

Statistical Analysis of Accidents Reported in the Algerian Oil Refining Industry for the Period 2003–2013

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Abstract

The risk of major is associated with the presence of dangerous substances at such quantities and under such conditions that an uncontrolled accident with potential adverse effects to human health and the environment. That is why the accident become a detriment factor in many type of industries who constitutes a potential source of human loss, equipment damage and environmental impact and as the oil refining industry is by its nature subject to the most hazardous industrial conditions and it is important to take into consideration that in a number of cases, these fatalities and serious injuries cost a million dollars. To help remediate these events and reduce their cost, the present study provides a review of accidents occurred in Algerian oil refining industry during the period of 2003 to 2013. The focus of this paper is analyzing these cases with a view to understand the potential damage of various type of accidents events, the main causes of accidents and extreme natural impact to identify several patterns which may be useful to illustrate what the industry should learn from major accidents and in such a way create opportunities for the future to prevent new major accidents.

1. Introduction

Algeria has four operational crude oil refineries and one condensate refinery, with a total nameplate capacity of 562000 bbl./d. The country's largest refinery, Skikda, is located along Algeria's northern coastline and is the largest refinery in Africa. It has the capacity to process 300000 bbl./d of crude oil and accounts for more than half of Algeria's total refinery capacity. Skikda processes the Saharan blend, which derives from the Hassi Messaoud oil fields.

Algeria's two other coastal refineries, Arzew and Algiers, each one have the capacity to process 60000 bbl./d of crude oil. The country's inland refinery, Hassi Messaoud is connected to local oil fields and supply oil products to nearby areas [1].

The availability of liquid petroleum in the form of crude oil and its refined products is a key driver for all sorts of activities in modern society; its widespread use also inevitably results in accidental and intentional releases [2] and in an evolving world the expansion of industry is a necessity. Such an expansion is usually associated with an increase of industrial accidents [3]. For this, the refining industry finds itself the subject of a range of major accidents (explosions, fires, emissions of dangerous materials...etc.) that have occurred over the last decade [4]. Each year, Algeria sees a number of deaths, injuries and property losses due the accidents resulting of petroleum refining operations, which has become a menace to human safety such as the Skikda 2004, Skikda 2005, and Arzew 2007. The impact of those accidents is primarily perceived as a major environmental problem, but associated socio-economic effects also play an important role [5]. That is why accident statistics are important measures for the success of safety programs add determining if their procedures are working effectively [6]. In order to assess how life safety is being affected year after year, this paper presents an overview of accidents related to petroleum refining in Algeria during the period 2003-2013. A detailed analysis of over 44 accidents / incidents covering all types of accidental events is presented. Statistical comparisons are made based on the type and the causes of accidents. The basic idea of the document is to provide a collection of information that can help to understand and to control this type of events.

2. Overall statistics

A series of major accidents on refinery sites across Algeria in the late 2000s and early 2010s led to growing concern over the safe operation of industrial sites, particularly those which could present major hazard effects to local populations. Considering the

economic importance of the Skikda and Arzew refineries and the absence of data on accidents in refineries of Algiers and Hassi Messaoud, our study will focus on statistical analysis of accidents related to Skikda and Arzew refineries.

