclusions and proposals for more effective management of Major Industrial Accidents. Note that when the accident took place, in Greece, SEVESO II Directive was in force of law. Since February 2016, SEVESO III Directive 2012/18/EC was conveyed into Greek law by Joint Ministerial Decision 172058/354B/17.02.2016 is legislative applicable.

**Index Terms**— Major Industrial Accidents, Seveso Directive, prevention, CHYMA S.A..

## 1 INTRODUCTION

The European Union tried to respond to the new-challenges by adopting the Seveso I, II and III Directives and their relevant amendments, in order to prevent major accidents from industrial activities and to reduce their consequences on humans and environment, in case they finally occur. The basic premise of the Seveso Directive is that a major accident cannot be confronted only by suppression measures. For this reason, the Directive emphasizes prevention, through an integrated emergency planning.

However, despite the integrated institutional framework at the international, European and national level, industrial accidents are still a threat, whereas when they occur their effects are usually destructive and difficult to reduce. This derives from the fact that we pay little attention to the prevention phase, as well as to the omissions and gaps at the emergency planning and the promotion of suppression measures

The EU SEVESO II Directive (which at the time had legislative implementation) aims at the prevention of major accidents which involve dangerous substances and the limitation of their consequences for man and the environment, (with a

view to ensuring) providing high levels of protection throughout the Community in a consistent and effective manner [1]. The Seveso II Directive 96/82/EC, as amended by the Directive 2003/105/EC, was conveyed into Greek law by Joint Ministerial Decision 12044/613/19.03.2007 "Measures and terms for the control of major-accident hazards involving dangerous substances". Depending on the nature and amounts of dangerous substances that may be present in the site, JMD 12044/613/2007 distinguishes "upper tier" from "lower-tier" sites [2]:

In the case of "low tier" sites the operator must send to the licensing authority a "Notification" with certain details about the establishment and its function (trade name, full address, person in charge, quantity and physical form of the dangerous substance or substances involved, installation's activity, prediction of the likelihood and the possibility of domino effects). The operator must also draw up and send to the licensing authority a document setting out his major-accident prevention policy and to ensure that it is properly implemented.

On the other hand, "upper tier" sites are bounded by more stringent commitments. Initially, the operator must produce and send to the licensing authority a "Safety Report" to prove that a major-accident prevention policy and a safety management system for implementing it have been put into effect. Operators must also draw up an "Internal Emergency Plan" including measures to be taken inside the establishment. This plan is necessary to be supplied by the operator to local authorities, so as to enable them to draw up External Emergency Plans. In addition, "upper tier" operators, as well as public authorities, have certain obligations to inform the pub-

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lic about safety measures and about the requisite behavior in the event of an accident.

### 1.1 Aims

The purpose of this study is to identify advantageous practices and omissions in dealing with an industrial major accident and to consider the environmental effects of a potential accident, through the case study of the incident at the CHYMA S.A. Company, in Lavrio, Greece. Specific objectives of the study are:

1. An overview of the legal framework which was established by the European Union to address risks from accidents at facilities using hazardous substances.
2. The study of the impact of such accidents on human health, environment and the society of the affected area.
3. An examination of the roles and responsibilities of each stakeholder in accordance with current legislation and the description of the treatment's phases.
4. The description of CHYMA S.A. Company accident and the evaluation of its management.
5. The examination of the environmental damage caused by the accident.
6. Drawing conclusions and proposals for more effective management of Major Industrial Accidents.

### 1.2 Background

The assumptions adopted for the purposes of this study are the following:

1. The negative effects of industrial accidents are unavoidable and their extent depends on the type of hazardous substances involved, the kind of the accident and the features of the affected area. However, proper planning is feasible and ensures the mitigation of the impact. For this reason, effective planning is considered to be an integral part of an event's management procedure.
2. An integrated and comprehensive approach to emergency management is a cyclical process that includes four pillars: prevention, preparedness, response and recovery. However, this study focuses on the pillars of response and recovery, namely the phases after a disaster occurs.

### 1.3 Experimental/Methodology

The sources used for the writing of the study based on:

1. Community legislation (Seveso I and II Directives)
2. Greek legislation for emergency planning
3. Greek and international bibliography on industrial accidents
4. Interviews based on questionnaires, with officials from the Ministry of Environment, the General Secretary of Civil Protection, the Prefecture of Attica and the Fire Service.

Regarding methodology, primarily we attempted to approach the theoretical framework by studying the legal framework for addressing the risks of major accidents at facilities using hazardous substances and the impacts of such accidents. Then, meetings and interviews with actors involved in the management of the examined accident took place, in order to gather

collect reliable information about the data of the event and the actions to address it. Finally, there has been made an attempt to combine theoretical framework with facts, so that we would be able to extract key findings concerning the management of the accident at issue and the assessment of environmental impacts caused.

## 2. CHYMA S.A. MAJOR INDUSTRIAL ACCIDENT

### 2.1 CHYMA S.A. Company

The solvents and chemicals company "CHYMA S.A." is located in Lavrio, Attica, near the sea and adjacent to the premises of Public Power Corporation (P.P.C. S.A.) and chemical company DOW. Its main activity was storing liquid chemicals, especially organic solvents, in closed containers, and distributing, directly or after mixing, to other industries. Solvents are substances particularly hazardous for human health and the environment.

