# Seveso Safety Case on Ammonium Nitrate Storage

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Irish Industrial Explosives

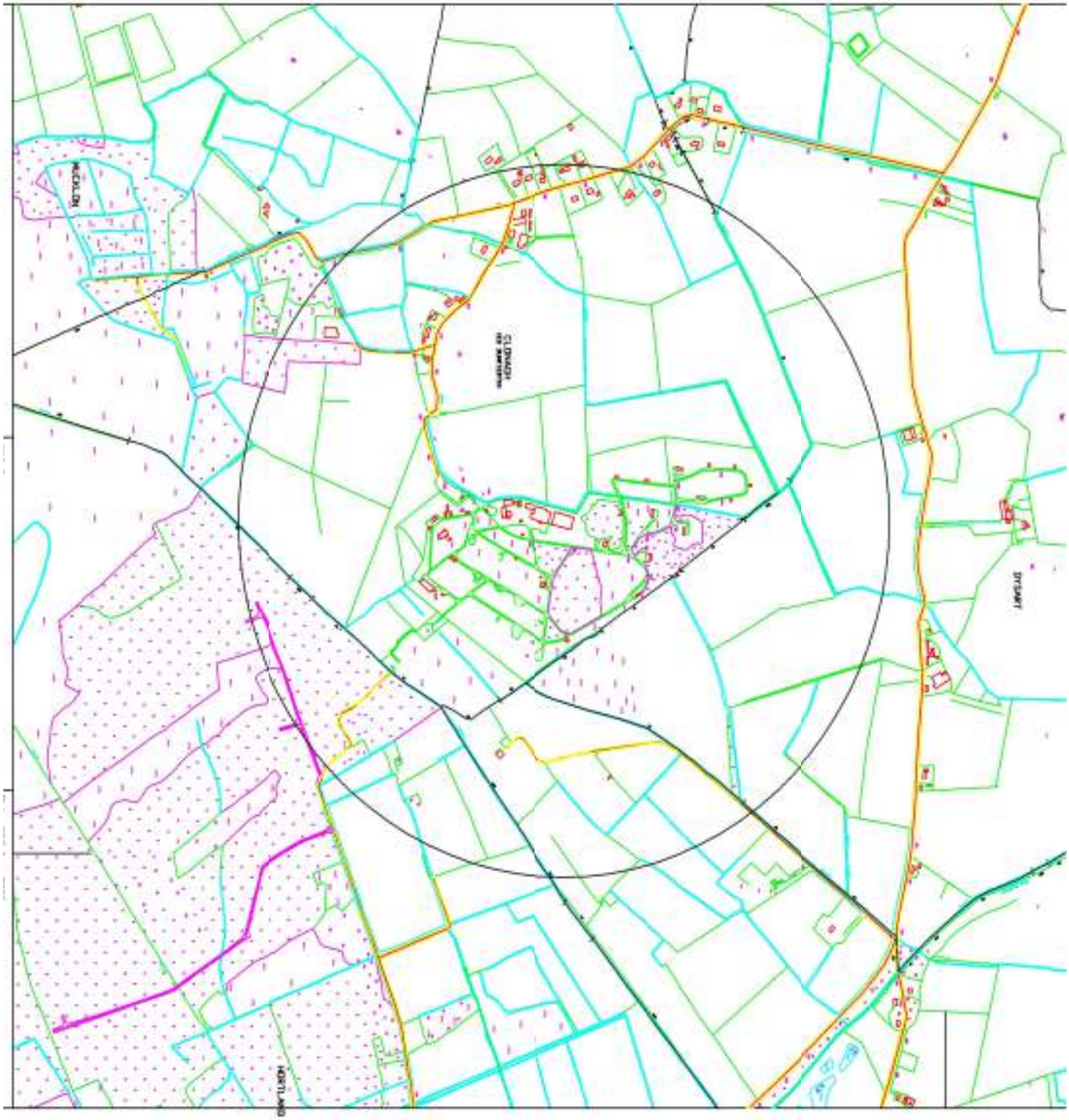
SAFEX 2008

# Irish Industrial Explosives

- Operating in Ireland since 1967
- Provides full range of commercial explosive products
- Manufactures catridged emulsions, bulk emulsions and ANFO
- Top tier Seveso site
- Located in rural area


