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Minimizing the Impact of Accidental Chemical Releases

Dispersion modeling to predict plume behavior is key for contingency planning — in advance of any incident

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A hazardous chemical has spilled from one of a large tank onsite. Immediately, the question arises — is it dangerous? On the heels of this question come countless others: Who has cause for concern? What actions should be taken? Do the employees need to evacuate ? Do surrounding businesses and neighborhoods need to be alerted?

When facility managers and emergency responders are faced with such a weighty situation, they must take immediate, decisive action, and provide satisfactory answers to this barrage of questions. The lives of those at the plant and in the surrounding communities may hang in the balance, potential liability is enormous, and the company's reputation is on the line — the outcome of all these things rests upon the shoulders of plant managers, depending on the decisions they make.

For facilities that store and use hazardous chemicals, one spill could be devastating to employees and the surrounding community if it is not handled properly. Advance planning, and a good working knowledge of the tools that can help plant personnel to make quick and accurate assessments in the event of an actual incident, are both critical for plant personnel.

Accidental spills of toxic liquids or releases of gaseous chemicals, such as those resulting from tank ruptures, accidental spills from transfer lines, or releases from compressed gas tankers, can have a devastating impact on plant employees and surrounding residents. Ammonia, chlorine, formaldehyde, hydrochloric acid...the list of hazardous chemicals that can create serious problems if spilled or released goes on and on.

FIGURE 1. **Tank farms at facilities should be treated as high-risk areas for potential accidental chemical releases**

Whether a facility stores thousands of gallons of these chemicals in large tanks (Figure 1) or merely a few gallons in totes and drums, the unexpected release of toxic chemicals can lead to concentrations in the air that range from an odor nuisance level to an IDLH (Immediately Dangerous to Life and Health) level. Different concentration levels of various chemicals in air create different impacts on the facility and its surroundings, and each potential scenario requires a different planned response.

The impact area for a specific spill or release event must be determined using various factors. These include the particular attributes of the chemical of concern, the size of the release, the topography and existing structures in the surrounding area, and a variety of atmospheric conditions, such as wind speed and direction, humidity, and ambient temperature, that will impact how the chemical cloud will disseminate once it has been released. Depending on the toxicity of the chemical, response actions range from personal protection to evacuation. Actions for basic protection may include special respiratory protection, while more drastic actions may involve evacuation of the facility premises or evacuation of residents around the facility if an impact area is determined to proliferate beyond the facility property.

How can a company prepare itself to handle such an incident? Contingency planning is the key. The use of plume dispersion modeling can aid in this contingency planning.

How such modeling works

Dispersion models use complex calculations to determine the area affected by a toxic release and the chemical concentrations within the affected area. There are different kinds of modeling programs based on the type of chemical release that might be possible at a given site. Through numerous iterations, a Gaussian plume model takes into account the nature of the chemical released, as well as atmospheric factors, to determine how the release is likely to disperse into the atmosphere.

Certain characteristics of the chemical, such as its density, affect its transport, and are thus a factor in determining how high above ground the plume will likely rise. Plume height is an important attribute to model, as it affects the diffusion of the chemical at the ground — the location where toxic concentration levels are most crucial.

Atmospheric considerations, such as air turbulence and wind velocity, also affect the dispersion of any gaseous chemical release. The models that underlie today's user-friendly plume dispersion software programs take into account all of these variables to give a risk assessment scenario for a given toxic release.

To use these models, information about facility layout is typically provided by the user, as are details about facility property lines and building layout and dimensions. The user must also provide information regarding the location of the potential sources, and potential emission rates. Emissions can occur from dry storage piles, pools of liquid, volume sources such as entire building, and point sources such as stacks or vents. If the facility is not able to provide such information, site visits can be conducted by engineers to determine the appropriate input data for such sources.

Meanwhile, meteorological data related to temperature, wind speed and wind direction can be obtained from regional air quality regulators, to best represent the meteorological conditions at the site. It is rare, but possible, that the facility might have a monitoring station onsite that records meteorological data, which can then be used in the modeling process. Similarly, terrain data can be obtained from an independent agency that is licensed to provide such data, in cases where the terrain migh have a substnatial impact on the modeling results.

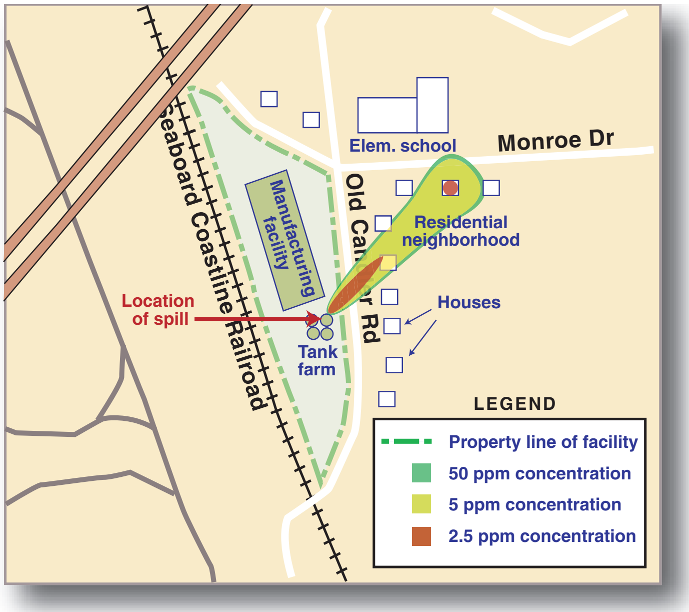

FIGURE 2. The dispersion pattern, concentration and impact area of a large hydrochloric acid release (327 lb of 37% solution) at a facility is shown here. This release requires evacuation of the surrounding residents

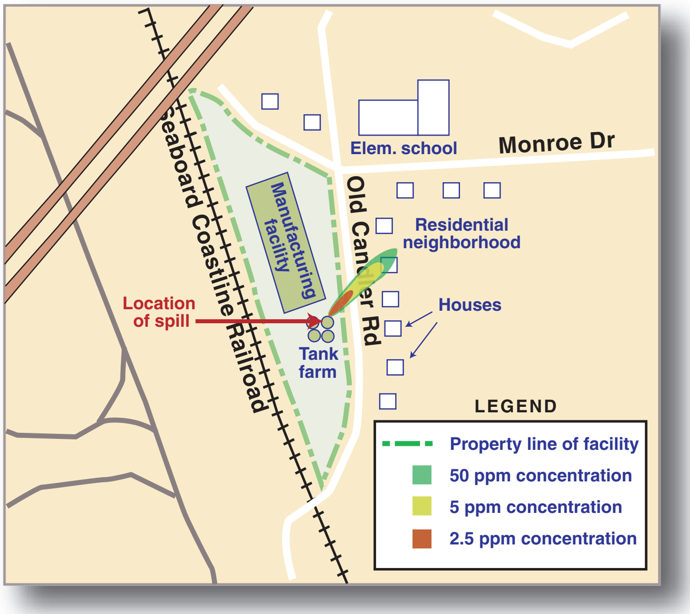

FIGURE 3. For this smaller hydrochloric acid release (164 lbs of 37% solution), the dispersion pattern and impacted area called for more-limited measures to protect the neighborhood

Planning for the worst

Using pre-determined atmospheric conditions, the location of the spill/release, and various spill/release sizes for each chemical, the program then calculates the concentrations of the different hazardous chemicals in the air at ground level. Three different impact levels are considered – nuisance odor (half of the Permissible Exposure Limit, or PEL, value), the PEL value, and IDLH. Today's dispersion modeling programs typically allow the user to model a variety of scenarios, such as worse case, intermediate case and best case, and the

THE UNDERLYING MODELS

Described here are the different types of software programs that are available to model the type of chemical-release sources that may be present at chemical process facilities. These models are available in the public domain from EPA (at www.epa.gov/scram001). Many of today's commercially available dispersion-modeling software packages use these models, but add various customization features to improve the user interface, the handling of graphics and so on.

Examples of several prevailing models include:

- *SLAB* for dense-gas releases; this program uses dense-gas algorithms, allowing heavier-than-air gas releases to be accurately modeled. SLAB has the ability to model each of the EPA-recognized release types, including 10-minute releases that are needed for Risk Management Plans (RMP). Modeling of vertical or horizontal "jet" releases are a particular specialty of SLAB.
- *INPUFF2* for simple gas-release modeling; this is one of the few puff models to allow multiple sources at multiple locations to be modeled concurrently. Additionally, source emissions and meteorological data conditions can be changed during the modeling period. This program even allows moving sources to be modeled.
- *SCREEN3* lets users carry out quick steady-state comparisons of the concentration of pollutants at ground level. SCREEN3 is EPA's most versatile screening model. SCREEN3 uses preset meteorological data to give a worst-case concentration quickly and easily. This single-source model accommodates flat as well as elevated terrain. The source that is modeled may be a point, flare, area, or volume source.
- *ISCST3 (Industrial Source Complex Model)* lets users conduct refined modeling for steady state concentrations at ground level

These are just a few of the models available from the EPA. ❒

facility may also have other specific models that it would like to run and those scenarios can be modeled, too. Once the modeling of these scenarios is complete, the computed results can be applied to develop contingency emergency-response plans.

Necessary response actions, such as the use of respiratory protection, evacuation of certain areas within the facility premises, or evacuation of individuals residing in the community surrounding the facility, can be determined from the results of a plume model. Any facility that stores or uses toxic gaseous chemicals should fully prepare itself to implement appropriate action in the case of a hazardous spill or release.

Users can depict likely dispersion patterns using graphical representations that show the size of potential spills or releases superimposed on maps depicting the facility and its surroundings. Such a graphical display shows what areas of the facility and community might be impacted during a given spill scenario (Figures 2 and 3), and help facility operators to easily determine which emergency situations require what type of response.

Today, chemical process facilities are able to develop site-specific contingency planning through the use of plume modeling program. By implementing a more-targeted contingency plan, a company becomes ready to protect not only its employees, but also the surrounding community should an accidental spill or release occur at its facility. *Edited by Suzanne Shelley*

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