According to the Seveso Directive the company belonged to the category of "lower tier" establishments and was not bound by the stringent requirements imposed on the 'upper limit' establishments [3].

### 2.2 Brief Description of the accident

The incident occurred on the morning of July 26, 2006, due to ignition of combustible material in the drum filling station, while the transfer of xylene through a centrifugal pump was taking place. The suspected cause seems to have been sparks or static electricity or friction. The company's facilities were poorly protected against fire, and as a result, the fire became rampant in little time. Soon, barrel and tank explosions followed, along with pool fire and jet fire. Indeed, some tanks were detached from their base and launched like rockets [4].

### 2.3 Management of the accident

The accident's management required the activation and cooperation of many different agencies (see Table 1) and the disposal of even more resources. The main target of the operations was to prevent fire expansion to the tanks that were not affected and to the two adjacent facilities (P.P.C. and DOW), which were evacuated right from the beginning as a precaution.

The resources made available were the following:

1. 4 fire extinguishing planes and 3 helicopters
2. 53 water tender vehicles with 200 firefighters
3. 12 water tender vehicles from the adjacent municipalities
4. 2 fire boats

The fire suppressants used by the Fire Service was water and foam. The task of dealing with the accident was extremely difficult, particularly due to major factors such as:

1. The type of burned substances (creating dense smoke)
2. Strong winds
3. Lack of suitable foam (alcohol type foam which is alcohol resistant)
4. Tanks explosions
5. Insufficient information about the nature of the substances and the exact number of tanks (due to incomplete implementation of the Seveso Directive)

6. Residents' concern increase when information comes delayed about the risks from exposure to toxic cloud. Finally, thanks to the coordinated efforts of the firefighters, the fire was under partial control at midnight, but continued extinguishing until next day at 6.00 a.m., destroying most of the facilities of the company. The fire did not spread to neighboring plants of the chemical industry DOW.

TABLE 1

Actions per player to address the accident [5]

PLAYER	ROLE
FIRE SERVICE	Coordination of operations, Extinguish fire, Preliminary investigation on fire exacts cause, Major Industrial Accident Report
HELLENIC POLICE	Adjusted traffic and facilitated firefighting vehicles transit. Information provision about the situation, Set vehicles in readiness for potential transfer of population.
COAST GUARD	Placing of special absorptive booms along the fence to prevent any leakage to seashore. Allocated vessel to conduct samplings
EASTERN ATTICA PREFECTURE	Guidelines provision to people. Conducted autopsy. Quality measurements on waters supply and soil
GENERAL SECRETARY FOR CIVIL PROTECTION / CIVIL PROTECTION OPERATIONS CENTRE	Ongoing communication with stakeholders for information and promotion of requests. Prepared "Destruction File"
NEIGHBORING MUNICIPALITIES	Water tender vehicles supply
MINISTRY FOR THE ENVIRONMENT, PHYSICAL PLANNING AND PUBLIC WORKS	Air pollution measurements. Technical report. Reported the accident to the European Commission, through Major Accidents Reporting System (MARS)
MINISTRY FOR HEALTH / NATIONAL CENTRE FOR HEALTH	Set hospitals in readiness. Self-protection guidelines to Lavrion citizens. Reinforced Lavrion's Health Center capacity with equipment and personnel
HELLENIC METEOROLOGICAL SERVICE	Provided meteorological data
GENERAL CHEMICAL STATE LABORATORY OF	Assessment of CO dispersion for delineation of protection

GREECE	zones
REFINERIES (Eleusina & Corinthus)	Equipment and personnel supplies
Lavrion P.P.C.	Foam supplies
HELLENIC CENTRE FOR MARINE RESEARCH.	Consideration of the status of the marine environment and relevant report
TECHNICAL CHAMBER OF GREECE	Accident investigation report

## 2.4 The Accident's Impacts

### 2.4.1 Health Impacts

Regarding the accident's impact on health, fortunately, there were no deaths or serious injuries of residents, employees of the company and the staff of the Fire Service. Solvents are among the most toxic substances and when they burn they produce even more dangerous gasses. However, this combustion caused no serious long-term effects on human health, as it was of short duration. The prevailing meteorological conditions had also a key role in reducing the risk. The products of combustion were swept away by east winds at long distances over the sea and, therefore, people were not in danger. The measurements have shown increased air pollutants, however within acceptable limits.

### 2.4.2 Economic Impacts

On the contrary, the economic impact of the accident was remarkably high and it includes the cost of the destruction of facilities, the cost to address the incident and to restore the area and the impact on chemical industry in general, as CHYMA S.A. had a key role in the operation of other industries [6].

