iJournals: International Journal of Software & Hardware Research in Engineering
ISSN-2347-4890
Volume 7 Issue 7 July 2019

Risk Analysis of Gas Discharge in Household Gas Pipelines Using the Gauss Dispersion Model

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ABSTRACT

The condition of natural resources in Indonesia in the form of oil and gas is the basic capital for the development of the oil and gas industry and the petrochemical industry in the country. The risks from these industries are also relatively high, such as fire and explosion accidents that have various impacts. The impact of chemical leaks on the oil and gas industry and the petrochemical industry can cause various kinds of losses. These leaks usually emit flammable material or toxic material.

This study aims to model gas leaks on household gas network pipes. Modeling takes into account meteorological factors such as wind speed and direction. So that it can determine the extent of gas dispersion, and also pay attention to topographic factors and atmospheric stability. Simulation or modeling results in the form of dispersion maps will be used for risk analysis or as a guide for a company or industry in managing risk.

Gas leak dispersion in the lowest wind conditions with stability A has the highest yield or concentration concentration compared to some of the modeled wind conditions.

Keywords: Dispertion and Modeling

1. INTRODUCTION

The condition of natural resources in Indonesia in the form of oil and gas is the basic capital for the development of the oil and gas industry and the petrochemical industry in the country. Important elements needed to develop the oil and gas industry and the petrochemical industry in Indonesia are abundantly available. The risks from the industry are also relatively high, such as fire and explosion accidents that have various impacts.[1]

The impact of gas leaks on the oil and gas industry and the petrochemical industry can cause various kinds of losses. These leaks usually emit flammable material or toxic material. [2]. Several accidents and explosions occurred in various countries, among others Surabaya, Friday 26 October 2018 a gas network pipe leak is located at Ngagel Madya V Surabaya. The cause of the leak was the cracking of the pipe due to the use of heavy equipment around the gas pipeline. The incident injured three local residents.

Surabaya is one of the big cities in Indonesia, the need for natural resources such as natural gas or nature is high because of the large number of people in the city. The Surabaya City Government has built a household gas pipeline network distributed by langsug to residents' homes that have been registered to reduce the need for LPG gas cylinders. By conducting dispersion modeling/simulation on a household gas pipeline network, it can be used as an illustration and as part of the initial efforts to control potential safety risks, so that the extent of the impact is known.

Making a description of the dispersion of a gas can use several models, one of which is the Gauss Model. Some factors that need to be considered or needed in determining dispersion with the Gauss equation are the background of gas or concentration, source of emissions, meteorological conditions (wind speed and direction) and topographic conditions. This study uses the Gauss equation to determine the dispersion of gas leaks.

2. MATERIAL AND METHODS

This study discusses the dispersion model of the release of toxic or flammable gas due to an accident or major force that might occur. In principle, the gas that has the potential to escape from the source of the leak will diffuse around the source and become infected following air movement (following the wind direction). Both of these phenomena (diffusion and convection) can be expressed in dispersion models.

Using mathematical models of dispersion models, we can know the potential distribution patterns expressed in map / map dispersion. This dispersion map is dynamic in accordance with changes in the level of leakage (load emitted), meteorological conditions (atmospheric stability, wind direction and speed), and topography of the dispersion area (elevation, obstacle, absorbent, etc.).

2.1 Material

Data needed to do modeling are wind speed and direction, air temperature, air humidity, gas characteristics, pressure in the pipe, pipe diameter, gas network map, gas composition.

2.2 Methods

Modeling is done by using the gauss equation to determine the gas dispersion that occurs. Using these data, dispersion modeling can be done. The gauss equation is as follows [3]:

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

The results of the calculation using the Gauss equation in the form of the concentration of the release of gas with variations in meteorological conditions or the environment around the point of release of gas then the concentration of gas release.

3. RESULT AND DISCUSSION

3.1 Gas Release

The release of gas in household pipelines caused by several factors, is assumed to be the release of gas caused by a hole in the piping system where the diameter of the hole or leakage of the pipe is 5 mm. Calculation of the amount or rate of gas coming out of the leak uses the equation below to find out the reduction in force [4].

$$\frac{P_2}{P_1} = \left(\frac{2}{(k+1)}\right)^{\frac{(k+1)}{(k-1)}}$$

$$q_s = C_d x A_h x \psi x \sqrt{\left\{\rho_0 x P_2 x \left(\frac{2}{(k+1)}\right)^{\frac{(k+1)}{(k-1)}}\right\}}$$

