Safety Alert

Explosives Inspectorate

Safety Alert No. 44 V2
15 March 2011

Prevention and management of blast fumes

Figure 1 – Oxides of nitrogen generated by blasting

Reference

A. Queensland Mines Inspectorate Safety Bulletin No. 61
B. Queensland Explosives Inspectorate Safety Alert No. 28 Post Blast Gases
C. *Explosives Act 1999* (Qld)
D. *Coal Mining Safety and Health Act 1999* (Qld)
E. *Mining and Quarrying Safety and Health Act 1999* (Qld)

Purpose

1. The purpose of this alert is to make sure that everyone involved in open-cut blasting is aware of the potential for oxides of nitrogen to be generated from the use of ammonium-nitrate-based explosives (see Figure 1). Exposure to oxides of nitrogen can pose a serious health risk.

Scope

2. All Site Senior Executives, drill and blast superintendents, explosives company managers, shotfirers and other relevant people must risk-manage the potential hazards created by post-blast gases.

Background

3. Post-blast fume is a product of combustion from a blast. The products of combustion from a blast may include oxides of nitrogen, ammonia, nitric acid, carbon monoxide and carbon dioxide. These gases are often referred to as fumes. Nitrogen dioxide is visible as a reddish brown colour; the others are not visible.
4. Other than water ingress , known causes for the generation of oxides of nitrogen (including nitrogen dioxide) are:
    a. incorrect fuel to oxygen ratio
    b. product pre-compression
    c. insufficient priming
    d. acidic soils
    e. presence of pyrite
    f. product formulation.

5. Post-blast fume is composed of toxic gases (including oxides of nitrogen) which can be released into the atmosphere in significant quantities from blasting operations. Exposure to even quite low concentrations can pose a serious health risk.
6. The recent wet conditions and increased groundwater with the use of down hole ammonium-nitrate-based products have led to an increase in post-blast gases. Four events have occurred in the past fortnight in open-cut operations. In two of these events, 24 people required treatment and hospital observation for exposure to oxides of nitrogen.

   The department has previously provided References A and B in regard to the management of post-blast gases. These are available on its website at:
   a. http://www.dme.qld.gov.au/mines/safety_compliance.cfm (Reference A)
   b. http://www.dme.qld.gov.au/mines/safetyalerts.cfm (Reference B)

7. From 1992 to 2002, the United States of America had eight post-gas events that resulted in injuries to workers and the public, including a fatality.
8. In the Philippines in 2006, a shotfirer was conducting a post-blast inspection at a quarry when he fell eight metres into a cavity. He was rescued and taken to hospital with apparently only minor injuries. At the time of his recovery, it was noticed that his breathing was laboured, but this information was not passed on to the hospital staff. He died the next day of severe pulmonary oedema (NOx poisoning), which was not recognised by either the medical team or operational staff.

Issues

9. The operator's safety management system must include all the different control phases for post-blast fumes. The phases are:
   a. prevention — i.e. how to prevent or minimise post-blast fumes
   b. management of fumes — i.e. where post-blast fumes extend beyond the exclusion zone
   c. management of an exposure — i.e. for when people are exposed to fumes.

Prevention

10. To prevent or minimise post-blast fumes, it is necessary to have a knowledge and understanding of ground conditions, water (wet holes and the depth of the water), explosives product and their application, meteorology, and the toxicological effects of the gas.

11. There is a strong correlation between wet ground and the production of excessive fume. The presence of water can degrade the explosive resulting in a poor blast and excess fume.

12. Fume can be reduced if:
   a. the explosives product selected is correct for the conditions
   b. holes are dewatered before loading
   c. sleep times are kept to the minimum time recommended by the manufacturer.

13. An understanding and application of meteorology (i.e. weather conditions, wind speed and direction and stability classes) and gas cloud distributions will enable calculation of how long a gas plume will take to reach a point of interest such as a crib hut, workshop, house.[i] Such understanding and application also help determine the dispersion of the gas cloud, how far it will spread sideways, and how the gas concentration will change with distance. The people developing these plans must understand the gas toxicology, exposure to gas and the exposure standards of a gases, such as nitrogen dioxide, particularly high concentration exposures over relatively short periods.

