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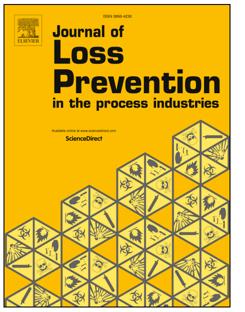

Engineering aspects of the preparation for managing accidental Hydrogen Sulphide releases at a process site

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Engineering Aspects of the Preparation for Managing Accidental Hydrogen Sulphide Releases at a Process Site

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Abstract
The scope of documentation that deals with siting and laying out process facilities is often limited to combustible gases and flammable or combustible liquids. Generic documentation for siting and laying out process facilities with respect to airborne toxic materials, and how to approach the management of inadvertent releases, is usually not readily available. Barring an inherent safety solution; i.e., substitution of the toxic material with a non-toxic material, there are two basic approaches when dealing with Hydrogen Sulphide (H_2S): evacuation and shelter-in-place. This paper deals with several engineering aspects of a holistic safety management approach that covers both evacuation and shelter-in-place. The engineering aspects include dispersion modeling and functional safety aspects of the gas detection systems as well as (potential) problems with their application.

Keywords: toxic gas release, Hydrogen Sulphide, shelter-in-place, gas detection, dispersion modeling, surface roughness

1. Introduction

There have been multiple publications of processes for the siting and layout of process facilities. They often use spacing tables as a starting point for an initial site layout [1]. Current spacing tables reflect empirical experiences with facilities that were constructed 30 to 50 years ago, at a time when facilities were much smaller and had fewer control monitoring capabilities. It is therefore to be expected that a fair amount of optimization work will be needed to upgrade an initial site layout to that of a modern facility. This effort usually includes consequence modeling software that can be based on published equations; e.g., The Yellow Book [2] or more advanced methods such as computational fluid dynamics. The desired result will be a facility, with adequate maintenance and emergency access, where equipment and buildings are properly spaced and engineered to withstand blast and heat loads at their respective locations. Such engineered solutions are usually deterministic; i.e., based on consequences and not on risk.
The availability of a site's fire and vapour cloud explosion (VCE) information has been utilized for the preparation of useful management systems. For example, many refinery and petrochemical process sites have plot plans with superimposed VCE isobars that allow easy and safe location of temporary trailers, based on their design specifications.
There does not seem to be an equivalent simple process safety management tool for inadvertent toxic releases, specifically for Hydrogen Sulphide (H_2S). H_2S is of special interest because it is probably the most common toxic gas in the process industry where it is produced and converted into Sulphur as part of refinery desulphurization processes. These processes include hydrotreaters, amine treatment, sour water systems and Claus (Sulphur) plants.
One reason why toxic issues have taken a back seat to fire and explosion issues might be that siting and layout publications focus on flammable materials and sometimes simply state that "toxic concerns may require greater spacing"[1]. This could actually be counter-productive because increasing spacing between interconnected equipment will increase the inventories in the interconnecting piping. Furthermore, without some indication of what concentration or dose is important, from a process safety perspective, a practitioner might be tempted to select occupational Threshold Limit Values (TLVs). The latter are issued by the American Conference of Governmental Industrial Hygienists (ACGIH®).
Until 2010, the ACGIH®) had recommended 10 ppm(v) as a time-weighted average (TWA; i.e., eight-hour working day/40 hour week) H_2S TLV[20]. In 2010 the ACGIH issued new TLVs for H_2S; a TWA of 1 ppm(v) and a STEL of 5 ppm(v) (was 15 previously). The sole objective of the ACGIH® is to develop TLVs as guidelines to assist in the control of health hazards and not for use as legal standards. This is regardless of technical or economic feasibility; e.g., the 1 ppm(v) level would almost certainly cause spurious alarms in desulphurization facilities. The ACGIH® points out on their website that users of TLVs must recognize the constraints and limitations subject to their proper use and bear the responsibility for such use[21]. The TLVs represent conditions under which ACGIH® believes that nearly all workers may be repeatedly exposed without adverse health effects. This is, of course, quite different from a low probability process safety incident that might expose staff to H_2S. Obviously the use of TLVs, 10 ppm(v) or less, is not useful as a process safety criterion for inadvertent releases.
The aforementioned lack of guidance is a concern, as it was observed in the 1980s that toxicity data for at least one toxic industrial gas (Chlorine) might be wrong[5, 6]. Moreover, simulating the 10 ppm(v) H_2S cloud outline of a major inadvertent release from a high purity (> 92 vol-% H_2S) main process line resulted in a large cloud that overwhelms other scenarios. This renders any effort to develop a practical management benchmarking tool ineffective and highlights the need for a crisp discriminating concentration or risk criterion.
In order to satisfy the need for an effective H_2S process safety management tool, an effort was initiated to develop one. This tool is intended to show a site or plot plan with super-imposed H_2S concentration or risk contours of interest. It would allow managers and designers to make quick decisions about where facilities such as buildings, would require special design features and where trailers could be located.

The development of the tool got further complicated when a need arose to voluntarily satisfy the Canadian Environmental Emergency regulations (E2) [7] with modeling parameters that had been suggested by the local environmental authorities. Three of these parameters are considered potentially abnormal for many process facilities such as:

- modeling of complete guillotine pipe failures;