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**G03-01**

# **Type E High Explosives**

Classification and Authorization  
General and Detailed Requirements for Type E Explosives

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Explosives Regulatory Division

**Canada**

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## 1. INTRODUCTION

This guideline is published in accordance with the *Explosives Regulations* made under the *Explosives Act*. It is written in conjunction with the Explosives Regulatory Division (ERD) document titled *Authorization and Classification of Explosives*, and it specifies the documentation and testing needed for authorization of Type E explosives.

The potential effects hazard category of commercial high explosives (as outlined in Directive Letter #59) is PE1 (explosives having a mass explosion hazard).

In the proposed new explosives regulations, explosives will be also classified by type, according to their intended purpose. High explosives will be referred to Type E explosives, and there will be three sub-types in this group:

- E.1 - blasting and bulk explosives (explosives used for commercial blasting applications or for their manufacture);
- E.2 - perforating explosives (intended for use in the oil and gas well industry);
- E.3 - special-application explosives (high explosives used for other applications, including primary explosives).

### 1.1 Scope

This guideline applies to Type E high explosives intended for commercial or industrial use, as well as to high explosive raw materials used for their manufacture, which have a mass explosion hazard and are classified for transport with compatibility group D or S. High explosives are materials that are characterized by a very high rate of reaction, high pressure development, and the presence of a detonation wave.

The guideline applies to the following explosives:

- blasting explosives in bulk or in packaged form, e.g.;
  - ANFO (ammonium nitrate / fuel oil);
  - emulsion explosives, including blends with AN or ANFO (included here are the unsensitized base emulsions used to produce gassed or microballoon sensitized explosives, and partially sensitized emulsions);
  - water gel explosives, including blends with AN or ANFO;
  - slurry explosives, including blends with AN or ANFO;
  - dynamites.
- boosters;
- binary explosives;
- shaped charges, perforating guns and other specialty explosives incorporating detonating explosives used in the oil and gas well industry;
- plastic explosives.

Appendix 1 contains a list of terms and definitions.

This guideline specifies the requirements for obtaining a Canadian product authorization and classification. In addition, it specifies what must be declared by the manufacturer or the manufacturer's representative.

It does not apply to national defence and law enforcement explosives.

The perforating guns manufactured by members of the Petroleum Services Association of Canada will be authorized when these perforating guns are manufactured in conformance with the following document:

- The current version of the Perforating Industry Code of Practice.

Authorizations of perforating guns are also based on the following documents:

- Hazard Classification Testing proposal for: "Jet Perforating Guns, charged, oil well, without detonator" dated September 17, 2004.

The above mentioned document refers to the test reports titled:

- UN 12m Drop testing of jet Perforating Guns charged, oil well, without detonator, dated September 2, 2004, with ERD file reference XP1000-3;
- Vibration Testing Component of hazard Testing of: Jet perforating Guns, charged, oil well, without detonator, dated January 2004, with ERD file reference XP1000-3.

Changes to any authorized products, unless otherwise indicated in the approval, require ERD approval (refer to the document titled Authorization and Classification of Explosives (March 28, 2006) to determine the significance of a change).

This guideline will be applied to the authorization of all new type E explosives and to any currently authorized products that have been significantly modified or changed.

Products and systems that are now authorized and that now appear on the current list of authorized explosives, unless materially changed or involved in any safety-related incidents or safety issues that may be currently undetermined or unclear, will not be required to:

- a) meet all requirements of this guideline,
- b) re-submit documentation, or
- c) perform additional testing.

The intention of the authorization process is to ensure that the manufacturer has applied sound principles of design and exercised due diligence in evaluating the safety-related properties of the explosive.

As documentation reveals the details of design, which constitutes the intellectual property of the manufacturer, the submission will be kept confidential in accordance with the *Explosives Act* and Regulations.

## **1.2 Approvals - Authorization of explosives**

Authorization of explosives may be granted after a review of the required documentation, including any applicable test results. Part 6 of the ERD document entitled Authorization and Classification of Explosives describes this process, including documentation, language and format.

