

# Impact Assessment of Gaseous Fire and Explosion by Using Dispersion Modelling in City Piping Network

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**ABSTRACT:** This paper provide direction on the assessment of gaseous fire and explosion by using dispersion model in gas processing industry. Gas leakage/spill, fire and explosion have been identified as major potential hazards for gas storage, transportation and handling area and pose risk to personnel, assets and the environment. Current fire and explosion assessment tools like dispersion models, software based models and others engineering practice. Modelling of the atmospheric dispersion of gas from accidental leak is one of the critical steps in such hazard analyses. This paper describes evaluation for the assessment of gas dispersion model and comprises scientific evaluation of the numerical and physical basis of model for the dispersion of gas, model verification, validation resulting in a comprehensive model evaluation. The tool features built-in calculations for fire and explosion impact assessment for gas leak/spill mass discharge rate, estimation of gas/liquid release distance. Impact assessment analysis provides decisions support to safety based operations.

**KEYWORDS:** Natural gas, Fire and Explosion, Pasquill-Gifford dispersion model, Model evaluation, Impact assessment.

## I. INTRODUCTION

Natural Gas is basic energy source in the oil and gas industry. The availability of huge reserves of natural gas, its environment friendly and easy to transport. This colourless, odourless gas is treated systematically and converted to the usable Compressed Natural Gas (CNG) and Piped Natural gas (PNG) which is distributed to the end users across towns and cities through the City Gas Distribution (CGD) network. The network consists of pipelines crisscrossing across the length and breadth of the city, reaching out occasionally to small industrial but mostly to commercial and residential consumers. Natural Gas from the treatment plants in the exploration areas are received generally at the outskirts of the city, the point being named as the “tap-off point”. The tap-off point acts as the city gate for the distribution of gas in the city and here the gas is further treated with respect to the pressure. A low and medium pressure is maintained according to the requirement of either the residential or commercial consumers respectively.

Safety and Disaster management is one of the key issues in City Gas Distribution, as because the pipelines pass through populated areas. At the city gate a few precautions are taken, for example Mercaptor is added for easy detect ability in case of any leakage. The CNG for automobile usage is distributed through CNG stations situated in strategic locations in the city. The PNG is distributed through pipelines directly at the place of requirement of the end users.

City piping network consist of steel pipeline and MDPE (Medium Density Polyethylene) Pipeline. City Gas station are the tap-off's at the main pipeline. These are the termination station for a city where the various processes like pressure reduction, filtration, and odourisation is done. The gas from the main pipeline is brought down to a pressure of 19 to 22 bars and then transferred through steel pipeline to DRS (District Regulation Station). DRS are installed where the distribution is to be done like in the industrial area and domestic/commercial segment. Gas to the various consumers is transferred after being maintained at a pressure of about 4 to 5 bar. Then the gas is transmitted to Single Stream Regulator (SR) through 4 bar medium pressure MDPE pipelines. SR further reduces the pressure from 4 bar to 100 millibar. From SR the gas is supplied through a 100 millibar low pressure MDPE pipeline to a GI (Galvanized Iron)

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Riser Isolation wall. From this valve the gas is carried through a GI 100 millibar pipelines to end user. The control valve is placed at the height of 5 feet which controls the flow and then a regulator are installed which brings down the pressure to 21 millibar for basic home users. A meter is installed which tells the amount of gas being used depending on which they are charged.

## II. FIRE AND EXPLOSION

Fire and explosion are unplanned events in the workplaces especially where the handling, transportation and storage of hazardous material took place. Natural gas possesses a substantial hazard in the form of fires and explosions. The three most common gas processing industry accidents are fires, explosions, and flammable gas releases. The existence of this results in huge losses in terms of human life, machinery and environment.

Fire is define as exothermic self catalytic chemical reaction with the characteristics ability to propagated through a combustible medium usually fuel which is combustible material, an oxidizer which is generally oxygen and heat. At city piping network possess fire hazard in the form of Jet fire, Flash fire.

Explosion in the gas processing industries causes fewer serious accidents than fire but more than gas release. When it does occur, however, it often inflicts greater loss of life and damage than fire. Explosion is usually regarded as having a disaster potential greater than that of fire but less than that of gas release.

