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STUDY OF BOIL-OVER PHENOMENON, THE ALGERIAN PETROLEUM AS A MODEL FOR INSPECTION

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ABSTRACT

With the development of oil facilities, development of industrial security and evolved methods of preventionn but industrial risks always remain present. In this work, we we'll examine a very serious phenomenon, which "Boil-Over". This phenomenon appears in petroleum reservoirs (oil has a high viscosity), and that in the event of a fire on the roof of the tank with the presence of water at the bottom of the tank. We chose the Algerian Petroleum to conduct this study. We will talk to the disastrous results of this phenomenon, and risks to all people, equipment and the environment.

Keywords: *Safety, Environment; Storage, Fire, Boil-Over.*

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1. INTRODUCTION

Oil is the primary source of energy requested worldwide, with representation from 37% compared to other forms of energy. Algeria is one of the largest producers and exporters of crude oil, it is the 18th producer of oil, 9th producer of natural gas and 8th exporter of natural gas in the world [1]. In 2014, Algeria produced 66.0 million tons of oil, the equivalent of 1.53 million barrels per day. Algeria rank is the 3rd in Africa behind Nigeria and Angola [1].

Industrial Security is to secure the safety of individuals and the workplace through the procedures used to maintain security and safety within enterprises and institutions and its facilities. In oil installations, there are many dangers, such dangers mechanical, chemical, electrical, and so on.

We will talk in this paper, on one of the big risks (major risk) and that occur in places petroleum storage, this threat or phenomenon called Boil-Over. We chose the Algerian Petroleum to conduct this study. We represent the identification and estimation of this phenomenon (causes and consequences and prevention measures such as this phenomenon).

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2. DEFINITION OF PHENOMENON BOIL-OVER

The boil-Over is a phenomenon long recognized for flammable liquids. There are three conditions in order to verify this phenomenon. The conditions are:

- Fire Bac roof;
- Presence of water in the tank bottom;
- Liquid has a high viscosity.

The kinetic of phenomenon Boil-Over as follows: when you have a fire in an open bac containing a liquid hydrocarbon having a wide boiling range. Ten percent of the tank volume is involved in this disaster occurs. Small cuts down this hydrocarbon boiling rise to the surface and feeds the fire, while the heaviest cuts to high boiling flow to the tank bottom and form a warm layer called "heat wave", once this wave reaches the water, located at the bottom of the tank directly evaporates. The water steam acts as a piston on the remaining quantity of hydrocarbon, and expels out the tank (like a ball of fire) before falling as rain flames) [2].

The Boil-Over generally occurs suddenly after a long period almost stationary fire, it induces an uncontrollable fire which may in the worst case, completely or partially destroy the infrastructure of fight against the fire, and endanger firefighters involved around the tank even when the surrounding population did not evacuate. Therefore, even if the phenomenon of kinetic allows the protection and evacuation of residents, prior fire often extends over several hours. This phenomenon is the cause of violent projection of fuel, boiling the contents of the tank, the extension of the flame and the formation of a fireball. Five serious incidents involving Boil-Over phenomena are:

- Yokkaichi (Japan), October 15, 1955.
- Tacoa (Venezuela), December 19, 1982.
- Milford Haven (UK), August 30, 1983.
- Thessaloniki (Greece), 24 February 1986.
- Port Edouard-Herriot (France), June 2, 1987.

3. GOVERNING EQUATIONS

3.1. Boil-Over factor propensity (PBO)

In order to take account of semi-empirically the conditions presented above for characterizing the tendency of the hydrocarbon to undergo Boil-Over, a propensity factor (PBO) has been defined as follows [3, 4]:

$$\mathrm{PBO} = \left(\left(1 - \frac{393}{T_{eb}} \right) \left(\frac{T_{eb} - T_{st}}{60} \right) \left(\frac{\upsilon}{0.73} \right) \right) \tag{1}$$

with:
T_{eb}: the average boiling temperature of the hydrocarbon [K];
T_{st}: Crude Storage temperature [K];
υ : Hydrocarbon of the kinematic viscosity at 120 ° C [m²/s].

The choice to consider a Boil-Over scenario will be based on the following criteria:

- PBO≥0.6 consider a BOIL-OVER;
- PBO<<<0.6 do not consider a BOIL-OVER;
- PBO< or close to 0.6 prudently consider a Boil-Over (eg limiting case of some kerosene).