## **1.3 Regulation of use**

ERD does not regulate the use of high explosives. The use of high explosives falls under provincial and territorial jurisdiction. However, as part of the approval and testing process by the Explosives Branch, ERD requires that information be submitted to ensure that the explosive can be safely used as recommended by the manufacturer.

## **1.4 Required documentation**

This guideline, in conjunction with the Authorization and Classification of Explosives document, outlines the requirements to be met by a manufacturer who applies for approval of an explosive and, when applicable, its use only with manufacturer-specified system components.

The documentation for the authorization must:

- a) be as specified and structured as set out in the ERD document titled Authorization and Classification of Explosives and must include the mandatory supporting documentation as identified in the following sections; and
- b) be submitted by the manufacturer who applies for approval or by its representative.

## **1.5 Continuing authorization**

The Explosives Regulatory Division (ERD) may periodically request samples or undertake audits to validate the continuing authorization of the articles on the Canadian list of authorized explosives. Audits are used to assess the effectiveness of the quality control system, identify its weaknesses, risks and areas needing improvement, and to ensure that products comply with the specifications and performance results as supplied to obtain authorization.

## **2. REQUEST FOR AUTHORIZATION**

A request for authorization of explosives covered by this standard includes the submission of the application form (available from the ERD website), with the information requested on the application form, and all additional information on the explosive in question requested in this document, including any test data generated by the manufacturer, commercial test agency and national competent authority test agencies such as the Canadian Explosives Research Laboratory (CERL). How the submission will be evaluated is described in sections 7 and 8 of the Authorization and Classification of Explosives document. The submission is a legal declaration to the Government of Canada in order to obtain authorization. It is the first indication of the care a company exercises in achieving a product of acceptable quality. Poor submissions do affect perception.

The review process does not start until all information has been submitted.

### **2.1 List of articles**

A list of all the articles in the submission by name, preferably with an identifying part number, is required.

### **2.2 Mandatory documentation**

The following information must be provided:

- chemical formulation(s) with tolerances;
- example of packaging and labelling. All labelling giving instructions or safety precautions must be in English and French;
- intended use;
- expected transport classification, including a copy of a letter from the competent authority classifying the explosive when available.

Note that any testing in support of the UN classification should be supplied for review, and that acceptable test results from another test facility may be accepted in lieu of testing at CERL for these tests.

Refer to Table 1 (section 4) for characteristics and test results to be supplied by the manufacturer.

#### **2.2.1 Additional mandatory documentation specific to bulk explosives used for commercial blasting**

- For bulk water gels and emulsion: the transportation temperature.
- Physical properties of water gel and emulsion, i.e., colour, unsensitized density, target chemically sensitized density.
- Processing temperatures and maximum pumping pressures for water gels and emulsions.
- Explosives properties, including critical diameter, velocity of detonation (VOD) (for sensitized material in the case of water gels and emulsions), recommended smallest diameter, recommended smallest primer.

### **2.2.2 Additional mandatory documentation specific to packaged explosives, including boosters**

- Packaged product sizes and types of packing, e.g., paper shell, plastic cartridge, polymer wrap.
- Physical properties of water gel and emulsion, e.g., colour, density.
- Example of labelling on the article for packaged products. All labelling giving instructions or safety precautions must be in English and French.
- Example of the labelling on the Gaylords or overpacks and individual ANFO bags or emulsion cartridges:
  - The labelling must cover the following:
    - Type of product and dimensions
    - Product date code
    - Total number of cartridges contained with the Gaylord
    - Suitable space to note magazine identification codes (usually a ladder is used)
  - ANFO bags or individual emulsion cartridges must have the company name, manufacturing date (and shift, if appropriate) and trade name printed on the packaging.