Distinction between Fire and Explosion-The major distinction between fire and explosion is the rate of energy release. Fire release energy slowly, whereas explosion release energy rapidly, typically on the order of microseconds. Fire can also result from explosion, and explosion can result from fire.

## III. METHODOLOGY

Source models are constructed from fundamental or empirical equations representing the physicochemical processes occurring during the release of materials. Once the incident is known, source models are selected to describe how materials are discharged from the process. The source model provides a description-

1. The rate of discharge,
2. The total quantity discharged (or total time of discharge),
3. The state of the discharge (that is, solid, liquid, vapour, or a combination).

Release mechanisms are classified into wide and limited aperture releases. In the wide aperture case a large hole develops in the process unit, releasing a substantial amount of material in a short time. An example is the over pressuring and explosion of a storage tank. For the limited aperture case material is released at a slow enough rate that upstream conditions are not immediately affected; the assumption of constant upstream pressure is frequently valid. For these releases material is ejected from holes and cracks in tanks and pipes, leaks in flanges, valves, and pumps, and severed or ruptured pipes. Relief systems, designed to prevent the over pressuring of tanks and process vessels, are also potential sources of released material.

### Pasquill-Gifford Dispersion Model

Dispersion models describe the airborne transport of toxic materials away from the accident site and into the plant and community. After a release the airborne toxic material is carried away by the wind in a characteristic plume, or a puff. The maximum concentration of toxic material occurs at the release point (which may not be at ground level). Concentrations downwind are less, because of turbulent mixing and dispersion of the toxic substance with air. Dispersion model is subsequently used to describe how the material is transported downwind and dispersed to some concentration levels. For flammable releases fire and explosion models convert the source model information on the release into energy hazard potentials, such as thermal radiation and explosion overpressures.

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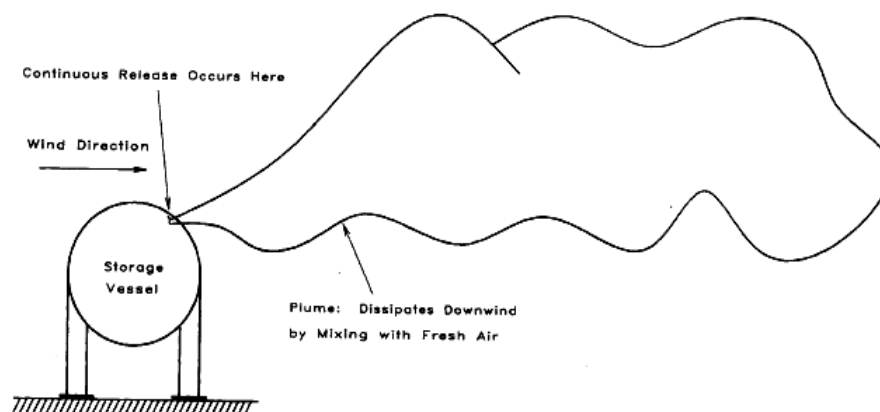


Figure-1 Plume Mode made by release of material

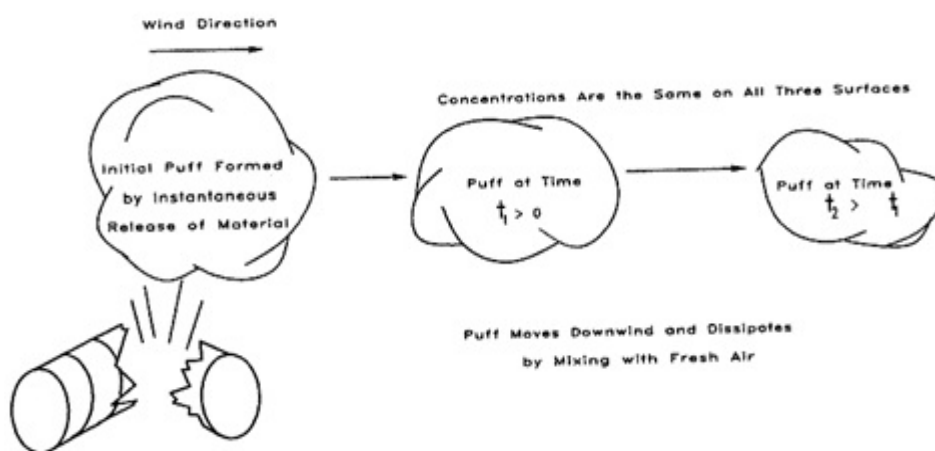


Figure-2 Puff mode made by release of material

In case of the release of flammable gas, the greatest danger arises from the sudden massive escape of liquid or gases producing a large cloud of flammable and possibly explosive vapour. If the cloud is ignited, the effects of combustion would depend on many factors such as wind speed and the extent to which the cloud is diluted with air. Such hazards could lead to a large number of casualties and extensive damage on site and beyond its boundaries. Nevertheless, even for severe accidents the effects are generally limited to few hundred meters from the site of accident.

