BEST PRACTICES FOR CONTROL OF MAJOR FIRE ACCIDENTS AT THE CENTRAL PROCESSING FACILITY (CPF) IN IN AMENAS. QUANTITATIVE RISK ASSESSMENT STUDY.

Abdelatif DOUADI[(1)]
(1) Algerian Petroleum Institute, IAP Spa, Avenue du 1er Novembre Boumerdes 35000, Algérie
E-mail: douadi.abdelatif@gmail.com

Abstract- In recent years there have been many spectacular accidents when working in hydrocarbon processing sites which have resulted in major fires and explosions causing the loss of lives and damage to property.

For this reason Sonatrach has to address these problems by looking for potential weaknesses in all aspects of its regulations, procedures and risk assessment which are the heart of the HSE management systems.

In this modest work we have dealt with those weaknesses in a way that can assist Sonatrach to reduce the potential for major fire accidents.

We have completed a comparison between the UK and Algerian legislation which allowed us to come out with a gap analysis that can help to narrow the gap between them.

We have stayed at site for a long period and we have talked with many operators in different divisions which allowed us to find out the best practices existing at the plant regarding fire protection.

We have also looked for the best practices that should be in place which can help to reduce the occurrence of major accidents in the site.

The most important part of my work is the achievement of quantitative fire risk assessment studies for two real case studies, Off-specification condensate storage tank and On-specification LPG storage bullet, which can give the site line- management an idea about the frequency and the consequence of such events.

We have found that the risk of these events taking place of such major fires is acceptable and therefore no control measures are envisaged at the current time.

Keywords: Quantitative Risk Assessment-Best Practices

1. INTRODUCTION

Hydrocarbon industry processes involve the handling of an enormous number of combustible and flammable materials. Storage and processing operations involving these materials provide countless opportunities for their release and subsequent ignition. It is important to analyse all materials and processes for the potential for fire including production, manufacturing, storage, or treatment facilities.

Accidents in the hydrocarbon industries around the world have resulted in major consequences. This includes loss of life, property destruction and environmental damage. However, in the last two decades the international average number of major accidents has significantly decreased which has not been the case for Algeria. This reduction in the international average may be attributed to all the improvements and innovations realised during this time.

But still the cost of accidents in terms of lives, injuries and assets remains high. As a result, efforts to reduce the rate of accidents are taking new dimensions within the chemical process industry.

Under these circumstances, it is essential to apply approaches which have the aim to understand, assess and reduce those major fire accidents. In our study we will count on the quantitative risk assessment (QRA) approach within the estimating of the frequencies and consequences of rare accidents and this synthesis process that provides a basis for understanding risk. Using this synthesis process, we can develop risk estimates for hypothetical accidents based upon the experience with the individual basic events that combine to cause the accident.

The accidents that SONATRACH experienced in recent years especially the one in SKIKDA in 2004 has led to significant fatalities, huge property damage and financial losses. These accidents have played a major role in the awareness of the senior managers of the importance of safety in general and the control of major accidents in particular.

The central processing facility (CPF) in In Amenas supplies considerable quantities of dry gas, condensate and liquefied petroleum gas (LPG). The occurrence of major accidents in such areas will harm people's lives and the national economy which makes the prevention of those accidents a major priority.

The aim of this project is to highlight an effective QRA approach based on the principle of (identify, assess and control) and also demonstrate its usefulness in application at CPF to help in the control of major fire accidents.

To achieve the aim of the project, the following objectives have been set:

- Analyse the legal framework surrounding the control of major accident hazards in Algeria and worldwide;
- Integrate the fire prevention system in the health safety and environment management system to ensure major risk prevention and control;
- Demonstrate the best practices existing at CPF and recommend ones that do not exist;
- Carry out quantitative fire risk assessment on real case studies at CPF by using suitable techniques.

2. AREA OVERVIEW

The In Amenas project, a joint development between BP, Sonatrach and Statoil is some 850 kilometres south of Hassi Messaoud, in the south-east of Algeria. The development includes a gathering system to collect the hydrocarbon fluids from the production wells and transport them to CPF.

The CPF is composed of the following sections:

- Installation of reception ;
- Three identical trains of treatment ;

.

