

## **PROCESS RISK MANAGEMENT FOR BETTER INSURANCE BENEFITS**

**J . RAMESH BABSU**  
**CHOLAMANDALAM MS RISK SERVICES LTD.**

### **Abstract**

*Underwriting major refinery/ petrochemical risks has been the challenge for any insurer/ reinsurer. All over the world insurers have been considering process risk management measures while accepting and evaluating the risks. In India erstwhile petrochemical tariff was adopting Dow Index methodology as the basis for premium calculations. In the present de-tariffed scenario decisions on accepting the risk and deciding the terms and conditions will be crucial for underwriters. On the other hand the insured also will be looking for merit based rating instead of general market driven premium calculations. Generalising the risks based on the type of occupancy or based on past experience will also not do good either to the insured or to the insurer. The Layer of Protection Analysis (LOPA) can be used as a effective tool in the entire gamut of underwriting of petrochemical risks in case of property insurance. This technique invented by American Institute of Chemical Engineers, USA will give credit for the highly reliable safety systems used on the modern Oil & gas installations and will motivate others to go in for the highly reliable process safety/ instrumentation systems.*

### **Background**

Oil & Gas Industry is exposed to major risks like fire and explosion, oil spill etc by virtue of its nature and operations. Such risks are caused by failure of hardware systems and procedural lapses. In addition to man made disasters the natural hazards like earthquake, floods, hurricane etc also contribute to major losses in the oil and gas sector all over the world. Such risks lead to consequences like human fatality, severe injury, environmental pollution, property damage and business interruption etc. The above consequences can also lead to huge liability claims from the various stakeholders of the company and also by the third parties. Over 379 losses of over \$ 10 Million each *Table 1* gives the synopsis of the major losses experienced by the oil & gas sector during the thirty year period (1970 -1999). A total loss of \$ 22 billion property damage measured in terms of January 2000. The loss amounts include property damage, debris removal and cleanup costs while the costs of business interruption, extra expense, employee injuries and fatalities, and liability claims are excluded. The direct, on-premises cleanup costs due to asbestos abatement, PCB removal or released hydrocarbons and chemicals following a fire, explosion or other loss event traditionally have been considered part of the property damage loss. These costs, to the extent insurance is applicable, are paid by property insurance underwriters. Although nearly all the losses involved fires or explosions, many losses occurred as the direct result of floods, windstorm and pressure vessel rupture related events. Marine transportation losses are excluded, except for those involving marine vessels moored at plant docks. Such huge losses

continue to happen in the oil & gas sector during the subsequent period also. The major explosions and fire that happened in BP, Texas during 2005 can be cited as examples. In India the Mumbai high fire badly hit the ONGC and resulted in large losses. Recent fires in IOC, Vadodara (2004) and IPCL, Nagathone (2008) are testimony to the risk potential of the oil industry despite the various control measures undertaken the respective managements. As oil industry transfer such risks to the insurers on payment of agreed premium insurers share the concern of the insured in managing the risks and exercise care while underwriting the above petrochemical risks. In addition to obtaining the suitable protection from the insurance companies better risk management systems and practices fetches the attractive insurance deal also.

Table 1 - Some of the major property losses over \$150 billion

**Onshore**

Date	Location	Plant Type	Event Type	PD Loss (\$MM)
10-23-89	Texas	Petrochemical	VCE	839
5-4-88	Nevada	Chemical	Explosion	383
5-5-88	Louisiana	Refinery	VCE	368
11-14-87	Texas	Petrochemical	VCE	285
12-25-97	Malaysia	Gas Plant	Explosion	282
7-23-84	Illinois	Refinery	VCE	268
11-9-92	France	Refinery	VCE	262
12-13-94	Iowa	Chemical	Explosion	224
9-18-89	Virgin Islands	Refinery	Hurricane	207
8-17-99	Turkey	Refinery	Earthquake	200
9-27-98	Mississippi	Refinery	Hurricane	200
5-27-94	Ohio	Chemical	Explosion	200
9-25-98	Australia	Gas Plant	Explosion	187
10-16-92	Japan	Refinery	Explosion	187
3-4-77	Qatar	Gas Plant	VCE	174
6-1-74	England	Petrochemical	VCE	164