The sudden release of a very large quantity of toxic material has the potential to cause deaths and severe injuries at a much greater distance. In such release would, in certain weather conditions, produce lethal concentrations at several kilometers from the point of release, but the actual number of casualties would depend on the population density in the path of the cloud and effectiveness of the emergency arrangements, which might include evacuation.

The dispersion coefficients  $\sigma_x$ ,  $\sigma_y$ ,  $\sigma_z$  represents the standard deviations of the concentration in the downwind, crosswind, and vertical (x, y, z) directions respectively. The dispersion coefficients are a function of atmospheric conditions and the distance downwind from the release. The Atmospheric conditions are classified according to six different stability classes shown in Table-1

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Surface wind speed (m/s)	Day radiation intensity			Night cloud cover	
	Strong	Medium	Slight	Cloudy	Calm & Clear
Greater than 2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
Less than 6	C	D	D	D	D

Table-1 Atmospheric stability classes for use with the Pasquill-Gifford dispersion model

Where, Stability classes

A, B : Unstable

C, D : Neutral

E, F : Stable

Plume with continuous steady-state source at ground level and wind moving in x direction at constant velocity u then the ground-level concentration is evaluated by given equation-

$$C(x, y, z) = \frac{Q_m}{\pi \sigma_y \sigma_z u} \exp \left[ -\frac{1}{2} \left( \frac{y^2}{\sigma_y^2} + \frac{z^2}{\sigma_z^2} \right) \right]$$

Puff with instantaneous point source at ground level, coordinates fixed at release point, constant wind only in x direction with constant velocity u then the ground-level concentration is evaluated by given equation-

$$C(x, y, z, t) = \frac{Q_m}{\sqrt{2\pi}^{3/2} \sigma_x \sigma_y \sigma_z} \exp \left\{ -\frac{1}{2} \left[ \left( \frac{x - ut}{\sigma_x} \right)^2 + \frac{y^2}{\sigma_y^2} + \frac{z^2}{\sigma_z^2} \right] \right\}$$

Model evaluation key steps to be undertaken are model description, scientific assessment including limits of applicability, user oriented assessment including ease to use, verification and validation. Verification is the process of showing that a model produces output in accordance with its specification such as solves the right equations and to satisfactory accuracy. Validation is the process of showing that the model reproduces measurements of physical parameters, such as concentration, to satisfactory accuracy and across its claimed range of applicability.

## IV. IMPACT ASSESSMENT

Impact assessment is the process evaluating and identifying the future consequences of current activities of gas processing industries. Dispersion model use to evaluate and consequences of fire and explosions. The purpose of dispersion and source models solve conservation of mass, momentum and energy equation, and can use to model the dispersion of clouds in presence of obstacles even of complex geometry. Moreover, they can deal with heavy, natural or light gas dispersion, then assuming preventive measures must be the main aim of the all those involved in potentially hazardous activity, from those responsible for fixing the objectives and details of a task, to the operatives that carry out the work. This includes the setting of measures to enable the operatives to avoid accidents on the job.

## V. CONCLUSION

This paper has described a approach that can be used for evaluating dispersion model for the leakage or spillage of natural gas .The approach is based on scientific assessment, verification and validation. A comprehensive evaluation methodology Pasquill-Gifford dispersion model calculates all information of incident scenario which helps to response and takes necessary action to control them. The purpose of impact assessment is to improve community preparedness for off-site releases. It is a mechanism to initiate public protection actions and facilitate effective unified incident management. The plan affects the facility, local emergency response agencies and external supporting facilities and entities. However carefully these measures are developed and applied, an accident cannot always be avoided, the 'zero accident' possibility is fiction beyond reach. Apart from prevention measures, it is also necessary to conceive protection measures, intended to minimise the consequences of an accident that could not be prevented.

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