Modélisation de la dispersion atmosphérique

1- Généralités

La dispersion des gaz engendrés par un incendie est assez difficile à définir et il n'existe pas, à l'heure actuelle, de méthode parfaitement établie. On sait que les gaz chauds ont tendance à s'élever rapidement du fait de leur faible densité (une élévation de température de 300 ° divise environ par 2 la densité d'un gaz ; or les fumées atteignent rapidement des températures de l'ordre de 600 °C).

Pour la chronologie de l'incendie, le TNO propose d'envisager deux phases :

- **Au moment du démarrage**, lorsque les fumées s'accumulent sous les toitures et ne s'échappent que par les ouvertures de désenfumage. La température des fumées est alors encore relativement peu élevée et les fumées s'échappent à faible débit, elles sont donc directement entraînables par les vents. L'impact toxique est alors limité par le fait que les surfaces en combustion sont peu étendues.

- **Au moment de l'intensité maximale** du sinistre, lorsque la totalité du stock est embrasée ; alors le débit des gaz toxiques est plus élevé, mais la température des fumées également. Un panache se forme, la dispersion des toxiques peut être modélisée.

La dispersion atmosphérique des polluants résultant de la combustion des marchandises stockées est modélisée à l'aide d'un modèle de dispersion en panache de type Gaussien (modèle de Pasquill Giffird).

L'INERIS préconise de prendre en considération les cas de figure ci-après : Etat A (au sens de Pasquill) pour des vents de 2 m/s, état D pour des vents de 5 m/s et état F pour des vents de 3 m/s.

2- Modélisation de la dispersion

Comme indiqué si dessus, la dispersion atmosphérique résulte de la combinaison de deux phénomènes principaux qui agissent simultanément : le transport et la diffusion. L'étude d'une dispersion de toxiques est complexe et nécessite de distinguer deux cas :

- La dispersion rapprochée,
- La dispersion lointaine.

Dans le cas de la dispersion lointaine, on démontre que cette phase échappe aux effets du sol et à la présence d'obstacles ainsi qu'aux effets induits par la densité du polluant émis.
Il devient alors possible d'utiliser un modèle classique simplifié de type Gaussien.

Le modèle de dispersion employé est le modèle gaussien développé selon la méthode de Pasquill et Grifford. Ce modèle s'applique dans différents cas de figure possibles définis en fonction de la vitesse du vent et de différents états atmosphériques désignés comme « classes » par Pasquill.

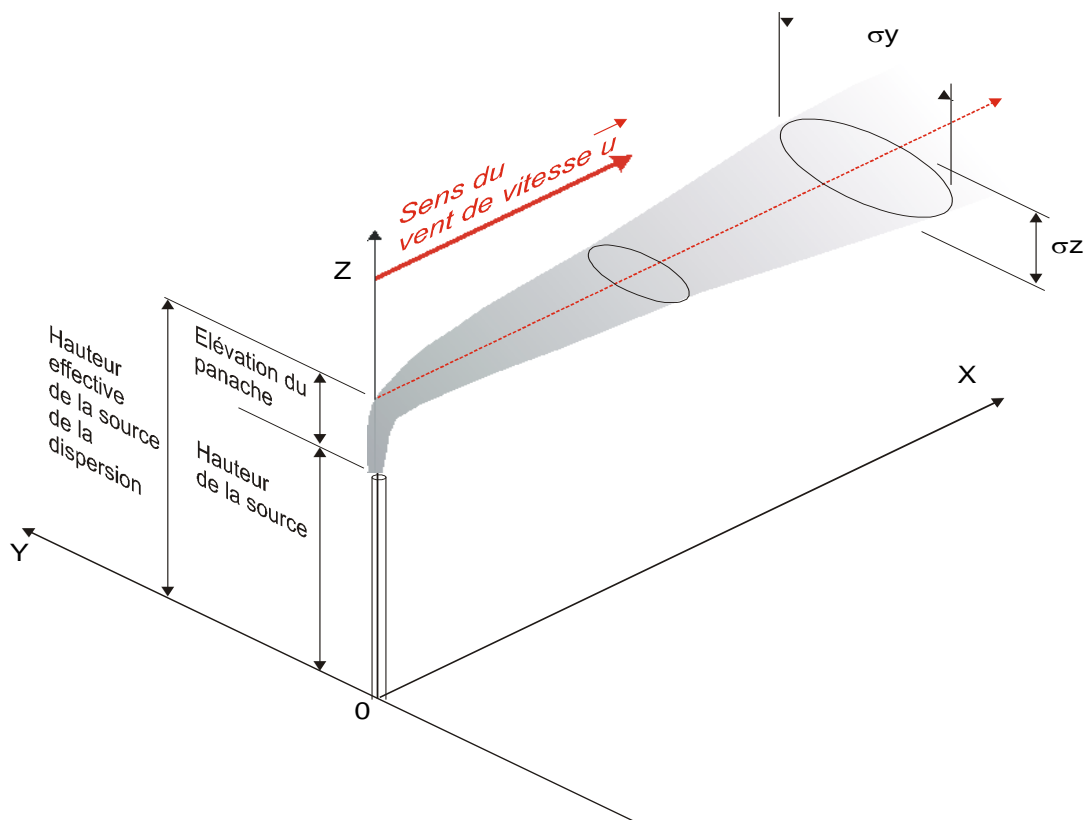Ces classes sont au nombre de 6, caractérisées par l'intensité de la turbulence :