Table (1) shows the value of the propensity factor for some hydrocarbons.

Table.1. Boil-Over factor propensity for some kinds of hydrocarbons [4, 5].

HC	PBO	Boil-Over trend
heavy crude oil	6.76	+
Crude light	1.83	+
Fuel oïl	3.03	+
Diesel	1.2	+
Kerosene	0.53	-
Essence	-0 .25	-

Table (2) represents the characteristics of the Algerian crude oil that contained in the storage tank.

Table.2. characteristics of the Algerian crude oil that contained in the storage tank.

Ambient operating temperature	ambient
Boiling point	504 [K]
critical temperature	686 [K]
Gas density at 300K	6.69 [Kg.$^{m-3}$]
Heat of combustion	4.33 107 J.Kg^{-1}
Heat of vaporization at boiling T	2.92 105 J.Kg^{-1}
Liquid density at 288K	802 [Kg.m^{-3}]
temperature at 15% distilled	348 [K]
temperature at 85% distillation	890 [K]
Upper Flammable Limit	7.6%

3.2.The characteristics of the fireball

This phenomenon can’t be achieved only if there is water in the bottom of the tank. We can calculate the quantity of water (VEFB) in the following relationship [4]:

$$\mathrm{VEFB} = \frac{\mathrm{V}}{200} \tag{2}$$

The thick of water at the bottom of the tank (EEFB) is given the following relationship [4]:

$$\mathrm{EEFB} = \frac{\mathrm{VEFB}}{\mathrm{S}} = 4\frac{\mathrm{VEFB}}{\pi \mathrm{D}^2} \tag{3}$$

Where, (S) is the surface of the first ferrule (bottom ferrule) of the tank.

For the characteristics of the fireball, the RBF is the radius of the fireball, it is given on the basis of the mass (M) of crude, it is given by the formula number (4) [4].

$$\mathrm{RBF} = 1{,}192\,\mathrm{M}^{\frac{1}{3}} \tag{4}$$

The life expectancy of the fireball (DVBF) is given by the following empirical formula [4, 6]:

$$\mathrm{DVBF} = 0{,}295\,\mathrm{M}^{\frac{1}{3}} \tag{5}$$

The distance of significant effects (RES) is given by [4]:

$$RES = 8{,}23\, M^{\frac{1}{3}} \tag{6}$$

The distance of serious effects (REG) is given by the formula number (7) [4].

$$REG = 5{,}86\, M^{\frac{1}{3}} \tag{7}$$

The distance of very serious effects (RETG) is given the following relationship [4]:

$$RETG = 4{,}68\, M^{\frac{1}{3}} \tag{8}$$

The interface hydrocarbon pressure wallpaper water (P_i) is given by [4]:

$$P_i = P_{atm} + \rho g h \tag{9}$$

The trigger of the BOIL-OVER time (TDBO) is given by [4]:

$$TDBO = \frac{h}{116667} 10^9 \tag{10}$$

The thick of water at the bottom of the tray (EEFB) is given the following relationship [4]:

$$EEFB = \frac{VEFB}{S} = 4\frac{VEFB}{\pi D^2} \tag{11}$$

The height of the fireball of BOIL-OVER (HFBO) is given by [4]:

$$HFBO = 2000\ EEFB \tag{12}$$

3. RESULTS AND INTERPRETATION

Also it knows that one liter of water gives a thousand and seven hundred liters of water vapor when evaporation. The figures (1) and (2) show the quantity and thickness of the water content in the bottom of the tank.

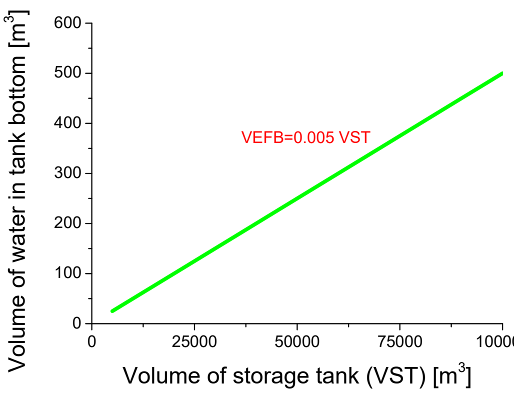

Figure.1. The volume of water in tank bottom.