*The loss amounts were adjusted for inflation.*

## Offshore

Date	Location	Facility Type	Event Type	PD Loss (SMM)
7-7-88	North Sea	Platform	Explosion	1,085
8-26-92	Gulf of Mexico	Platform	Hurricane	931
8-23-91	North Sea	Concrete Jacket	MD	474
4-24-88	Brazil	Platform	Blowout	421
11-1-92	Australia	Jacket	MD	314
1-20-89	North Sea	Drilling	Blowout	273
11-2-99	Angola	Process Deck	MD	210
7-1-74	Dubai	Platform	Blowout	204
10-1-74	North Sea	Platform	MD	196

*The loss amounts were adjusted for inflation.*

*MD - Mechanical Damage*

## Operation of Insurance

Considering the loss potential and the probability of occurrence of such major accident insurers retain the limited portion of the risks with them depending on their risk bearing capacity and transfer the remaining portion of the risk to the various reinsurers (insurers of insurers) located in India and abroad through various reinsurance layers based on the mutual agreement . Underwriting principles of reinsurers vary and the insurers should take the concurrence of the reinsurers with whom they are tying up with in case of underwriting a particular business. Reinsurers are apprehensive generally about any petrochemical plants (which indicate industry – on shore/ off shore petroleum processing, chemical plants handling large quantities of hydrocarbons/ petroleum derivatives etc) and study their risk exposure and experience before accepting the offer for reinsurance. The insurance coverage for the above type of plants is also called as Energy Insurance by the global insurers. In the past few decades various attempts are made by insurance industry all over the world to assess the risks of such Petrochemical/ energy plants.

## Insurers' Risk assessment

In early days, oil, gas and petrochemical plants were regarded under the general category of "Industrial Property" by the insurers. As such the focus of attention in terms of Insurance Loss Prevention tended to be the hardware aspects of fire mitigation systems including fire water pumps and water sprays. In addition PML (Probable Maximum Loss) calculations were based on fire scenarios. (Refer box 2 for the definition of PML)

**Table 2 : Probable Maximum Loss (PML)**

The Probable Maximum Loss is an estimate of the monetary loss which can be sustained by insurers on a single risk as a result of a single fire or explosion considered by the underwriters to be within the realms of probability. The estimate ignores such remote coincidences and catastrophes as may be possibilities but will remain unlikely.

Following factors were not taken into an account while assessing the PML:

- Any horizontal separation
- Fire resisting doors
- The absence of any normal source of ignition
- Existence of installation of fire detection, prevention or extinguishment arrangements including sprinkler and the adequacy or otherwise, fire brigade facility
- Safety features of the process equipment

PML is also termed as Expected Maximum Loss (EML) or Maximum Probable Loss (MPL) with minor difference in definitions.

In these circumstances the role of risk analytical techniques were not given due regard for underwriting.

- No systematic identification of hazards was undertaken.
- The scrutiny of preventative measures (in terms of both hardware and management systems) for possible failure scenarios was not carried out.
- The likelihood of major losses was not assessed even in relative terms.
- The consequences of certain relevant major accident scenarios (i.e. Vapour Cloud Explosions) were not addressed.

The perception of insurers with respect to the risk potential of On shore Petrochemical installations was different from that of Off shore petrochemical installations.

### **On Shore Petrochemical Installations**

The destruction of the Flixborough Plant in 1974 proved instrumental in changing the approach to Onshore Petrochemical Insurance. The Vapour Cloud Explosion at Flixborough resulted in 28 fatalities, over 400 injuries and a property loss of \$200 million (in 1993 money values). The fire scenario estimates used by Insurers at the time were equivalent to Property Damage PML's in the region of \$40 million.

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This situation prompted a number of fundamental changes within the Property Insurance sector including:-

1. The establishment of specialist energy underwriting divisions and companies with teams (comprising underwriters and experienced engineers) capable of understanding the complexities of such high hazard plants.
2. The development of broadly based qualitative risk assessment methods which accounted for both preventative and mitigating measures and both hardware and management systems. These evaluations formed the basis of "Quality of Risk" judgements.
3. The development of explosion modelling techniques for use in estimating Vapour Cloud Explosion (VCE) PML's. Initially, 2 distinct methods were developed and used:-
  - an empirical approach in which the actual damage caused by previous explosions was analysed and related to the quantity of flammable material released and distance from the source of the explosion.
  - a TNT equivalent method which equates the quantity of flammable vapour in the cloud with an equivalent mass of TNT. Military experience of TNT explosions was then used to estimate the damage.

