The PIPELINE

2010 I VOLUME TWO

Pipeline Risk - What Are The Risks Posed By My Pipelines?

The current environment can make it stressful to own or operate a pipeline. New pipeline integrity regulations have been promulgated in recent years. Energy usage, throughputs and revenues are down because of the recession. Recent incidents such as the San Bruno catastrophe, which resulted in eight public fatalities, have heightening public awareness. And every day, the nation's pipeline network ages.

How can an operator determine the risks posed by his pipeline assets?

A pipeline operator can evaluate his risk by performing release modeling. Using this technique, the potential life safety and environmental impacts can be determined. Release modeling can also be used to comply with the U.S. Department of Transportation's Integrity Management Program, Consequence Analysis requirements (49 CFR 195.452).

What is pipeline modeling and how is it done?

Pipeline modeling takes into consideration the characteristics of the pipe (diameter, operating pressure, length to segmenting block valves, etc.), the pipe contents, the size of the release (function of hole diameter), and the environmental conditions (wind speed, atmospheric stability, etc.), among other factors. For a gas pipeline, like the one in San Bruno, California, two scenarios are modeled: vapor cloud dispersion and torch fires. For a hazardous liquid pipeline, vapor cloud dispersion and pool fires are typically modeled.

Vapor Cloud Dispersion Modeling

When flammable gas vapor clouds are within the flammable range, they can be ignited. Depending on local conditions, this can result in either a flash fire or an explosion. In most cases, risk assessments assume that individuals exposed to a flash fire will be fatally injured, since they will be exposed directly to the flame.

San Bruno, California pipeline explosion
September 9, 2010 - photo by Thomas Hawk, 2010

Many gases (e.g., natural gas) do not explode unless they are confined to some degree, are within a specific range of mixtures with air, and are subjected to an ignition source. However, if an explosion does occur, the physiological effects of overpressures can be life threatening. The degree of injury depends on the peak overpressure level that reaches a person. If a person is far enough from the source of overpressure, the explosion overpressure level would be incapable of causing injuries. The following endpoints are often used to determine explosion impacts. (Indoor explosions result in more severe injuries due to flying glass and other debris.)

- 1% Mortality – 2.4 psig outdoors, 2.4 psig indoors
- 50% Mortality – 13 psig outdoors, 5.7 psig indoors
- 99% Mortality – 72 psig outdoors, 13 psig indoors

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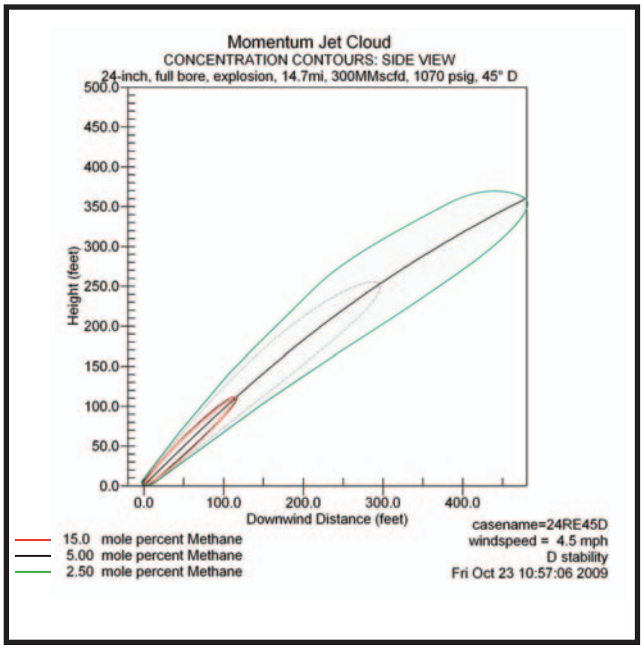
For toxic gases, the seriousness of injuries depends on the gas toxicity, concentration, and duration of the exposure.

The figure below presents the modeling results for a typical natural gas pipeline release. The portion of the vapor cloud within the flammable limit is located between 5 and 15% methane, the boundary of the flash fire.



