2012 4th International Conference on Chemical, Biological and Environmental Engineering
IPCBEE vol.43 (2012) © (2012) IACSIT Press, Singapore
DOI: 10.7763/IPCBEE. 2012. V43. 33

Risk Assessment of Aviation Fuel Shipment

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Abstract. Recently, transition to quantitative statement is required for management risk associated withshipment hazardous loads.This issue describes shipment aviation fuels toairport for assurance that product quality has been assessed, and any deficiencies are addressed by a suitable action plan. The process clarifies responsibilities and provides an audit trail to which Air British Petroleum would be exposed. While performing vapor dispersion, consequence analysis is characterized in regional areas,No attempt has been made to cover all quantitative risk assessment methodologies. A comprehensive coverage of employedenvironmental impact assessment (EIA) is given as anapproach to the principal means of the applied method.However, the complexity of the shipment process and the lack of historical data pursued estimation incident frequency according to the previous expected aviation fuel discharge of similar projects.

Keywords: Environmental Risk Assessment - Environmental Impact Assessment (EIA)- Air Dispersion modeling

1. Introduction

First, it is necessary to differentiate between "hazard" and "risk". A poisonous chemical represents a hazard, since it is possible to envisage an accident in which the contents would be spilt or otherwise discharged. A hazard is thus a situation that, in particular circumstances could lead to harm. While, risk is defined as an event that has a probability of occurrence, and could be either expressed in rational percentage of specific time or operational cost. The risk analysis is set to identification hazards, measurement probability of occurrence and estimating their consequence in virtual values. This carefully considered for public's timely judged to reveal performance in values.The risk assessment can detect hazards during the total life cycle of any complex system in a “cause and effect” analysis. The “cause” is the event that might occur, while the “effect” is the potential impact to a project, should the event occur. In general, risk assessment is an estimation of the frequency of the end-events and an evaluation of the consequence of the end-events (Marvin, 2004)[1].This issue is carried out by Air British Petroleum to determine if any proposed is acceptable to Air British Petroleum for the shipment of aviation fuels (Jet-A1) with a rang to optimization design to update risks associated to grant new Environmental Permit. The shipment length of pipelines can be a significant source of aviation fuel contamination from: (1) drain water; (2) indirect dirt ;(3) surfactants; (4) microbiological growth; (5) other products (from multi product pipelines).In practical analysis, risk quantification is the main purpose of environmental impactassessment in the regional area.This application will ensure project sustainability atvarious levels to control operations and address activities in the buildup areas at western Alexandria.(DNV, 2010)[2].

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2. Hazardous Identification

In general, hazards associated with shipment fuels pipelines will involve fuel storage, distribution, handling and management procedures, taking into account the volatility of the fuels involved, the method of delivery and the potential for a hazardous fuel/air mixture and a heat/ ignition source to be present at the same time. The pipeline will be externally coated with a factory applied layers of polyethylene coating (three layers) and have a cathodic protection system to prevent any corrosion of the pipeline connection (Mouchel/DNV, 2002)[3]. Jet A1 is a flammable liquid with a flash point greater than 38°C The maximum and minimum recorded temperatures in Alexandria West are 36.1°C and 5.2°C, with a mean of 8.17 days per year with a maximum temperature over 33°C per year (statistics report, 2008)[4]. Therefore no flammable Jet A1 vapour hazard to neighbouring properties is expected during normal operations or from spills contained on site. Physical and chemical properties of Jet A1 are summarized below. Note that the precise composition of Jet A1 can vary, so some variation in the figures is expected (Fewtrell, 2000)[5].

Table 1: Physical and chemical properties of fuel aviation fuel Jet A1

Properties	Value
Liquid density	775-820 kg/m^3@15°C - 840 kg/m^3
Boiling Point	150°C Initial
Minimum Flash Point	38°C (40°C Test)
Flammable Limits	1-6% vol
Burning Rate	0.053 $kg/m^2/s$
Pool rate of flame spread	<0.5 m/s
Auto-ignition Temperature	220 °C[1]
Minimum ignition energy	0.2mJ
Vapour pressure	<0.1 kPa @ 20°C kPa
Viscosity	$1.4\times10^{-3} kgm^{-1}s^{-1}$[24]
Latent heat of vaporization	291 kJ/kg (based on kerosene)
Specific heat	2.19 kJ/kg (based on n-decane)

1. Under less ideal circumstances, the auto-ignition temperature may be substantially higher than 220oC. HSL have measured auto-ignition temperatures of 690oC and 540C for tests using sprays of Jet A1 onto heated surfaces (Fewtrell, 2000)[05], but Jet A1 has also been ignited when sprayed onto hot engines with probable maximum temperatures of 420oC (Fewtrell, 2000)[05]. In many circumstances, surface temperatures much higher than 220oC may therefore be required to ignite Jet A1

2.1 Smoke Description

The combustion products of aviation fuel include carbon dioxide, nitrogen oxides and sulphur oxides. Incomplete combustion will generate thick black smoke and potentially hazardous gases including carbon monoxide. However smoke from such fires is buoyant and does not tend to seriously impact people on the ground in the open air. The composition of smoke plume of heavy hydrocarbons is estimated 11.8% CO_2 and 800ppm of CO. At 800 ppm, the time required for incapacitation is about 48 seconds and at 300ppm, the time required is 20 minutes (EIA report, 2002)[6].