### 2.4.3 Environmental Impacts

The environmental damage caused by the accident was also significant and it includes pollution of the marine ecosystem, soil, and air pollution. For the assessment of damage to the marine environment, the competent authorities collected samples from both the coastal and the wider marine area, while a total of three samples of seawater were carried out [7]. The samplings detected residues of a large number of volatile and semi-volatile organic compounds (Detailed results of the samplings carried out are available at the Technical report of the Hellenic Centre for Marine Research, 2006). Soil contamination resulted from solvents' leakage to it, either directly from the tanks, (either) through fire water or as air pollutants fall to the ground. Furthermore, the ground was covered with a layer of dust because of the disintegration of asbestos cement [8].

### 2.4.5 Restoration Project

The company had the responsibility to fulfill the restoration project according to the "polluter pays" principle. The restoration work focused on emptying the tanks, removing contaminated soil and replacing it with new- good quality one- and the proper management of all hazardous waste. The project lasted six months and the cost was exceptionally high. After remediation was completed, there was a prediction for the implementation of an Environment Quality Monitoring Program at the establishment and around it, in order to determine the evolution of the environmental situation in the

atmosphere, soil and subsoil, groundwater, sea and seabed through samplings and measurements of certain features [9].

### 3. RESULTS AND DISCUSSION

The management of CHYMA S.A. accident has been, in general, satisfactory, as the intervention of the fire service forces was direct, the fire spread to neighboring facilities was averted and, most important, there were no casualties. However, there were significant omissions, which increased the level of the operation's difficulty and, under different circumstances, could lead to disastrous results.

#### 3.1 Deficiencies

The main deficiencies were the following:

1. Lack of appropriate, quantitative and qualitative, resources to address the incident.
2. Lack of the appropriate personal protective equipment for firefighters.
3. Failure to inform the public in time about the effects of smoke on health, due to delayed measurements, ignorance of the contents of some tanks and the lack of textbooks that included information about the burning substances.

Such omissions are closely related with the poor implementation of legislation on Major Industrial Accidents.

#### 3.2 Lack of Preventive Measures

The lack of preventive measures at the case of CHYMA S.A. Company is a typical example (of poor implementation) of law misapplication. More specifically:

The studies carried out for the authorization of the installation were incomplete, so it was not possible to identify key hazards and take measures to prevent or limit the impact. Additionally, the company did not meet its legal obligations and was also accused of the illegal installation of four new chemical storage tanks. On the other hand, the competent public authorities adopted the above studies, despite their inefficiencies and bureaucratic nature. They were also responsible for the absence of any on-site inspection, through which they could have identified vulnerabilities in the installation and the existence of illegal tanks.

Another aspect of the absence of preventive measures is inadequate emergency planning. Emergency planning is the main tool for the limitation of the impact and the effective management of a possible incident. One of the most important components of emergency planning is the registration of the available material and human resources to address potential accidents and the performance of clearly defined roles for stakeholders, in advance. The registration of available resources and a clear definition of "who does what and when", before the outbreak of the incident, is of great importance for the immediate and effective management of the situation, without delays and duplications and the limitation of the adverse impacts, as well.

Prevention in the Seveso II Directive is also expressed by the obligation of the authorities to supply information on safety measures and the requisite behavior / reaction, in the event of an accident (to the public living) near facilities that manage

hazardous substances (Article 13). However, experience has shown that the level of application of article 13 in Greece is frustrating [10]. The absence of any information - to the residents of Lavrio before the accident - about the risks of the establishment's operation, as well as delayed guidance after the incident, caused the panic situation and, under different circumstances, could have serious consequences.

#### 3.3 Legal Gaps

Apart from the omissions observed, the existence of legal gaps is also a factor that enhances the difficulty of dealing with such accidents. The ascertainment of legislative gaps is related to obligations under the Seveso II Directive for the two facilities categories (upper and lower limit). Regarding the case-study of this research, although CHYMA S.A. was classified as a "low tier" site (and, therefore, was bounded by less stringent commitments than "upper tier" sites), the incident had all the hallmarks of an accident at an "upper tier" facility. This fact raises concerns over the need for an extension of the provisions applicable to "upper tier" sites to "low tier" sites as well, not equally of course and by taking into consideration the size of the hazardous installation.

#### 3.4 Poor restoration process

Finally, another gap at the management of the incident in issue is relevant to the environmental impact assessment. Even though there was provision for the implementation of an Environment Quality Monitoring Program, such program never took place. Comprehensive research to examine the immediate and long-term effects on the environment were delayed, due to lack of funding, while some destroyed tanks remain in place even today. This indicates that restoration process phase of emergency cases is not being followed.

### 4 CONCLUSION

Although the implementation of the Seveso Directive has contributed to important progress in the fields of prevention and mitigation of Major Industrial Accidents, such accidents still remain a threat and when they occur their effects are destructive and difficult to reduce. This emanates, among other things, from the misapplication of law, by operators and the State, and the existence of legal gaps as well.

In summary, the finding worth-deducing from this study is that the management of an emergency industrial accident is an ongoing process that begins long before the outbreak of the event and continues after drawing conclusions from it. Emphasis should be on prevention, rather than on suppression measures, as experience has shown that "prevention pays". A comprehensive emergency management accident does not stop when the fire goes out. Restoration of the environment is of paramount importance, not only for the local environment but also for human health and sustainable development of the region in general.

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