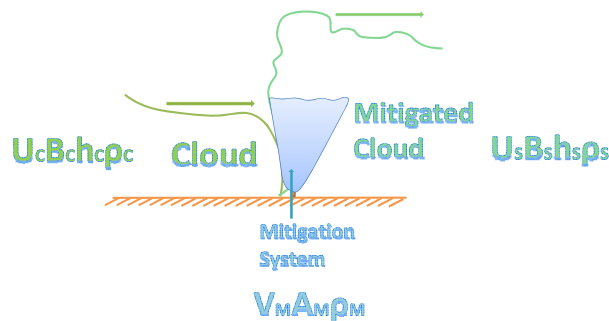


## Modeling Mitigation systems

Mitigation is important for reducing damages in flammable and toxic gas release incidents. However, mitigation is applied on gas dispersion when concentration can be reduced to avoid an explosion or toxic damage. The large amount of toxic gases requires analyzing the application of mitigation systems in order to avoid catastrophic results. During last decades several experiments on applying mitigation systems have been reported for various compounds such as chlorine, ammonia, and hydrofluoric acid.

Mitigation systems reduce the concentration of gas cloud throughout application of fluids. Some mitigation fluids are easy to handle, e.g. water, air, or steam. Generally, mitigation systems generate barriers against the cloud. The mitigation effect is carried out via absorption, dilution, or even reaction. Since each gas has its own property and physical phenomena during mitigation, it becomes extremely complicated to predict the whole behavior precisely.

Models to explain physical behaviors with mitigation systems should consider weather conditions affecting cloud dispersions, and the mitigation system design such as nozzle type and size. Dense gas dispersion can be predicted with SLAB, DEGADIS, etc. To analyze cloud dispersion after mitigated, a new model has been developed with using the SLAB model for the basic balances such as mass, heat and momentum balances between the gas and mitigation fluids. In particular, the water curtain model considers droplet sizes and applies an experimental correlation to compute mass and heat transfer from the droplet. The model is represented basically with the following variables: Temperature,  $T$ , velocity,  $U$ , composition,  $\omega$ , width,  $B$ , height,  $h$ , density,  $\rho$ ; and, it identifies the flow with subscripts  $C$ , cloud,  $M$ , mitigation, and  $S$ , mitigated cloud. The picture below represents a mitigation system with mass inputs and outputs:



The balance for the mass conservation considers the formulation from the picture, and is defined as:

$$U_c B_c h_c \rho_c + V_M \rho_M A_M = U_s B_s h_s \rho_s$$

Also, a balance for gas toxic is developed, such as:

$$U_c B_c h_c \rho_c \omega_c = U_s B_s h_s \rho_s \omega_s$$

A balance of humidity depends of quantity of water, in case of air curtain the balance is:

$$U_M \rho_M A_M Y_M = U_S B_s h_s \rho_s (1 - \omega_s) Y_s$$

Energy balance is:

$$U_C B_c h_c \rho_c H_c + V_M \rho_M A_M H_M = U_S B_s h_s \rho_s H_s$$

Where  $H$  is the enthalpy, which is function of temperature and composition. A momentum balance in  $x$  direction is developed considered the buoyancy of the gas, such as:

$$B_s h_s U_s^2 \rho_s - B_c h_c U_c^2 \rho_c + \frac{g}{2} h_s^2 B_s (\rho_s - \rho_A) - \frac{g}{2} h_c^2 B_c (\rho_c - \rho_A) = 0$$

The next picture concentration in a chlorine study case which is compared between non mitigation and mitigation systems.