### **2.2.3 Documentation and requirements related to the use of waste oil**

Note that approval for use in surface applications of waste oil in bulk ANFO products, in bulk ANFO products mixed to form ANFO-emulsion blends and bulk emulsion products, can be considered when:

- the waste oil is generated, characterized and used within the same province or territory;
- approvals have been received from the provincial authority having jurisdiction over use and transport of waste oil;
- its use is described in the factory licence;
- the products are authorized and include the limiting percentages of waste oil (not more than 50% waste oil may be used in the oil phase);
- explosive product use and sale is restricted to the base factory site where the waste oil originated.

This policy limits the use of waste oil to waste oil generated at a mine site and ensures that oil from all types of sources is not used unless the composition and the source are known and characterized. Accordingly, the following requirements apply to the sources of waste oil:

- a specification against which waste oils can be tested and evaluated; this specification must define:
  - i) composition, i.e., expected contents as well as what is not acceptable (e.g., hydrocarbons, a small quantity of additives, a little water, traces of heavy metals would be expected, but glycols or chlorinated hydrocarbons would not);
  - ii) viscosity limits (very viscous oils may cause problems with application and absorption);
  - iii) flashpoint limits (i.e., low flash point can affect pumping safety).
- test methods so that the oil can either be accepted or rejected before it is blended with virgin oils and before their use;

- companies must develop guidelines for the use and testing of waste oil and waste oil blends. The guidelines must include testing or certification of pre-blend waste oil prior to use, defining limits for water and glycol, checking for AN absorption, and conducting routine visual checks for any observed separation of the oil in the blends. Records must be available for inspection.

#### **2.2.4 Additional mandatory documentation specific to nitrate ester products**

- antacid equivalent to the neutralizing power of magnesium carbonate added at 1% of the nitrate ester in the composition.

### **2.3 Outsourcing**

If some components of a multi-component explosive assembly are purchased from another source (e.g., detonating cord and shaped charges for oil and gas well guns), this must be indicated on the drawing and a reference to that source must be given. ERD will decide whether a separate testing scheme for the outsourced material will be required.

### **2.4 Field use and development testing**

#### **2.4.1 Field testing and field use experience**

Provide a summary that describes field test and use results obtained, in Canada or abroad, from any trial or commercial use prior to the authorization application. This summary and supporting information will be used to determine which category of authorization is appropriate for a product and system. For example, products having extensive satisfactory test and commercial use experience are much more likely to be considered for authorization for an unlimited period than products with only test experience and no commercial experience. Similarly, prototype products and systems with no field use might only be considered for provisional authorization for a specified period, and then only when submitted by companies known to ERD and known to have an established product development protocol which demonstrates reliability before actual field trials and results are available.

Submissions requesting authorization for an unspecified period should summarize field use results such as:

- Details of usage including reports of all observed successes and problems as well as any findings, corrective actions and recommendations for use.
- Any incident, accident or unusual occurrence associated with use; identify corrective actions taken to prevent re-occurrence.

Similarly, submissions requesting provisional authorization for a specified period would be expected to generate similar information during the specified period.

#### **2.4.2 Development testing**

When little or no usage or field-test data is available, then prototype products and systems or new products similar to those already authorized by a company may only be considered for



provisional authorization for a specified period. The conditions and specified period applied to the authorization would be based on factors such as:

- Whether product and system is similar to current company products or based on new technology.
- Whether the company is known to ERD and known to have an established product development protocol which demonstrates reliability before actual field trials and the results of those field trials are available and which defines the probability of normal and aberrant behaviour.

Submissions for provisional authorization for a specified period would be expected to include similar information to that described in paragraph 2.2.

### 3. SUBMISSION REVIEW AND SAMPLING

This section describes the requirements for the acceptance of a submission and the sample selection methodology.

#### 3.1 Products not authorized in Canada

Certain explosives will not be authorized.

The following types of explosives will not be authorized for commercial purposes:

- unmarked plastic explosives (i.e., explosives embedded in a polymeric matrix) that do not contain a detection agent as required by the Explosives Act and Regulations;
- explosives not properly labeled;
- explosives that have a history of injuries due to poor design or manufacture.

