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STUDY OF ACCIDENTAL RELEASES HEAVY GAS DISPERSION COMPARING SLAB MODELS AND SCREEN-3 MODEL

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ABSTRACT

Most of the chemical industries such as petroleum industries, refinery industries, fertilizer industries etc. releases rarely accidental gases it may be heavy gases like liquefied petroleum gas, chlorine, natural gas, ammonia etc do occur. The impact of these heavy gases (high molecular weight than air) in the surrounding atmosphere is very harmful/ hazardous to the human health because the formation of heavy clouds of the respective gases nears the earth surface. In present paper, considered the effect of atmospheric parameter such as, direction of air, wind speed etc. as well as stack parameter like height of stack and released gas parameter as density, venting speed of the gas on the dispersion of heavy gas in to the surrounding.

Here present work done to identify the downwind concentration along with the horizontal distances through a case study of industrial accidental release (Ammonia Gas) scenario. SLAB model for the heavy gas dispersion and SCREEN-3 a single source Gaussian plume model these two types of dispersion models readily available in the public domain for industrial releases of gases. Result of downwind concentration of ammonia vapour in both of model has presented.

KEYWORDS: Heavy gas dispersion, SLAB model, SCREEN-3 model, Ammonia Vapour.

INTRODUCTION

In dispersion phenomenon, pollutant gases going to diffuse in pure air as they transport from one place to another heavier gas slump toward the earth surface. These pollutant gases having higher density than air density such gases called as heavy gases or dense gases. This result can be due to a gas with a molecular weight greater than the air, or a gas with a low temperature due to auto-refrigeration during release. The mechanisms of dense gas dispersion differ markedly from neutrally buoyant clouds which has basically depends upon density of gas. When dense gases are initially released, considered the effect of atmospheric parameter such as direction of air, wind speed etc. as well as stack parameter like height of stack and released gas parameter as density, venting speed of the gas on the dispersion of heavy gas in to the surrounding these gases slump towards the ground and move both upwind and downwind. e.g. Hydrogen sulphide, Ammonia, Chlorine, CF4, Liquefied petroleum gas, , C 2F6, etc.

Many gases from petroleum industries, refinery industries, fertilizer industries etc processes may have molecular weights larger than air and are denser than air even at ambient temperatures. In proximity to the ground, a dense cloud will tend to dispersed laterally and the vertical diffusion will be suppressed. This can give rise to high ground-level concentrations, so the prediction of dense gas dispersion in the atmosphere is a topic of considerable interest for emergency response and site safety studies.

The dispersing cloud of a heavy gas release can be divided into three major phases:

(1) Source of emission
(2) Initial acceleration and diluting phase
(3) An initial gravity dominated phase or slumping phase
(4) The transition phase
(5) The buoyancy dominated phase

The dispersion of a dense gas cloud or plume proceeds through several phases (in continuous releases), dependent on the dominant physical mechanism involved as shown in figure I.

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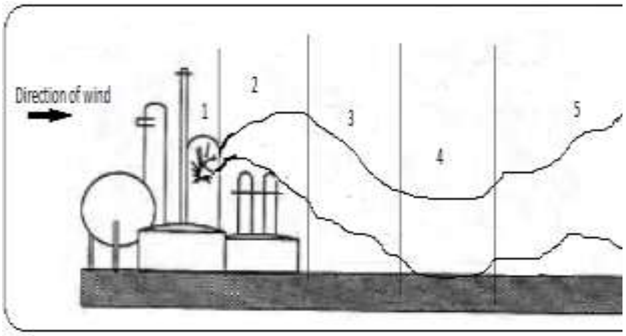

Figure I: An illustration of different phases in the dispersion of heavy gas clouds [3]

MATERIALS AND METHODS

Britter (1989), Hanna and Drivas (1996), Markiewicz (2003, 2004) The mathematical heavy gas dispersion models can be classified using different criteria. The mathematical principles, emission source type and model complexity are used as the criteria. Based on this last criterion heavy gas dispersion models are divided into three groups. The models are known as [7],

1. Phenomenological (empirical) models
2. Intermediate (engineering) models
3. Computational fluid dynamic (research) models

Accidental release of ammonia from the storage tank vent was considered for computing ground level concentration using SLAB (a heavy gas dispersion model), SCREEN3 model. The result obtained from these models is presented in this paper.

SLAB MODEL

The SLAB model was developed to simulate the atmospheric transport and dispersion of dense gas releases from area sources. The solution of SLAB model generally applies to neutral (passive) gas and buoyant gas releases. It solves the one-dimensional i.e. in downwind distance equations of momentum, conservation of mass, energy, species and the equation of state. SLAB itself describe that the concentration of gas considered in horizontal, vertical and cross direction. The model can be applied to instantaneous and continuous releases and enhanced simulate jet releases also. SLAB can calculate the dispersion from horizontal and vertical jets at any height, liquid pool evaporation and instantaneous volume sources. [19]

SCREEN3 MODEL

SCREEN-3 model generally applicable for screening purpose have easy to use method of getting concentration of pollutant. Screening calculations makes by SCREEN3 model can be accessible to a wide range of users and this advantage of the rapid growth in the availability by easy to download.