Table 2: Estimated potential frequency downwind direction

	Failure frequency (year)	Downwind frequency (year)	Population density (person/km)	Estimated potential frequency (year)
Day Time	1.73×10^{-4}	0.001	0.794	1.37×10^{-7}
Night Time	1.73×10^{-4}	0.001	0.594	1.02×10^{-7}

Based on the potential frequencies of smoke impact, the smoke plume envelope from a fire at the facility in a 5 m/s wind is suggested for planning purposes to limit the height of buildings near to the tank facility and maintain risk levels for up to 10 fatalities within the acceptable envelope of the technical estimation values in Technical Memorandum, (EIAO, 2002)[7].

2.2 Vapor Dispersion

The peak concentration of Jet A1 vapour identified outside the storage tank facility (in Abo Bassasa Village) during normal operations is 0.36odour units (1 odour unit 5.4 mg/m^3) – see Air Quality assessment in this EIA (Section 4.6) (EIA report, 2005)[8].

$$C = \frac{0.36 \times (5.4 \times 10^{-6})(\frac{kg}{m^3}) \times 29}{156 \times 1.2\ (\frac{kg}{m^3})} = 3 \times 10^{-7}$$

This is less than 1 ppm, which is a factor of 10,000 below the lower flammability limit.

3. Consequences Analysis

Obviously, the consequence of an event has impact will influence method of risk evaluation. The management priorities depend largely on the cost of risk analysis. This perceived risks and benefits of performing such study. There are several methods to predict the consequence and hence the impact of accidents scenario for initial and final settings. Joksimovic[9] indicate that risk is composed of two parts:

$$Risk = P\ (accident)\ \times C(consquenc) \tag{1}$$

Where: P is the probability of failure, and C is the consequences of an incidentLoss of containment due to various causes such as corrosion or material/weld defect but is largely dominated by improper operation and lack of training,The consequence may be reduced by a factor of evacuation response at time of incident as explained (Leonardi, 2009)[10].

$$C = v\ n \tag{2}$$

Where:v is the ability to perform vulnerability when incident occur, and n is exposure in number of person or equipment of goods at the incident time. Parry, (1981)[11] attempted to consider public perception of risk rather than just the physical consequences i.e,

$$Risk = \sum_{i=1}^{l} P_i\ \times (C_i)^k \tag{3}$$

where:P is the probability per unit length of incident (i); C is the consequence of incident (i);l is the total length of pipeline segment (s); while k is a parameter to be selected to provide a larger weight to the high consequence accidents than to smaller ones occurring so frequently that the physical effects on the whole population are the same. This leads to the terms safety assessment and risk assessment are interchangeable (Apostolakis, 1978)[12].

$$S_{safety} = 1/Risk \tag{4}$$

Table 3: Estimate of failure frequency per year for storage facility

Data applicable to BP Facility	**Lower Estimate**	**Upper Estimate**
Tank population (m^3) (a)	2,400,000	2,400,000
Applicable experience (Years) (b)	30	30
Applicable number of incident (c)	0.1	0.35
Release frequency per year (c/b/a)	1.39 x 10^{-9}	4.86 x10^{-9}

Note: lower and upper estimates for tank population and experience years are reversed in the calculation of failure frequency.

The historic record of incident is not available so, estimate of failures numbers, tank populations and the period over which they apply have been made, to derive the failure frequency directly. For the cautious best estimate, a number of incidents of 0.35 is taken corresponding to a 30% chance of not having seen such an incident in the experience period. For a lower estimate, we take a nominal estimate of 0.1 incidents corresponding to 90% chance of not having seen such an incident in the experience period. For the upper estimate, we assume that the additional factors and safeguards identified above have a 20% chance of failure (a high figure for human error), giving approximately 2 incidents in the experience period. A number of incidents are recorded in the 1970's, so it would be unreasonable to take a period of less than 30 years, so this is also taken as a lower limit. Therefore 30 years is taken as the cautious best estimate for the experience period.In a transport network, any path segment (s) between a given lengths(k-r) would typically consist of series of links. Let the probability of having an incident is constant along shipment line segment as a common order of 10^{-8}. The following assumption is quite common in the risk literature (Verter, 2001)[13]:

$$\sum_{s=1}^{r} \grave{P}_s = \sum_{s=1}^{r} l_s \times P_s \tag{5}$$

Where: P_s is the incident probability for the path segment ls.