Table 1: The history of refining accidents in the period of 2003-2013

Date and site	Unit type	Equipment	Substance	Ignition source	Primary accident	Damage
10/06/03 Skikda	Unit 100	Heater	Gas	Flame	fire	- 3 injuries
---/06/03 Arzew	Ammoniac Unit 2			Bursting of a beam of heating diesel	Explosion	- 2 fatalities + material damage
16/07/03 Arzew	Unit 22			Propane release	Fire	No injuries or damage
---/10/03 Arzew	Ammoniac unit			Bursting of a beam of heating diesel	Explosion	- 1 fatality + material damage
19/10/03 Arzew	Train 300			Gas release	Fire	No injuries or damage
19/01/04 Skikda	Unit 40		LNG	Gas leak	Explosion	-27 fatalities +74 injuries - 3 units are destroyed. - 800 million of damage
21/04/04 Skikda	CTE	Basin 1-cell A	Gas	Spark	Fire	No injuries or damage
03/10/04 Skikda	Unit 100	Top reactor 100-R3	H2	Auto inflammation of H2	Fire	No injuries or damage
20/11/04 Skikda	Central laboratory	Room Bitumen	bitumen	Flame	Fire	Destruction of the conduct of gases and extractor
17/03/05 Skikda	Unit 1020, section A	First cell cool tower	hydrocarbon and gas	Spark	Fire	Destruction of engine, chimneys and wiring.
15/08/05 Arzew		Pipeline 30	Condensate	Condensate leak	Fire	No injuries or damage
24/09/05 Skikda	Natural area	Pipe 22 inches	Crude reduced	Gas leak	Product release	- Soil contamination. - Cracking of pipe section. - Impact pollution.
05/10/05 Skikda	tanks 105, 106			Accumulation of gas	Explosion	- 2 fatalities + 7 injuries - 6 million \$ of damage
21/01/06 Skikda	At weight scales passage	Brak of tank of truck	Bitumen	Gas leak	Product release	- Soil contamination.
06/06/06 Skikda	Industrial area	Pipe	Crude reduced	Flame	Fire	- Calcination of pipe
09/08/06 Skikda	Plat form SH/ENG		Brushwood	Spark	Fire	- An area de100 m2 brush is burn
25/02/07 Skikda		Truck			Falling	- 1 fatality
13/06/07 Skikda		Recovery tank		Driver inattention	Skidding of vehicle tank	- Failure of line of fire network system
24/10/07 Skikda	Unit 100	Pneumatic transmitter	Naphta B	Spark	Fire	- 1 fatality - Damage of: electrical and instrument cables
09/11/07 Arzew		Methanol enip	Methanol	defecting of a gas mixer	Explosion	- 7 injuries + material damage
11/06/08 Skikda	Naturel area	Sludge pit	Hydrocarbo n waste	Hot point (fiery debris)	Fire	- Shutdown of process pumps, coolers, pollution

07/07/08 Skikda	Unit 62	Vessel	HCl		Explosion	Distraction of vessel, automatic valves, remote control and loss of HCl
-- /02/09 Skikda	Air conditioning			Short-circuit caused by flooding	Fire	No injuries or damage to materials
03/04/09 Skikda	Topping 10	Valve flange	Gas-oil	Braking of flange, fuel release	Fire	- 3 Injuries +damage of : pipe, instrument cables
30/07/09 Arzew	Training center				Fire	- 3 fatalities
24/09/09 Skikda	Air conditioning		Hydrocarbon and gas	Hot point	Fire	Distraction of electrical equipment
10/11/09 Skikda	Unit 10	Transformer		Infiltration of rain water	Explosion	- Shearing of the terminal box of the transformer
---/02/10 Skikda	Reforming unit		petrol	Hydrogen release	Fire	No injuries or damage
12/03/10 Skikda	Storage area	water output of tanks	Gas-oil	Contact of the steam pipe MS	Auto inflammation	- Contamination water and soil
19/12/10 Arzew				Valve left spring of petrol,	Explosion	- 1 fatality + 3 injuries
05/02/11 Skikda	Reforming Unit	electric transformer	electric current	Increase of the current intensity	Electrical failure	Destruction of electrical cables and transformers
06/02/11 Skikda	Unit 100	Exchanger E1		Compressor voltage down	Hydrogen leak	Destruction of: exchanger, compressor
11/03/11 Skikda	Unité 100	Pipe	Fuel	Leak in the pipe	Leak	Deterioration of the pipe line Pipway
05/03/12 Skikda	Reforming unit		Petrol		Explosion	Material damage
21/06/12 Skikda	All site				Electrical failure	No injuries or damage
22/10/12 Skikda	Unit 30			Pipe burst	Leak	-Temporary shutdown of the unit
17/12/12 Skikda	Unit 11			Gas release	Explosion	- 3 Injuries + material damage
23/12/12 Skikda	Unit 200				Gas release	No injuries or damage
03/01/13 Skikda	Unit 100	Heater 100-F-1	Naphta B and H2	Burner flames	Explosion	- 2 Injuries - Deterioration of: heater and electrical cables
13/02/13 Skikda	Unit 11	Electrical substation.		Short-circuit	Fire	No injuries or damage
06/03/13 Skikda	Deposits			Spark	Fire	Material damage
06/08/13 Skikda	Unit 100			pump failure	Fire	No injuries or damage
10/08/13 Skikda	Unit 100			flame rejected by the torch	Fire	No injuries or damage
09/07/13 Skikda				Landslide	landslide	- 1 fatality + 1 injury
-- /02/09 Skikda	Air conditioning			Short-circuit caused by flooding	Fire	No injuries or damage to materials
03/04/09 Skikda	Topping 10	Valve flange	Gas-oil	Braking of flange, fuel release	Fire	- 3 Injuries +damage of : pipe, instrument cables
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06/08/13 Skikda	Unit 100			pump failure	Fire	No injuries or damage
10/08/13 Skikda	Unit 100			flame rejected by the torch	Fire	No injuries or damage
09/07/13 Skikda				Landslide	landslide	- 1 fatality + 1 injury

The information collected about each accident has been summarized in the table 1, who presents data on accidents in the oil refining industry during 2003 to 2013.