- Section of residual gas compression ;
- Section of storage and expedition of LPG and Condensate ;

Process and common utilities

3. THE STUDY RESULTS

3.1 Gap analysis

There is a big gap between the Algerian regulations on the one hand and the UK regulations on the other. The NFPA standards should not be compared either to the Algerian regulations or to the UK ones. The NFPA standards contain very detailed codes of various aspects related to fire such as fire safety engineering, fire prevention, fire management… etc.

In my point of view, it is not fair to compare the UK regulations which have been in existence for more than 30 years and the Algerian ones which have been implemented for only 2 years. We can summarise the weaknesses of the Algerian regulations using the following points:

- The Algerian regulations are very generic and do not contain regulations specific to the industrial sites.
- There is no definition of a major hazard site.
- The Health Safety and environment management system is mentioned only by name. There are no details and explanations about it. Duties and obligations about establishing it do not exist.
- Roles, responsibilities and accountabilities are not determined and attributed during the occurrence of the major accidents.
- The emergency plan contains only generalities of its elements. There are no actions or measures mentioned that should be taken during the occurrence of a major accident either on or off-site.
- Simulations and training programs mentioned are very good and useful but should be performed in practice at regular intervals.

3.2 Fire engineering best practices should be present at CPF

A visual inspection of all CO2 cylinders in the turbo-compressor and the turbo-generator should be carried out annually by a competent person. The inspection should include a means of determining if any leakage has occurred and verification that all valves, wires, levers/pulls, pipe-work, markings and operational instructions should be maintained in a satisfactory condition.

In the event of fire, water deluge systems in the three trains will be activated through a button in the central control room (CCR) but if that does not work it has to be activated via deluge valve which is very close to the trains. The same problem can be found in the activation valve in condensate storage and worst because there is no remote activation from the CCR. CPF fire-water deluge systems should be inspected from the floor level annually. They should be free of corrosion, paint and physical damage and should be installed in the proper orientation.

Other aspects of best practices:

- The intervention team has only one fire truck which should be maintained regularly and could be unserviceable from time to time;
- There has to be training for using manual fire fighting equipments especially the portable ones for the CPF operators which can help extinguish fires from the start when it is small;
- There has to be a good maintenance strategy dealing with the huge problems at the CPF such as the diesel pumps;

The chemical storage area should be well arranged to make sure every type of chemical

- is sufficient distance from the others;

The chemical storage area does not contain active fire protection systems. There are only firewater network nozzles which are not sufficient to extinguish major fires such as the ones arising from the methanol storage;

- The foam storage is not considered sufficiently well stored and exposed to the sun;
- There has to be more fire fighting systems in the hot oil area which contains only one chariot of foam extinguisher;
- There is significant doubt concerning the materials used to construct the central control room which should be constructed to provide specific protection criteria;
- There are a limited number of detectors which are not well placed such as the open path gas detectors DGO 14101T and DGO 14102T in LPG storage area. They are placed in the walkway used by the operators;
- In the event of emergency evacuation, operators will find difficulties in evacuating from the CPF if they are in the turbo-compressors or storage zone and the fire in the train one where the only nearest entrance is opened. The other exits are locked for security reasons.