The Flixborough explosion was instrumental in promoting a step change in the role of risk based techniques in Onshore Petrochemical/ Energy Insurance, however, in the form of a relatively superficial indirect and qualitative estimate of accident likelihood and a very coarse estimate of consequences.

### **Off Shore Installations**

In the case of the Offshore Energy Sector the insurers perceived the risk as virtually non-existent. The market underwriting capacity available for marine risks of this type (e.g. via Lloyds) was (and is) very large. This led to competition between underwriters for business and underwriting discipline was not followed by the insurers. Bell (1) summarized the approach to Offshore Energy Underwriting as follows:-

- Little research or surveys were carried out prior to underwriting the risk.
- No distinction was made by the insurers between the good and bad installations
- Decision of underwriting was left to the single individual and the decision was based on the available little information
- Questioning of quality of operations kept to a minimum.

To put it simple, premium income was much more important than risk analysis and assessment. At best, intuitive risk assessments were made by underwriters based on knowledge of a company's past loss record, superficial information regarding the nature of its operations and personal contact with its Insurance Manager.

Risk engineering surveys conducted in the off shore plants tended to focus exclusively on the condition of the installation hardware with little or no evaluation of management systems. To make things worse, PML estimates were not used for underwriting. Instead underwriters tended to base their % share on Total Insured Value rather than PML.

Though major off shore disaster Piper Alpha (1988) has changed the perception of insurers no major risk based techniques were used in the Onshore Energy Insurance Sector.

### The Current Situation – Global Scenario

#### Onshore

The use of Insurance Risk Surveys and PML/ EML calculations is now generally accepted practice in the Onshore Energy Sector. "Quality of Risk" is still expressed in qualitative terms although a number of Insurers and Brokers now use some form of risk ranking system. For example CTS services has developed a Key Risk Rating Indicator System (KRRIS) method to cover key risk factors prevail in the hydrocarbon industries with due allowance for any compensatory factors which exist. In this method the rating process is clearly defined with freedom for the assessor to differentiate between different facilities. The key risk indicators are grouped in to three categories – hardware, software and protection systems. Table 3 gives the various factors identified by CTS for rating petrochemical risks. The assessment of the risk on above indicators are done on the 0 -5 scale.

<b>TABLE 3 : KRRIS INDICATORS</b>		
<b>Hardware</b>	<b>Software</b>	<b>Protections</b>
Natural Perils	Organization	Fire & Gas detection system
External exposure	Operating procedures	Water Supplies
Inherent hazards	Permit to work systems	Drainage
Lay out	Maintenance	Process Area fire protection
Control Systems	Engineering/ Technical services	Offsite Area fire protection
Process safety systems	Management of change	Utility area fire protection
Loading/ Unloading	Inspection Procedures	Passive Fire Protection
Storage	Safety Procedures and Practices	Foam supplies
Utilities	Emergency Response	Portable Equipment

Machinery	Security	Testing and Inspection
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Empirical and TNT EML/PML methods are still used; In addition, both insurers and brokers have drawn an extensive explosion modelling research conducted by companies such as Shell and British Gas in recent years. In addition the software packages like Ex Tool, SLAM etc have been developed by the reinsurance companies like Swis Re, Sedgwick etc. The other modified empirical approaches developed by companies like CIGNA takes site specific factors such as layout, spacing and degree of process plant congestion etc in to account.

### **Offshore**

The use of onshore type Insurance Risk Surveys in the Offshore Energy Sector is still relatively rare. The underwriting is mostly driven by market demand. The market capacity and dynamics are such that, in the majority of cases, underwriting decisions are made based on sketchy information regarding the installations in question. Only few UK based companies employ experienced Offshore Engineers. In many cases these engineers encounter some difficulties in gaining agreement from the installation operator to conduct a survey.

EML methods are still not generally used. However, a couple of companies have recently developed an Offshore EML Methodology in conjunction. These methods are based on the British Gas CHAOS (Consequence & Hazard Analysis for Offshore Structures) computer code. CHAOS was developed by British Gas following a research programme involving extensive field trials.

This EML methodology, in conjunction with Offshore Surveys, represents a significant step forward in the application of risk analytical techniques to Offshore Energy Insurance.