In Table 1 an overview is provided of a numbers of accident / incident that have occurred over the last 11 years. Each accident includes, according to availability and as it was specified in the corresponding reference:

- The date of the event;
- The company name;
- The type of accident and the quoted prime cause (whether it started as a fire, explosion or toxic release);
- The specific place it happened (as quoted);
- The chemicals involved (substances quoted);
- The number of deaths, injuries, and material damage

3. Discussion

3.1. Number of refining accident analysis

The distribution of reported incidents in the Algerian refining industry per year and for the period 2003–2013 is shown in figure 1. Refining accidents are considered to be high in Algeria; the overall number of accidents is 44 declared accidents/incidents over the period 2003–2013. The annual average of accidents which occurred between 2003-2008s1 and 2008s2–2013 were 21 and 23, respectively.

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 (2012–2013), noticing that in 2009, the frequency increases by about 60 % on the previous year's figure. Figure 1 shows the trends of the accidents over this period.

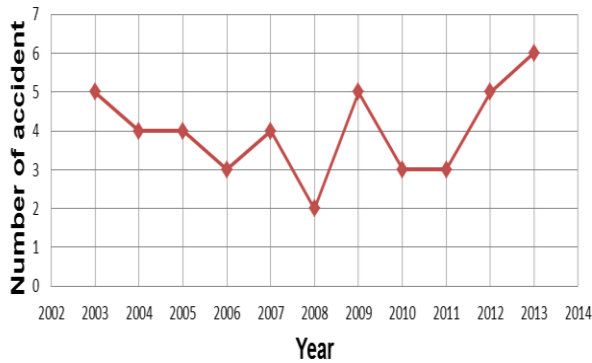


Figure 1: Annual number of oil refining accident in Skikda and Arzew per year of occurrence (2003-2013)

3.2. Analysis according to the accidents causes

The identification of the accident initiators is obviously a key aspect of the overall risk assessment and great care must be put into its completeness since those accident events not included at this stage are very unlikely to enter in the analysis at a later stage [7].

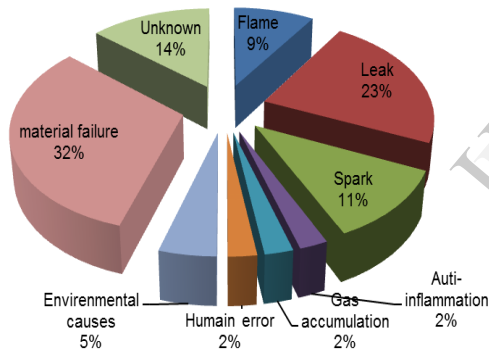


Figure 2: Primary causes of accidents oil refining accident in Skikda and Arzew (2003-2013)

Incidents are caused by a combination of events coming together to produce the final outcome [8]. The following analysis shown in figure 2, explores the incidence of refining of different sizes in terms of the primary event or operation in progress. Accidents for which the relevant information was not available or where the cause was not one of those given are listed under "Unknown".

As showed in figure 2, material failure was the most frequent cause of accident with 32 % and the leak or product release was the second most frequent cause with 23 %. The rest were spark with 11 %, open flame for 9 %, environmental causes of 5 %. While auto-inflammation, human error, gas accumulation played a minor role 2 % for each.

3.3. Types of primary accidents

What type of accident is most likely to occur at the refinery? This is the famous question still waiting for answer. The events recorded in this study indicate that the fire is the most frequent in the total number of occurrence with 20 accidents from total of 44, followed by the explosion by 11 accidents (see figure 3).

With 44 cases as indicated in Table 1. Fire and explosion together accounted for 75% of total cases. Toxic gas release and electric failure were the third and the fourth most frequent, respectively. Incidents involving explosion, product release and electric failure have been much more prevalent in refining operations. For incidents involving fire, overall numbers have trended downward since the early-mid 2008s (see figure 4). There are two major causes of refining fires, the first one is the spark and the second is the flame, the third is the secondary effects such as short-circuit or equipment failure...etc.