4. APPLICATION OF QUANTITATIVE FIRE RISK ASSESSMENT FOR TWO REAL CASE STUDIES AT CPF

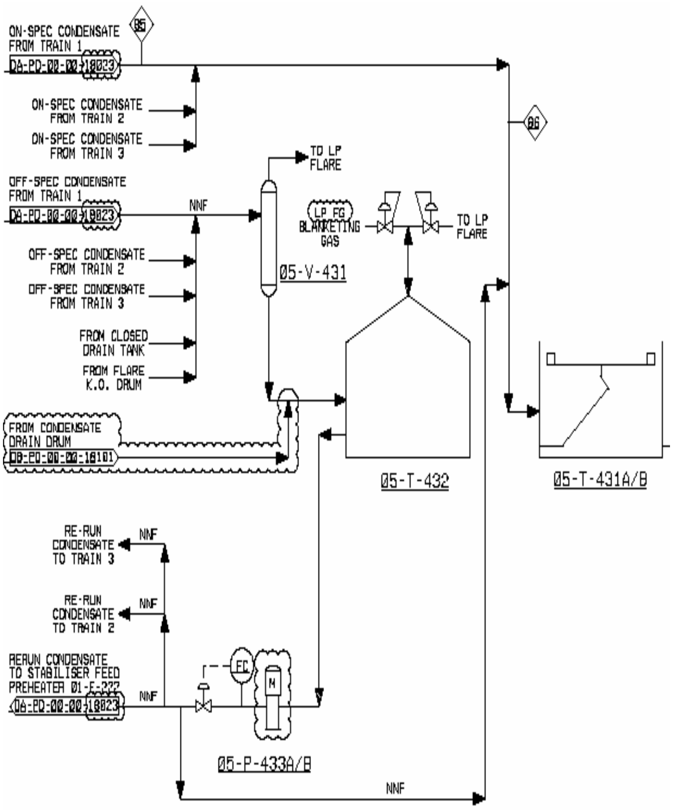
In this part we have dealt with two real case studies at CPF. We have applied one approach of risk assessment which is the quantitative one. We have applied this technique in the condensate storage tank and the LPG storage bullets.

4.1 Condensate storage and export (case study 01)

4.1.1 Process description

The off-spec condensate tank 05-T-432 is a fixed roof type storage tank with capacity 3608m3, equivalent to almost 10 hours of storage at the design production rate. The tank operates at a pressure between 22 mbarg and 12 mbarg. The pressure is maintained within this range by a blanket gas system. Self-regulating pressure control valve 05-PCV-4335 supplies nitrogen to the tank vapour space to maintain pressure and 05-PCV-4330 vents excess pressure to the LP flare system. Condensate flows from the off-spec condensate tank through the tank outlet shutdown valve 05-SDV-4337 to the suction of the condensate re-run pumps 05-P-433A/B. (JK, 2004)

Figure 1: Condensate storage process flow diagram



A connection to a sampling system assembly is provided downstream of 05-SDV-4337 to allow samples to be taken for analysis when required.

4.1.2 Hazard identification

The HAZOP has been used to identify the most serious hazard as a major fire from the offspec condensate storage tank.

This incident is the top event that will be developed in the fault tree. The established HAZOP tables are just some of the identified hazards that can arise from the condensate storage tank.

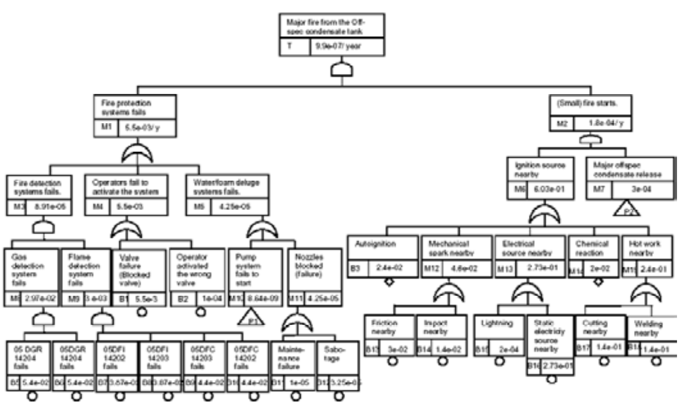
4.1.3 Estimating frequency

In our QRA study, direct historical frequency data is not available in sufficient quantities to provide adequate estimation of hydrocarbon hazard realisation frequency. Thus, FTA can be considered as an alternative where initiating event frequencies will be used for all condensate storage tank fires or releases, with event development modelling carried out to predict the frequencies of hazardous event outcomes, based on an initiating event frequency.

Based on the knowledge of the system and initiating events in the HAZOP study, the tree will be constructed manually. Every event will be labelled sequentially with a "B" for basic or undeveloped event, "M" for intermediate event, and "T" for the top event. The procedure starts at the top event, major fire from the offspec condensate storage tank, and determines the possible events that could lead to this incident.

