Mine Safety: Complying with Canada's New Lower NO_2 Limits by Implementing Appropriate Gas Detection Technology

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ABSTRACT

Nitrogen dioxide (NO_2) is a highly toxic gas that is generated as a component of diesel engine emissions and as a byproduct of blasting.

To support mine safety, there is an emerging global trend to reduce levels of human exposure to NO_2 in mining workplaces. In Canada, the generally accepted threshold level has been 3 parts per million (ppm). However, there is a recent trend to reduce this level to 0.2 ppm – which is 15 times lower than it was in the past.

In Canada, permissible exposure levels for NO_2 are regulated by province/territory. To date, the ACGIH exposure limits for NO_2 at TLV-0.2 ppm and STEL 1.0 ppm have been adopted by British Columbia, Manitoba, Newfoundland and Labrador, and Nova Scotia.

This whitepaper addresses current NO_2 limits in Canada and new legislation designed to protect worker health and improve mine safety. It also explores innovative gas detection technologies that can help mines comply with this new legislation.

Recommendation from the Scientific Committee on Occupational Exposure Limits (SCOEL) for Nitrogen Dioxide:

8-hour Time Weighted Average (TWA): 0.5 ppm (0.955 mg/m³)
Short Term Exposure Limit (STEL) (15-min): 1 ppm (1.91 mg/m³)
This recommendation is based on compilations by the World Health Organization (WHO) (1997), Dutch Expert Committee on Occupational Standards (DECOS) (2004), US Environmental Protection Agency (EPA) (2008), German Research Foundation (DFG) (2005 and 2010), American Conference of Governmental Industrial Hygienists (ACGIH) (2012) and National Research Council of the National Academies (2012).

[Source: SCOEL/SUM/53 European Commission, June 2014]

"Mines will have to be more diligent in their approach to the measuring and recording of information to meet the legislative requirements in their various districts that continue to change and reduce the allowable personal exposure levels (i.e., ACGIH reduction of NO_2 levels). Mines therefore require adequate monitoring tools capable of measuring these lower values of contaminants to establish and evaluate the appropriate controls and confirm compliance to legislation."

– Douglas O'Connor, President of DOCL, a Hard Rock Mine Ventilation Consultant, Sudbury, Ontario

BACKGROUND

Definition of nitrogen dioxide

Nitrogen dioxide (NO_2) is a highly toxic gas that is barely noticeable to humans. Depending on the temperature, nitrogen dioxide can be a colorless solid, a yellow liquid, or a reddish-brown gas. It is heavier than air and is acidic, corrosive, and oxidizing.

Effect of NO_2 on humans

The human olfactory perception threshold of NO_2 is between 0.1 and 0.2 ppm, depending on the study conditions.* With slowly increasing concentrations, the odour of NO_2 is not perceived until much higher concentrations have been reached (Henschler et al 1960), so the natural human warning effect of the gas is poor. For this reason, portable instruments with integrated NO_2 sensors are becoming increasingly important in mines.

*Source: Feldman JG (1974). The combined action on a human body of a mixture of the main components of motor traffic exhaust gases (carbon monoxide, nitrogen dioxide, formaldehyde and hexane). Gig Sanit 10:7-10.

Shalamberidze OP, Tsereteli NT (1971). Effect of small concentrations of sulfurous gas and nitrogen dioxide on the estrual cycle and the genital function of animals in experiments (Russian). Gig Sanit 8:13-17.

