

## **Basing Loss Prevention Recommendations on Risk**

By  
K. Gerry Phillips  
Sr. Loss Prevention Engineer  
NOVA Chemicals Corporation

### **Introduction**

The Loss Prevention Engineer is often put in the position of having to evaluate recommendations from underwriters, audit teams, and management. These recommendations can take several forms, including,

- changes to Management Systems,
- additional training of personnel,
- enhanced preventive maintenance, and
- facility improvements.

Recommendations are normally based on the experience of the auditor/inspector, practices in place at other facilities, or a concern for the potential consequences of a given scenario; however, recommendations often fail to take into account the risk which they are attempting to mitigate. Such risks are normally associated with injury or fatality to personnel, or property damage and the resulting business interruption. The costs to implement these recommendations can be significant.

NOVA Risk Management uses quantitative risk analysis to evaluate loss prevention recommendations in situations where the cost is high or the consequences are major. In the case of recommendations dealing with reducing the risk of fatalities or injuries, the existing risk is determined and compared to acceptable risk criteria<sup>1</sup>. Recommendations aimed at reducing property damage and business interruption are assessed on a probable return on investment basis by developing fault trees for the existing case and the modified case. Probable loss is determined based on fire and explosion scenarios that could be expected to occur. Savings attributable to the modification can be determined from this analysis and the probable return on investment calculated to determine if the capital expenditure is justified.

### **Determining Probable Return on Investment for a Single Area**

For recommendations that can reduce damage to a single portion of a facility, e.g., fireproofing on a vessel, a single scenario, such as a pool fire or jet fire, can be used. To calculate the annual probable loss for the existing situation, the frequency of the event must be determined and multiplied by the losses that would be expected to occur as a result of the event. The calculation is then repeated using values for frequency and losses that would represent the situation with the proposed recommendation

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<sup>1</sup> McPhail, M.R., and Windhorst, J.C.A., 'Integration of Risk Management into Process Safety Standards and Application of those standards', Proceedings from the International Process Safety Management Conference and Workshop, San Francisco, CA, sponsored by American Institute of Chemical Engineers Centre for Chemical Process Safety, Sept. 22-24, 1993.

implemented. The savings associated with implementing the recommendation are calculated and a probable return on investment determined based on the cost of the recommendation. This return can be compared to company criteria to assess the value of implementing the recommendation. The following example outlines this process.

**Example 1:** An insurance company has recommended that a certain vessel be fireproofed to prevent failure of the vessel in the event of a pool fire in the diked area around the tank. The cost of the fireproofing is \$15,000.

The frequency of a leak at the tank due to such things as a drain left open or a leak in a flange is determined to be once in 500 years. Given the leak, the probability that the leak will be ignited is one in five based on known sources of ignition and site wind patterns. Given a fire under the vessel, there is a 95% probability that the property damage would be \$90,000 to replace the tank and business interruption would be 3 months at \$10,000 per day. The remaining 5% of the time the tank will rupture catastrophically, resulting in property damage of \$25,000,000 and business interruption of 16 months.

The expected frequency of the fire scenario is:

$$(1 \text{ release}/500 \text{ yr}) * (1 \text{ fire}/5 \text{ releases}) = 1 \text{ fire every } 2500 \text{ years}$$

The probable loss due to fire for the existing situation is:

$$(\$90,000 + 90 \text{ days} * \$10,000/\text{day}) * .95 + \\ (\$25,000,000 + 16 \text{ months} * 30 \text{ days}/\text{month} * \$10,000/\text{day}) * .05 \\ = \$2,430,500.$$

The expected annual loss for the existing situation is:

$$1/2500 \text{ yr} * \$2,430,500 = \$972.20/\text{yr} \text{ or about } \$1000 \text{ per year.}$$

If the vessel is fireproofed, the frequency of the event will remain the same but the damage and business interruption will be negligible, resulting in a probable saving of \$1000 per year. Based on the cost of the fireproofing, the return on investment is:

$$\$1000 \text{ per yr}/\$15,000 = .067/\text{yr} \text{ or } 6.7\%/\text{yr.}$$

### **Determining Probable Return on Investment for a Facility**

For recommendations which affect the protection for an entire facility, e.g., the fire water supply pumps, the contribution to the probable loss for each part of the facility must be considered. Event frequencies and losses associated with events in each unit are used to calculate probable losses. These are then combined to arrive at a facility probable loss. The following example illustrates this process.