The results of calculations with the above equation can be seen the release rate that can occur in the diameter of five mm household gas network pipe leak holes which is equal to 0.00059 (Kg/s). Where the calculation results can be influenced by the pressure in the pipe, the diameter of the leak hole, the chemicals in the pipe, the density and the outer surface of the hole

3.2 Plume rise

Plume rise is the height of the puff released by the chimney. The height of the puff and the heat emission rate affect the dispersion concentration of emissions in the surrounding environment calculated using the Equations below. Where this equation was developed by Thomas to get puff height or plume rise [5].

$$Q_h = \frac{\pi d_s^2 V_s}{4}\, x \frac{P\,M_w}{R_u T_s}\, C_p(T_s - T_a)$$

$$\Delta h = 4.71\,\frac{Q_h^{0.444}}{U_s^{0.694}}$$

The results of calculations with the above equation can be known that the puff height that can occur in the diameter of the five mm household gas network pipe leak hole which is equal to 0.623 m after that, continued into the calculation of the gas distribution concentration released into the air. Where based on the calculation of puff height or plume rise is influenced by several factors such as hole diameter, hole cross-sectional area, heat emission rate.

3.3 Model Kebocoran Gas Metana

Based on the parameter value, it can be calculated the concentration of methane gas released into the air and the exposure distance from the gas. Where based on the concentration can be known areas that are toxic and flammable. Gas dispersion at methane gas leak with a hole diameter of 5 mm.

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

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By knowing the concentration of emissions, it can be seen that areas including Toxic, Flammable and safe conditions. Quality standards for the area *Toxic* PAC-1: 65000 ppm, PAC-2: 230000 ppm, PAC-3: 400000 ppm, and *Flammable* LEL: 50000 ppm, UEL: 150000 ppm. The quality standard used is the same as ALOHA software. The calculation results with the Gauss equation are illustrated in the graph of the concentration comparison with the downwind distance, which can be seen in Figure 1.

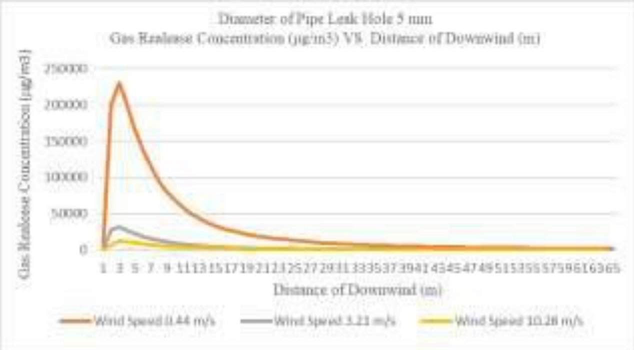

Figure 1 Gas Concentration at 5 mm Pipe Leak Hole Diameter

Based on the graph in Figure 4.9, it can be seen the dispersion radius of network pipe leak emissions with the network pipe leakage hole diameter of 5 mm, in some wind speed conditions, namely 0.44 m/s (low wind speed), the calculation results of the highest concentration of 230754.92 ppm as far as 3 m, wind speed 3.21 m/s (average wind speed) shows the highest gas concentration of 31629.95 ppm as far as 3 m and the highest wind speed of 10.28 m/s has the highest concentration of 12164.34 ppm as far as 3 m. dispersion radius is presented in Table 4.9

Table 1 Radius Dispersion Gas Leak Hole Diameter 5 mm

No	Wind Speed	PAC-1	PAC-2	PAC-3	LEL	UEL
1	0.44 m/s	1 m	3 m	-	1 m	1 m
2	3.21 m/s	-	-	-	2 m	-
3	10.28 m/s	-	-	-	2 m	-

Based on the table above the conditions of 0.44 m / s, PAC-1 has a movement distance of 1 m. PAC-2 has a movement distance of 3 m. PAC-3 has an undetectable movement distance. LEL has a movement distance of 1 m. and UEL 1 m. Condition 3.21, PAC-1 has an undetectable movement distance. PAC-2 has an undetectable movement distance. PAC-3 has an undetected movement distance. LEL has a movement distance of 2 m. and UEL is not detected.

Wind speed conditions of 10.28 m / s, PAC-1 has an undetectable movement distance. PAC-2 has an undetected movement distance. PAC-3 is not detected. LEL has a movement distance of 2 m. and UEL is not detected..

4. CONCLUSION

Gas leak dispersion in the lowest wind conditions with stability A has the highest yield or concentration value compared to some of the modeled wind conditions

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