Ireland
International boundary
County boundary
National capital
County seat
Cork County borough
Railroad
Road
50 Kilometers
50 Miles
Northern Ireland (U.K.)
Scotland (U.K.)
Enfield
Dublin
Belfast
Derry
Galway
Limerick
Cork
Waterford
Wexford
Wicklow
Arklow
Kilkenny
Carlow
Tullamore
Mullingar
Trim
Navan
Drogheda
Dundalk
Monaghan
Cavan
Longford
Athlone
Tipperary
Clonmel
Nenagh
Ennis
Killarney
Tralee
Mallow
Dungarvan
Youghal
Sligo
Ballina
Castlebar
Westport
Claremorris
Roscommon
Carrick on Shannon
Irish Sea
Saint George's Channel
NORTH ATLANTIC OCEAN

# SAFEX 2008




Ammonium Nitrate
VARA

# Introduction

- Ammonium Nitrate – storage is carried out at all explosives manufacturing plants
- At IIE limit of storage is 1500 tons, in practice 1200 tons stored
- Stored on a concrete pad with a steel clad roof and partial steel clad sides
- Pad is located more than 100m from manufacturing plants and explosives storage

# Hazardous Properties of Ammonium Nitrate

- Ammonium Nitrate is an oxidiser – capable of detonation if
  - Heated under confinement
  - Contaminated with carbonaceous materials will increase sensitivity to detonation
- Ammonium Nitrate will release toxic fumes if heated to decomposition - these are mainly oxides of Nitrogen – NO and $NO_2$ and $NH_3$.

# Hazard Identification

- 3 main sources used
  - NFPA 490 - Code for the Storage of Ammonium Nitrate 1998 edition.
  - UK HSE - Storage and Handling of Ammonium Nitrate
  - Factory Mutual - FM Global Property Loss Prevention Data Sheet no. 7-89. Revised Sept 2000.
- The main hazards were extracted from the above study and then 2 scenarios selected for further examination. These scenarios were
  - Detonation from a fire in AN pad due to maintenance / hot work
  - Toxic Gas Release
    - Fire in AN pad due to a forklift fire
    - Fire in adjacent forklift / spare parts store and spread.

# Consequence Assessment

- To detonate 3 conditions are generally required to be met
  - Contamination
  - Major source of initiation (eg fire or some other significant source of heat)
  - Confinement
- However in this safety case the detonation can be caused by a strong initiation source
- A stack of 173 tons was used as the basis for the assessment – 2m H x 3m W x 32 bags length
- The TNT equivalence method was used – based on FM and HSE guidelines 57 tons of TNT was quantity used

# Overpressure Effects

| Distance | Overpressure (mbar) | Description of damage |
|---|---|---|
| • 50m | 10000 | Total destruction |
| • 100m | 1700 | Total destruction |
| • 200m | 430 | Nearly complete destruction of houses. |
| • 300m | 200 | Steel frame building distorted and pulled away from foundations. >50% destruction of brick work of houses. |
| • 400m | 125 | Corrugated steel panels fastenings fail. |
| • 500m | 110 | Steel frame of clad building partially distorted.Houses – moderate damage. |
| • 600m | 70 | Windows shattered. Possible damage to window frames. |

**Points of Interest**

| | | |
|---|---|---|
| • 846m | 50 mbar | Onset of irreversible effects. |
| • 1290m | 30 mbar | Specified area end point. |
| • 385m | 140 mbar | First deaths LC1% |
| • 145m | 900 mbar | Nearest magazine (M11) |

# Explosion Overpressure Plot

# Fire Modelling

- AN fires are difficult to model
  - Rate of decomposition variability
  - Ratio of gases released (NO v $NO_2$)
  - Buoyancy of the gas plume and for warehouses gas movement effects
- Using results from HSE experiments
  - A forklift fire is simulated
  - A fire in nearby stores

# Forklift Fire

- $NO_2$ produced from:
  - Thermal radiation emitted from the fire
  - Contact between the fire and the AN