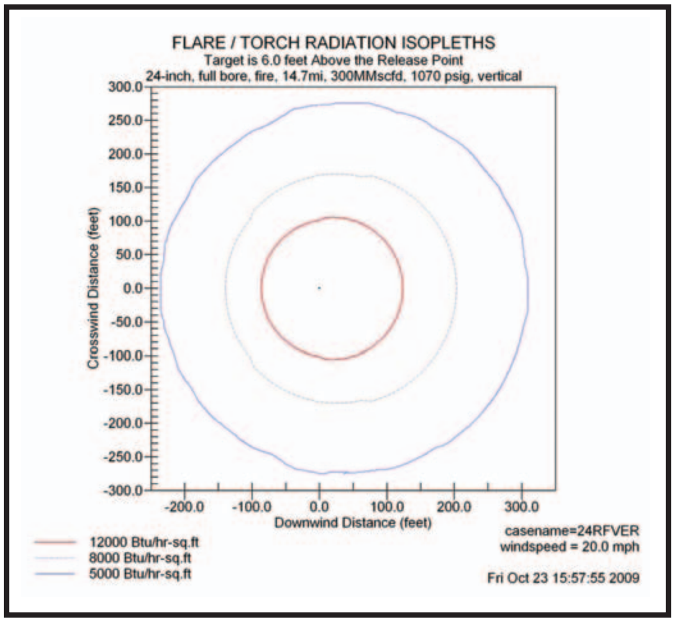
Torch and Pool Fire Modeling

Torch and pool fire models are used to evaluate the potential radiant heat flux impacts to humans exposed to a fire. A torch fire occurs when a combustible gas is being released from a pipeline and is subsequently ignited. A pool fire occurs when a flammable liquid pool is formed and ignited.

The physiological effect of fire to humans depends on the rate at which heat is transferred from the fire to the person and the amount of time the person is exposed to the fire. Skin that is in contact with flames can be seriously injured, even if the duration of the exposure is just a few seconds. Thus, a person wearing normal clothing is likely to receive serious burns to unprotected areas of the skin when directly exposed to the flames. Humans in the vicinity of a fire, but not in contact with the flames, receive heat from the fire in the form of thermal radiation. Radiant heat flux decreases with increasing distance from a fire. So those close to the fire receive thermal radiation at a higher rate than those farther away.

The ability of a fire to cause skin burns due to radiant heating depends on the radiant heat flux to which the skin is exposed and the duration of the exposure. As a result, short-term exposure to high radiant heat flux levels can be injurious. But, if an individual is far enough from the fire, the radiant heat flux would be lower, likely incapable of causing injury, regardless of the duration of the exposure. The following endpoints are often used to estimate the impacts to those exposed to a torch or pool fire:

- 5,000 btu/ft^2-hr – 1% mortality after 30 seconds
- 8,000 btu/ft^2-hr – 50% mortality after 30 seconds
- 12,000 btu/ft^2-hr – 99% mortality after 30 seconds



The modeling results for a typical natural gas pipeline release are shown in the figure above. In this case, potentially fatal impacts extend only about 300-feet downwind from the release.

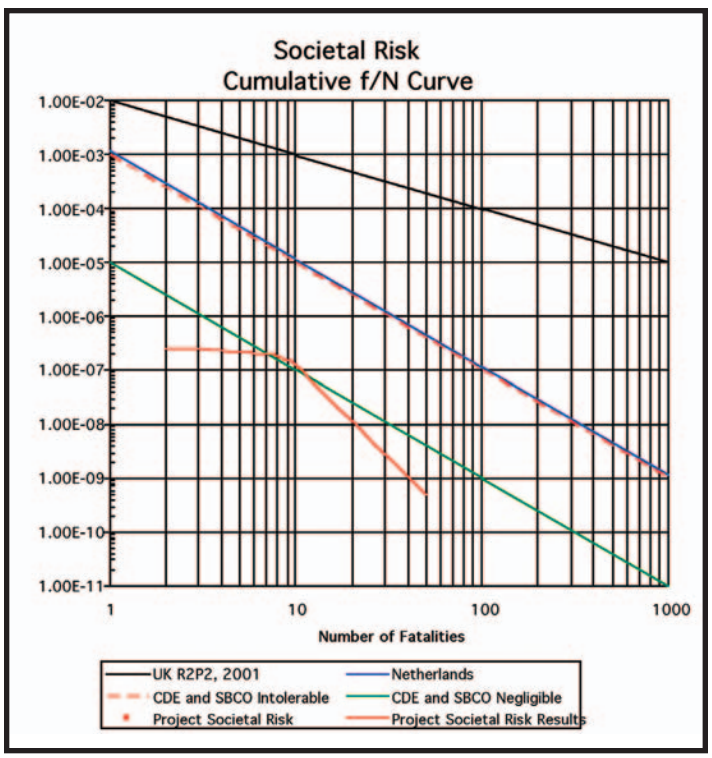
How are the modeling data combined to perform a quantitative risk assessment (QRA)?