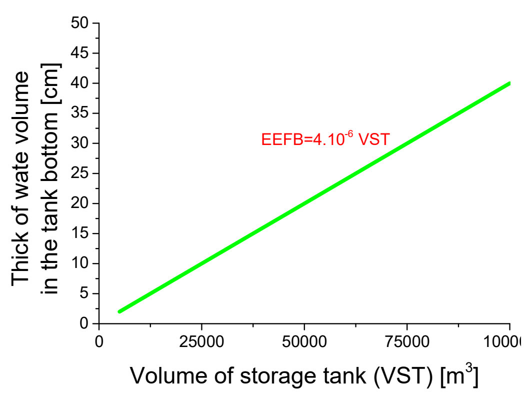

Figure.2. The thick of water volume in the tank bottom.

The figures (3, 4, 5 and 6) endanger the fireball properties, resulting from evaporation surprises and rapid of the water (1 Liter water (liquid) = 1700 liters water vapor).

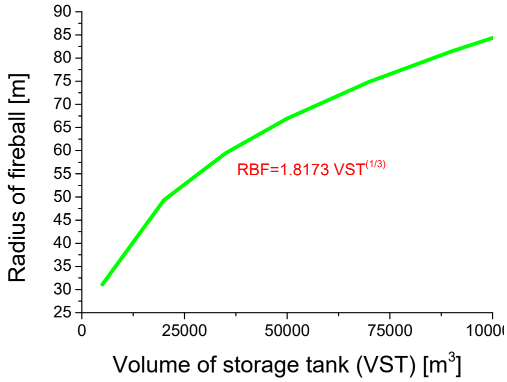

Figure.3. The radius of the fireball.

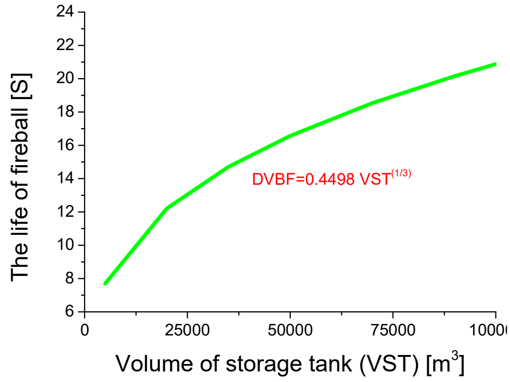

Figure.4. The life of the fireball.

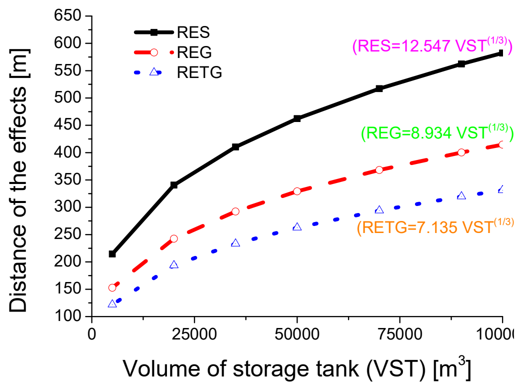

Figure.5. The distance of the effects.

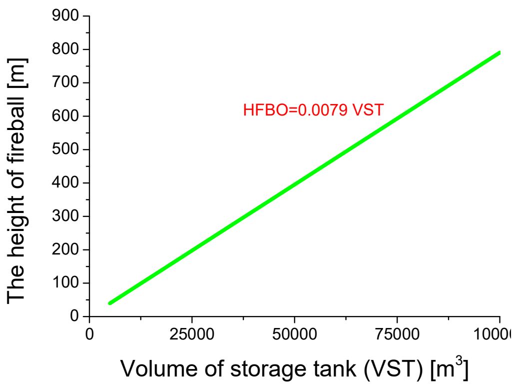

Figure.6. The height of the fireball.

As shown in Figure (5), the Boil-Over occurs after a long time period to fire almost stationary on the surface of liquid (Fuel Oil, Diesel, heavy crude oil, crud light), But very difficult to control this fire on the surface of the liquid. Table (3) shows a summary of the planner of phenomenon studied (fire in the storage tank roof).