> classe A   : « très instable »
> classe B   : « instable »
> classe C   : « légèrement instable »
> classe D   : « neutre »
> classe E   : « stable »
> classe F   : « très stable »

Le tableau ci-dessous fournit les conditions dans lesquelles sont définies les classes de Pasquill-Turner :

Vitesse du vent	Jour Selon un rayonnement solaire incident			Nuit Selon une couverture nuageuse	
(m/s	Fort Eté – ciel dégagé	Modéré Ciel nuageux	Léger Hiver – ciel couvert	Dense >1/2 surface	Dégagée <1/2 surface
< 2	A	A – B	B		
2 à 3	A – B	B	C	E	F
3 à 5	B	B – C	C	D	E
5 à 6	C	C – D	D	D	D
>6	C	D	D	D	D

Le modèle de Pasquill et Grifford repose sur l'idée qu'une substance à l'état gazeux se diffuse dans l'atmosphère de manière aléatoire selon une fonction de distribution de Gauss, on caractérise alors l'allure de la distribution par son « écart-type » σ.

La représentation de la diffusion dans l'espace se fait généralement en définissant l'axe des X comme celui du sens du vent. Dans le cas de la diffusion dans un panache continu, on ne tient compte que de deux axes de diffusion : en largeur (axe Y) et en hauteur (axe Z) ; et par conséquent on ne définit que deux écarts-types pour déterminer la distribution : σ_y et σ_z. La distribution étant définie par une concentration en fonction de l'éloignement de la source, les écart-types sont mesurés en mètres. Ils résultent d'observations réalisées par les différents auteurs des modèles, qui fournissent des équations empiriques qui permettent d'en calculer l'évolution dans l'espace en fonction des conditions de stabilité de l'atmosphère.

La *figure ci-dessus* montre un exemple de panache continu. :

L'équation générale de la dispersion d'un panache suivant une distribution gausienne est la suivante :

$$C = \frac{Q}{2\pi.u.\sigma_z.\sigma_y}.\exp\left(-\frac{y_2}{2.\sigma_y^2}\right).\exp\left(-\frac{(z-h)^2}{2.\sigma_z^2}\right)$$

dans laquelle :

    C (kg/m³)   est la concentration de la substance considérée au point M(x,y,z)
    Q (kg/s)   est le débit massique de la substance à la source
    u (m/s)   est la vitesse du vent
    σ_y (m)   est l'écart type de la distribution horizontale
    σ_z (m)   est l'écart type de la distribution verticale
    h (m)   est la hauteur *effective* de l'émission

Dans le cas des dispersions près du sol, on doit de plus tenir compte de l'effet miroir du sol. Il en résulte l'introduction d'un facteur de correction sur l'exponentielle donnant la dispersion suivant l'axe Z par addition d'un facteur de réflexion, ce qui donne l'équation de Pasquill Grifford :

$$C=\frac{Q}{2\pi.u.\sigma_z.\sigma_y}.\exp\left(-\frac{y_2}{2\cdot\sigma_y^2}\right).\left[\exp\left(-\frac{(z-h)^2}{2\cdot\sigma_z^2}\right)+\exp\left(-\frac{(z+h)^2}{2\cdot\sigma_z^2}\right)\right]$$

La distribution est exprimée sous la forme d'écarts types σ_y pour la dispersion horizontale et σ_z pour la dispersion verticale.