[i] Buildings should not be used as shelters, unless they have been assessed by competent persons as safe havens.

Management of fumes

14. Before a gas plume occurs, it is important to have a system for managing a potential incident, including evacuations. The system should include information on wind speed and direction and on whether there is a gas-tight shelter nearby. Communication systems should also be in place, and there should be monitors to record concentrations of toxic fumes.

Management of an exposure

15. Exposure to nitrogen dioxide can result in delayed health effects that may be potentially life-threatening, even though the exposed person may at first appear relatively unaffected. For this reason, anyone who has been exposed to nitrogen dioxide should undergo an immediate medical assessment and a continued period of observation at the advice of the treating doctor.

16. The plan must include a health management plan for an exposure, which needs to be integrated with the local health providers. This should include medical advice to the treating physician. Attached to this alert is a sample advice letter that can be provided to the treating physician. Exposure should be treated seriously and referred for medical treatment based upon an exposure or stated dose.

17. All people involved in the management of blasting activities should review their safety management systems, including standard operating procedures and emergency response plans, to ensure that the management of situations, where clouds of oxides of nitrogen are generated, are properly managed.

Recommendations

1. All people involved in the management of blasting activities should ensure that the management plan for situations where plumes of oxides of nitrogen have been generated has been deployed and is operational. This should include health management and medical management plans.
2. The provision of material safety data sheets relative to the types of products being used should be made readily available to all persons involved in the blasting process.
3. All efforts should be made to reduce the likelihood of the production of post-blast gases during blasting operations.
4. Where doubt exists as to the potential cause of post-blast gases, those involved in the blasting process should contact the supplier of the explosives for further information.
5. Ensure that all relevant people in the organisation receive a copy of this Safety Alert.

Attachment: Information for Treating Doctor

Chief Inspector of Explosives

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INFORMATION FOR TREATING DOCTOR

Dear Doctor

This patient has been exposed to NOx. This is a gas usually produced on mines after the use of explosives.

NOx consists of multiple combinations of nitrogen and oxygen (N_2O, NO, NO_2, N_2O_4, N_2O_3, N_2O_5). Nitrogen Dioxide (NO_2) is the principal hazardous nitrous fume.

NOx irritates the eyes and mucous membranes primarily by dissolving on contact with moisture and forming a mixture of nitric and nitrous acids. But this is not the only way injury can occur. Inhalation results in both respiratory tract irritation and pulmonary oedema. High-level exposure can cause methhaemoglobinaemia. Some people, particularly asthmatics, can experience significant broncospasm at very low concentrations.

The following effects are commonly encountered after NOx exposure:

ACUTE

- cough
- shortness of breath
- irritations of the mucous membranes of the eyes, nose and throat

SHORT TERM

- pulmonary oedema, **which may be delayed from 4 to 12 hours**

MEDIUM TERM

- RADS (Reactive Airways Dysfunction Syndrome)
- in rare cases, bronchiolitis obliterans, which may take from two to six weeks to appear

LONG TERM

- chronic respiratory insufficiency

High-level exposure, particularly associated with methhaemoglobinaemia, can cause chest pain, cyanosis and shortness of breath, tachypnoea and tachycardia. Deaths have been reported after exposure and are usually delayed. Even non-irritant concentrations of NOx may cause pulmonary oedema. Symptoms of pulmonary oedema often show until a few hours after exposure and are aggravated by physical effort.

Before transfer to you the patient should have been advised to rest and, if any respiratory symptoms were present, should have been administered oxygen. The patient will need to be treated symptomatically, but as a base line it is suggested that the following may be required:

- spirometry
- chest x-ray
- methheamoglobin estimation.

Because of the risk of delayed onset pulmonary edema, it is recommended that as a precaution the patient be observed for up to 12 hours. As no specific antidote for NOx exists symptoms will have to be treated on their merits.

Information provided by Dr Vern Madden, Health Advantage Toowoomba