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Statistical analysis of incidents reported in the Greek Petrochemical Industry for the period 1997–2003

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Abstract

This paper makes an analysis of all reported accidents and incidents in the Greek Petrochemical Industry for the period spanning from 1997 to 2003. The work performed is related to the analysis of important parameters of the incidents, their inclusion in a database adequately designed for the purposes of this analysis and an importance assessment of this reporting scheme.

Indeed, various stakeholders have highlighted the importance of a reporting system for industrial accidents and incidents. The European Union has established for this purpose the Major Accident Reporting System (MARS) for the reporting of major accidents in the Member States. However, major accidents are not the only measure that can characterize the safety status of an establishment; neither are the former the only events from which important lessons can be learned. Near misses, industrial incidents without major consequences, as well as occupational accidents could equally supply with important findings the interested analyst, while statistical analysis of these incidents could give significant insight in the understanding and the prevention of similar incidents or major accidents in the future. This analysis could be more significant, if each industrial sector was separately analyzed, as the authors do for the petrochemical sector in the present article.

Keywords: Accident database; Statistical analysis; Near misses; Industrial incidents; Lessons learned; Petrochemical sector

1. Introduction

The experience accumulated from past accident investigation analysis in the chemical sector has shown that despite the innovative safety systems that have been created and put in place in the process industry together with the sophisticated methods devised for the identification of vulnerabilities, accidents and similar incidents still occur. Chung and Jefferson claim [1] that the chemical industry as a whole does not learn from past accidents, while Kletz quotes [2] that mistakes in design and operation are repeated leading to similar accidents to re-occur. This incapacity, however, to learn from past incidents is not intentional by designers or operators; it rather reflects a barrier in human perception and capabilities. As Drogaris has stated [3] "the conclusions of several accident investigations or studies on safety-related issues often show that similar lesson had already been learned a few years before in similar accidents". This indicates that although the knowledge needed to prevent major accident and/or to minimize their consequences is often available, lack of the proper safety culture to enable effective use of this knowledge and lack of a structured communication system to diffuse this knowledge still constitute a serious handicap.

To this end the setting in place of a Safety Management System together with the proper design of an Accident Reporting System is of high importance for the process industry. The European Union having conceived this issue has already included in the Seveso I and II directives [4,5] the implementation of a safety management system in big industrial installations in order to create and support an up-to-date safety policy culture. Both directives require that the Competent Authorities of the EU Member States notify major accidents, which occur in their own country, to the European Commission. For this purpose, the Major Accident Reporting System (MARS) has been created at the JRC, Ispra [6], with the main purpose to analyze the accident reported by the member states to the Commission aiming at the generation of lessons learned from these accidents. This should help to identify areas of concern, together with the set-

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ting of priorities for further improvements and the undertaking of new research and regulatory intervention for industry, where necessary [7].

Major accidents analysis is an indispensable source for the further development of the state of the art in current safety technology and perception [8]. However, many important lessons could be learned from near misses and ordinary accidents. Kirchsteiger claims [9] that "the same deficiencies can be revealed by events without accident consequences . . ., as the former can provide a useful complement in identifying deficiencies and promoting changes to the actual safety system". Apart from near misses important conclusions for the safety culture of an establishment can be pointed out by ordinary and occupational accidents. Findings concerning the operator behaviour and habits, together with data concerning mechanical equipment and trends in safety policy can be revealed by examining the frequency of certain events and the overall safety status of the establishment.

That is the reason why a database comprising more than just the major accident data is necessary. Indeed MARS has foreseen the notification and reporting of near misses too. However, it is up to the Competent Authorities to motivate industries to forward this information. Moreover, it would be quite impractical for one database to keep records of all incidents in all Member States.

Databases on National level are more adequate and possibly easier to manage and use. Furthermore, the division in specific sectors of the industry would increase the efficiency of the system. Similar databases have already been developed for other kind of accidents covering diverse sectors from road-traffic accidents [10] to accidents related with the energy sector [11]. A recent study covered also incidents in the chemical industry with domino effects [12].

This paper discusses the development of a database containing accidents and incidents from the Greek Petrochemical Industry. In Section 2 of this paper, an overview of the database is given, while Section 3 presents the statistical analysis of the accidents and incidents of the database. Last, Section 4 concludes the paper referring also to the lessons learned from the analysis.

