

# Quantitative Risk Analysis of stored explosives



*Small-scale test to investigate the effects of an accidental explosion in ammunition magazines.*

The risk of an accidental explosion is inherent in the handling and storage of ammunition and energetic materials. Depending on the nature of the explosion and the infrastructure, the consequences of an accidental explosion range from only minor structural damage to large-scale catastrophes in which many people can be killed. The EU SEVESO II Directive obliges companies handling dangerous goods to give authorities insight information into the hazards involved. Quantitative Risk Analysis (QRA) is the methodology to quantify and analyse the risks of storing and handling dangerous goods. With a QRA, process safety managers are able to take adequate risk-reducing organisational and constructive measures. TNO has the expertise to QRA for stored dangerous goods, expressly Ammunition and Explosives.

## QRA model RISKANAL

TNO has developed, on behalf of the Netherlands Ministry of Defence, the QRA model RISKANAL. This model assesses the risk related to the storage and handling of Ammunition and Explosives.

Possible accident scenarios are qualitatively described first. The probabilities that certain undesired events will take place are assessed with reference to the UN Class 1 Compatibility Groups, the kind and number of activities and environmental aspects. Then the explosion effects of possible explosion scenarios are quantified as well as the probability of people being killed or injured by the accidental explosion. The risk is presented in iso-risk contours with regard to the individual risk and a so-called F/N-curve with regard to the societal risk.

Input parameters of the model regarding the storage site are:

- amount of Net Explosives Quantity;
- Hazard Division of Class 1 (HD1.1, HD1.2 and HD1.3);
- type of storage facility (light structure, igloo, earth covered, etc.);
- position of storage facility.

Input parameters regarding the environment are:

- position and number of exposed objects (buildings and individuals) inside the site;
- position and number of exposed objects (buildings and individuals) outside the site;
- inhabited buildings;
- individuals in free field.

Explosion effects taken into account are:

- airblast;
- ammunition fragments;
- facility and earth-cover debris;
- thermal radiation.

The Dutch Green Book 'Methods for the determination of possible damage to people and objects resulting from releases of hazardous materials' (CPR 16E) is implemented to assess the probability of kill due to the explosion effects. The effects on people included are:

- direct airblast;
- head and total body impact;
- glass fragments from window-pane breakage;
- building collapse;
- fragment/debris hit;
- first and second degree burning.

With the knowledge of the contribution of each input parameter, the risk becomes controllable. Organisational and constructive advice can then be given to make the risk As Low As Reasonably Achievable (ALARA principle). The further development of the QRA model RISKANAL is a continuous process. Input sources are:

- the NATO AC/258 Risk Analysis Working Group advice;
- (inter-)national R&D programmes.



Full-scale test with a net explosives quantity of 1,000 kg (300 mm zoom lens at 1300 metres).



Test-programmes on window-pane failure with one of TNO's shock tubes.

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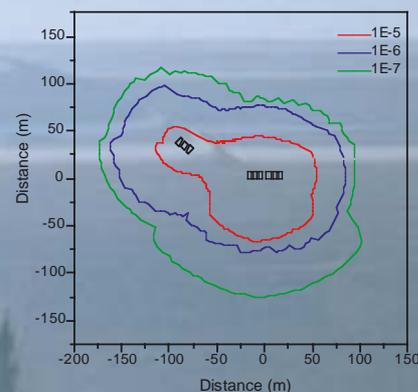
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## Examples of work

- On behalf of the Netherlands Ministry of Defence, the risk of military storage sites in the Netherlands is determined.
- For industrial installations, air bag producers and fireworks or ammunition and explosives factories, QRA was performed. The results are used to minimise the risk with organisational and constructive advice.
- QRA of the transfer of dangerous goods of class 1 at sea- and airports are performed to determine the safest place for handling and temporarily storing of class 1 goods and to argue waivers and exemptions.



ISO-risk contours of explosives storage site.

Photo (background): Full-scale explosion trial (joint UK/Australian test programme).