Evaluating Risk using COPE

by Ir. Loo Chee Kin

COPE is an acronym which stands for the four characteristics an underwriter reviews [1] when evaluating the risk presented by a building: Construction, Occupancy, Protection and Exposure.

Although the COPE approach has traditionally been used to evaluate the risk presented by existing buildings, this approach can also be used to manage the risk presented by a project. By classifying risks into the four groups of Construction, Occupancy, Protection and Exposure, an engineer can systematically identify and manage the key risks associated with a project. This will ensure that the final product is a building with a low risk. In this article, we will show how the COPE approach can be used by project engineers to build a low risk building. This advice is based on FM Global's extensive experience and expertise in project risk management.

Before we begin, it is worthwhile to talk about why risk management is important. Studies have shown that companies with strong physical risk management deliver more stable earnings [2]. Businesses with strong physical risk management programs produced earnings that fluctuate an average of 18%, compared to an average earnings volatility of more than 30% among companies with weak physical risk management practices. The best kind of risk management not only stops bad things from happening, but also has a positive impact on the bottom line for companies.

Figure 1: Fire testing at the FM Global Research Centre, fire on storage racks without any form of active fire protection. The fire was well developed within five minutes

Figure 2: Storage racks with an installed in-rack automatic sprinkler system

CONSTRUCTION

Plastic has been labelled as an environment unfriendly material in many ways. In risk management, most common plastics are a similar foe too. Plastics are used as pipe insulation, insulated wall panels, exhaust ducts, cable insulation, skylights and corrosive material bench. Small and large scale fire tests have shown that ordinary plastics will ignite easily and burn rapidly. Burning plastic typically releases heavy dense smoke, fumes, as well as toxic and corrosive gases. Fire retardants are added to plastics to make them safer. But not all plastic additives and formulations are the same. Large scale fire tests will validate the plastics that are fire safe. FM Approvals [3] maintains a list of such test materials. Plastic materials used for cleanrooms (such as in semiconductor or pharmaceutical plants) should inherently be fire safe. Materials meeting the FM 4910 test protocol have the heat, smoke and combustion gases measured during the test and damage indexes developed.

A building will have to be built to code as a minimum. It would have been ideal if the building only consisted of four-sided solid brick walls with a well-installed roof. However, due to occupancy requirements, buildings are made multi-floors with different areas for various uses.

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This introduces hazards that need to be segregated and, typically, these separations will be with fire rated walls. On any wall, there will be openings made for people and material movement and these need to be protected. The weakest fire wall is the penetration with the lowest fire rating. As such, personnel doorway needs to have fire doors or shutters. Utility, ducts and cable penetrations need to have fire stops installed. Additionally, the conveyor of the material handling system needs to be stopped, the conveyor tracks parted and the wall opening closed automatically. A breach in a fire wall will allow smoke, heat, ambers and even flames to travel to the other side.

Depending on the occupancy hazard and available protection, fire resistive rated construction may be needed. An all steel frame building will collapse in minutes when it is exposed to the heat from a fire – steel loses about half its strength when heated to temperatures of 540°C or higher. Often, steel structures in warehouses storing flammable liquids will need building columns and overhead steel protection. When the occupancy handles materials that have a high explosive potential, the building needs to be engineered such that the explosion impact is controlled. The engineering of this is with damage-limiting construction (DLC). DLC will have two components; pressure-resistant and relieving elements. The internal wall, floor and roof construction are designed to resist the overpressures caused by a deflagration. As the explosion energy needs to be dissipated, pressure relieving construction is needed. This will come in the form of lightweight, exterior wall panels designed to barely resist design wind loads and yet are easily released during a deflagration.

There is a common English idiom that states, 'Don't put all your eggs in one basket'. The same holds true when planning a site. Larger properties are generally subdivided into fire areas to limit the spread of fire. Horizontal fire spread is limited by space separations between buildings or by maximum foreseeable loss (MFL) fire walls [4]. In multi-storey buildings, it is a bit more complex as vertical fire spread from one storey to another needs to be limited by floor construction, exterior wall construction, and by enclosures around stairways, elevator shafts and other openings.

OCCUPANCY

Occupancy related risk can be as varied as the type of goods we see on a supermarket shelf. Every manufacturing location has dissimilar hazards. The fire risk in a warehouse could be devastating as the neat storage arrangement will allow quick fire spread to create an intense fire. A semiconductor facility uses various types of flammable, pyrophoric, corrosive and toxic liquid and gases. Additionally, in their ultra cleanrooms, any small incident from a fire, chemical spills or accidental release will cause major contamination to the controlled environment.