2. Development of the database

2.1. Introduction

The database comprises accidents and incidents from all the Petrochemical installations in Greece and for the period 1997–2003. The petrochemical sector was chosen among all sectors because petrochemical installations are characterized by high risk potential because of the nature of processed flammable and explosive substances and of the severity of consequences in case of a major accident in these establishments. Many specific accident types are closely related to the petrochemical installations (e.g. BLEVEs, fireballs, UVCEs) the consequences of which can affect many people inside and outside these establishments, but also the surrounding environment as mentioned by Papazoglou et al. [13]. As was pointed out in previous work of the authors, petrochemical installations represent the 17% of the total number in industrial accidents in Europe, which is the second most important sector in industrial installations behind general chemicals with 32%. This data is coming from the statistical analysis of major accidents notified in MARS.

2.2. Data collection

The analysis covers the period of 6 years from 1997 to 2003. This was decided in order to have a common basis since management and status of some sites have changed in the last years and it was difficult to obtain data previously to 1997. Additionally, in some establishments the systematic collection of incidents in specially organized archives has started after 1997. In order to have a common approach for all the establishments the abovementioned period has been chosen. The establishments comprise the entire Greek Petrochemical Industry together with the Cyprus Refinery and range from extraction sites and offshore facilities, to refineries, production and storage sites in central and northern Greece and on the island of Cyprus. The refineries cover the 85% of the active Greek market gross products with a total output of the crude oil products of approximately 18 million tonnes while the total needs of the Greek market reach approximately 21 million tonnes. The deficit is covered by imports. The total number of personnel working in this sector reaches 5000 people from which more than 3000 are employees of the production and storage sites (the data are provided from the official sites of the petrochemical companies).

The research team retrieved the data directly from the different establishments having access to the archives and the initial reports of the incidents. Data have been collected in collaboration with the safety engineers of the sites under a specific cooperation memorandum with the companies management board comprising also a clause of confidentiality for all the data provided to the research team. The collection of data took place in a period of 1 year with on-site visiting, surveying of the recording systems, checking of the initial reports and meetings with the safety personnel in the plants. When necessary additional discussions and meetings with key personnel and operators have been held in order to collect more details concerning certain incidents and to define the exact evolution of an event. In some cases, these discussions revealed also deeper causes of the incidents farther than the conclusions drawn from the analysis of the very incidents by the corresponding internal departments of the companies.

2.3. Data organization

In the development of the database, the authors have decided to use similar fields as in the MARS database in order to provide the capability for a future comparison of the two databases, if wanted. Additional fields have been also used to include further details and data where available.

The database consists of three parts:

(A) *A general first part*, where all descriptive information of the incident is given. Details concerning the time of the accident (date and hour), the place of the accident (operation unit and equipment), the status of the unit when the acci-

dent took place, the substances involved, the type of the accident (occupational, near miss, fire, explosion, release) and a detailed description of it. Corrective actions or post-accidents measures that might have been put in place after the accident occurrence, are also included in fields dedicated for this purpose.

(B) *A second part*, where the analysis of causes is given. Causes are categorized as human-related, organization-related, mechanical failure causes and external ones. Further division in specific causes is given under the main categorization.

(C) *A third part*, where the consequences of the accident (if any) are given. Consequences comprise fatalities and injuries (with subdivision of injuries according to the treatment the patients received—first aids, hospitalization, absence from work), community disruption, environmental effects and material loss.

2.4. Expansion of the database

The distribution of the database to other interested parties is still to be decided. Specific care has been taken so that data that could lead to the identification of a specific establishment were omitted, allowing in this way the dissemination of the information among different industrial establishments, without confidentiality issues arising. In this way, the distribution of the acquired knowledge to several stakeholders or different industrial sectors is also possible so that they can take advantage of these findings too.

In a first step, the database has been distributed among the members of the Greek Petrochemical Industry, the ones that have also provided the data. Further distribution to Competent Authorities and to other industrial sectors, allowing thus its expansion, will be considered in a later stage.

3. Statistical analysis

3.1. Introduction

The statistical analysis was based on 1115 reported incidents for a 6 years period, from 1997 to 2003, from all the Greek Petrochemical Industry plus the Cyprus Refinery that include refineries, onshore and offshore facilities, storage locations and extraction sites.

Reported incidents comprise:

- near misses;
- occupational incidents (slips, falls, burnings, cuttings);
- industrial accidents (leaks, releases, fires, explosions);
- operation incidents (shutdowns, trips);
- traffic incidents and accidents;
- accidents on the way to the workplace;
- accidents leaving the workplace;
- external actions affecting the establishment;
- meteorological phenomena affecting the establishment;
- unusual events.