  Energy released by forklift fire is a maximum of 3000kW for 30 mins worst case

  AN decomposition rate in worst case scenario is 150 g/s/m²

  $NO_2$ release from thermal radiation = 0.1073 kg/s

  $NO_2$ release from contact reactions = 0.1000 kg/s

  Using the ADMS – suited to modelling buoyant releases:

# Dispersion Modelling

| Weather Class | ERPG2 (15ppm) | ERPG1 (1 ppm) | DTL (56.5ppm) | ½DTL (28.8ppm) |
|---|---|---|---|---|
| F 1.5m/s | 0 m | 16.7m | 0 m | 0 m |
| D 5 m/s | ***83.3 m*** | >500 m | 0 m | 50 m |
| D 10 m/s | 66.7 m | 400 m | 0 m | 50 m |

Based on this data the thermal radiation event is a serious event

# Fire in nearby Stores

- Model of effect of thermal radiation in nearby parts store (10m separation)
- Heat transfer calculations:
  - Temp of fire 1100C, emmissivity = 0.9
  - 16kW/m² results in decomp rate of 1 g/m²/s
  - Based on exposed area of AN the NO2 production rate is 0.0093 kg/s
  - Lower than the previous values for a forklift fire

This fire event is categorised as a serious incident

# Frequency Analysis

- Estimate of fire rate for fork trucks
  - Use HGVs accident statistics as data
  - $221 \times 10^{8}$ km/yr by HGV = 50,800km/yr
  - Crashes are 2578, 19 crash fires
  - $0.1166 \times 10^{-6}$ fires/km
  - $5.9 \times 10^{-3}$ fires/yr per HGV

  Assumed forklift has similar rate to that of HGV
- Fire in nearby store – use BS7974
  - Gives probability of a fire 0.0352/yr (1 in 28.3yrs)

## Ammonium Nitrate Pad – Frequency Rating

| Scenario | Consequence | Protective Measures | Frequency Rating |
|---|---|---|---|
| Internal fire due to maintenance, hot work leading to a fire and/or detonation | Fire with toxic gas release | Rare to do hot work, permits system in place, fire detection system, no combustible materials present | Hot work = 0.2/yr.<br>Hot work permit failure = 0.001<br>Fire response failure = 0.4<br>Fire spread = 0.01<br><br>Total = 0.8x10-6/yr ( 1 in 1,250,000 yrs) |
| | Explosion with equivalence to 57 ton of TNT ie 1 stack | Significant probability that fire will not lead to detonation (1 in 10 chance) | Detonation / Fire ratio = 0.1<br><br>Total = 0.8x 10-7 yr ( 1 in 12,500,000 yrs) |
| Internal fire due to Forklift fire | Fire with toxic gas release | Low frequency of forklifts in area, Driver always present, fire extinguishers present, fire detection system in place | Basic forklift fire = 5.9 x 10-3 /yr<br>Forklift present = 0.024,<br>Driver does not extinguish fire = 0.7<br>Fire response failure = 0.4<br><br>Total = 3.96x10-5/yr ( 1 in 25,222 yrs) |
| | Explosion with equivalence to 57 ton of TNT<br>ie 1 stack | Significant probability that fire will not lead to detonation (1 in 10 chance) | Detonation / Fire ratio = 0.1<br>Fire spread = 0.01<br><br>Total = 3.96x 10-8 yr ( 1 in 25,222,000 yrs) |
| External fire in forklift/spare parts store | Fire with toxic gas release | No ignition sources present, fire wall between store and pad, fire detection system, no combustible materials present | Basic estimation = 3.52 x 10-2/yr,<br>Fire response failure = 0.4<br>Concrete wall = 0.01<br><br>Total = 1.41x10-4/yr ( 1 in 7102 yrs) |
| | Explosion with equivalence to 57 ton of TNT<br>ie 1 stack | Significant probability that fire will not lead to detonation (1 in 10 chance) | Detonation / Fire ratio = 0.1<br>Fire Spread = 0.01<br><br>Total = 1.41x 10-7 yr ( 1 in 7,102,000yrs) |