Risk is PoF x CoF: where should the focus be?

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This simple equation: Risk = PoF x CoF shows us that there are two general ways to reduce risk. We can reduce PoF or CoF. On which are our energies best spent?

While both are essential, there is a compelling argument to be made that probability of failure (PoF) issues should dominate both our risk assessment and risk management efforts.

Let's examine this by first looking at how we measure risk. Most of my previous columns for *Pipelines International* have focused on either managing risk or measuring the probability of failure. This speaks not only to the need for more guidance on how to measure PoF, but also hints that PoF generally plays a larger role in risk management.

This should in no way be seen as a suggestion to ignore consequence of failure (CoF). Reducing CoF is the final opportunity to protect lives, property, and environment, and should never be discounted.

COF MODELING AND MANAGEMENT

Back to measurements of risk. Historically there has been more focus on measurement of CoF potential rather than PoF potential. We have, for many years, had multiple choices in sophisticated modeling solutions to gas dispersion, thermal radiation, explosion forces, contamination effects, more recently liquid overland flow, and most other aspects of CoF. We also have greatly simplified models, derived from the complex models, that are now used in regulations. The well-known potential impact radius PIR equations such as 0.69 x SQRT (P x D2) are examples.

Even before we employ these modeling options, we recognise that CoF associated with any pipeline release can be efficiently understood as being comprised of four parts acting in a dependent relationship:

$CoF = P \times V \times D \times R$

Where

P = product hazard (toxicity, flammability, etc)

V = release quantity (quantity of the liquid or vapor release)

D = dispersion (spread or range of the release, including early- and late-ignition scenarios)

R = receptors (all things that could be damaged by the release).

The dependent relationship is illustrated in the use of the multiplier in this equation[1]. Each factor can have a dramatic impact on total CoF. Any directional changes – higher or lower – in any of these four variables will generally forecast the change in consequence potential. To reduce overall consequence potential, any single component can be reduced. If any goes to zero, then there are zero consequences.

This helps us to understand the risk management options that focus on CoF. Consistent with this guiding equation, we can reduce CoF and, hence, risk, by actions such as:

- Changing the product
- Reducing product pressure or flowrate
- Preventing dispersion (e.g. secondary containment, boom deployment, etc.)
- Reducing spill quantities (e.g. leak detection, remotely operated equipment, etc.)
- Relocating people, property, environment.

Of course, these have varying levels of practicality. Even the more practical opportunities are far from fool proof. Their ability to reliably reduce CoF are highly location and scenario specific. In some instances, they play a significant, valuable role. In others much less so. This is why it is always preferable to prevent an incident, rather than trying to limit consequences as the incident unfolds.

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HAZARD ZONES

For predictions of CoF, estimation of hazard zones (or 'areas') is a key element. A hazard zone is a geographical area in which certain spill/leak effects are expected.

The estimation of hazard zones is consistent with our guiding equation above. The hazard zone is a function of the product characteristics, the spill volume, and the dispersion characteristics at the release site. These are the first three of the four CoF ingredients from the equation. With the three general sets of inputs and usually some significant assumptions, the models give us impact distances which form the hazard areas.

Having this hazard zone, the number, type, and vulnerabilities of various receptors potentially within the hazard zone can be assessed. So, the mathematical version of our guiding equation can combine the first three terms into the hazard zone and now look something like this:

CoF ($/incident) =
Hazard zone (m2) x
∑[receptors (units/m2) x receptor value ($/unit) x receptor damage rate (%)][2]

This applies to all types of pipeline releases: from water or O2 to hydrocarbons in gaseous, liquid, or HVL states. All of the required inputs are fairly well understood and generally available.

POF VS COF FOCUS

Now, back to the title topic of this column. First, the risk assessment process. While there is great variability in potential CoF scenarios, we have and have had good tools with which to understand the scenarios. Since we already have models and data to better understand potential CoF, perhaps energies are better spent in the less supported PoF assessment arena. For instance, imagine how much better our PoF estimates could be if we had reliable, location-specific data on exposure frequencies and mitigation effectiveness, or if we had accurate but simple ways to estimate resistance to multiple loading scenarios coincident with various defect configurations.

Next, the practical needs, i.e. managing the risk via PoF versus CoF. This is a simple comparison. The best guarantee of low CoF is to avoid the failure in the first place. "An ounce of prevention is better than a pound of cure" as the old saying[3] goes. A focus on PoF reduction is the path to prevention.

Bottom line: spend time and energy on both PoF and CoF, but recognise that you may, for good reasons, end up spending more energy on PoF. P

1. This is more of a conceptual equation rather than mathematical.
2. Monetising the receptors' value is not without controversy.
3. Attributed to Benjamin Franklin and, although many use the quote when referring to health, Franklin actually was addressing fire safety (according to Google).

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