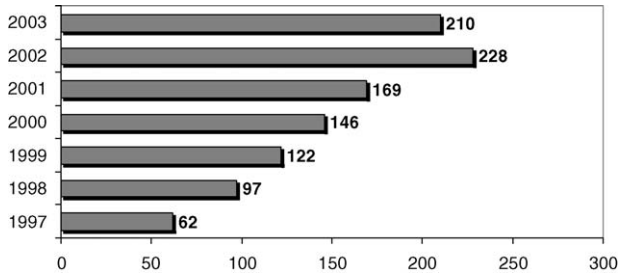

Fig. 1. Number of reported incidents in the Greek Petrochemical Industry per year of occurrence.

3.2. Accident terminology

Near misses are generally defined as those hazardous situations (events or unsafe acts) that could have led to an accident if the sequence of events had not been interrupted. It is largely accepted that near misses, however small, do occur in industrial facilities very often. This represents a large pool of data the collection of which can be used to extract valuable lessons.

According to the definitions provided by the participating establishments *accidents* are more usually associated with events on-site leading to adverse consequences for the establishment (like leaks, fires and explosions), while *incidents* are either referred to events associated exclusively with the personnel (operational incidents like slips or falls) or with the production line (operational incidents like trips or unanticipated shutdowns).

The fields that have been analyzed are briefly discussed in the following paragraphs.

3.3. Year of occurrence

The distribution of reported incidents in the Greek Petrochemical Industry per year and for the period 1997–2003 is shown in Fig. 1.

The chart presents a continuous increase in the number of reported incidents during the years 1997–2002 and a slight stabilization for the last 2 years (2002–2003). This of course does not mean necessarily that incidents in the Greek Petrochemical Industry have increased during the last years, but it is rather a proof of a radical change in personnel mentality to report all incidents (even the not significant ones and near misses) and also a radical change in the management of the reporting system and of the data archiving system. The implementation of Seveso I and II directives in the Greek Legislation along with the more rigorous legal framework concerning occupational health and safety together with a stricter inspection scheme from the competent authorities are the main reasons for this trend. On the other hand, the modernization of plants and of safety equipment together with switching towards intrinsically safer operations and working environments justify the incident stabilization.

3.4. Month of occurrence

Fig. 2 presents the total number of reported incidents in the Greek Petrochemical Industry for the period 1997–2003 per

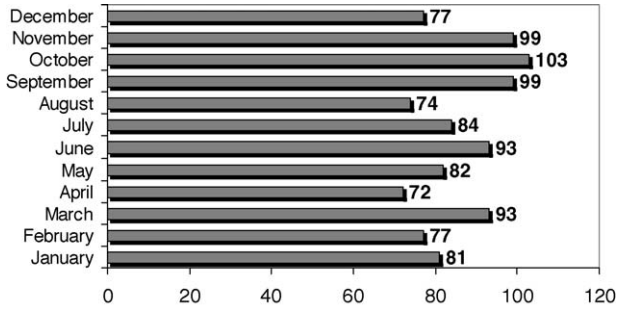

Fig. 2. Total number of reported incidents in the Greek Petrochemical Industry per month per occurrence.

month of occurrence. The number of reported incidents per month is quite similar over the whole year period with an exception for the months September–November. During these months a slight increase in the number of reported incidents is recorded. This increase can be explained by the fact that these three months are usually the months where shutdowns of the units (for maintenance and repairs) and restarts are taking place. Shutdown and restarts are very "sensitive" periods in the life-cycle of the process industry with quite high percentage of incidents and major accidents taking place during them. Additionally, overtime working also with contractors' personnel (for maintenance reasons) in the establishments increases the proness to incidents during the above-mentioned months.

3.5. Day of occurrence

In Fig. 3, the distribution of reported incidents in the Greek Petrochemical Industry per day of occurrence is presented. It is noted that the distribution is quite equal for all weekdays, but decreases significantly during the weekend days (Saturday and Sunday). This is due to the reduced presence of personnel during the weekend (operators do have around the clock shifts, but administration and management personnel have a 5 days per week working program). Maintenance and repair works are also not so intense during weekends.

3.6. Time of occurrence

The distribution of reported incidents in a 24-h scale is shown in Fig. 4. For these incidents one must take into account that in many cases exact time snap was not mentioned in the incidents reports, so this distribution is obviously based only on the incidents for which this exact time point was available. These incidents represent 57% of the totally reported ones.