Ces écarts type traduisent l'étalement de la distribution gaussienne à mesure que l'on s'éloigne de la source d'émission.
Leur établissement a fait l'objet de nombreux travaux et on trouve différentes méthodes pour les évaluer (méthode de Briggs, méthode de Pasquill Grifford).

La méthode de Pasquill Grifford est adaptée aux dispersions dans des environnements dégagées. Dans le cas présent les écarts type ont été calculés à partir de cette méthode.

Modélisation de la dispersion atmosphérique des toxiques en cas d'incendie d'une cellule de stockage de produits combustibles

Incendie d'une cellule de stockage
Dispersion des suies
Condition A, vent 2 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1120 hours ST (using computer's clock)

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 2 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: A (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 22.23 kilograms/sec   Source Height: 233 meters
  Release Duration: 60 minutes
  Release Rate: 1,330 kilograms/min
  Total Amount Released: 80,028 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red : **LOC is not exceeded** --- (79 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion des suies
Condition D, vent 5 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1122 hours ST (using computer's clock)

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 5 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: D
  No Inversion Height   Relative Humidity: 50%

SOURCE STRENGTH:
  Direct Source: 22.23 kilograms/sec   Source Height: 93 meters
  Release Duration: 60 minutes
  Release Rate: 1,330 kilograms/min
  Total Amount Released: 80,028 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (79 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion des suies
Condition F, vent 3 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1123 hours ST (using computer's clock)

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 3 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 15° C   **Stability Class: F (user override)**
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 22.23 kilograms/sec   Source Height: 155 meters
  Release Duration: 60 minutes
  Release Rate: 1,330 kilograms/min
  Total Amount Released: 80,028 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (79 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du Monoxyde de carbone
Condition A, vent 2 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1125 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: CARBON MONOXIDE   Molecular Weight: 28.01 g/mol
  AEGL-1 (60 min): N/A   AEGL-2 (60 min): 83 ppm   AEGL-3 (60 min): 330 ppm
  IDLH: 1200 ppm   LEL: 125000 ppm   UEL: 742000 ppm
  Ambient Boiling Point: -312.6° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 2 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: A (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 69.74 kilograms/sec   Source Height: 233 meters
  Release Duration: 60 minutes
  Release Rate: 4,180 kilograms/min
  Total Amount Released: 251,064 kilograms
  Note: This chemical may flash boil and/or result in two phase flow.
    Use both dispersion modules to investigate its potential behavior.

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (3520 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (880 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC..

Incendie d'une cellule de stockage
Dispersion du Monoxyde de carbone
Condition D, vent 5 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1125 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: CARBON MONOXIDE   Molecular Weight: 28.01 g/mol
  AEGL-1 (60 min): N/A   AEGL-2 (60 min): 83 ppm   AEGL-3 (60 min): 330 ppm
  IDLH: 1200 ppm   LEL: 125000 ppm   UEL: 742000 ppm
  Ambient Boiling Point: -312.6° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 5 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: D
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 69.74 kilograms/sec   Source Height: 93 meters
  Release Duration: 60 minutes
  Release Rate: 4,180 kilograms/min
  Total Amount Released: 251,064 kilograms
  Note: This chemical may flash boil and/or result in two phase flow.
    Use both dispersion modules to investigate its potential behavior.

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (3520 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (880 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du Monoxyde de carbone
Condition F, vent 3 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1127 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: CARBON MONOXIDE   Molecular Weight: 28.01 g/mol
  AEGL-1 (60 min): N/A   AEGL-2 (60 min): 83 ppm   AEGL-3 (60 min): 330 ppm
  IDLH: 1200 ppm   LEL: 125000 ppm   UEL: 742000 ppm
  Ambient Boiling Point: -312.6° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 3 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 15° C   **Stability Class: F (user override)**
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 69.74 kilograms/sec   Source Height: 155 meters
  Release Duration: 60 minutes
  Release Rate: 4,180 kilograms/min
  Total Amount Released: 251,064 kilograms
  Note: This chemical may flash boil and/or result in two phase flow.
    Use both dispersion modules to investigate its potential behavior.