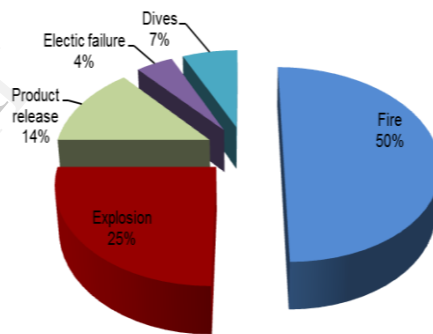


Figure 3: Types of primary accidents of oil refining Skikda and Arzew (2003-2013)

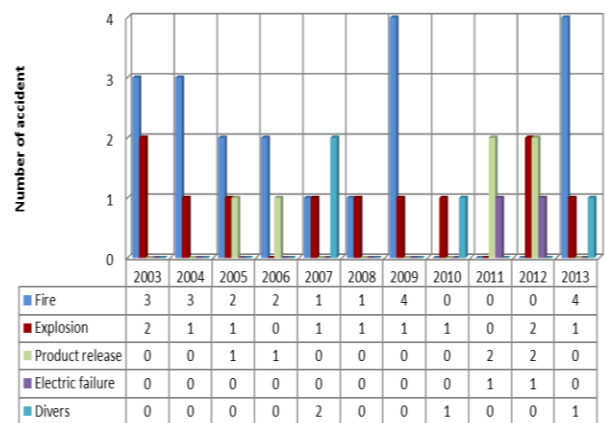


Figure 4: Types of primary accidents of oil refining Skikda and Arzew per year (2003-2013).

3.4. Substances involving in accidents of Algerian oil refining industry

Figure 5 present the substances involved in the accidents of the Algerian oil refining Industry for the period 2003-2013.

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.

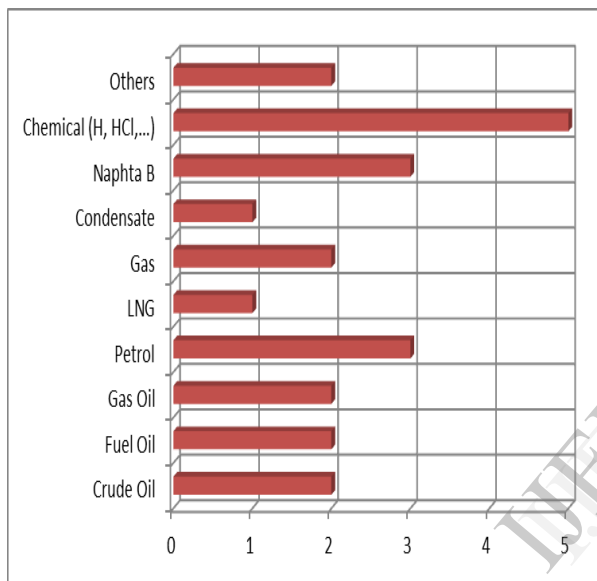


Figure 5: Substances involving in accidents of Algerian oil refining industry

The most usual substances involved in incidents are chemical substances such as HCl and H, petrol and Naphta B, were present in 11 cases. Crude oil, fuel oil, gas oil and gas were also frequently involved in incidents and were reported in 8 cases. In 1 incident LNG was involved, while condensate and other heavy hydrocarbons (H/C) were present in 1 and 2 incidents, respectively.

3.4. Refining accidents and the related injuries and fatalities

The review reports 142 injuries (including 39 fatalities) in 2003-2013 which resulted from fire and explosion related incidents. The information has been broken down into five categories: fire, explosion, product release, electric failure and others.

Figure 5 present the refining accidents and the related injuries and fatalities. Product release and electric failure presented as the event causing the least of death or injury. However, explosion was

identified as the principal cause of fatalities and injuries. Fire was the most frequent type of material loss with 10 of 22 cases. Knowing that, in case of an accident starting with an explosion (25 %), fire follows preferentially. If fire occurs first (50 %) a following explosion is expected. However, the most probable global sequence is an explosion followed by fire.

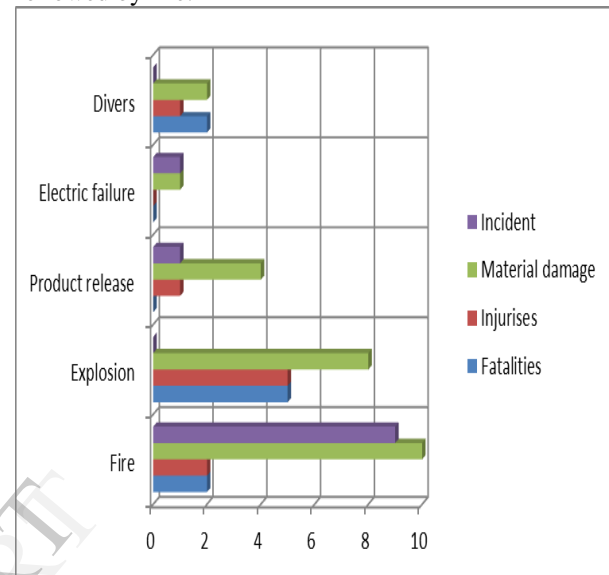


Figure 6: Refining accidents and the related injuries and fatalities

The population affected by the accidents is divided into two classes according to the entity of the consequences suffered: number of deaths, number of injuries. Figure 6 presents all the information on these classes. The accident that caused more deaths happened in the refinery of Skikda, 2004, where a series of explosions killing approximately 27 people. The total number of injuries is 142. In 27% of accidents there were no injured persons. The accident that caused most injuries happened in the refinery of Skikda, described above with 74 injuries human beings.

3.5. Accident location

Accidents were classed into two categories depending on the place where they occurred: the refining of Skikda and the refining of Arzew. As showed in figure 7 the most of the accidents are concentrated in the in the largest refinery in Algeria: Skikda refinery as expected, probably because major industrial activity is there, the massive presence of hazardous substances, worn out equipment the non-safe use material in the refinery explains the entity results. Nevertheless it is of great interest that 80% of all accidents are concentrated in the Skikda refinery, but it should be reminded that, this conclusion is based on the

number of accidents reported and that in some refineries, due to the political, economic or social conditions, several accidents are not reported in the international databases and media, especially in recent years databases.

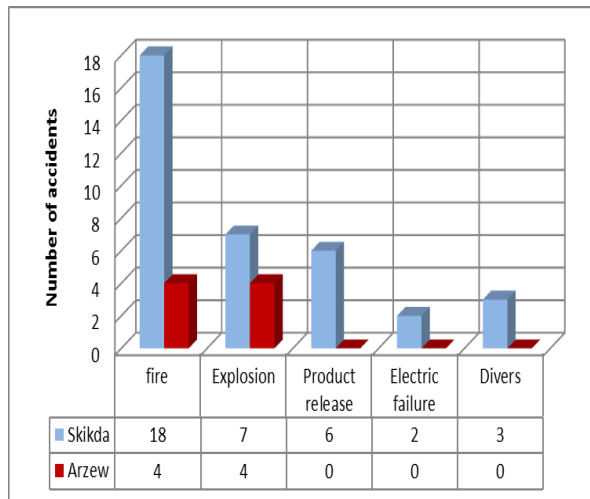


Figure 7: Refining accidents and the related location

4. Summary and conclusion

Contrary to popular perceptions after recent catastrophic events, refining accident frequencies in Algeria have not decreased significantly over the last 10 years, particularly in the last few years, despite overall the improvement of safety, development of risk analysis techniques and the establishment of more restrictive directives and regulations did not lead to a decrease of the number of accidents involving fire and explosion phenomenon. This permanent presence of catastrophic accidents is related to several factors such as equipment failure is usually due to the worn out equipment and their mishandling as well as bad maintenance operations. However, major accidents due to refining operations, have had bad consequences on the reputation of oil refining in Algeria

This paper reviews 44 accidents occurred in Algerian refining industry facilities over last 11 years. The historical analysis has shown that the frequency of refining accidents was fairly constant with a slight increase over the last two years. Most of these accidents have occurred in the most importance refinery in Algeria: Skikda refinery (from which, furthermore more information is available).

The most frequent sequences are fire and explosion account for 77 % of the accidents. The results show that 32 % of accidents occurred in oil refineries are

caused by equipment failure. Other causes were product release, open flame, spark...etc. This suggests the need to further promote the training of employees, and a further improvement of safety measures, especially in storage areas (Tanks), because most of those accidents would have been avoided if good engineering in design, good maintenance operation has been practiced and safety management program has been implemented and executed.

5. References

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