#### 3.2 Tolerances

As indicated on the application form, tolerances are to be provided.

##### 3.2.1 Chemical

Tolerances for each ingredient in an explosive, which are expressed as a percentage of the total explosive, shall not exceed the following:

- (a) Physical sensitizers: the tolerances established by the applicant;
- (b) Aluminum:  $\pm 0.7\%$ ; and
- (c) Moisture and ingredients other than specified in points (a), (b) and (c) of this section: the tolerances specified in Table 1.

**Table 1: Tolerances for moisture and other ingredients**

Quantity of ingredients (as percent of total explosive or sheath)	Tolerance percent
0 to 5.0	1.2
5.1 to 10	1.5
10.1 to 20.0	1.7
20.1 to 30.0	2.0
30.1 to 40.0	2.3
40.1 to 50.0	2.5
50.1 to 55.0	2.8
55.1 to 100	3.0

Tolerances as outlined above will apply to the following product types:

- ANFO;
- Emulsion explosives:
  - Unsensitized base emulsions;
  - Partially sensitized emulsions;
  - Blends of emulsion with AN or ANFO;
- Watergel explosives (including blends with AN or ANFO);
- Dynamites.

The tolerances above do not apply to the following products, they will be dealt with on a case-by-case basis:

- Boosters;
- Slurry explosives;
- Binary explosives;
- Shaped charges, perforating guns and other specialty explosives incorporating detonating explosives used in the oil and gas well industry;
- Plastic explosives.

All declared ingredients must be present. Ingredients not declared must not be present at a level exceeding 0.5% (mass/mass of composition analyzed).

### **3.2.2 Physical**

Tolerances for physical characteristics may be set by the company.

### **3.2.3 Charge weights**

Tolerances for charge weights for the various sizes of packaged products may be set by the company.

### **3.3 Marking and labelling**

The labelling and markings on packages must conform to the requirements of the *Explosives Regulations*.

### **3.4 Packaging**

Packaging must comply with the requirements of the *Explosives Regulations* and with the specifications set out in the most recent National Standard of Canada entitled Packaging of Explosives (Class 1) for Transportation.

### **3.5 Sampling of the submission**

Not all articles need to be tested. Large submissions are sampled and the acceptance of the submission depends on the behaviour of the sample. New products similar to existing ones from established and known companies may be authorized by analogy to existing products of that company.

The choice to sample rests with the inspector and depends on factors such as past experience, history of complaints, and availability of articles from the same company to use as analogues, or the time elapsed since articles from the company were last tested.

The description of sampling below represents a typical minimum sampling requirement. Inspectors may decide that additional samples are needed to better evaluate a submission.

Bulk water gels, emulsion, ANFO:	10 kg of the unsensitized product unless sensitized product is specifically requested.
Packaged water gels, emulsions, ANFO	10 kg of the packaged product in the smallest diameter offered
Dynamites	1 case of the smallest diameter offered
Boosters	1 case

The sample quantity for all other high explosives (oil and gas well explosives, binary explosives and plastic explosives) will be determined after a review of the submission for authorization and test data available for the explosive.

The actual number of samples will be specified in the test plan developed by CERL in conjunction with ERD (refer to section 6.5 of the Authorization and Classification of Explosives document.).

Applicable test limits reflect normal or routine conditions for transport, storage or use and do not reflect extreme limits at which failures or malfunctions can be reasonably explained. In addition, ERD only accepts samples that have been prepared and supplied by the company itself. For these reasons, any failure or malfunction will be carefully and critically reviewed by the inspector; and since in general any defect involving testing of any important attributes constitutes failure of the article, explanations will only be considered if justified and sound.

## 4. TESTING AND AUTHORIZATION

Section 6.1 of the Authorization and Classification of Explosives document describes the general authorization process. This includes the selection of samples by ERD, the preparation of a test plan by CERL, and the issuance of a CIE report by CERL to ERD that includes recommendations for the authorization and classification of the products. This section describes more specifically the basis under which explosives will be given a classification and authorization.