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (3520 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (880 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du Dioxyde de carbone
Condition A, vent 2 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1132 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: CARBON DIOXIDE
  CAS Number: 124-38-9   Molecular Weight: 44.01 g/mol
  IDLH: 40000 ppm
  Normal Boiling Point: -unavail-
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%
  Note: Not enough chemical data to use Heavy Gas option

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: **2 meters/second** from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   **Stability Class: A** (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 697.4 kilograms/sec   Source Height: 233 meters
  Release Duration: 60 minutes
  Release Rate: 41,800 kilograms/min
  Total Amount Released: 2,510,640 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (89980 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du Dioxyde de carbone
Condition D, vent 5 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1133 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: CARBON DIOXIDE
  CAS Number: 124-38-9   Molecular Weight: 44.01 g/mol
  IDLH: 40000 ppm
  Normal Boiling Point: -unavail-
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%
  Note: Not enough chemical data to use Heavy Gas option

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: **5 meters/second** from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: D
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 697.4 kilograms/sec   Source Height: 93 meters
  Release Duration: 60 minutes
  Release Rate: 41,800 kilograms/min
  Total Amount Released: 2,510,640 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded --- (89980 mg/(cu m))**
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du Dioxyde de carbone
Condition F, vent 3 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1135 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: CARBON DIOXIDE
  CAS Number: 124-38-9   Molecular Weight: 44.01 g/mol
  IDLH: 40000 ppm
  Normal Boiling Point: -unavail-
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%
  Note: Not enough chemical data to use Heavy Gas option

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: **3 meters/second** from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 15° C   **Stability Class: F** (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 697.4 kilograms/sec   Source Height: 155 meters
  Release Duration: 60 minutes
  Release Rate: 41,800 kilograms/min
  Total Amount Released: 2,510,640 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (89980 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du HCl
Condition A, vent 2 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1143 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: HYDROGEN CHLORIDE   Molecular Weight: 36.46 g/mol
  AEGL-1 (60 min): 1.8 ppm   AEGL-2 (60 min): 22 ppm   AEGL-3 (60 min): 100 ppm
  IDLH: 50 ppm
  Ambient Boiling Point: -121.0° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 2 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: A (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 26.28 kilograms/sec   Source Height: 233 meters
  Release Duration: 60 minutes
  Release Rate: 1,580 kilograms/min
  Total Amount Released: 94,608 kilograms
  Note: This chemical may flash boil and/or result in two phase flow.

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (358 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (60 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC..

Incendie d'une cellule de stockage
Dispersion du HCl
Condition D, vent 5 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1144 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: HYDROGEN CHLORIDE   Molecular Weight: 36.46 g/mol
  AEGL-1 (60 min): 1.8 ppm   AEGL-2 (60 min): 22 ppm   AEGL-3 (60 min): 100 ppm
  IDLH: 50 ppm
  Ambient Boiling Point: -121.0° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 5 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: D
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 26.28 kilograms/sec   Source Height: 93 meters
  Release Duration: 60 minutes
  Release Rate: 1,580 kilograms/min
  Total Amount Released: 94,608 kilograms
  Note: This chemical may flash boil and/or result in two phase flow.

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (358 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (60 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du HCl
Condition F, vent 3 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1146 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: HYDROGEN CHLORIDE   Molecular Weight: 36.46 g/mol
  AEGL-1 (60 min): 1.8 ppm   AEGL-2 (60 min): 22 ppm   AEGL-3 (60 min): 100 ppm
  IDLH: 50 ppm
  Ambient Boiling Point: -121.0° F
  Vapor Pressure at Ambient Temperature: greater than 1 atm
  Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 3 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 15° C   Stability Class: F (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 26.28 kilograms/sec   Source Height: 155 meters
  Release Duration: 60 minutes
  Release Rate: 1,580 kilograms/min
  Total Amount Released: 94,608 kilograms
  Note: This chemical may flash boil and/or result in two phase flow.

