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# CERTIFICATION SERVICES FOR EXPLOSIVES AND EQUIPMENT USED IN UNDERGROUND MINES

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# CERTIFICATION SERVICES FOR EXPLOSIVES AND EQUIPMENT USED IN UNDERGROUND MINES

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## ABSTRACT

Certification services for explosives and equipment are carried out at CANMET by two of its laboratories: the Canadian Explosives Research Laboratory (CERL) and the Canadian Explosive Atmospheres Laboratory (CEAL).

While the research and certification work on explosives at CERL is directed also towards other industries on a national scale and the service furnished by CEAL has been expanded into many areas beyond its initial mandate, certification services to the Canadian underground mining industry have always been the major emphasis of their work.

This presentation outlines the roles and objectives of the two laboratories and describes their testing and research activities related to the certification of explosives, equipment and materials used in underground mines.

# SERVICE DE CERTIFICATION POUR EXPLOSIFS ET EQUIPEMENT UTILISÉS DANS LES MINES SOUTERRAINES

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## RÉSUMÉ

Les services de certification pour explosifs et équipement sont conduits à CANMET dans deux laboratoires: le Laboratoire canadien de recherche sur les explosifs (CERL) et le Laboratoire canadien d'atmosphères explosives (CEAL).

L'ouvrage de recherche et certification sur les explosifs à CERL est aussi dirigé vers d'autres industries sur un plan national et le service fourni par CEAL a été agrandi dans beaucoup de places au-delà de son mandat initial; les services de certification pour l'industrie minière souterraine ont toujours été le but principal de leur ouvrage.

Cette présentation souligne les roles et objectifs des deux laboratoires et explique leurs activités d'essais et recherche qui sont reliés à la certification des explosifs, équipement et matériel utilisés dans les mines souterraines.

## INTRODUCTION

The Canadian Explosives Research Laboratory and the Canadian Explosive Atmospheres Laboratory of CANMET have been serving the Canadian mining industry through certification testing of explosives and equipment.

Over the years, the laboratories have accumulated considerable experience from the research and development inspired by unanswered questions arising from the certification work. The knowledge gained from these exercises allows CANMET to engage and spearhead many activities affecting the health and safety of workers in the underground mining industry, for example: contributions to the formulation of national standards; development of equipment and techniques to solve or minimize health and safety problems; establishment of better testing criteria; and refinement of testing facilities. Such a knowledge base also allows CANMET to be called upon to perform the expert witness or advising functions in many situations.

This presentation is intended to give an overview of the roles and objectives of the two laboratories and a brief description of how the laboratories perform their certification duties. Some of their recent efforts relating to the certification work are also discussed.

## CERTIFICATION SERVICE FOR EXPLOSIVES

### The Role of the Canadian Explosives Research Laboratory (CERL)

Since its inception in 1920, the Explosives Laboratory (now the Canadian Explosives Research Laboratory) has furnished technical advice to the Chief Inspector of Explosives concerning the administration of the Explosives Act.

A major objective of the Explosives Act, which is administered by the Explosive Branch under the Department of Energy, Mines and

Resources Canada (EMR), is the reduction of hazard from explosives and pyrotechnics. An important tool in its attainment is the authority given to the Chief Inspector of Explosives to declare an explosive as an "authorized explosive". Explosives for use in Canada must be so declared with the exception of explosives under the control of the Minister of National Defence.

Explosive samples forwarded to the Chief Inspector for authorization are subjected to necessary tests to ensure that the explosives can be safely manufactured, handled, stored, transported and used.

These tests are conducted at CERL in its capacity as the appointed "chemists" under the Explosives Act. Test results are analyzed at CERL and are used as the basis for recommendation to the Chief Inspector regarding whether the explosive is suitable for authorization.

## Test Requirements

### General

Under the Explosives Regulations, explosives submitted for authorization shall be subjected to a series of tests. These tests are specified in the Regulations for the determination of the physical properties, the chemical composition, the stability, the ignition characteristics, the mechanical sensitivities, the detonation characteristics, the strength, the composition of gases evolved upon explosion and such other tests deemed necessary by the Chief Inspector of Explosives.