### 4.1 Packaging for samples

When samples are sent to CERL for product testing, they should preferably be shipped in their intended packaging with the appropriate labeling and instructions. Note that all packaging for shipping must comply with TDG regulations.

### 4.2 Test methods and acceptance criteria

Table 1 summarizes the requirements for blasting explosives in bulk and packaged form, indicating the specific tests required for each type of product.

Table 2 summarizes the tests, indicating the origin of the test and the test criteria for blasting explosives.

The tests for authorization of blasting explosives are based on the requirements detailed in the *Explosives Regulations*. The actual tests and test criteria originated from three sources:

- Tests developed by the CERL and used in Canada for authorizations in the past;
- Standards approved by the European Committee for Standardization (May 2005), also known as CEN Standards - Explosives for civil uses - High explosives;
- The UN tests referred to in the table are described in detail in the Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria, Fourth Revised Edition (or most recent edition), United Nations, New York and Geneva, 2003.

The CEN and CERL tests focus on ensuring the safety of products for manufacturing, storage and handling, while the UN tests are more concerned with classification of the products for transportation.

Certain tests, (indicated by “M” in Table 1 below) will require manufacturers to submit test results to substantiate their claims regarding the properties of the product. Tests indicated by “A” are authorization tests to be done by the CERL.

The symbol "-" in the UN test criteria means a result where no reaction (explosion, ignition or in certain cases a rise in temperature) was observed. The symbol "+" means some type of reaction (explosion, ignition, or in certain cases a rise in temperature) was observed, and usually indicates a failure.

Table 3 summarizes the requirements for shaped charges and perforating guns, indicating the specific tests required for each type of product.

Table 4 summarizes the tests, indicating the origin of each test and test criteria for the explosives types listed in Table 3.

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Note that not all tests listed would necessarily be required for each authorization submission.

Binary explosives and plastic explosives will be handled on a case-by-case basis.

**Table 1: List of tests, and testing requirements for blasting explosives**

Attribute	Type of Blasting Explosive				
	ANFO	Packaged explosives (emulsion, water gel, slurry)	Dynamites (Div. 1.1 only)	Boosters (Div. 1.1 only)	Bulk (emulsion, water gel, slurry) See Notes
Packaging	A	A	A	A	
Sample characteristics	A	A	A	A	
Density	A	A	A	A	A
Composition	A	A	A	A	A
Particle size	A				A
Impact sensitiveness	A	A	A	A	A (more stringent requirement)
Friction sensitiveness	A	A	A	A	A
Thermal stability: UN Test Abel Test	A	A	A	A	A
			A		
Small scale burning	A	A	A	A	A
Velocity of detonation		M	M	M	
Cap sensitiveness	A (Div. 1.5 only)	A (Div. 1.5 only)			A
DDT under confinement	A (Div. 1.5 only)	A (Div. 1.5 only)			A
Effect of external fire on packaged product	A (Div. 1.5 only - not normally performed by CERL)	A (Div. 1.5 only - not normally performed by CERL)			
Thermal stability large containers					A
Sensitiveness to intense heat under confinement					A
Sensitiveness to shock at declared maximum process transport temperature					A

Attribute	Type of Blasting Explosive				
	ANFO	Packaged explosives (emulsion, water gel, slurry)	Dynamites (Div. 1.1 only)	Boosters (Div. 1.1 only)	Bulk (emulsion, water gel, slurry) See Notes
Minimum burning pressure					A (only explosives <i>handled</i> using pumps or augers - handled: see TDG definition of handling)
Resistance to water	M	M	M	M	M
Resistance to hydrostatic pressure	M	M	M	M	M
Safety and reliability at extreme temperatures	M	M	M	M	M
Transmission of detonation	M	M	M	M	M
Thermodynamic properties	M	M	M	M	M
Oxygen balance calculation	M	M	M	M <sup>(1)</sup>	M
Means of initiation	M	M	M	M	M

## Notes:

A = authorization test

M = test performed by manufacturer to substantiate its claims regarding the properties of the product.