**Example 2:** An insurance company has recommended that an additional firewater pump be installed in a facility to supplement the two existing pumps. The reliability of the existing pumps, based on regular testing, shows that the pumps fail to start, on average, once every ten demands. The installed cost of a new pump is \$200,000

The facility is made up of four units - feed preparation, reaction, distillation, and product storage. The facility handles flammable liquids so pool fires are the main concern.

Existing Situation: The frequencies of release, probability of ignition, property damage and business interruption with two fire water pumps operational, one fire water pump operational, and no fire water pumps operational have been determined per Table 1.

Table 1 - Frequency and Loss Data For Plant XYZ

Area	Event Data		2 Pumps Operate Prob. = 0.80		1 Pump Fails to Operate Prob. = 0.19		2 Pumps Fail to Operate Prob. = 0.01	
	Freq	Ign	PD (\$)	BI (\$)	PD (\$)	BI (\$)	PD (\$)	BI (\$)
Feed Prep	.05/yr	.10	100k	100k	300k	500k	2M	10M
Reaction	.10/yr	.05	500k	700k	900k	1000k	4M	20M
Distillation	.10/yr	.20	100k	100k	200k	300k	1M	20M
Prod Storage	.05/yr	.05	50K	100k	100K	300k	.5M	20M

The expected loss due to fire is calculated by multiplying the sum of the property damage and business interruption by the probability that the damage will occur. These are added to give the total expected loss. The total loss is multiplied by the frequency to determine the probable annual loss. The results are given in Table 2.

Table 2 - Calculation of Probable Annual Loss due to Fire for Plant XYZ

Area	Expected Loss due to Fire (k\$)			Total Loss (\$)	Freq (fires/yr)	Probable Loss (\$/yr)
	2 Pumps Operate	1 Pump Operates	No Pumps Operate			
Feed Prep	160	152	120	432k	.005	2,160
Reaction	960	361	240	1561k	.005	7,805
Distillation	160	95	210	465k	.02	9,300
Prod Storage	120	76	205	401k	.0025	1,002
Total						20,267

Modified Situation: With the additional pump installed, the reliability of the system will improve significantly if two out of the three pumps are required to operate. Table 3 outlines the frequency and loss data with the extra pump installed.

Table 3 - Frequency and Loss Data for Plant XYZ after modifications

Area	Event Data		1 Pump Fails to Operate Prob. = 0.970		2 Pumps Fail to Operate Prob. = 0.029		3 Pumps Fail to Operate Prob. = 0.001	
	Freq	Ign	PD (\$)	BI (\$)	PD (\$)	BI (\$)	PD (\$)	BI (\$)
Feed Prep	.05/yr	.10	100k	100k	300k	500k	2M	10M
Reaction	.10/yr	.05	500k	700k	900k	1000	4M	20M
Distillation	.10/yr	.20	100k	100k	200k	300k	1M	20M
Prod Storage	.05/yr	.05	50K	100k	100K	300k	.5M	20M

The probable annual loss due to fire is calculated as described previously. The results are shown in Table 4.

Table 4 - Calculation of Probable Annual Loss due to Fire for Plant XYZ after modifications

Area	Expected Loss due to Fire (k\$)				Freq. (fires/yr)	Probable Loss (\$/yr)
	2 Pumps Operate	1 Pump Operates	0 Pumps Operate	Total Loss (k\$)		
Feed Prep	194.0	23.2	12.0	229.2	.005	1,146
Reaction	1164.0	55.1	24.0	1243.1	.005	6,216
Distillation	194.0	14.5	21.0	229.5	.02	4,590
Prod Storage	145.5	11.6	20.5	177.6	.0025	444
Total						12,396

Savings as a result of the addition of the firewater pump are:

$$\$20,267/\text{yr} - \$12,396/\text{yr} = \$7,871/\text{yr} \text{ or approximately } \$8,000/\text{yr}$$

The probable return on investment is

$$\$8,000/\$200,000 = .04/\text{yr} \text{ or } 4\% \text{ per year}$$

### Case Study - Nova Chemicals

Insurance underwriters recommended that Nova Chemicals install a second diesel-driven firewater pump at a facility and that Nova Chemicals provide a larger water supply from the MOEE with the provision to by-pass the existing fire water storage tank if the tank were unavailable. Fault Tree Analysis was used to identify the cost benefit associated with implementing these recommendations.