Test methods and procedures are either adopted from standard industrial practices or developed in-house. Recently, the laboratory has adopted test methods developed for the United Nations standardization of explosives classification (for transportation purpose).

Post-blast Fume Evaluation (Fume Test)

The determination of the composition of gases evolved upon explosion is required for explosives destined for underground use.

The detonation of an explosives charge in a surface operation does not normally present a hazard since the combustion gases are rapidly dispersed into the open air. When explosives are used in a confined location, such as in an underground mine, the post-blast toxic fumes must be controlled to protect the safety and health of the workers. The major toxic components from the fumes are carbon monoxide and oxides of nitrogen.

One of the fume tests conducted at CERL is adopted from the Institute of Makers of Explosives (IME) in the U.S. IME has established a classification of fumes based on the amount of toxic gases emitted from a standard cartridge (contains approx. 200 gm. of explosive) when it is detonated under certain prescribed test conditions inside the explosion chamber of an apparatus called the Bichel Gauge.

Only explosives meeting IME Fume Class 1 will be authorized for use in underground mines. Fume Class 1 requires that the combined amount of all toxic gases shall not be more than 22.656 litres from the detonation of one kilogram of explosives.

CERL has also developed a computer modelling method to make theoretical estimates of fume production. This is currently used in conjunction with the Bichel Gauge method.

The measurement of toxic gases using the Bichel Gauge method does not always reflect the total production of post-blast toxic gases. The pressure from the explosion inside the 15-litre explosion chamber causes immediate moisture condensation after the blast and the absorption

of a portion of the gases by the moisture. Furthermore, the explosives detonated are not performing work in the same manner as those that are restricted inside a bored hole. This affects the process of combustion and in turn affects the gas production.

This concern has prompted the design of a new fume testing facility to allow for the simulation of an actual blast and to avoid the absorption of gases. The new fume testing facility has been constructed and is now under functional tests. Once the tests are completed, the new facilities will be used in conjunction with the Bichel Gauge and the test results will be compared.

A new industrial fume standard is being developed at CERL. The new fume test facility is expected to be a useful tool in the standard development. The new standard will also take into account the degree of toxicity of individual components. The current procedure looks at the total amount of toxic gases and does not take into account the different toxicities of different gases.

## CERTIFICATION OF EQUIPMENT AND MATERIALS FOR UNDERGROUND MINES

### The Role of the Canadian Explosive Atmospheres Laboratory (CEAL)

CEAL was established in 1955 as a result of a request from the chief provincial inspectors of mines. The request called for the federal government to set up a national centre for the certification of electrical equipment for use in coal mines.

Over the years, as the demand for the certification of other mining equipment grew, the service has been expanded to include many other categories of equipment and materials.

Today, CEAL performs certification and R/D functions relevant to: flameproof electrical and diesel-powered equipment, diesel equipment

for non-gaseous mines, fire-resistant and anti-static conveyor belting, fire-resistant and anti-static ventilating ducts, intrinsically safe electrical equipment, combustible gas detection systems, fire-resistant electrical cables and fire-resistant hydraulic fluids.

CANMET has no authority to permit the use of the certified apparatus or material in a mine. That responsibility rests with the provincial or federal mining inspection authority having jurisdiction. A certificate issued by CANMET simply serves to demonstrate that the equipment or material is in compliance with the stated requirements. Certificates are issued by the designated "Certification Officer".

## Certification Requirements

### Certification Standards

The criteria for the certification of equipment and materials are pertain to the prevention of fire and explosion and the control of health hazards only.

CEAL uses available CSA Standards for its certification work. In earlier days before the applicable Canadian standard were developed, CEAL simply certified the product to foreign standards. As experience and knowledge grew, the laboratory started to develop its own testing criteria. Some of these criteria have become the blueprints of a number of CSA standards for underground mines.

Today, nearly all electrical equipment is certified to CSA standards that are generally under Part II of the Canadian Electrical Code.

A number of CSA standards are now available for underground mining mechanical equipment and fire-resistant materials. Other CSA Standards, such as those for non-gaseous mine diesel machine and fire-

resistant ventilation materials, are being developed. The technical working committees of both standards are chaired by staff from CEAL.