The data sources are the following: (RPI, 1997), (PDO, 2002), (E&P, 1996), (FRED, 1997), (Lees, 1996), (CCPS, 2000), (CCPS, 2003) and (Jukka-Pekka, 2004)

Figure 2: Section of the constructed fault tree of the Off-spec condensate storage tank 05-T-432



4.1.4 Evaluating consequences manually

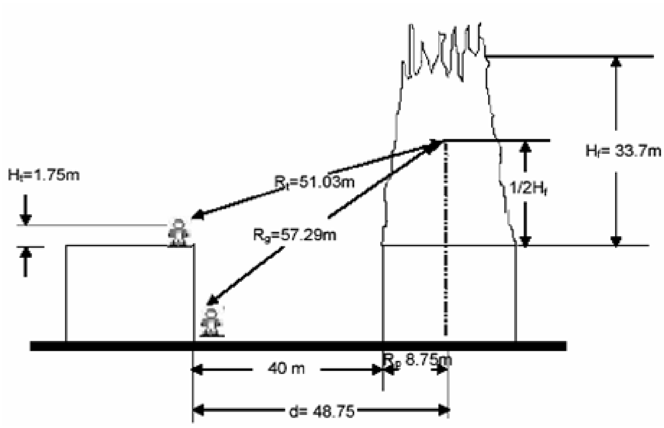
Our condensate Off-spec condensate tank 05-T-432 is a horizontal fixed roof tank. It has 17.5 meters diameter and 15 meters high. Its capacity is 3608 cubic meters. The distance between this tank and the adjacent on-spec tank is 40 meters.

We have determined impact of the Off-spec condensate storage tank fire on adjacent personnel, a series of calculations have been required. We have dealt with this case:

• The radiant exposure to personnel on top of an adjacent tank and others in the ground.

The determination of consequences has been performed by series of calculations.

Figure 3: Schematic of Off-spec condensate tank fire exposure to personnel



We have found that:

The heat release rate (Q) is 752.25 MW

The flame height is 33.70 m

The radiant fraction of heat released is 1.04125

The incident heat flux per unit area to the person on the top of the adjacent tank is 22.87 KW/m^2

The incident heat flux per unit area to the person on the ground of the adjacent tank is 16.15 KW/m^2

The emissive power of the fire is 41.62KW/m^2

The view factor is approximately 0.1

The incident heat flux to the target is 4.16 KW/m^2

As a result of those findings an incident heat flux of 4.16 KW/m^2 will produce first degree burns on unprotected personnel within 16 seconds and second-degree burns within 40 seconds. Emergency actions lasting several minutes can be performed by personnel without shielding, but with appropriate clothing this accident. (Beyler, 2002)

4.1.5 Evaluating consequences using aloha software

For the precedent problem ALOHA gave us these results:

SITE DATA INFORMATION:

Location: CPF (IN AMENAS), ALGERIA

Building Air Exchanges Per Hour: 6.19 (sheltered single storied)

CHEMICAL INFORMATION:

Chemical Name: Off-spec condensate Molecular Weight: 100.20 kg/kmol

Footprint Level of Concern: 750 ppm

Boiling Point: 98.43° C

Vapour Pressure at Ambient Temperature: 0.060 atm

Ambient Saturation Concentration: 64,314 ppm or 6.43%

ATMOSPHERIC INFORMATION: (MANUAL INPUT OF DATA)

Wind: 50 meters/sec from ESE at 10 meters

No Inversion Height

Stability Class: D Air Temperature: 25° C

Relative Humidity: 50% Ground Roughness: open country

Cloud Cover: 0 tenths

SOURCE STRENGTH INFORMATION:

Leak from hole in vertical cylindrical tank

Tank Diameter: 17.5 meters

Tank Length: 15 meters

Tank Volume: 3,608 cubic meters

Tank contains liquid

Internal Temperature: 56° C

Chemical Mass in Tank: 2,602 tons

Tank is 100% full

Circular Opening Diameter: 1 meters

Opening is 1 meters from tank bottom

Soil Type: Sandy

Ground Temp: 25 C Max Puddle Diameter: 40 meters

Release Duration: ALOHA limited the duration to 1 hour

Max Computed Release Rate: 3,260 kilograms/min

Max Average Sustained Release Rate: 2,980 kilograms/ min

(averaged over a minute or more)

Total Amount Released: 143,423 kilograms

Note: The chemical escaped as a liquid and formed an evaporating puddle.