The top event for the analysis was 'Loss of profit due to fire' with sub events representing losses from each of the process areas protected by deluge or sprinkler systems. Damage associated with a fire under the existing firewater supply situation was calculated using estimated fire frequencies for the area and expected damage given a fire. The fault trees were then modified to include the upgrades, and the expected loss was recalculated.

The results of the study showed that damage from fire is expected to average about 148 k\$ per year given the existing situation. A key value used in the analysis was the expected frequency of a complete power outage at the site since this would result in the electric fire pumps being unavailable. At the time of the study, this value was once every 50 years.

If the upgrades were installed, the damage could be reduced to 114 k\$ per year for an expected annual saving of 34 k\$. Given the estimated cost of about 600 k\$ for the upgrades, the savings would represent a probable return on investment of about 6%. On the basis of this return, the project was not justified.

### **Discussion of Results of the Case Study**

The greatest contribution to the loss from the existing situation resulted from a fire in the compressor building in the low-density plant. The high business interruption loss along with the direct damage is the main reason for the potential loss of 77 k\$/yr. This represents 52% of the loss contribution.

The loss from deluge area Z in the high-density facility represented 29.7% of the loss contribution due to the high damage resulting from a potential BLEVE coupled with failure of the deluge due to being damaged by a vapour cloud explosion. The other significant contribution comes from deluge area A in the low density facility. The high damage potential is due to loss of the deluge due to explosion.

The upgrade would have minimal effect in all areas other than deluge area C in the low density plant. The increased reliability of the water supply system would provide adequate water to supply all the required deluge systems.

### **Other Considerations in the Case Study**

One item identified in the study was the potential for failure of the water supply tank. Under the conditions existing at the time of the study, it was not possible to enter the tank for inspection without shutting down the plant and removing all hydrocarbons. Even

if all hydrocarbons are removed there is no guarantee that a significant loss would not be incurred.

Water supply tanks tend to suffer from corrosion on the exterior of the tank, especially on the bottom of the tank, due to condensation. There is a good possibility that this type of corrosion could lead to leaking and eventual failure of this tank within the next five to ten years. If this were to occur it would likely result in an unscheduled shutdown and a significant loss due to business interruption. In order to avoid this, the tank should be emptied and inspected; however, this would leave the plant unprotected. Loss of protection could be avoided if the larger supply from the MOEE coupled with the tank by-pass was installed.

In assessing the loss from a fire in the compressor building, it is expected that the major source of damage would result from a lube oil fire in the building. The potential loss could be significantly reduced by assuring that the area drains away from the compressor building. Installation of concrete pads inside the building and in the lube oil storage area would provide the required drainage by routing any spills to a holding area.

The deluge protection in the hexene storage area has the potential to create more damage than it will avoid due to filling of the diked area with water and subsequent overflow of the dike. Where hexene is concerned it is reasonable to extinguish the fire since hexene is not a liquefied gas. Therefore, consideration should be given to providing a foam supply to the dike to extinguish the fire and blanket the material.

### **Case Study Recommendations**

1. Do not install a second diesel-driven firewater pump.
2. Install a larger supply from the MOEE and provide a by-pass around the water supply tank.
3. Install drainage and holding facilities for lube oil spills in the compressor building area.
4. Provide foam protection for the hexene storage area.
5. Inspect the bottom of the firewater supply tank at the earliest opportunity.

### **Conclusion**

Although the analysis showed the value added by the recommendations did not justify the cost of a new diesel-driven firewater pump, the additional information gained through the analysis was useful in identifying low cost effective changes that were required to manage the risk of fire at the facility.

### **Follow-up to the Study**

When the original study was completed, a value for the expected frequency of complete electrical failure was 1 in 50 years. Recent events have resulted in three complete power failures in 3 years, and although it is not certain that the failures will continue at the current rate, it is reasonable to expect that losses will be significantly higher given the higher failure rate. Based on this latest data, it is almost certain that the installation of an additional firewater pump would be justified on a return on investment basis. We fully expect the recommendation to be included in the report from the next Loss Prevention Survey of the site.