### Recognized Agencies

Recognized agencies are those from which EMR may accept test results from their test reports and/or certification documentations in lieu of testing performed by CEAL staff.

Certification agencies currently recognized by EMR are: the Canadian Standards Association, the Health and Safety Executive in the U.K., the Mine Safety and Health Administration in the U.S., Factory Mutual, Underwriter's Laboratory in the U.S., and a number of agencies from Germany, France, USSR and Japan.

## Categories of Equipment and Materials

### Flameproof Electrical Equipment

Flameproof electrical enclosures are tested to CSA Standard C22.2 No.30, "Explosion Proof Enclosures for use In Class I Hazardous Locations". Flameproof motors and generators are tested to CSA Standard C22.2 No.145, "Motors and Generators for Use in Hazardous Locations".

The objective of the tests is to ensure that, when a gas explosion occurs inside the equipment enclosure, the equipment shall be able to withstand the explosion without sustaining significant structural damage and that the flame from the internal explosion shall not cause the ignition of the explosive gas mixture outside.

The tests require the use of explosive gases and oxygen in a very precise manner. Equipment developed in-house has allowed the work to be carried out at a lower cost than might otherwise have been the case.

Flameproof electrical equipment is certified by CANMET under "gaseous mines" category only. Equipment certified for "gaseous mines" is suitable for use at ambient temperatures from 0 to +40°C as compared to a temperature range of -50 to +40°C for other explosion proof classifications. Equipment with a lower ambient temperature rating is subjected to more severe tests as the explosion pressure increases at lower temperatures. The use of exposed light metal alloy is generally prohibited in the construction of "gaseous mine" equipment.

CEAL also performs explosion tests for CSA on other classifications of explosion proof electrical equipment.

Intrinsically Safe Equipment

Intrinsically safe equipment is certified under CSA Standard C22.2 No. 157 - "Intrinsically Safe Equipment for use in Hazardous Locations". Acceptability of equipment is determined either by testing methods with specific testing apparatus or by analytical means.

Conveyor Belting

Belting is certified in accordance with CSA Standard M422, "Fire-performance and Antistatic Requirements for Conveyor Belting". The tests performed are:

Flame Test

This test involves the application of a flame to a small sample of belting and the measurement of the duration of the continuous burning or glow after the removal of the initial ignition source. One of the concerns regarding this test is that the result is not always reproducible.

CEAL has experienced with another small-scale test called the

"Critical Oxygen Index Test". The test measures the minimum percentage of oxygen in a flowing oxygen/nitrogen stream that will keep the sample burning. The test is found to yield reproducible results.

Flame Propagation Test (Propane Gallery Test)

The purpose of the test is to simulate the effect of a mine fire and determine the flame propagation characteristics of a belting material. This test uses quite a large sample (0.9m by 4m). The main test parameters are: post-burn time, length of sample undamaged, temperature of exhaust and the total heat output. For product development, this is an expensive and difficult test. The staff at CEAL have devised a scheme to help manufacturers to predict the result of a full scale flame propagation test by carrying out screening tests using the small-scale tests. The product is likely to pass the flame propagation test if it performs well on all the small-scale tests. This scheme has already been used successfully by some Canadian conveyor belt companies.

Drum Friction Test

The objective of the test is to simulate the situation in which a belt is stalled on a rotating drum that generates heat in the belting. The drum continues to rotate for a period of time or until the belt breaks. The result is used to determine the classification of the belt.

Electrical Surface Resistance Test

The test involves the measurements of the resistance between two electrodes placed on the surface of the belting. The resistance affects the generation and accumulation of static electricity which can be dangerous in a gaseous mine.

CEAL has carried out a study on the effects of temperature on surface resistance of belting. The results revealed that the surface

resistance of PVC belts increased very rapidly with decreasing temperature. Rubber belts, on the other hand, increased in surface resistance very slowly with decreasing temperature.

The test is performed inside a room where the humidity and temperature are precisely controlled and maintained.

