Graniteville, South Carolina, Disaster of January 6, 2005

By Frank Rebelo

On January 6, 2005 there was a collision of two Norfolk Southern freight trains. One of the trains was traveling northbound while transporting liquefied chlorine, sodium hydroxide and cresol. This train collided with another stationary freight train on an industrial rail spur in Graniteville, South Carolina at approximately 2:40 am. The switching mechanism was set to send the northbound train off the main rail and onto the rail spur line. The collision of the two trains caused a rupture in one of the 90-ton tank cars, which contained pressurized liquid chlorine (Cl^2). The rupture in the rail car ejected chlorine gas and aerosol particles. The constituents formed a dense toxic cloud around the collision site. This cloud killed nine workers who were at a nearby textile mill and caused injury to more than 500 others. Due to the threat of additional tanks rupturing, near by residents had to relocate for over a week. Graniteville, South Carolina is located about 240km east of Atlanta, Georgia.

The Savannah River National Laboratory (SRNL) mesonet, between 3:00 a.m. and 6:00 am observed 2-4 mph winds (surface) from the south-southwest, 7-10 mph winds (61m). The mesonet consists of 14 stations in a 25km radius of Graniteville. Their heights range from 10-60m above ground level and the spacing between stations range from 3-15km. Recorded data shows temperatures ranging between 52-56 ^{o}F and a relative humidity of 92-98%. Atmospheric stability was ranked as E and D on the Pasquill-Gifford stability scale, (A- very unstable through F-very stable). Cloudiness at Augusta Regional Airport (AGS), Bush Field in Augusta, Georgia. was noted as partly cloudy. Bush Field in Augusta is within 30km of Graniteville, South Carolina to the southwest.

The turbulence measured that morning showed that there was a greater than average amount of turbulence in the atmosphere compared to an average midwinter night. Turbulence varied between neutral and weakly stable. With the lack of a strongly stable boundary layer, "…meteorological conditions were probably sufficient to cause some turbulent mixing and steady erosion of contaminant along the periphery of the dense cloud that formed immediately after the crash and tank rupture" (Buckley et. al. 2007). By morning, the sky was clear and most of the chlorine cloud had dispersed.

During the day the chlorine molecules degrade by photolysis. This happens in which sunlight breaks apart the chlorine molecule to form two chlorine radicals. The two radicals then react with organic molecules to form hydrochloric acid. In midday summer sunlight conditions photodissociation has a rate constant of approximately 1.6 x10^-3 second^-1, which corresponds to a half-life of 7.2 min. However, during midday winter sunlight conditions, like the conditions of Graniteville on January 6, 2005, the photodissociation rate constant is approx .2x10^-3 second^-1, this leads to a half-life of approximately 58 minutes (ATSDR 2011).

SRNL used a Puff/Plum program to predict the movement of the toxic cloud. They predicted, "…downwind concentrations would be greater than the Emergency Response Planning Guide Level 2 (ERPG-2) threshold of 3ppm extended no more than 1.6 km (1 mi) downwind of the accident site". Emergency Response Planning Guidelines (ERPG) Level-2 for chlorine is 3 ppmv. "Unsubstantiated reports by motorists along Interstate 20, ~20 km north of the incident, indicated that odors had been noted; however, SC-DHEC reported no evidence of detectable levels of chlorine in areas downwind of the immediate incident after daylight" (Buckley et. al. 2007). (Chlorine has an odor threshold at 3.5ppm) Although chlorine gas is much denser than air, throughout the night to early morning, there was sufficient turbulence for mixing to occur. Mixing was even great enough to even push the toxic plume over higher terrain to the northeast. This minimized harmful effects of the toxic plume greatly.

Had the conditions been different with an extremely stable atmosphere and no winds, the chlorine toxic cloud could have hugged tightly to the surface and not dispersing as readily then this incident would have been far deadlier than it was. The chlorine cloud, denser than air, would have remained in the lower terrain areas around the crash site until the surface of the earth could have received enough energy to have a turbulent effect on the atmosphere. Then, as mixing would become more vigorous, it would flush out the chlorine.

References

[1] Buckley, R.L.; Hunter, C.H.; Addis, R.P.; Parker, M.J. *Modeling Dispersion from Toxic Gas Released after a Train Collision in Graniteville, SC.* Journal of the Air & Waste Management Association. **2007**, 57, 268-278.

[2] Agency for Toxic Substances & Disease Registry. *Toxic Profiles: Chlorine: Potential for Human Exposure.* Atlanta, GA, 2011; available at http://www.atsdr.cdc.gov/toxprofiles/tp172-c6.pdf (accessed 2011)

[3] CAMEO Chemicals. *Chemical Datasheet: Chlorine.* National Oceanic and Atmosphere Administration. 2011; available at http://cameochemicals.noaa.gov/chemical/2862 (accessed 2011)