“Bulk” means emulsion, slurry, water gel or solid explosive transported in containers containing more than 454 kg. Not cartridged. Does not necessarily include explosives in drums, bins, tote bags, etc.

(1): Although an oxygen balance calculation must be submitted for boosters, the result is not required to meet the requirement listed in Table 2 (see section 4.2.3).



**Table 2 Description of tests and acceptance criteria for blasting explosives**

Attribute	Test or tests	Criteria
<b>Packaging</b>	<ul style="list-style-type: none"> <li>- Check UN packaging certification on package.</li> <li>- Check compliance with CGSB packaging instruction.</li> <li>- Check presence and correctness of TDG label, shipping name, PIN, manufacturers product name or part number, address, phone number.</li> <li>- Confirm presence of ladder.</li> <li>- Check dimensions as declared.</li> </ul>	<ul style="list-style-type: none"> <li>- The certification must be present.</li> <li>- Must meet packaging instruction.</li> <li>- Required markings must be on packaging.</li> <li>- The ladder must be on the packaging.</li> </ul>
<b>Sample characteristics</b>	<ul style="list-style-type: none"> <li>- Substance - colour and form must meet declaration.</li> <li>- Articles - dimension, masses, materials and labelling must be as declared.</li> <li>- Articles must have "Explosive - Danger - Explosif"</li> </ul>	<ul style="list-style-type: none"> <li>- Must be as per declaration and within declared tolerances.</li> <li>- Article must have appropriate marking including the warning.</li> </ul>
<b>Density</b>	<ul style="list-style-type: none"> <li>- Determine density by CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives</li> <li>- Part 13: Determination of density (unsensitized and sensitized product where applicable)</li> </ul>	<p>CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: the density as measured by 3 replicates shall be within the limits claimed by the manufacturer.</p>
<b>Composition</b>	<p>Chemical analysis dependent on specific explosives but typically includes:</p> <ul style="list-style-type: none"> <li>- Water by Karl Fischer</li> <li>- Elements by WD-XRF</li> <li>- Water soluble and/or acid soluble ions by IC or ICP</li> <li>- Organic compounds by extraction and / or LC or GC</li> </ul>	<ul style="list-style-type: none"> <li>- All declared ingredients must be present.</li> <li>- No undeclared ingredients can be present (0.5% allowing for impurities and uncertainty in analysis).</li> <li>- Nitrate ester based explosives must contain "antacid" to the level equivalent to 1% MgCO<sub>3</sub> and must not contain more than 0.6% water (all water).</li> </ul> <p>The concentrations of ingredients must be within the tolerances declared by the manufacturer.</p>
<b>Particle size</b>	<p>Particle size analysis depends on the type of explosive, but typically includes sieve analysis.</p>	<p>Must meet manufacturer's declaration.</p>
<b>Impact sensitiveness</b>	<p>Determine impact sensitiveness by Bureau of explosives - UN 3(a)(i), BAM Fallhammer - UN3(a)(ii) or Type 12 - UN 3(a)(v)</p>	<p>Must be "-" by the criteria in the UN Manual of Tests and Criteria with the exception that the impact sensitiveness of mechanically handled explosives must exceed a limiting energy of 6 J by the BAM Fallhammer test.</p>

