RELEASE OF CO2

When there is a leak or rupture in for example a storage container or pipeline, CO_2 will discharge into the atmosphere. The release rate decreases with time as the equipment depressurizes. Once a material has been released into the atmosphere and has expanded so that its internal pressure is equal to atmospheric pressure, it will travel away from the release point under the influence of its own initial velocity, the wind, buoyancy and diffusion forces.

Loss of Containment (LOC) scenarios can occur under different process conditions, including from gaseous, liquid or dense phase inventories or even solids. These releases could occur above or below water, on for example offshore platforms, subsea, below or above ground and within densely packed and congested plant areas. The process conditions and surroundings have an impact on the discharge and dispersion of a material.

The discharge behavior of a CO_2 release depends mainly on the above mentioned parameters. The discharge velocity depends mostly on the pressure differential and nature of the rupture (a catastrophic rupture or a (small) leak). The bigger the pressure differential, the larger the discharge velocity will be. During a catastrophic rupture of a vessel the complete inventory is released directly.

Upon release the stored material expands to ambient pressure. Dispersion will take over during the loss of expansion energy. Releases from a hole in a pressure vessel or a broken pipe will form a CO_2 jet, which expands and moves away due to the initial momentum of the release. Dispersion will take over after the ambient pressure is reached and the momentum has dissipated.

Also, the state of matter (e.g. liquid, gas, two-phase or solid) in which the CO_2 is influences the discharge behavior. Accidental releases from vessels with liquid and dense phase CO_2 inventories are significantly more complex. In these cases, as the CO_2 enters the atmosphere it makes a transition from the liquid phase to a two-phase gas/solid mixture where the solid fraction depends on the upstream conditions. The solids particles that are formed will become entrained in the gaseous release, where it will sublime into the cloud. Under certain conditions some solids may rain out on the ground, where it will form a vapor blanket upon subsequent sublimation.

The dispersion is influenced by the medium in which the CO_2 is discharged (e.g. air, water or underground) as well. For accidental releases, which occur under water from subsea pipelines, seagoing vessels or barges, the CO_2 must rise to the surface before being dispersed.

The CO_2 will spread as it rises in the bubble column and the size of the area at the surface can be much larger than the area of the hole. The size of the area is likely to increase with increasing release depths. Furthermore the CO_2 release will lose momentum, which may significantly increase the hazardous distance.

Using the North Sea as an example, at the sea bed the pressure and temperature are around 10 bara (corresponding to the hydrostatic pressure of 100 meter water column) and 4 °C, respectively. At these conditions, CO_2 is in the gas phase. A pipeline could, however, contain liquid or dense phase CO_2. Hence at a pipeline rupture or fitting failure at the sea bed there could be a very complex region of mixing between the CO_2 (undergoing phase change) and the water. However, within a short distance from the release, gaseous bubbles of CO_2 will have formed, which then rise through the water forming a bubble column. The evolution of this bubble column must be tracked using some form of model to give the size of the release at the sea surface.

CO_2 releases at greater water depths could cause the pH of the seawater to drop due to dissolving of CO_2 in seawater. Barry et al. have found pH's close to 4 at the seawater/CO_2 interface. However, this is only for the case when CO_2 will be a liquid. For depths lower than 2500 m. the CO_2 will rise to the surface and for depths lower than 500 m. CO_2 will rise as gas bubbles.

When CO_2 is released in a depth greater than 3000 m. the CO_2 will be more dense than seawater and will sink to the bottom.

Source: http://hub.globalccsinstitute.com/publications/co2-liquid-logistics-shipping-concept-llsc-safety-health-and-environment-she-report/34