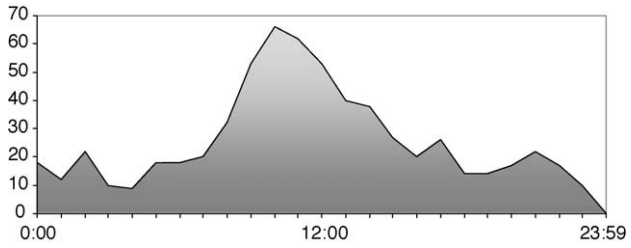

Fig. 4. Distribution of reported incidents in the Greek Petrochemical Industry per time of the day.

From the distribution of these incidents over the whole 24-h period, it becomes evident, as expected, that the main bulk is accumulated around midday (from 9:00 to 14:00 h). This is explained by the fact that during these hours, both administration and management personnel and operators are present in the establishments, while in the afternoon and evening shifts only operators are working. In addition to that maintenance work as well as most of peripheral production activities (such as commissioning, shipping, delivering, distribution, transportation) usually take place in the morning shift (7:00–15:00 h).

The percentage of reported incidents that took place during night (after 19:00 h and before 6:00 h) is only 13% of the total reported incidents, while for incidents that took place during the day this raises to 44% of the total reported incidents. It should be also noted that during the night shifts a certain number of small and unimportant events are not always reported and/or registered. For the rest of the reported incidents details considering the exact time of occurrence were not given.

3.7. Type of accident

The distribution of notified accidents per type of accident is shown in Fig. 5. In almost 44% of the cases, accidents were mostly labeled as occupational. However, releases and/or leaks is the most frequently registered type of incident. Fires (pool fires, jet fires and flash fires) have occurred in 146 incidents and explosion phenomena (from small explosions to more serious ones including Vapor Cloud Explosions) took place in 27 incidents. Material loss has happened in 145 cases. One hundred and seventy eight incidents could not be classified to any accident

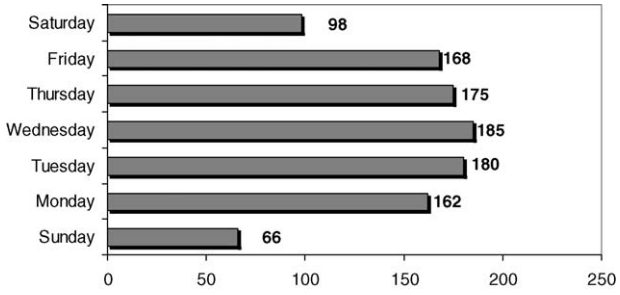

Fig. 3. Total number of reported incidents in the Greek Petrochemical Industry per day of occurrence.

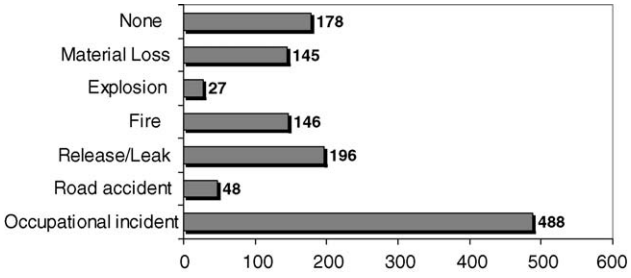

Fig. 5. Number of reported incidents in the Greek Petrochemical Industry per type of incident reported.

type owing to the minor magnitude of their consequences and represent the category "none".

It is evident and already reported in other similar works [7] that accidents may consist of complex event sequences therefore their outcome may be classified in more than one categories type. That is the reason why these categories in certain incidents may co-exist and overlap.

It should be mentioned that the categorization of incidents comprises also traffic accidents that took place either inside the plant roads, or on the way to and from the work. This category comprises 48 incidents.

In the total of reported incidents for the Greek Petrochemical Industry, period 1997–2003, near misses represented the 26% of the total incidents, underlining in this way the importance of near misses, as well as their increased frequency. Additionally, the number of reported near misses highlights the importance that the management of the establishments places on these incidents, as in all establishments visited there is a formal requirement to report on them. According to plant managers, it is also a clear mentality change sign of operators who now do report small and without consequences events too, instead of hiding or neglecting them.

3.8. Substances

Fig. 6 is a diagram of the substances involved in all reported incidents of the Greek Petrochemical Industry for the period 1997–2003.

These substances were present in the reported incidents either as a direct release/leak or in the case of occupational accidents as the cause for burnings, intoxications or irritations.

The analysis is considering the general presence of the substances without defining the type of incident.

The most usual substances involved in incidents are gasoline and light hydrocarbons, which were present in 47 cases. LPG and gaseous hydrocarbons were also frequently involved in incidents and were reported in 33 cases. In 29 incidents crude oil was involved, while naphtha and other heavy hydrocarbons (H/C) were present in 18 and 27 incidents, respectively. Diesel (another heavy H/C) was involved in 18 incidents. Slurry and gaseous combustion products were present in 12 and 3 cases, respectively. Sulphuric products (H_2S, SO_2, H_2SO_4, biosulphides, DMDS) were also frequently registered in cases of incidents – 31 incidents in total – and hydrogen was present in 17 cases.

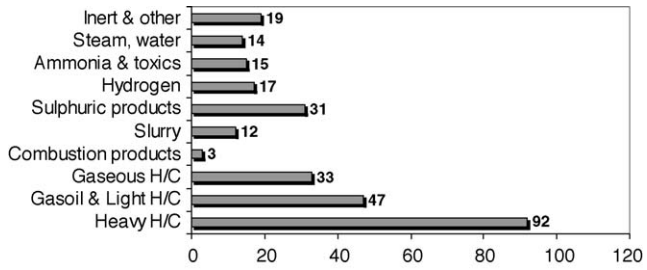

Fig. 6. Substances involved in reported incidents of the Greek Petrochemical Industry and number of their appearance.

Table 1
Substances categories and substances included

Category	Substances
Heavy H/C	Crude oil, naphtha, diesel, waxy distillate, bitumen, lubricants
Gasoline and light H/C	Gas oil, vacuum gas oil, kerosene, xylene, isomerization products
Gaseous H/C	LPG, propane, butane, fuel gas
Combustion Products	Carbon monoxide, carbon dioxide
Slurry	Slurry and residuals
Sulphuric products	Hydrogen sulphide, sulphur, DMDS, sulphur dioxide, sulphuric acid
Hydrogen	Hydrogen
Ammonia and toxics	Ammonia, caustic soda, chlorine, hydrochloric acid
Steam, water	Steam and hot water
Inert and other	All substances not classified above (catalysts, special chemicals)

Ammonia, toxic substances and caustic soda were present only in four to six cases, respectively. Steam and hot water caused problems in 14 cases. Inert and other substances like catalysts and special chemicals were present in 19 cases. The substances that are included in each category are presented in Table 1.

Is it notable that the total number of incidents with reported substances is much smaller than the total number of reported incidents. This is normal as incident reporting includes many occupational accidents, which do not necessarily involve a substance release or leak. There are also certain few cases where the involved substances are not mentioned.

3.9. Unit

In Fig. 7, the units where the reported incident took place are presented. As expected an important percentage (20%) of the reported incidents in the Greek Petrochemical Industry for the period 1997–2003 took place in the distillation unit (18% for distillation and 2% in the vacuum distillation). The distillation unit is the core of the production in the Petrochemical Industry,

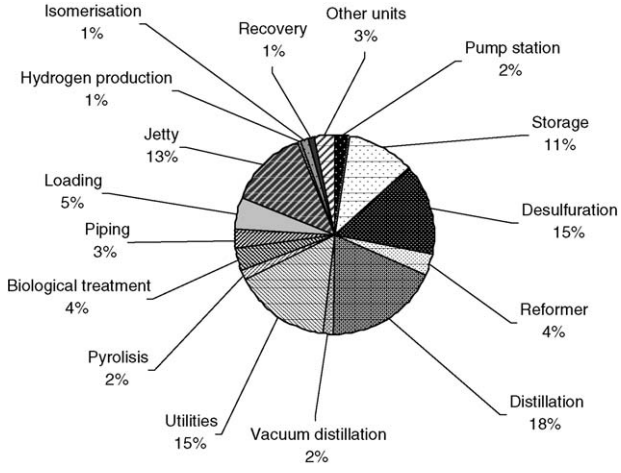

Fig. 7. Percentage of incidents reported in the Greek Petrochemical Industry per production units.

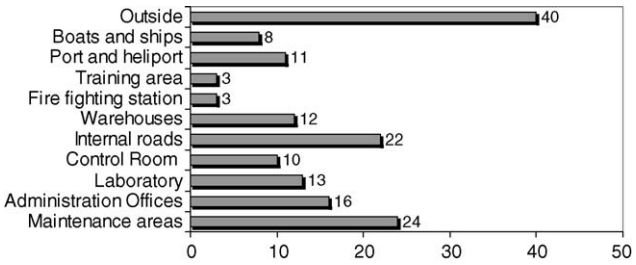

Fig. 8. Number of reported incidents in the Greek Petrochemical Industry in areas outside of the production units.

most plants having two or three distillation units in use and at least one unit of vacuum distillation.