Table.3. Information about the incident.

area	**Tank storage area**
function	Storage of stabilized crude oil
scenario	Fire at storage tank roof, with the presence of water in their bottom.
dangerous phenomenon	Boil-over (the potential risk)
rejection time (hour)	Depending on the storage tank height and the liquid density (according to the equation number (1) and (10)).
concerned gravity matrices	On site (the storage area and the neighbors areas)

Now we will mention some of the consequences of such apparently disastrous, such as:

A. Economically

- Losses surfaces of equipment and facilities;
- Production stopped in the center in which the disaster occurred and deterioration of basic infrastructure;
- Rehabilitation and development investment plan;
- Replacement of damaged units;
- Compensation for victims;

B. Socially

- Loss of workers;
- direct allocation of casualties to hospital;
- Social and psychological care of affected agents;
- Anxiety and stress affecting the industrial pole;
- Worry and anxiety of residents and families of industrial workers;
- Rehabilitation of the collective complex (Production Center).

C. Environmentally

- In general, ocean pollution (air, earth, water)

To avoid Boil-Over phenomenon must:

- must be the water draining operation From the bottom of the tank, the operation periodically
- The heat on the tank should be checked where possible.
- Inspection of storage tanks (protective equipment);
- Periodic testing of fire trays fixed systems;
- fixed and mobile establishment of extinguishing equipment needed to fight anti fire (tank fire);
- Setting up the better and sufficient quantity of the foam;
- Formation and training of the intervention team on tank fire conditions (simulation exercises).

Security throughout the enterprise is a very important thing, it is an objective mind. Its purpose is the absence of circumstances likely to cause, either an accident or death of persons, either degradation or loss of equipment and property, either to cause adverse effects on the environment. These are the concept of risk in its many aspects (health, safety, environment), which shows the need to implement security. To this must be:

- Sure and enforce the necessary prevention to eliminate the risk of accidents of any kind;
- Control and report any situation or process contrary to the rules and the legal provisions on safety, hygiene, health and the environment;
- Inform, educate, train control teams against the fire and environmental risks to develop staff knowledge according to the material provided on the site;
- review and updating emergency plans;
- updating POI and PPI;
- updated hazard studies and impact assessment.

4. CONCLUSION

This study is a summary of the phenomenon of writing. Is a very dangerous phenomenon and with disastrous results of the first class. The main reason for the occurrence of the disaster is a fire on the roof of a tank of liquid incombustible outbreak, liquid with a high viscosity; at the same time the presence of water in the bottom of the tank. Ten percent of the tank volume is involved in this disaster occurs. The kinetic of phenomenon Boil-Over as follows: at the beginning of fire at the tank, the product occupies the entire volume of the tank with a substantially homogeneous composition. Due to the radiation of the flames on the surface of the liquid, the liquid undergoes a distillation resulting in separation light cuts of the heavier cuts, the latter progressively descending towards the bottom of the tank under the effect of gravity; it is the formation of a heat wave. This phenomenon continues until the heaviest cuts (heat wave), reach the water located in the tank bottom. These heat waves at a very high temperature (much more than a hundred degrees). The contact between the wave of heat and water causes the sudden vaporization of the water. This abrupt vaporization leads to a large increase in volume and plays the role of piston suspending the flammable liquid is left in the tank. Part of the liquid overflowing from the tank, and another is suspended in breaking up into drops, and vaporizing crossing the flames to form a fireball during combustion. Can be said in conclusion, prevent the risk returns to place actions in a loop between knowledge and the identification, management and risk control.

Nomenclature

Symbols

D	diameter of tank, m
EEFB	depth of water in the bottom tank, m
DVBF	life of the fireball, s
g	gravity, $m.s^{-2}$
h	level of product in the tank, m
M	product mass, Kg
RBF	radius of the fireball, m
REG	distance of serious damage, m
RETG	distance of very serious effects, m
RES	distance significant effects, m
T	temperature, K
P	Pressure, Nm^{-2}
PBO	BOIL-OVER propensity factor
V	volume, m^3
VEFB	Water volume in the tank bottom, m^3

Greek letters

ρ	density, $kg.m^{-3}$
υ	kinematic viscosity, $m^2.s^{-1}$

Indices / Exhibitors

atm	atmospheric
eb	boiling
i	Water bottom hydrocarbon interface
st	storage

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