ISSN 2063-5346

# ANALYSING THE LEAKAGE OF ACETALDEHYDE FUMES USING FIRE DYNAMICS SIMULATOR

**K. Raja[1], D. Surya Prakash[2], K. Harisivasri Phanindra[3], S. Sanjay [4]**

==========

**Article History: Received: 19.04.2023 Revised: 02.05.2023 Accepted: 10.06.2023**

**Abstract**

*In this study, we analysed Acetaldehyde fumes leakage in a closed room. To analyse the leakages of different types of gases inside the room or laboratories with the help of Fire Dynamics Simulator. Today, it is a well-founded Computational program for thermal dynamics developed by a renowned institution. In this experiment, we simulated for acetaldehyde fumes leakage in an enclosed space for certain volume. We compared with FDS simulation results of acetaldehyde and bromine fumes data has been collected and presented in the form of graphical representation. In that graph shows the time taken by a chemical fume to spread in a closed room.*

***Keywords:*** *Fire Dynamics Simulator, Acetaldehyde, Bromine, Leakage, Closed Room.*

[1,3] Assistant Professor, Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India.

[2] Associate Professor, Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India.

[4] P.G Scholar, M. Tech Industrial Safety and Engineering, Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, India.

**DOI: 10.48047/ecb/2023.12.si12.087**

# 1. Introduction

Different kinds of chemicals are used in all kinds of industries like pharmaceutical, laboratories, manufacturing, chemical industries etc…so storing of chemicals is very important, if the organisation is not giving importance for storage of chemicals, then there will be a chemical leakage. To avoid the exposure of the chemical fumes that affects the people working inside the organisation. So, preventing the leakage of fumes is very important. After leakage of fumes what are the proactive measures should be taken that also need to be analysed and discussed before the leakage of chemical fumes.

According to the other literature paper during fire emergencies, hazardous fire conditions and unsuccessful evacuation attempts can expose occupants to significant risk to their health. So, to avoid such unsuccessful evacuation, we can do simulation demonstration for chemical fumes leakage using Fire Dynamics Simulator. We can know the spreading time of chemical fumes and we can save the people against those toxic fumes within the time limit. This FDS simulator will show the data of time taken for the fumes to spread for a given dimension and also taken reference from other paper states that, Fire scene reconstruction helps investigators identify the fire behaviour in a specific space like that, we have done for chemical fumes leakage in a closed room has been done in this simulation.

In this study, Acetaldehyde fumes leakage is analysed using Fire dynamics simulator (FDS).Acetaldehyde is a chemical liquid that can turn into fumes at room temperature that fumes could cause headache, dizziness, light headness, damage to lungs etc… In this simulation software, we can simulate the smoke spread and also transportation of heat from fire, with the help of this simulator fumes leakage is analysed. In this model, we are examining the leakage of acetaldehyde fumes in a closed room. We studied the fumes spreading time for a particular dimension of a room for acetaldehyde solution using FDS.

# 2. Methodology

For this experiment, Acetaldehyde fumes is simulated separately in a closed room for a particular dimension. The room has been constructed using concrete in the simulation. On the first step, we should create a input file for the acetaldehyde solution for example 50ml using the data of physical and chemical properties of the acetaldehyde solution. According to the fire dynamics simulator template the input file should be written using the data like dimensions, chemical name, temperature, density and time limit etc.

Simulation setup has been done with the reference of carbon monoxide transportation in a long channel titled literature using that literature has a reference study has been conducted with dimension of the room 3.5-meter length*3.5-meter breadth*3.5-meter height and acetaldehyde solution should be placed inside the room at room temperature 25°C to 27.3°C for some minutes or hours until the simulation is done. Save the input file in different folder in a desktop and run the file in command prompt in the computer or pc. After running the file, you will get an output called Smoke view file.

A computer programme called smoke view may be used to analyse numerical results from a machine model of fire-driven combustion. Fluid movement and dynamic distribution is calculated using a two-zone fire model, temperature, fire gases and smoke. The majority of Smoke view is created using C programming. Linguistic discrimination, a 3D graphics library, for using mental imaginary. For communicating with both PC algorithms and windows can be treated using algorithms to determining colour and various kinds of objects.

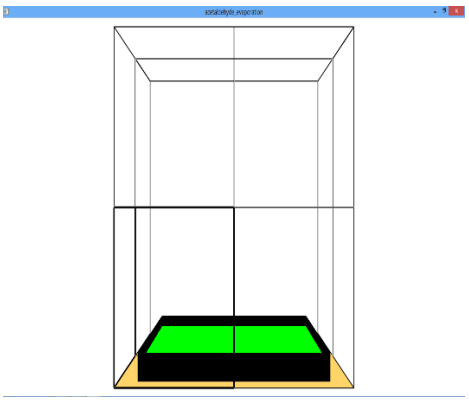

Figure 1: Output of Acetaldehyde Smoke View

The above given diagram figure 1 shows the output of the given input file. In this FDS simulation temperature and bromine fumes concentration at the measurement point in the full-scale experiments were predicted in FDS by "THCP" output commander.

Smoke view is nothing but the 3D model of the room and also you get the data of 50ml acetaldehyde fumes spread in a closed room of dimension 3.5*3.5*3.5 meter. Similarly, simulated for 50 ml of bromine solution in FDS.