The desulphurisation unit and utilities present also quite a high percentage in the total number of reported incidents, each one with 15%. Other important production units are the reformer unit with a percentage of 4% and the pyrolysis (catalytic or thermal) units with a percentage of 2%.

Incidents in the storage area represent 11% of the total number of reported incidents. Frequent are the incidents in the jetty and in the other loading areas—truck and rail wagons loading (11 and 5%, respectively), while the piping network and the pump station have a percentage of 3 and 2%, respectively. Recovery units, isomerization and hydrogen production unit contribute with 1% each in the total number of reported incidents. In units like acid decomposition, stabilization, oil separation and purification have been recorded one or two incidents for each one in the period of the 6 years. Since the individual percentage of each unit is negligible they are all represented and mentioned under the label "other". Finally, the unit concerning the waste treatment (biological treatment) of the plants participates with 4% in the totally reported incidents.

Other incidents, most of them belonging to the category of occupational accidents or to the category of traffic road accidents, took place in other location of the establishments, which are not in the production area per se. The distribution of these incidents is presented in Fig. 8. It is remarkable that a quite important number of incidents (40 in total) took place outside the establishments. These are incidents on the way to work, or on the way home from work that all Greek establishments record as they belong to the percentage of working hours (absence from work) that is covered by the social security.

Many occupational accidents took place in the maintenance areas of the establishments (24), while 22 incidents took place in internal roads, or at the entrance of the establishments. These are usually small collision of cars, or slips of the personnel. Sixteen incidents took place in the offices, 13 in the laboratory area and 10 in the control room, all of them recorded as occupational accidents. Twelve incidents took place in the warehouses, 11 at the ports and heliports of the establishment and 8 on boats, ships and other floating carriers (for personnel and/or material transportation). These incidents are both occupational accidents and material loss incidents. Finally, three incidents took place in the fire fighting station and in the training areas.

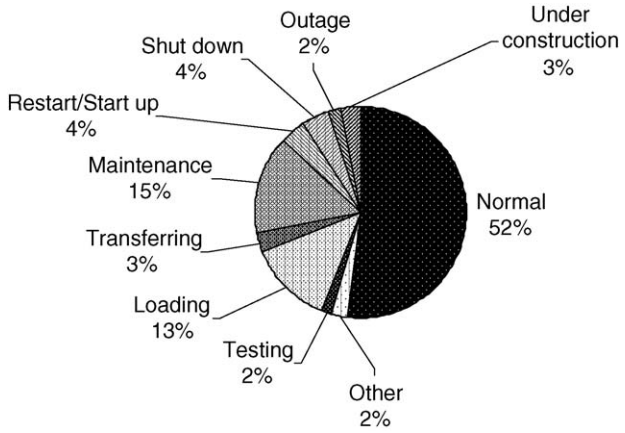

Fig. 9. Operational status during the occurrence of the reported incidents in the Greek Petrochemical Industry.

3.10. Operational status

Fig. 9 presents the operational status of the unit or of the industrial plant during the occurrence of the reported incident. In more than half of the cases (52%) the plant or unit was under normal operation. Critical phases like shutdown and restart/start-up are both represented by a percentage of 4%. Other phases which represent important percentage of the total number of incidents are (as expected): the maintenance phase (15%), the loading/unloading of materials phases (13%) and the transferring of substances and products (3%). In phases like testing the percentage is smaller (2%).

The phase of construction of a unit is also quite critical representing 3% of the incidents most of them being in the category of occupational accidents. Incidents due to outage of external utilities were registered in 2% of the cases.

The notion "other" comprises the period of sampling, drilling exercises and the non-operational period of a unit.

3.11. Causes

Fig. 10 presents the immediate causes of incidents in the Greek Petrochemical Industry for the period 1997–2003. The immediate causes are classified in five main categories each one consisting of several subcategories. The causes of incidents were indicated through accident investigation analysis of the appropriate departments of each company.

In certain cases, where more details were needed, personal contacts with the safety engineers and members of the personnel have been held during the research. The categorization is a synthesis of all causes detected in the safety forms and reports of each establishment with the necessary justifications.