Flameproof Diesel Equipment

Flameproof diesel equipment is certified in accordance with the requirements of CSA Standard M424.1, "Flameproof Non-rail-bound Diesel-Powered Machines for Use in Gassy Underground Coal Mines".

The major test on the engine is the determination of the undiluted concentrations of noxious constituents from the engine exhaust system. These include carbon monoxide, nitric oxide, nitrogen dioxide and respirable combustible dust (soot). The result is used to establish the Exhaust Quality Index (EQI). The test is repeated with the engine operating in different conditions until the largest EQI is identified.

The EQI is then used to determine the ventilation required for the engine. Consideration is also given to the limiting value of each constituent to ensure that no component will exceed its acceptable level. A certificate is issued with a prescribed ventilation level and an "engine fuelling specification" with fuel injection settings.

Exhaust emission tests are also carried out with exhaust treatment device. CEAL played a major role in the development of the well known Corning ceramic filter for trapping the soot that is present in the exhaust. Some countries do not consider the soot in their hazard evaluation. However, research at CEAL supported by numerous recent studies demonstrates that exhaust soot contributes significantly to the overall health hazard.

Other electrical and mechanical components of the machine are tested for their flameproof and intrinsically safe capabilities and fire-resistant properties, as required under relevant standards.

Non-Flameproof Diesel Equipment

Non-flameproof diesel equipment is only tested for its exhaust emissions, in the same manner as the flameproof diesel equipment.

Electric Cables and Cable Glands

Electric cables and cable glands are assessed in accordance with the relevant requirements of CSA Standard C22.2 No. 174, "Cables and Cable Glands for Use in Hazardous Locations".

The test for electric cables involves the determination of the fire-resistant properties of the cable jacket and conductor insulation under prescribed loading conditions.

Hose Conduits

The only test requirement for hose conduits is a small-scale flame test. The EMR test procedure was adapted from MSHA in the U.S.

Ventilation Duct Materials

A CSA standard for all ventilation materials is currently being developed. At present, fire resistant flexible mine duct materials are evaluated in accordance with the requirements of the U.K. National Coal Board (now British Coal) NCB Specification 245/1961. An additional large-scale test is required for materials that yield ambiguous results in the NCB test. The anti-static properties are tested in accordance with NCB Specification 158/1960.

Rigid ventilation duct materials are evaluated for fire resistance by a large-scale test, and the anti-static properties are determined in accordance with the requirements of CENELEC Standard EN50014.

Combustible Gas Detection Equipment

Combustible gas detection equipment is assessed in accordance with the relevant requirements of CSA Standard C22.2 No. 152, "Combustible Gas Detection Instruments". In addition to the verification of the system's flameproof or intrinsically safe capabilities, combustible gas detection equipment is also tested for performance.

Some of the tests in the CSA Standard relating to mechanical shock such as bounce and vibration are not performed at CEAL. The applicant is required to have the necessary test performed elsewhere and provide to CANMET satisfactory evidence of the tests.

Fire-Resistant Hydraulic Fluids

Fire-resistant hydraulic fluids are assessed in accordance with the requirements of CSA Standard M423, "Fire-Resistant Hydraulic Fluids". The two basic flammability tests are the spray-ignition test and the wick test. The tests are carried out to determine the flame persistence of the burning fluids after the removal of the ignition sources. The spray-ignition test is carried out by continuously spraying the test fluid out of a nozzle at a high pressure. The fluid is then ignited with a propane torch. The wick test consists of soaking a nonflammable wick in the fluid and applying a flame to it.

Some fluids tend to break down from use and become less fire-resistant. Other fluids, such as the water-in-oil emulsion types, tend to separate in time or under extreme temperature changes. These problems are taken into consideration in the test process by either pre-aging the test

fluid or testing for separation under extreme conditions.

It must be pointed out that although the CSA Standard requires the determination of the toxic and irritation-causing effects, it does not cover products of combustion from hydraulic fluids subjected to fire or heating.

Others

CEAL also certifies flameproof motor and generator repair facilities, miner's cap lamps and underground blasting machines using established procedures and requirements.

## CONTACT PERSONS

For more information regarding the certification services at CANMET, you are encouraged to contact:

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