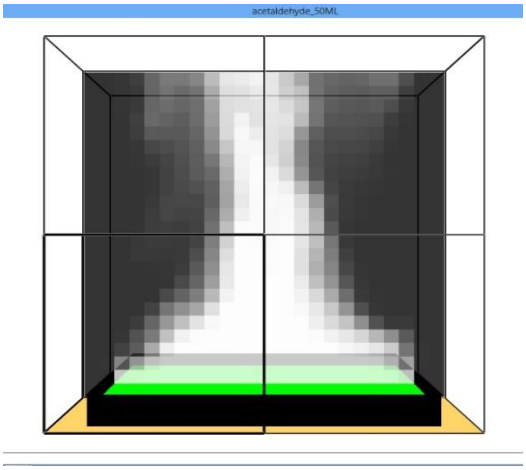


Figure 2: Acetaldehyde Fumes Leakage

Figure 2 shows the leakage of acetaldehyde fumes spreading in a closed room. In previous literature studies, they analysed for carbon monoxide, methanol, n-heptane etc…Unlikely the previous literature studies. In this study, we have simulated for acetaldehyde solution. This is not analysed before that's the reason. We have decided to simulate for acetaldehyde solution.

## 3. Results

After performing the simulation using FDS, experimental data has been generated by FDS software and data is saved in excel sheet. In that excel sheet data is generated like time and evaporation rate of the given toxic chemicals.

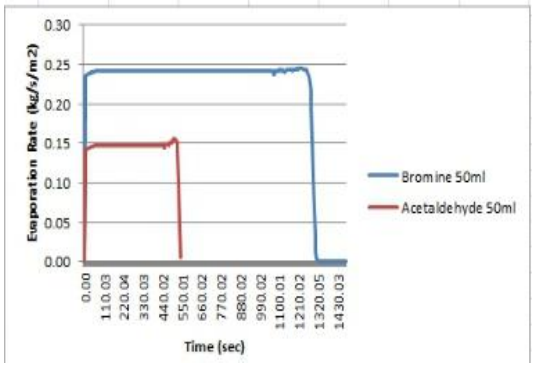


Figure 3: Comparison of Acetaldehyde 50ml vs Bromine 50ml

The above given results shown in the figure 3 graphical representation explains the time taken to spread by Acetaldehyde fumes and bromine fumes at a given dimension of a room. This result shows that acetaldehyde fumes taking 9.08 minutes of time to spread and Bromine fumes is taking 21.8 minutes to spread for a given dimension of a room. So, Acetaldehyde fumes are spreading fastly compared to bromine fumes. Any industries which are using toxic chemicals, they can prepare a simulation model for that chemicals available in their industry and that simulation model will give the results of how much time that chemical will take to spread in a given dimension.

In this study, simulation results help in determining the necessary safety precautions to be taken in industrial or laboratories were acetaldehyde and bromine is used. This study can aid in preventing potential accidents and by identifying areas of high risk and allowing for better safety measures to be put in place. Overall, the simulation model provides valuable insights into the behaviour of acetaldehyde fumes and bromine fumes in closed environments, which can be beneficial in creating a safe working environment and preparing for unforeseen emergencies.

## 4. Conclusion

We have created a simulation model using Fire Dynamics Simulator for Acetaldehyde. In this study, we analysed for Acetaldehyde Fumes and compared with Bromine fumes is tested for Simulation and fumes leakage has been examined in a closed room using FDS. The leakage is tested and analysed in different volumes of dimension using the simulation software. Currently, we have simulated for acetaldehyde solution in a packed room in

simulation software and compared the data with bromine fumes in a particular dimension of a room. This study is used for the usage of emergency preparedness in case of any leakage of fumes in industries or laboratory etc.

## Reference


[1] L.H. Hu, N.K. Fong, L.Z. Yang, W.K. Chow, Y.Z. Li, R. Huo "Modeling fire-induced smoke spread and carbon monoxide transportation in a long channel: Fire Dynamics Simulator comparisons with measured data," Journal of Hazardous Materials 140 (2007) 293–298.

[2] Junyi Li, Tarek Beji, Sylvain Brohez, Bart Merci, "Experimental and numerical study of pool fire dynamics in an air-tight compartment focusing on pressure variation," Fire Safety Journal (2020) 0372-7112.

[3] Aaron Yip, Jan B. Haelssig, Michael J. Pegg, "Simulating fire dynamics in multicomponent pool fires," Fire Safety Journal (2021) 0379-7112.

[4] Moohyun Cha, Soonhung Han, Jaikyung Lee, Byungil Choi, "A virtual reality-based fire training simulator integrated with fire dynamics data," Fire Safety Journal (2012) 0379-7112.

[5] Ziwei Li, Huang Huang, Nan Li, Mei Ling chu (Zan), Kincho Law "An agent-based simulator for indoor crowd evacuation considering fire impacts" Automation in Construction (2020)

[6] Z. Xu, X.Z. Lu, H. Guan, C.Chen, A.Z. Ren, "A virtual reality based fire training simulator with smoke hazard assessment capacity," Journal in Advances in Engineering Software (2014) 0379-7112.

[7] Chan-Sol Ahn, Boo-Hyoung Bang, Min-Woo Kim, Tae-Gun Kim, Scott James, Alexander. Yarin, Sam S. Yoon "Numerical investigation of smoke dynamics in unconfined and confined environments" Journal of Heat and Mass Transfer (2018) 0017-9310.

[8] Yongzheng Yao, Ying Zhen Li b, Haukur Ingason, Xudong Cheng, Heping Zhang, "Theoretical and numerical study on influence of wind on mass loss rates of heptane pool fires at different scales," Journal of Fire Safety (2020) 0379-7112.

[9] Yvon Mouilleau, Anousone Champassith, "CFD simulations of atmospheric gas dispersion using the Fire Dynamics Simulator (FDS)," Journal of Loss Prevention (2009) 0950-4230.