The five main categories of incident causation and their relevant percentages are shown in Fig. 10 and are shortly presented in the following:

(1) equipment–mechanical failure with 13%;
(2) human factor—operator error with 46%;
(3) external events with 2%;

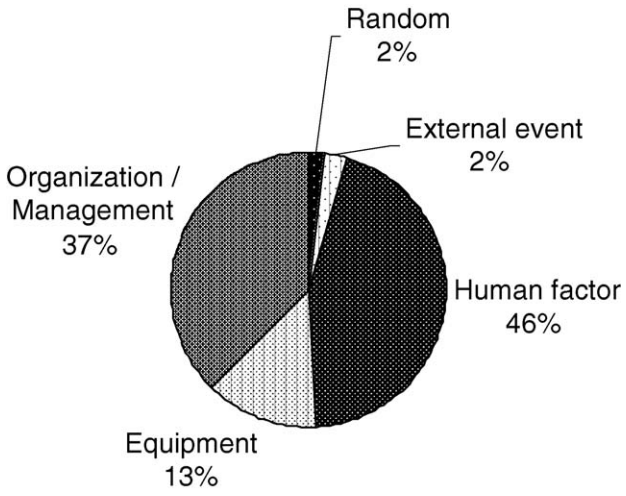

Fig. 10. Immediate causes of reported incidents in the Greek Petrochemical Industry.

(4) organization–management causes with 37%;
(5) random events with 2% of the total number of incidents.

Equipment and mechanical failure stands for all incidents where the main cause was either the malfunctioning of an equipment or instrument (15%), or a deterioration of the equipment (21%) or a material failure (64%). All numbers in paragraphs represent the percentage of the specific subcategory in the total number of incidents of its wider category.

Human factor is a term standing for the operator errors. These can be:

(a) errors of commission (17%) such as:
  - wrong use of equipment (7%);
  - misdiagnosis of a failure (7%);
  - wrong action (3%).
(b) errors of omission (83%) such as:
  - no use of personal protective equipment (6%);
  - violation of procedures (38%);
  - negligence (39%).

External events comprise meteorological phenomena (51%), outage of power (35%) and third parts interfering (14%).

Organization and management causes comprise all the faulty operations of administrative procedures put in place to prevent the incident. These are:

- improper equipment in use (9%);
- design deficiencies (17%);
- problems in communication (6%);
- work stress (1%);
- bad housekeeping (7%);
- lack of maintenance (17%);
- lack of supervision (11%);
- lack of inspections (8%);
- insufficient training (2%);
- unavailability of procedures (19%);
- poor ergonomy (3%).

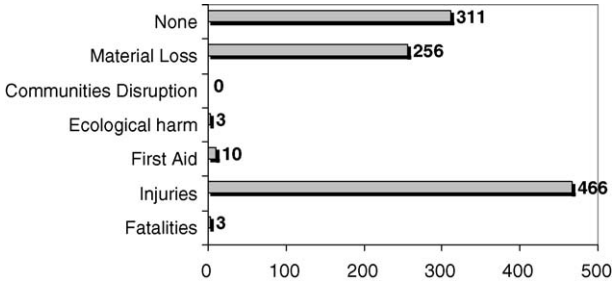

Fig. 11. Consequences of reported incidents in the Greek Petrochemical Industry.

It is evident that many incidents would have been prevented with a better functioning safety management system of the installations.

In the database there have been cases where investigation of accidents is still on going preventing the researchers from putting the exact causes in some accidents.

3.12. Consequences

In Fig. 11, the immediate consequences of the incidents reported in the Greek Petrochemical Industry for the period 1997–2003 are presented. As for the accident category types, there is a significant overlap among the consequence categories for many incidents registered. There are cases where no consequences were reported.

It is evident that in certain incidents with fatalities and/or injuries there is also material loss involved.

During the 6 years period only three accidents resulted in fatalities and three persons lost their lives. In many cases (466 in total) only injuries to the personnel have been reported. Injuries include wounds, burnings, cut-offs and generally every possible abrasion to the human body. The relative big number of injuries is attributed to occupational accidents that are included in this research. In 10 cases only preventive first aid was provided to the personnel involved without the need of any further hospitalization (no serious injury involved). In the 25% of the total number of occupational accidents (injuries), patients have received first aids support, in the next 11% patients needed medical assistance, while the biggest percentage of occupational accidents (64%) resulted in absence from the workplace for more than a day.

Incidents with immediate consequences to the environment were registered in three cases, while no case was found to cause community disruption such as evacuation of the surrounding areas or even notification of the neighbouring population.

Material loss was registered in many cases (256 in total), while 311 incidents had no significant consequences.