<b>Friction sensitiveness</b>	Determine friction sensitiveness by BAM Friction Apparatus - UN 3(b)(i)	Must be "-" by the criteria in the UN Manual of Tests and Criteria.
<b>Thermal stability</b>	Determine thermal stability by 75°C / 48 h test - UN 3(c)	Must be "-" by the criteria in the UN Manual of Tests and Criteria. (no reaction at 75°C for 48 h)
	Determine thermal stability by Abel test	The heat test time must be greater than 10 min. at 71.1°C for nitrate esters and nitrate ester containing explosives (higher temperature for certain cellulose nitrates).
<b>Sensitiveness to flames</b>	Determine sensitiveness to flames by Small-scale Burning Test - UN 3(d)	Must be "-" by the criteria in the UN Manual of Tests and Criteria. (no explosion when 10-g or 100-g amount subjected to flames in the test)
<b>Velocity of detonation</b>	Determine VOD by CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 14: Determination of velocity of detonation	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (at least 90% of the value quoted by the manufacturer for the smallest diameter offered in the market or for the smallest borehole diameter recommended by the manufacturer)
<b>Cap sensitiveness</b>	Determine sensitiveness to a blasting detonator by the Cap Sensitivity Test - UN 5(a)	<ul style="list-style-type: none"> <li>- Must be "-" similar to the criteria in the UN Manual of Tests and Criteria (must not detonate in the test when initiated with a minimum 0.780 g PETN equivalent base charge detonator).</li> <li>- Must be "-" after, for explosives whose sensitivity is temperature dependant, conditioning at 28 to 30°C for 30 h, or at an appropriate higher temperature if the product is going to be transported at a higher temperature, and, for explosives containing prilled ammonium nitrate, temperature cycling (25°C → 40°C → 25°C → 40°C → 25°C).</li> </ul>
<b>DDT under confinement</b>	Determine transition to detonation when ignited under confinement - DDT Test - UN 5(b)(ii)	Must be "-" by the criteria in the UN Manual of Tests and Criteria. (must not DDT with a 5 g black powder igniter in three trials - no DDT with one trial with a 20 g igniter is considered to meet the requirement)
<b>Effect of external fire on packaged product</b>	Determine transition to explosion when subjected to external fire in packaged form - External Fire Test - UN 5(c)	Must be "-" by the criteria in the UN Manual of Tests and Criteria. (no "mass explosion" when 0.15 m <sup>3</sup> of packaged product, but no more than 200 kg, is exposed to the fire in the test)
<b>Thermal stability large containers</b>	Determine thermal stability by Dewar Test - UN 8(a) at maximum storage/transport temperature plus 20°C	Must be "-" by the criteria in the UN Manual of Tests and Criteria. (the temperature rise in the test must not exceed 6°C)
<b>Sensitiveness to intense heat under confinement</b>	Determine sensitiveness to intense heat under confinement - Koenen Test - UN 2(b) / 8(c)	Must be "-" by the criteria in the UN Manual of Tests and Criteria. (the limiting diameter must be less than 2.0 mm in the test)

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<b>Sensitiveness to shock at declared maximum process transport temperature</b>	Determine sensitiveness to shock by the UN Gap Test [1(a)] or ANE Gap Tests [8(b)] at the maximum transport/storage temperature.	Must be "-" by the criteria in the UN Manual of Tests and Criteria.
<b>Minimum burning pressure</b>	Minimum burning pressure test for pumpable explosives.	Must not sustain burning in 5/5 trials performed at a pressure of at least the maximum possible pressure of the handling system plus 20%.
<b>Resistance to water</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 5: Determination of resistance to water	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (must detonate in 3/3 trials - water temperature 0° to 40°C, pressure 0 to 0.3 MPa above atmospheric)
<b>Resistance to hydrostatic pressure</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 6: Determination of resistance to hydrostatic pressure	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (must detonate in 3/3 trials - water temperature 0° to 40°C - this test is used if the manufacturer claims the explosives can be used at pressures in excess of 0.3 MPa above atmospheric)
<b>Safety and reliability at extreme temperatures</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 7: Determination of safety and reliability at extreme temperatures	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (if the manufacturer claims that the explosive can be used at temperatures or pressures outside of the ranges of validity of the standard tests, the tests shall be conducted at those temperatures).
<b>Transmission of detonation</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 11: Determination of transmission of detonation	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (Dmax shall not be less than 2 cm)
<b>Thermodynamic properties</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 15: Calculation of thermodynamic properties	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (no limits - data for manufacturer to quote, but values quoted by manufacturer should be within ±3% of those calculated by the procedure).
<b>Oxygen balance</b>	Oxygen balance calculation	Range: 0 to (-2.5)%
<b>Means of initiation</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 10: Method for the verification of the means of initiation	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (the velocity of detonation shall be at least 90% of the value quoted by the manufacturer in 3/3 trials for each means of detonation claimed by the manufacturer.