There are many occupancy hazards in today's specialised industry that requires specific engineering knowledge. In occupancy risk identification, an engineer will need to work very closely with the client, other engineers and stakeholders. The site's production process has to be understood in detail, as at this stage, the occupancy risks that have been identified will dictate the construction to contain the risk and also determine the level of protection that may be needed.

At times, the occupancy risk could be overlooked or under-quantified. Typical of most manufacturing locations, there will be a separate area for raw material, work-in-progress and finished goods. Depending on the storage or staging configuration, these could resemble a store or warehouse, and the storage racks in those areas should be protected as such. Where the storage area is large or there is exposure to the production area, the warehouse should be separated by appropriate fire walls.

PROTECTION

Protection falls into two broad classes: active and passive. Passive was discussed previously, while active protection comes in many forms. Most engineers would be familiar with fire protection. There are other forms of protection being put in place to prevent a hazardous condition, take action for proper control, intervene on an upset condition, or activate when the condition is out of control.

Take, for instance, the example of a powder spray paint booth, ventilation is provided to prevent the accumulation of dust to dangerous concentrations. The spray gun is interlocked from spraying until an exhaust flow is detected in the face of the booth. Infrared or ultraviolet detectors may be needed to detect a spark or fire from the spray gun, and to shut the entire system if needed. The system may be equipped with a booth protection to control a localised fire. For complete fire protection, an automatic sprinkler system is needed as the fire could persist and continue to consume the fugitive residual powder. Other preventive protection is provided to control ignition sources such as hazardous location rated electrical equipment (commonly known as explosion proof equipment, but should not be exclusive to these types of equipment), bonding and grounding.

Taking the above example further, there are more hazards in handling the exhaust or powder recycling system. There will typically be a dust explosion risk. Thus an explosion protection system is needed. This can be in the form of explosion vents on the cyclone or bag collectors. Whenever there are multi-spray booths, an explosion suppression system or fast-acting isolation gates may be needed to prevent a cascading explosion between equipment.

To take a different approach, when flammable liquids are handled, special fire protection may be needed.

For bulk tanks, a foam-water sprinkler system would be most suitable. The foam-water sprinkler system forms a blanket over the pool fire and snuffs out the fire. It should be noted that foam-water sprinkler systems are more complex than standard sprinkler systems, and are most suited for flammable-liquid floor-spill fire (*i.e.* a two-dimensional spill fire) in places such as aircraft hangars, flammable liquid stations and single-level flammable-liquid product manufacturing/processing/storage facilities.

When such flammable liquid fire risk is present in equipment, the option would be to protect it with a fixed fire suppression system. Special protection systems that are available include gaseous protection (such as carbon dioxide or FM-200), fine water spray or water mist. It should be noted that these protection systems are to be used in hazards and configurations of which the system has been tested and approved for. A system that worked successfully in a small test may not necessarily extinguish a fire in a large enclosure. For example, an FM-200 system that works well to extinguish a wet bench fire does not mean it will put out a gas turbine fire despite the system being up scaled in the same ratio. A list of FM Approved special protection systems and their intended applications can be found online. [3]

In many cases, automatic sprinklers have proven to be the best and most cost effective protection to most occupancies. With one set of fire pump and water supply, a large building or even a campus project can be protected. Sprinklers are an environmentally sustainable [5] risk management answer for fire protection.

EXPOSURE

Exposure is all around. There are usually two main forms of exposure. For any site, there will be direct exposure which surrounds the facility. The second is natural hazard exposure.

The first exposure is something that is within the control of the owner during site selection. For a proposed printing facility, the owner should not select a site that has an adjacent cement plant for obvious reasons; dust can affect their prints. Other exposures that need to be considered are the availability of stable, reliable utilities in the area. Early consultation with utility providers (TNB, JBA, gas, *etc*.) would help the engineer get the appropriate utility systems' reliability-availability data or their commitment on infrastructure development.

Natural hazard exposure is no stranger to us. This can be in the form of earthquake, rain, flood, freeze, snow, volcano eruption, lightning, windstorm and hail. There are other location specific hazards such as landslide, brush fire and, for location on the coast, tsunami and tidal surges. Fortunately for us in Malaysia, most of the colder climate natural hazards are not an relevent. However, engineers still need to consider soil movement, rain, flood and strong wind exposure hazards.