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (358 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (60 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du HCN
Condition A, vent 2 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1150 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: HYDROGEN CYANIDE   Molecular Weight: 27.03 g/mol
  AEGL-1 (60 min): 2 ppm   AEGL-2 (60 min): 7.1 ppm   AEGL-3 (60 min): 15 ppm
  IDLH: 50 ppm   LEL: 56000 ppm   UEL: 400000 ppm
  Ambient Boiling Point: 78.3° F
  Vapor Pressure at Ambient Temperature: 0.81 atm
  Ambient Saturation Concentration: 805,867 ppm or 80.6%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 2 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: A (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 2.04 kilograms/sec   Source Height: 233 meters
  Release Duration: 60 minutes
  Release Rate: 122 kilograms/min
  Total Amount Released: 7,344 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (45 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du HCN
Condition D, vent 5 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1152 hours ST (using computer's clock)

 CHEMICAL DATA:
  Chemical Name: HYDROGEN CYANIDE   Molecular Weight: 27.03 g/mol
  AEGL-1 (60 min): 2 ppm   AEGL-2 (60 min): 7.1 ppm   AEGL-3 (60 min): 15 ppm
  IDLH: 50 ppm   LEL: 56000 ppm   UEL: 400000 ppm
  Ambient Boiling Point: 78.3° F
  Vapor Pressure at Ambient Temperature: 0.81 atm
  Ambient Saturation Concentration: 805,867 ppm or 80.6%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 5 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   Stability Class: D
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 2.04 kilograms/sec   Source Height: 93 meters
  Release Duration: 60 minutes
  Release Rate: 122 kilograms/min
  Total Amount Released: 7,344 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (45 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion du HCN
Condition F, vent 3 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1155 hours ST (using computer's clock)

CHEMICAL DATA:
  Chemical Name: HYDROGEN CYANIDE   Molecular Weight: 27.03 g/mol
  AEGL-1 (60 min): 2 ppm   AEGL-2 (60 min): 7.1 ppm   AEGL-3 (60 min): 15 ppm
  IDLH: 50 ppm   LEL: 56000 ppm   UEL: 400000 ppm
  Ambient Boiling Point: 78.3° F
  Vapor Pressure at Ambient Temperature: 0.66 atm
  Ambient Saturation Concentration: 660,892 ppm or 66.1%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: 3 meters/second from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 15° C   Stability Class: F (user override)
  No Inversion Height   Relative Humidity: 50%

SOURCE STRENGTH:
  Direct Source: 2.04 kilograms/sec   Source Height: 155 meters
  Release Duration: 60 minutes
  Release Rate: 122 kilograms/min
  Total Amount Released: 7,344 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (45 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion des fumées de l'incendie (seuil équivalent)
Condition A, vent 2 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1202 hours ST (using computer's clock)

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: **2 meters/second** from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   **Stability Class: A** (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 3 176 kilograms/sec   Source Height: 233 meters
  Release Duration: 60 minutes
  Release Rate: 191,000 kilograms/min
  Total Amount Released: 11,433,600 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded ---** (21705 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (5568 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion des fumées de l'incendie (seuil équivalent)
Condition D, vent 5 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1205 hours ST (using computer's clock)

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: **5 meters/second** from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 20° C   **Stability Class: D**
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 3 176 kilograms/sec   Source Height: 93 meters
  Release Duration: 60 minutes
  Release Rate: 191,000 kilograms/min
  Total Amount Released: 11,433,600 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (21705 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange**: LOC is not exceeded** --- (5568 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.

Incendie d'une cellule de stockage
Dispersion des fumées de l'incendie (seuil équivalent)
Condition F, vent 3 m/s

SITE DATA:
  Location: FERRIERES-EN-GATINAIS, FRANCE
  Building Air Exchanges Per Hour: 0.42 (unsheltered single storied)
  Time: December 10, 2019 1207 hours ST (using computer's clock)

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
  Wind: **3 meters/second** from W at 3 meters
  Ground Roughness: open country   Cloud Cover: 5 tenths
  Air Temperature: 15° C   **Stability Class: F** (user override)
  No Inversion Height   Relative Humidity: 50%

 SOURCE STRENGTH:
  Direct Source: 3 176 kilograms/sec   Source Height: 155 meters
  Release Duration: 60 minutes
  Release Rate: 191,000 kilograms/min
  Total Amount Released: 11,433,600 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
  Model Run: Gaussian
  Red   : **LOC is not exceeded** --- (21705 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.
  Orange: **LOC is not exceeded** --- (5568 mg/(cu m))
  Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC.