

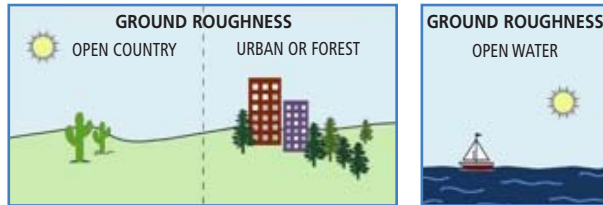
## Pasquill Stability Class Table

Pasquill Stability Classes: A-B : unstable; C-D: neutral; E-F: stable

WIND SPEED Meters per Second	DAYTIME: INCOMING SOLAR RADIATION (INSOLATION)			NIGHT TIME: CLOUD COVER	
	Strong	Moderate	Slight	4/8 (*)	3/8 (*)
Less than 2	A	A-B	B	F	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
More than 6	C	D	D	D	D

(\*) 4/8 and 3/8 means respectively that clouds cover more than 4/8 and less than 3/8 of the sky.

- Ground roughness



- Averaging time
- Slipstream effects (caused by the presence of buildings)
- The location, hour and date which will influence or act upon the vertical turbulence

### 3. The quantification

The impact distances on human health, environment and/or infrastructures are quantified with Levels of Concern. For emergency planning and land use planning these are the ones recommended by CRAIM:

EFFECT	Emergency Planning	Land use planning
<b>Heat radiation:</b>		
Slow kinetic: duration > 40 seconds	5 kW/m <sup>2</sup>	$3 < \phi \leq 12,5 \text{ kW/m}^2$
Fast kinetic: duration < 40 seconds	1000 (kW/m <sup>2</sup> ) <sup>4/3</sup> s	$500 < \text{TD} \leq 1800 \text{ (kW/m}^2\text{)}^{4/3}\text{s}$ with a probabilistic approach
Flash Fire	50 % LEL and more	50 % LEL < C ≤ LEL with a probabilistic approach
<b>Toxic</b>	AEGL-2*	AEGL-2 < C ≤ AEGL-3 with a probabilistic approach
<b>Overpressure</b>	1 psi	$0,3 < p \leq 8,7 \text{ psi}$

TD = thermal dose,  $\phi$  = heat flux, C = concentration, p = pressure

\* When available, otherwise: ERPG or TEEL or 1/10 of IDLH or other recognised value.

**For more information on elements in this pamphlet/TPP, you can refer to the following CRAIM documents:**

Risk Management Guide for Major Technological Accidents (updated English version expected in 2024).

Les valeurs de référence des seuils d'effets pour la planification des mesures d'urgence et l'aménagement du territoire, 2015 (only in French).

Technical Popularization Pamphlet

8



2<sup>nd</sup>  
EDITION

# Atmospheric dispersion modeling of dangerous substance leak

## Vision and Mission of the CRAIM

### Vision

**CRAIM** aims to be the benchmark in hazardous substance risk management within the scope of sustainable development by applying rigorous, responsible and concerted methodologies.

### Mission

**To DEVELOP** rigorous tools and methods that provide responsible management of risks related to hazardous substances.

**To PROMOTE** and support a culture of collaboration between all stakeholders to effectively manage the risks involving hazardous substances.

**To FOSTER**, with stakeholders, a reduction in the risks of major technological accidents through the implementation of appropriate prevention, preparedness, response and recovery measures.

**This document, based on current available facts, is designed to familiarize the reader with certain basic concepts. The reader must be aware that the information provided in this document is not complete, and therefore, other complementary sources must be consulted to avoid any unfortunate situations. The reader is entirely responsible for all decisions or actions taken on the basis of this document.**

## Definition of Atmospheric dispersion modeling:

- Illustration of the dispersion of a substance (ex. Gas) in the atmosphere
  - Provides an estimate of the impact distance
  - A mathematical representation of reality