### **The Current Situation – Indian Scenario**

Insurance business has been experiencing rapid changes after the liberalization of the market in India. Every insurance portfolio is being de-tariffed in phases. Particularly the decision of de-tariffing of property insurance or fire insurance has evinced interest among the insured and insurer. The Tariff Advisory Committee developed a specific petrochemical rating based on the Dow Index methodology during the tariff regime and was in vogue since 1970s. Though the insurance business is de-tariffed currently the same dow index methodology is adopted by the insurers in the absence of any other suitable methodology.

Rating procedure adopts the following steps:

- ❖ Consider each identifiable process unit in the plant by reference to the process flow chart.

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- ❖ For each such equipment in the process unit ascertain the **process/operation hazard factor** based on the unit operation/ unit process.
- ❖ Add the loading relating to the operating temperature with the flash point, boiling point, and auto-ignition and pressure as vacuum, low pressure, high pressure etc. to derive the **modified process hazard factor**.
- ❖ Ascertain the quantity of material in largest process vessel or train of process vessels connected together. Shut off valves that can be actuated from a remote location (control rooms) can be considered to reduce the exposure by half the total volume. The appropriate loading needs to be applied to the process hazard factor to derive the additional hazard factor to be added to the modified process hazard factor to arrive at the **final process hazard factor**.
- ❖ Take notes of all the raw materials, solvents, intermediates for finished products contained in the equipment under consideration and select the highest applicable material factor.
- ❖ The basic rate for process unit will be the highest of the basic rates so derived for the various equipment in the unit.

The basic rate currently adopted by insurers is driven by the market demand and competition among the insurers.

Following factors are considered in addition to the basic rates either for loading or for discounts and to include warranties wherever required.

- ❖ The distance between the plants/ storage area/ utilities / miscellaneous buildings/ flare etc.
- ❖ Availability of blow down system
- ❖ Availability of black topped road
- ❖ Emergency system
- ❖ Plinth level of control room
- ❖ Fire coating of steel supports
- ❖ Quantity of flammable materials (Class A/ B) stored in each tank
- ❖ Availability of inerting facility for tanks containing flammable chemicals
- ❖ Use of heater and furnaces in the process area
- ❖ Location and construction of control room
- ❖ Capacity of fire water pumps and fire water reservoir
- ❖ Lay out of electrical power cables

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- ❖ Type of roof of the tanks depending on the flash point of chemicals
- ❖ Fire protection system- Hydrant, spray, sprinkler, CO2 suppression system etc
- ❖ Availability of mutual aid arrangement with the neighboring industries

In case of off shore risk assessment the Indian insurers totally depend on the assessment of reinsurers which is described in the previous section of this paper.

### **Future situation**

Oil and gas installations both on shore and off shore have been increasingly using the hardware systems with higher level of safety and reliability. For example automated instrumented systems with the higher Safety Integrity Level are used in the crucial process circuits and Emergency Shut Down systems. Similarly Health Safety Environment Critical Equipment Systems (HSECES) are being introduced for the pressure vessels and other equipment and structures in the case of off shore installations. The presently followed rating procedure does not give credit for such highly advanced or automated systems with higher reliability. The owners and managers of petrochemical risks expect the due credit and benefit in terms of insurance premium. In the opinion of the author of this paper Layer of Protection Analysis (LOPA) can be used for risk assessment of petrochemical risks by the users.

Presently LOPA is used for assessing the risk levels by means of evaluating the adequacy of layers of protection to verify whether the residual risk is within the statutory or standard norms. However the same can be used underwriting the energy/ petrochemical risks also.

The underwriter can select accident screening criteria based on his site visit and the type of coverage offered by him. For example for a reinsurer the line of protection, type of reinsurance coverage and excess limits may be guiding factors to select the accident screening criteria. In case of local insurer the scope of insurance coverage, compulsory and voluntary excess and statutory norms binding on insurance coverage can be considered as the basis.

Once the criteria is selected the insurance engineer/ risk management consultant appointed by the insurance company can carry out the site visit. During site visit he can inspect the premises and identify the physical hazards leading to accident scenarios meeting the criteria selected. The documents like Quantitative Risk Analysis (QRA) and Hazard and Operability Study (HAZOP) can be helpful in identifying the accident scenarios.

The crucial step of LOPA is evaluation process and the following criteria can be used for assessment of risks.