CURRENT NO_2 LIMITS ACROSS CANADA BY PROVINCE/TERRITORY

PROVINCES	
Alberta	8-hour time weighted average (TWA) exposure limit of 3 ppm and 15-minute STEL of 5.0 ppm
British Columbia	TLV-0.2 ppm and STEL 1.0 ppm
Manitoba	TLV-0.2 ppm and STEL 1.0 ppm
New Brunswick	Information unavailable as of publication date
Newfoundland and Labrador	TLV-0.2 ppm and STEL 1.0 ppm
Nova Scotia	TLV-0.2 ppm and STEL 1.0 ppm
Ontario	8-hour TWA exposure limit of 3.0 ppm and 15-minute STEL of 5.0 ppm
PEI	No underground mining currently in operation.
Quebec	8-hour TWA exposure limit of 3.0 ppm
Saskatchewan	Referred to as Workplace Contamination Limits (WCL or CL for 8-hr or 15-min.): TLV-5.6mg/m^3 (3.0 ppm) and STEL-9 mg/m^3 (5.0 ppm)

TERRITORIES	
Northwest Territories	Information unavailable as of publication date
Nunavut	Information unavailable as of publication date
Yukon	Information unavailable as of publication date

The physical effect of NO_2 on humans is irritation of the deep compartments of the respiratory tract. To support mine safety, government agencies around the world have begun to mandate lower NO_2 levels in the ambient air in mining environments.

Causes of NO_2

In mining and tunneling, diesel engines produce nitrogen oxide (NO) as a byproduct of combustion. In the presence of air, NO reacts almost immediately with oxygen in the air to form NO_2. With the exception of certain drilling equipment and some specialty applications, much of the mechanized equipment used in metal mines today is powered by diesel fuel.

NO_2 is also caused by blasting. During an explosion, all explosive materials produce a cloud of reactive substances – the most toxic of which is NO_2.

Blasters are aware that the gases produced by a blast are unhealthy and typically wait for the gases to dissipate before allowing anyone to return to the blast area. However, less consideration is given to the NO that remains in the muck pile. The gases in the muck pile are predominately blasting fumes and do not dissipate.

As a part of mine safety awareness, it is important to be aware that NOx (NO/NO_2) will be released during the mucking operation with the potential for serious physical harm.

Source: "Behavior of Nitrogen Oxides in the Product Gases from Explosive Detonations"; Richard J. Mainiero, James H. Rowland III, Marcia L. Harris, and Michael J. Sapko, 2012

COMPLYING WITH NEW REGULATIONS AND SUPPORTING MINERS' HEALTH

Listed below are basic steps that mines can take to comply with the new regulations and protect their workers from harmful levels of NO_2.

Analyze current NO_2 levels

The first step is to determine the level of NO_2 to see if the working environment is in compliance. This includes clearance after blasting, ventilation checks, and exposure assessment of high risk work places.

Applicable technology: Portable gas detectors with low concentration NO_2 sensors.

Identify and eliminate sources of NO_2

It is crucial to identify and eliminate the biggest sources of NO_2. This may include finding the worst polluting engines and taking corrective measures to limit their NO_2 emissions.

Applicable technology: Emission testing units.

Continuously monitor the environment

After taking corrective action and documenting compliance with the new NO_2 limits, it is necessary to continually monitor the environment – especially in areas where workers will be at higher risk of exposure to NO_2, such as workers operating or in proximity to diesel engines, in less ventilated areas, and close to mucking or crushing operations.

Applicable technology: Stationary and portable gas detectors, data management of exposure records, and emission testing units

DRÄGER SOLUTIONS FOR HELPING MINES COMPLY WITH THE LOWER NO_2 LIMIT REGULATIONS

Based on significant experience with the mining industry worldwide, Dräger has developed a proven solution with products that can help mines accurately monitor NO_2 levels in work environments and document compliance. This comprehensive solution includes the following core products:

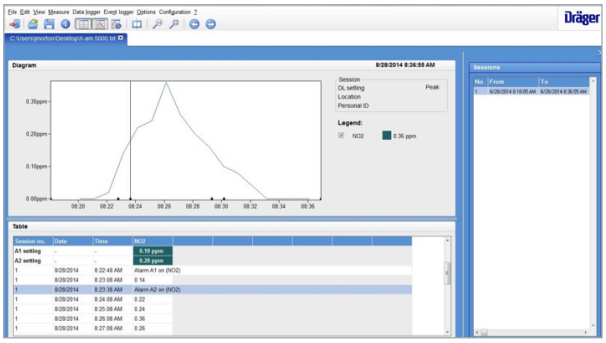
For detecting low levels of NO_2: Dräger NO_2 Sensor – Low Concentration
The NO_2 LC sensor was specifically developed to meet the rigorous requirements of the ACGIH changes. In addition to meeting the requirements for detecting low levels of NO_2, the sensor has a fast response time, very good repeatability and linearity, and very high resolution. With a detection limit of 0.04 ppm and a resolution of 0.02 ppm, it can support efforts to stay within a Permissible Exposure Limit or Threshold Limit Value.

It is possible to perform selective NO_2 measurements due to the sensor's extremely low cross sensitivities to NO and CO in areas where exhaust pollution is expected. The sensor also has low cross sensitivities to SO_2, which could be a factor with sulfurous ore materials.

For protecting workers from toxic gases: Dräger X-am® 5000 and Dräger X-am® 5600 Personal Monitor with Low Concentration NO_2 Sensor
Optimized for personal protection, the compact X-am 5000 five-gas personal monitor can be configured to meet the specific requirements of the operation by selecting from the 30 different electrochemical sensors. The X-am 5600 is an infrared-capable, six-gas personal monitor. Both monitors work in conjunction with the Dräger X-zone® to provide area monitoring.

For gathering data for control and compliance: Dräger X-dock® calibration and bump test station
The X-dock enables mine operators to manage their full fleet of portable Dräger gas detection instruments. Automatic bump tests and calibrations with short testing times reduce gas consumption, save time, and reduce operating expenses. Comprehensive evaluations and documentation provide a clear overview of the entire fleet, and can also report and document gas alarms and exposure levels.

As a networked solution, this software enables remote management of gas detection devices. The records produced by the X-dock reduce the time and effort required for compliance audits.



GasVision7 showing NO_2 measurements on an X-am® 5000 with the NO_2 LC sensor

For ventilation monitoring: Dräger Stationary NO_2 – Low Concentration Sensor
This stationary sensor can detect NO_2 concentrations as low as .05 ppm. It is suitable for use in a variety of Dräger fixed gas systems, including PointGard® II monitors, Polytron® 7000, 5100 and 8000 units. The Polytron 7000 is a low maintenance and intrinsically safe transmitter designed for toxic gas monitoring applications. Polytron 5100 and Polytron 8000 gas detector transmitters are explosion-proof.

For emissions testing at the source: Dräger EM200-E
This portable, handheld emission testing device was specifically tailored to the needs of the mining environment. It precisely determines the content of CO, NO, NO_2, and NOx in diesel engine exhaust and helps to identify engines outside of permissible emission limits with spot checks. This will help in identifying and eliminating the major sources of NOx emissions from combustion engines.

If integrated into regular engine maintenance intervals and evaluated properly, the monitoring of emission levels can also be used to adjust maintenance schedules to avoid breakdowns, provide spares in advance, and improve fuel efficiency. This can result in a significant increase in engine uptime and thus operational efficiency and increased productivity.

SUMMARY

Reliable technology now exists to continuously monitor levels of NO_2 and other toxic substances throughout the mining environment. These devices provide valuable information that can help mines protect their workers against exposure to harmful levels of NO_2. In addition, data collection and reporting software can reduce the time and effort involved in complying with the new regulations.

The ultimate benefit of reducing exposure to NO_2 in Canadian mines goes directly to those who work at the mine. By understanding the medical-based reasons for adopting the lower exposure levels for NO_2 and taking steps toward compliance now, mine operators can avoid unnecessary worker exposure to NO_2 – and can also avoid possible work disruption if the new exposure levels are adopted in their province/territory.

Questions?

To learn more about NO_2 detection and technology that can support mine safety and aid in compliance with new lower limits, please contact:

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