## Uses:

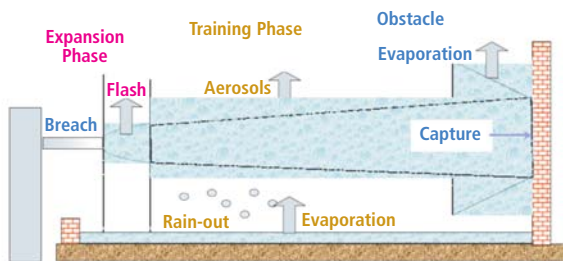
- Preparedness: helps with the preparation of adequate emergency plans
- Emergencies: helps establish distances for the working zones, the probable contaminated areas and the safe zone for the population and the responders
- Estimate compliance with environmental discharge standards

## The steps to model the impact:

1. Characterize the emission (source term)
2. Simulate the displacement and dilution of that source in the atmosphere (calculate the dispersion in the air)
3. The quantification of the consequences in the environment (impact)

### 1. The source term

- Definitions: (variable but similar, depending on the organizations)
  - ◆ The characteristics\* of the initial emission source that can be affected by the immediate surroundings (MEDD, France & INÉRIS, 2006)
    - \* characteristics: kinetic energy, release rate, duration, direction of the discharge, density of the released substance, conditions of the leak, etc.
  - ◆ The estimation, based on the release specification, on the current temperature conditions of the cloud, aerosol content, density, size, velocity and mass to be input into the dispersion model (CCPS, Combined Glossary of Terms, 2005).



Example of the source term for a continuous release of liquified gas (Ω-19, INÉRIS 2006)

- Criteria or parameters to take into consideration:
  - ◆ Kinetic energy, release rate, duration, direction of the discharge, density of the released substance
  - ◆ Release point height, thermodynamic properties, (concentration, temperature, pressure)
  - ◆ Physical state of the substance

## 2. Displacement in air

The atmospheric dispersion defines the way that a cloud is transported in time and space. It also defines the way a cloud is diluted.

The atmospheric displacement of the cloud depends on certain parameters, such as:

1. Source term
2. Density
3. Meteorological conditions
4. Environment (ground roughness, presence of obstacles).

Different types of mathematical models exist to model atmospheric displacement, such as:

- Gaussian model
- Heavy gas dispersion model
- CFD (Computational Fluid Dynamics) model

The commercial software packages (eg. ALOHA, RMP\*Comp, PHAST, FLACS) use these mathematical methods to model the dispersion. There are advantages and limitations inherent in each method and consequently with each software package.

### Modeling criteria:

For the calculation of impact distances of alternative scenarios, CRAIM recommends to facilities the following weather conditions:

**A :** Mandatory first scenario with night-time weather conditions \* :

1. Temperature 25°C
2. 50% relative humidity
3. Wind speed of 1.5 m/s\* at 10 meters above ground level
4. Atmospheric stability F.

\* if a facility can demonstrate the impossibility of an accident occurring at night, it may not use these weather conditions.

**B :** If the facility uses the wind rose of the region where it is located, the wind speed generating the greater distance must also be taken into account by excluding those that occur less than 5% of the time.

**C :** If the facility does not use local wind rose, it will need to model with the following criteria:

An initial modeling:

1. Temperature 25°C
2. 50% relative humidity
3. Wind speed of 5 m/s at 10 metres above ground
4. Atmospheric stability D.

Another model:

1. Temperature 25°C
2. 50% relative humidity
3. wind speed of 8 m/s at 10 metres above ground
4. Atmospheric stability D.

\* The above criteria could, under certain specific circumstances, not be the most penalizing weather conditions. One must be vigilant and prudent and ensure the most penalizing conditions are selected. For example, a higher wind speed will produce a greater exclusion zone, downwind, for pool fire and jet fire scenarios. If those wind speeds do not occur more than 5% of the time, based on available local weather records, they should not be used.

\*\* The atmospheric stability is affected by solar radiation (insolation), wind speed and other factors. Please refer to the simplified graphical representation of the stability classes, as influenced by the solar effect and the more detailed Pasquill Stability Table for further information on the relationship between wind speed, sunshine and stability class.