Table 4: initial estimation of frequency failure in shipment pipeline

Failure Source	Failure frequency(km/year) according to interactive dispersion		
	Low	**Moderate**	**High**
Corrosion or crack	0.93×10^{-4}	2.79×10^{-4}	3.36×10^{-4}
Other	0.44×10^{-4}	0.44×10^{-4}	0.44×10^{-4}
Total Frequency	1.37×10^{-4}	3.11×10^{-4}	3.80×10^{-4}

It is assumed that the moderate frequency is three times lower frequency and the high frequency parentage of moderate one. For a liquid under pressure, the release rates of the liquid through an orifice to the atmosphere is given by (Lees, 1996)[14]:

$$Q_l = F_o A_e (2\Gamma_l (P - P_s))^{1/2} \tag{6}$$

Where: Q_l is the liquid release rate (kg/s); F_o is the orifice factor (~0.6); Af is the effective area of orifice (m^2); is the liquid density; P is the pressure upstream of orifice (N/m^2) and Ps is the atmospheric pressure (N/m^2). This resume assumption for an incident scenario for specific size length according to the following table

Table 5: An estimated for probability of corrosion failure scenario

Failure Cause	Estimated Frequency	Leak Size (mm)	Size Probability	Spill Probability	Ignition Probability	Outcome Frequency (km/yr)
Corrosion	1.37×10^{-4}	20	0.58	0.03	0.02	4.8×10^{-9}
	1.37×10^{-4}	50	0.14	0.03	0.04	3.3×10^{-9}
	1.37×10^{-4}	500	0.29	0.03	0.09	1.1×10^{-8}

Spill size assessment is based mainly on the DNV Study, 2000(17). The DNV study made the reasonable assumption that only one cargo tank was damaged at any one time, as is generally the case. In order to take into account the remote possibility of all of the tanks within the tanker being ruptured, the DNV study has been extended, using ITOPF data, 2006[15]. As a conservative estimate, it is assumed that 2% of spills involve multiple ruptures (100% release). The probability of single tank ruptures (7% release) has been reduced accordingly from 60% to 58%.

4. Risk Ratio

Assessment of a risk involves measurement of probability for certain event will occur and its impact on the project in percentage cost. This can be measured in a number of ways, probability percentage for 1% to 100% or three ratings for impact; High, Medium and Low. The impact is usually estimated as a dollar amount that has a direct impact to the project. However, cost is sometimes estimated and reported as rational risk. The risk ratio makes it easier to compare one risk to another and assign priorities. For each of the impact categories the impact is assessed as follow (DNV, 2010)[2]:

$$Risk\ Ratio = \frac{\Delta Cost}{\Delta\ Risk}$$

$$(Risk\ Ratio) = \frac{C_m}{\sum_y \frac{\Delta C_r + \Delta C_p}{(1+R)^y}} \times \frac{1}{P_{failure}} \tag{7}$$

Where: C_m= cost of risk reducing measure*,* C_r= reduction in repair cost, C_p= reduction in production loss*,* $P_{failure}$ = probability of failure/failure frequency*,* R = interest rate, y = number of years

This risk ratio is a percentage value is an evaluation of the ratio between the increased cost of any additional measures and the recovery cost to reduce the risk.

Table 6: Risk ratio associated with failure frequency

Failure Cause	Leak Size (mm)	Outcome Frequency	Estimated Cost (U$)	Recovery Cost (U$)	Risk ratio
Corrosion	20	4.8	5,000	7,000	0.15
	50	2.3	10,000	12,000	0.36
	500	1.1	15,000	19,000	0.71

5. Risk Level Criteria (Individual Risk)

Risk levels in terms of identified potential numbers of fatalities and frequencies have been estimated for both individual risk and societal risk criteria. The individual risk levels assessed for the, lie in the region of 10^{-6}/yr for in site facility risk and close to 10^{-9}/yr farther to community off site facility. No off-site risk levels are identified that exceed the criterion of 1×10^{-5}/yr in the regular operations (Evans et al, 1997)[16]. A very common model is point representation of risk iso-lines over population centers. Traditionally, the impact area of an incident is assumed to be circle centered at the incident location and it is drawn with purple color Figure 1.

6. Conclusion

Based on the analysis, it is concluded that the operational risk assessment and societal risks posed by the PB tank farm and associated shipment activities environment are acceptable according to the criteria set out in technical estimation terms.

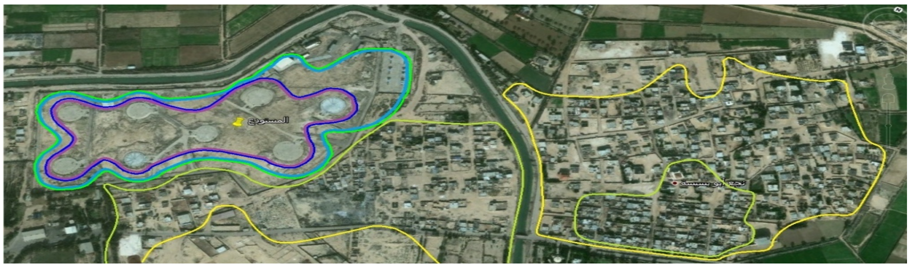

Fig. 1: Risk lines over population vicinity to storage tank facility

7. Reference

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