- Consequence class characteristics,

➤ Likelihood estimation

The basis for classification depends on local regulations and corporate safety and environment philosophy. Consequences are measured in terms of damage to people, property and environment. The extent of damage can be predicted by means of experimental values or simulated values available for the chemicals. The advantage of LOPA technique lies in the fact that it can be used even if no software simulation is available for quantification of consequences. To minimize the subjectivity in estimation the damage effects identified by Centre for Chemical Process Safety (CCPS) based on the quantity of chemical released can be used.

In case of likelihood estimation the frequency of initiating event can be estimated based on the past industry data, company experience or incident histories. If no data available, estimation can be made based on the subjective assessment of expert team. Some of the data used by the industry for various events have been published in the literature mentioned under references.

Then Independent Protective Layers available in the system to prevent occurrence of accident scenarios or mitigate the consequences need to be identified along with their Probability of Failure on Demand (PFD). In case of non- availability of specific PFD values the standard values given in the literatures can be taken as guidelines. The final residual risk measured in terms of consequence class and frequency. Let us consider an example of LPG storage and use LOPA method for underwriting the LPG storage risk.

**Table 4: Accident Scenarios : Fire / Explosion due to LPG release**

Location: LPG storage area

Equipment: LPG bullet & associated pipelines

Sl. No.	Initiating event (IE)	Probability Per year $f_{IE}$	Enabling Event (EE)	Probability Per year $f_{EE}$	Protective Independent Protective Layers (IPL)				Mitigating IPL PFD	Consequence	
					Probable Failure on demand (PFD)	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>		P <sub>4</sub>	P <sub>5</sub>
X	Y										
		F <sub>1</sub>		F <sub>2</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>	P <sub>5</sub>		F <sub>1</sub> X <sub>1</sub> F <sub>2</sub> X <sub>2</sub> P <sub>1</sub> xP <sub>2</sub> xP <sub>3</sub> xP <sub>4</sub> 4X P <sub>5</sub>

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1	Pipeline leak	$10^{-2}$	Presence of ignition source in the area	$10^{-2}$	$10^{-1}$	$10^{-1}$	$10^{-1}$	$10^{-1}$	$10^{-1}$	<b>5</b>	$10^{-9}$
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Table 4: LOPA underwriting sheet of LPG storage

Note:

Protective Layers present

P1 : Pipeline designed to withstand 1.5 times the maximum operating pressure

P2 : Safety Relief Valves are provided on pipeline

P3 : Periodic inspection and testing of pipeline is carried out

P4: LPG leak sensors are provided and maintained in good condition

P5: Fire hydrant system is provided to deal LPG fires

X : May lead to Category 5 scenario ( refer table 1) for the prescribed LPG quantity

- The final risk level of consequence category 5 and frequency of  $10^{-9}$  can be plotted in the risk acceptance- underwriting matrix and the underwriter can decide on the acceptability of the risk and on the rates to be charged. By adopting the above method insured will understand the clear basis for the premium rates charged and will get the due credit for the safety systems installed in the plant. They will be motivated to go in the additional layers of protection to improve the risk levels wherever applicable and minimize the premium outgo.

**Conclusion**

Process risk management system is seriously looked by the insurance companies while underwriting the petrochemical risks. Various assessment methods are being evolved by the risk management consultants to assess the existing systems of the insured properly and thereby motivating the installations to go in for a better reliable safety systems. On the part of petroleum industry safety performance is being projected in the recent times on par with or sometimes higher than the business performance. It is hoped with the projected commitment and enthusiasm in place the number and quantum of losses may come down in the petroleum installations in future.

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## About the author



**J. Ramesh Babu** is a chemical engineer with post graduation qualification in Business Administration. He holds the diploma in industrial safety. He is an Associate of Insurance Institute of India and Associate of Institute of Risk Management, UK. He has the experience of over 21 years in operations and risk management consultancy. He has conducted studies in the area of process safety, fire safety, insurance planning, risk and reliability for over seven hundred occupancies including Oil & Gas industry ( Offshore & On shore) located in Asia (SAARC, Middle East, South East Asian countries) and Africa. He has carried out a number of major fire investigations in Oil and Gas sector on behalf of insurance companies. He has conducted three hundred training programmes on various topics of risk management. He has presented papers in

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international seminars on Safety in Oil & Gas Industry held in India, Sri Lanka Singapore, South Korea etc. His articles have appeared in leading technical and management journals like InfoRM UK, International Cement Review, UK, Pravartak, India and leading websites like Safety Users Group, USA etc. He is presently working as General Manager- Risk Services in Cholamandalam MS Risk Services Ltd., Chennai, India