If a client would like to quantify the risk posed by their system, a quantitative risk assessment (QRA) can be performed. In this case, the modeling results discussed above are combined with population data to determine the number of potential fatalities for a given release, for each possible release scenario. Each release scenario is then evaluated by determining its probability of occurrence.




First, a baseline incident rate must be determined; this is the probability of a release and is normally expressed as the annual number of incidents per mile of pipe. Historical data may be obtained from the U. S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration to assist in developing an appropriate baseline incident rate. Then, the following items are evaluated to determine the conditional likelihood for each release scenario:

- What percentage of pipe failures are relatively small leaks versus full bore ruptures?
- What percentage of vapor clouds resulting from leaks and ruptures are ignited?
- What percentage of ignited vapor clouds burn versus explode?
- In the event of a fire or explosion, what is the degree of serious injuries or fatalities which may result?



These data are then combined for each possible release scenario. The results are often presented in a cumulative f/N curve, as depicted in the above figure. These results depict the annual likelihood of incurring a given number of fatalities. These data can then be compared to societal risk acceptance criteria.

Conclusion

Pipeline modeling allows an operator to assess the range of possible human life and environmental impacts that may result from an unintentional release. If desired, these data can be expanded to provide a quantitative assessment of probable risk. For new lines, this can help operators select the pipeline route which minimizes the impact to the public and/or the environment. For existing lines, the results can assist the operator in developing emergency response plans and mitigation measures, identifying high risk areas, etc.

The Firm

EDM Services, Inc. has performed hundreds of pipeline release models and provided numerous pipeline risk assessments for major projects. In 1993, the firm published the landmark California Hazardous Liquid Pipeline Risk Assessment, which included a statistical analysis of a completely audited pipeline release data set; this document provided insight into the causal factors of unintentional hazardous liquid pipeline releases. Since being published, the results have been used both nationally and internationally for conducting probabilistic pipeline risk assessments.

Examples of natural gas pipe ruptures.

In The Spotlight

*During his college years, **Michel Kadah** worked as a volunteer with a local non-profit organization, Al EKHAA (meaning fraternity), established to help children with disabilities by providing education, medical, and social services. Michel witnessed how critically important these services are in enabling children to thrive. Also, inspired by a professor, Michel began to practice Tae-Kwon-do and I.K.O. Kyokushin Karate. After receiving his black belt in 1994, he participated in multiple tournaments including the 1995 World Open Championship Tournament for Kyokushin Karate in Tokyo, Japan. Michel became an instructor in Kyokushin Karate and enjoyed teaching martial arts for 4 years.*

Following his college graduation, Michel worked in the civil engineering industry as a structural engineer for four years before being granted a U.S. Visa. Michel dreamed of pursuing professional engineering in the United States and was undeterred by the obstacles that lay ahead; Michel dedicated himself to pursuing his dream. With the support of his father who taught him that perseverance is one of the keys to success, Michel made the decision to move permanently to the United States from Syria in 1999. The move paved the road to fulfilling his dreams and opened the doors of possibility.

After moving to the United States, Michel was attracted to the location and beautiful weather of Ventura County. He recently chose to settle in the City of Moorpark with his wife, Lara. Moorpark is a small city known for its family living style and Michel enjoys the relaxed ambiance and great outdoor activities and hiking trails. Michel and Lara recently welcomed the arrival of their first child, John.

Michel first joined EDM Services in February 2001. With his structural engineering background, it was his first exposure to the oil and gas industry. The firm's team, including the founding principals Brian Payne and Butch Walls, helped Michel improve his knowledge and develop strong engineering skills. Michel believes that his dedication and hard work will contribute to the future of the firm's success. Michel is one of the firm's project managers and is proud to be a member of the EDM Services' team.

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