Most losses that are due to natural hazard can be prevented. The hindrance for an engineer or owner to manage these risks can be due to [6]:

- **Risk underestimation** – people may understand the risk, but assume that future disasters would not happen to them. The classic line is, "I have been here for 10 years and my place has never flooded."
- **Procrastination** – the natural tendency to postpone taking action, especially if it involves investing time and money to address the risk through actions such as putting in a floodgate to basement entrances.
- **Short-term focus** – the difficulty of computing the cost-benefit of disaster preparedness. If a plant manager invests in a new machine, production goes up, but if he adds in seismic dampers or bracing, he gets nothing till an earthquake actually occurs!

In flood mitigation, the higher the better, meaning the site should be as high from any body of water as possible. In hydrology, flood severity is normally designated by a recurrence interval of the flood (*i.e.* 25-year, 100-year, 500-year). The recurrence interval of an event gives the average length of time between occurrences. See the following table:

Flood recurrence interval	Time period being considered				
	1	2	5	10	50
10	9.52%	18.13%	39.35%	63.21%	99.33%
25	3.92%	7.69%	18.13%	32.97%	86.47%
50	1.98%	3.92%	9.52%	18.13%	63.21%
100	1.00%	1.98%	4.88%	9.52%	39.35%
250	0.40%	0.80%	1.98%	3.92%	18.13%
500	0.20%	0.40%	1.00%	1.98%	9.52%

Figure 3: Example of a site platform being elevated higher that the surrounding

So what does this mean? If a location is built on a 25-year recurrence interval flood level, should the plant be around for five years, the chance of flooding is 18.13% and if it was occupied for 50 years, the chance increases to 86.47%. So, by building a plant at the 500-year recurrence level, the probability of flooding would be drastically reduced to 9.52% if the client were to occupy the premises for 50 years. As such, the best option to engineer the floor risk is to elevate the site higher than the 500-year flood level. As part of the engineering practice, a margin of safety should be included – floodwaters are not known to be still and would have waves and velocity flow.

For existing locations, elevating the platform would not be possible – more so when the facility has below ground spaces. In these locations, engineered flood structures or defences are needed. This includes levees, floodgates, pumps, *etc*. Irrespective of the engineered system, it has to operate fast, be water tight, as well as be able to withstand the hydrostatic loads, hydrodynamic loads, breaking wave action and debris impact.

THE FIFTH FACTOR

When engineering has taken care of the COPE, there is still a fifth factor. This comes into play as an element that can provide a stop-gap measure for something that cannot be engineered; or it can be a factor that could make the engineer go back to the drawing board. The fifth factor is people, or better known as the human element in risk management circles. It should be acknowledged that every engineered facility will be used by man. When the facility is operated and maintained well, it will serve them well.

However, when safeguards fail or when there is a system breakdown, people are expected to take emergency action. Having a proper emergency response plan (ERP) in place will ensure that when an incident happens, people will take the appropriate action to mitigate the situation and put the recovery plan in action.

It can be argued that such an emergency happened in the first place because the engineering had failed. But any system owner will point out that one cannot over engineer the safeguards, otherwise the project will become unviable or the equipment will not operate appropriately. For example, a rice cooker can break down, yet the majority of us would not keep a spare cooker – at most, they may have a spare cylinder of gas. To expand further, there are only so many emergency brakes that can be provided on an elevator to prevent it from freefalling.

If there is a detailed evaluation of the COPE risk, proper planning can be made and resources can be allocated for it. This would typically be a business contingency plan (BCP) or a disaster recovery plan (DRP). Engineering backup can be provided in those plans, such as having a hot site, disaster recovery locations, duplication of records or providing redundancy. Redundancy could be in the form of secondary utility lines, spares or n+1 approach for critical equipment.

CONCLUSION

The COPE approach can be successfully used to manage the risks during a project to ensure that the final product is a low risk building. The Construction, Occupancy,

Figure 4: Example of a flood door to a below ground space

Protection and Exposure factors would be different in every project. For example, in a chemical factory, the occupancy hazard would be the highest and, as such, warrants the highest protection level for the risk faced. On the other hand, in a dam project, the exposure risk would be the highest, which needs to be addressed by construction. By following best practices and proper design standards, a balance between these four factors can be achieved.

The human element is important for proper facility operation. The engineering should be planned in such a way that the facility or system can be easily operated and maintained. If the latter is lacking, the possibility of an emergency happening is greater. Thus the engineering cycle starts again, that is to address or reduce the risk by engineering.

There is no single answer for any particular project. An engineering team effort is required to identify the risk and propose the COPE solutions. When the engineers make the risk evaluation and engineering recommendations, they will need to consider other interested parties and stakeholders as well, such as the authorities, safety, insurance, environment, sustainability and the community in general. ■

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