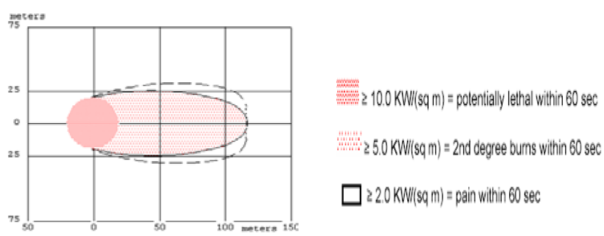
FOOTPRINT INFORMATION:

Dispersion Module: Gaussian

User-specified LOC: equals IDLH (750 ppm)

Max Threat Zone for LOC: 117 meters

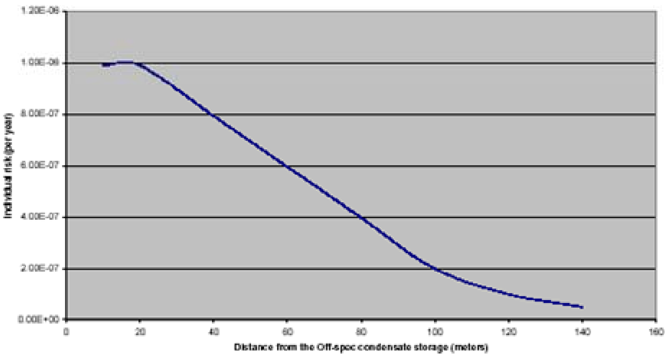
Figure 4: Footprint window



4.1.6 Risk estimation

In our study we will consider only the individual risk. From our frequency estimating and consequences evaluating studies we have found the results shown in the figure bellow:

Figure 5: Individual risk analysis



The risk will be highest at a point located immediately next to the tank. The risk for a given location decreases with increasing distance from the tank. This is due to the decreasing heat flux of the pool fire.

4.1.7 Risk evaluation and decision making

The risk evaluation has been established based on the international risk acceptance criteria. The ALARP principle has been also adopted for risk evaluation.

As a result evaluation of individual risks indicates that individual risk to workers at the CPF to be within the acceptable region. We conclude that additional risk reduction measures are optional.

4.2 LPG STORAGE AND EXPORT (CASE STUDY 02)

We have found the following results:

BLEVE frequency: 9.9E-06 per year.

BLEVE consequences:

ALOHA Software: maximum threat zone for workers is 255 meters.

Risk: acceptable.

5 CONCLUSIONS & RECOMMENDATIONS

As a conclusion of what has been discussed in the present work, the following conclusions are drawn:

- Major accidents prevention has to involve risk assessment process initiated in the design stage and go along side to side with the different activities through the whole life plant including construction, commissioning, operation and decommissioning.

- Algerian legislations regarding major hazards plants are very limited and mainly perspective and did not yet step up to the risk based approach.

- The risk in the two real cases studied in this project is acceptable and no control measures are needed in this time.

- We believe that the following recommendations should be taken into account:

- Adopting new regulations specific to the major hazards sites. These regulations should be detailed and dealing with all types of major hazards that can occur in a major hazards sites.

- Benchmarking from the international legislations and standards by taking the ones that suite our situation and modifying the others until they fit our working environment and culture.

- If there is no changing of the actual laws we suggest that the join venture establish its own code. This code should respect the overall state regulations and be specific to the major hazards site.

- We recommend that the joint venture keep and develop the best practices that we have dealt with in the section 7.3 and take corrective actions dealing with the best practices should exist that we have developed in section 7.4.
- We suggest that further quantitative fire risk assessment have to be done in the other sections in the plant
- The fire risk assessment can be also either qualitative or semi-quantitative one.
- Carry out a study that deals with the uncertainty of data.
- Inclusion of human factors in the quantitative risk assessment which can be done by use of human reliability analysis techniques. Therefore, to avoid under or overestimation of the actual risk, human error probability estimation must be reasonably accurate.
- Carry out detailed study deals with the fire impact to personnel, structures, and equipment.
- Carry out economic study of fire loss.
- Integrate fire prevention system into the health safety and environment management system.
- Carry out other studies deal with the other major accident such as explosions and gas releases.

Extend the present study to other sites to cover also the pipeline network and the wells.

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