The SCREEN3 model can be calculate maximum pollutant concentration at any distances by user defined in elevated or flat simple terrain, also for long-range transportation including distances out to 100km. Application of SCREEN3 are: The single source, Short-term calculations in the screening purpose, including predicting maximum concentrations at ground-level and the maximum distance, Estimating concentrations due to inversion break-up, Near wake and far wake regions, Incorporating the effects of building downwash on the maximum concentrations, Estimating concentrations in the cavity recirculation zone, and determining plume rise for flare releases. Due to plume impaction in complex terrain, the model can incorporate estimate 24-hour average concentrations and the effects of simple elevated terrain on maximum concentrations.

Industrial Accidental Scenario: Releases of Ammonia Vapour

In this case study, an accidental release of pressurized ammonia from storage tank was considered when it was released from the relief valve of 2.5 m height on top of the storage tank which is located at 10.5 m above the ground level. It was determined that a total of 3000 kg of ammonia was released in 5 min in the form of vertical jet release which results into the average release rate of 10 kg/s. The downwind distance concentrations of the ammonia vapour cloud due to the vertical jet release are computing using SLAB and SCREEN-3 models.

Details of the release conditions and representative meteorological conditions during the release events are summarized in Table I and II, respectively. In addition, the surrounding area is characterized as flat terrains and typically the surface roughness is taken as 1.2 m. [6]

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TABLE I: AMMONIA RELEASE PARAMETERS

Source Parameters	**Values**
Release quantity (Kg)	3000
Release duration (min)	5
Release rate (Kg / sec)	10
Release temperature (K)	318
Vent diameter (m)	0.37
Venting speed (m / sec)	125
Storage pressure (KPa)	1625

TABLE II: METEOROLOGICAL CONDITIONS FOR THE AMMONIA RELEASE SCENARIO

Meteorological Parameter	**Value**
Atmospheric stability class	D (neutral)
Wind speed (m / sec)	5.5
Atmospheric temperature (K)	300
Relative humidity (%)	50
Ambient Pressure (KPa)	107.3
Terrain of the area	Flat rural area with a roughness height of 1.2 m

RESULTS & DISCUSSION

Assumptions

1. Total vapour release
2. No liquid fraction
3. Adiabatic conditions

From the above industrial scenario, the leakage of ammonia vapours from the valve of the storage tank dispersed in the surrounding atmosphere. The maximum downwind concentrations at the downwind distances were calculated by using SLAB model and the SCREEN-3 model. The maximum downwind concentration is 559 ppm obtained in the SALB model and 204.92 ppm obtained in the SCREEN3 model at horizontal distance 800 m as shown in Figure II. It is observed that the concentration of the ammonia vapours decreases with increasing horizontal distance. The initial concentration of the ammonia vapours

given by SLAB model is found to be very large than the values predicted by SCREEN3 model.

The downwind concentration profile of the SLAB model and SCREEN-3 model shows similar behaviour. At horizontal distance of about 6000 m both concentration profiles are close to each other.

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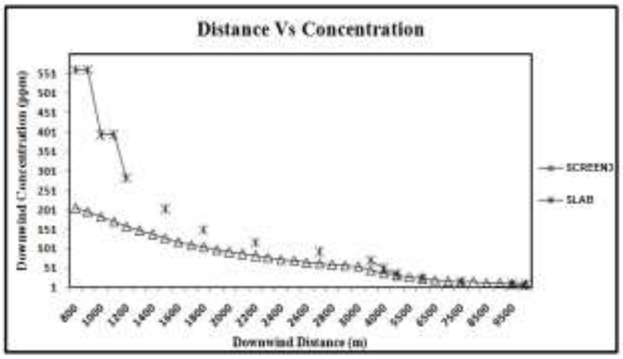

Figure II: Variation of concentration with downwind distance computed using SLAB and SCREEN3 models

CONCLUSION

The present study covers the different steps required for the identification of the various hazardous distances and their concentration due accidental release of heavy gas through the vertical jet form. The study includes the different model equations to analyse the maximum horizontal safety distance at surrounding atmosphere release of heavy gas.

Accidental release of heavy gases from the chemical industrial processes or storage containers can typically be modelled by either dense-gas model i.e. SLAB or screening model i.e. SCREEN-3.

As shown in the case studies, while more than one model can be applied to a specific release scenario, different models may give different results due to inherent assumptions and limitations associated with each model. Details of the release scenario should be reviewed carefully in order to reach a reasonable decision. More importantly, a model that gives best result may not be the most suitable model for the occasion. Comparison of SLAB and SCREEN-3 models results show that SLAB given higher values at distance close to the source than SCREEN-3 model. However, at larger distances both models showed same results.As the pollutants being heavier than air it is recommended that use of heavy gas dispersion model such as SLAB, which are conservative values. Applications of SLAB model and other heavy gas models will be useful for computing safe distances and for providing risk based action plan for taking appropriate measures for reducing any material/human loss due to accidental releases.

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