3.13. Corrective actions

In Fig. 12, the corrective actions taken after the ending of the reported incident are presented. It is obvious from the type of incidents that this research includes, that not all of the incidents

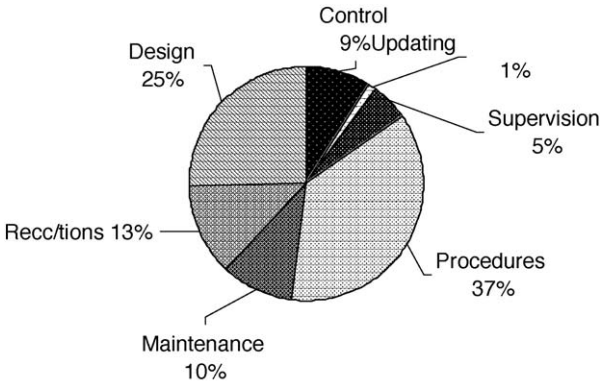

Fig. 12. Corrective actions and post-accident measures for incidents reported in the Greek Petrochemical Industry.

require a corrective action, most of them being ordinary events without serious consequences. Yet, this can reveal important deficiencies in the company Safety Management System, if these events are repeated frequently.

The corrective post-accident actions include measures of prevention in order to reduce the frequency of similar incidents, measures of mitigation in order to reduce the consequences of the incidents or both of them.

In most of the cases changes or review or even a new development (where absent) of procedures followed the reported incident (37%). In 25% of the cases a change in the design took place, while in 13% of the cases only recommendations and instructions to the personnel have been issued. Intensification and better control was stressed in 9% of the cases, while the enhanced role of shift operators and supervisors was decided in 5% of the cases. Maintenance of the equipment followed the accident in 10% of the cases while in 1% of the cases an update of the system was suggested as necessary.

Many of the reported incidents are still under investigation. Corrective actions concerning mainly the mitigation of consequences of these incidents are already put in place, but other corrective actions and post-accident measures for prevention of similar incidents may take place after the completion of the investigation.

4. Conclusions

4.1. The value of the incident collection system

The objective of creating a database to gather data from incidents that have happened during the last years in the Greek Petrochemical Industry came to fulfill a gap that existed in this area, although databases covering other industrial sectors already existed in Greece, like the energy sector. Databases, which cover major accidents in the Petrochemical Industry, do also exist at European level. Yet, it is the first time that this is attempted in Greece comprising all incidents of the Petrochemical Industry and not only the major accidents.

All relevant stakeholders – industry included – appraised this effort, as with the distribution of the database to all participating companies and the competent authorities, interested parties will be able to exchange information on incidents and knowledge on prevention measures and mitigation of consequences. Moreover, lessons learned from accidents and statistical analysis of the reported incidents could be an additional tool in the hands of the safety engineers so as to push further the barriers in Safety Analysis in the Greek Petrochemical Industry.

4.2. Near misses

The inclusion of near misses in the reported incidents scheme highlights the very important aspects of these incidents. Even if these events do not have significant consequences, they can provide useful information in identifying deficiencies and vulnerabilities of the site. It has already been stated that there is no fundamental difference in the causes of major and minor events [11], the same statement being valid for near misses too.

4.3. Human factor contribution

Accident analysis reveals the magnitude of human factor contribution in the causes of the reported accidents. The determination of accident causes by the petrochemical companies themselves is related both to the immediate and to the specific causes of the incidents. In this way, the generic categories of mechanical, human and organizational causes are further analyzed into subcategories tracing the exact cause of each incident. This was very helpful in identifying the importance of the human factors related causes, which participated in the 46% of the totally reported incidents. If to this percentage one adds the organizational/management related causes, which can fall in the category of human causative factors the overall percentage reaches the 73% of the totally reported incidents. This high percentage is directly affected by the safety management system of the establishment. Despite the increased hazard awareness and a pro safety mentality that has been registered, deficiencies still exist leading to human related incidents and accidents.

4.4. Lessons learned

A comparison between the causes of the reported incidents and the corrective actions for preventing them from happening again shows clearly what was mentioned in the previous paragraph. Indeed in most of the cases (where corrective actions are mentioned) changes in the design and development of procedures have been proposed. If one takes a look at the organization related causes the main stream is: unavailability of procedures (19%) and design deficiencies (17%). Again, in cases where the main registered cause was mechanical failure, a deeper investigation could have probably led to an organization related failure since the existence of proper procedures or the correct design and the adequate maintenance could have prevented the failure. Our investigation could not go in such depth for every incident. For the more important ones, the analysis showed that in certain cases the incident could have been prevented with a better safety management system of the installation in place.

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