**Table 3: List of tests, and testing requirements for oilfield and specialty explosives**

Attribute	Type of Explosive				
	Perforators	Perforating guns	Cutters, cartridges, miscellaneous	Power charges	Linear shaped charges
	UN0059, UN0439, UN0440, UN0441	UN0124 & UN0494	UN0349, UN0350, UN0351, UN0352, UN0353, UN0354, UN0355, UN0356, UN0462, UN0463, UN0464, UN0465, UN0466, UN0467, UN0468, UN0469, UN0470, UN0471, UN0472	UN0275, UN0276, UN0323, UN0381	UN0237, UN0288
Packaging	A	A	A	A	A
Sample characteristics	A	A	A	A	A
Thermal stability (UN 4(a))	A	A	A	A	A
12-m drop test (UN 4(b)(ii))	A	A	A	A	A
Potential for mass explosion (UN 6(a)) <sup>1</sup>	A	A	A	A	A
Potential for package-to-package propagation (UN 6(b)) <sup>2</sup>	A	A	A	A	A
Effect of external fire on packaged product (UN 6(c))	A	A	A	A	A
Potential for hazardous effects outside of package (UN 6(d))	A <sup>3</sup>			A <sup>4</sup>	
Resistance to water	M	M	M	M	M
Resistance to hydrostatic pressure	M	M	M	M	M
Safety and reliability at extreme temperatures	M	M	M	M	M
Transmission of detonation	M	M	M	M	M
Thermo-dynamic properties	M	M	M	M	M
Means of initiation	M	M	M	M	M

Notes:

A = authorization test.

M = test performed by manufacturer to substantiate its claims on the properties of the product.

<sup>1</sup> May be waived if 6(d) test is performed and indicates no potential for mass explosion.

<sup>2</sup> May be waived if 6(a) and/or 6(d) test indicates no potential for package-to-package propagation.

<sup>3</sup> UN0441 only

<sup>4</sup> UN0323 only

**Table 4: Description of tests and acceptance criteria for oilfield and specialty explosives**

<b>Attribute</b>	<b>Test or tests</b>	<b>Criteria</b>
<b>Packaging</b>	<ul style="list-style-type: none"> <li>- Check UN packaging certification on package.</li> <li>- Check compliance with CGSB packaging instruction.</li> <li>- Check presence and correctness of TDG label, shipping name, PIN, manufacturer's product name or part number, name and address of the manufacturer, safety warnings in both English and French.</li> <li>- Confirm presence of ladder.</li> <li>- Check dimensions as declared.</li> </ul>	<ul style="list-style-type: none"> <li>- The certification must be present.</li> <li>- Must meet packaging instructions.</li> <li>- Required markings must be on packaging.</li> <li>- The ladder must be on the packaging.</li> </ul>
<b>Sample characteristics</b>	<ul style="list-style-type: none"> <li>- dimension, masses, materials and labelling must be as declared.</li> <li>- must have "Explosive - Danger - Explosif" marking or label, or a bomb burst logo if the article is too small to carry a warning.</li> </ul>	<ul style="list-style-type: none"> <li>- Must be as per declaration and within declared tolerances.</li> <li>- Article must have appropriate marking including the warning or bomb burst logo as appropriate.</li> </ul>
<b>Thermal stability</b>	Determine thermal stability by 75°C / 48 h test - UN 4(a)	Must be "-" by the criteria in the UN Manual of Tests and Criteria (no reaction at 75°C for 48 h).
<b>12-m Drop test</b>	Determine impact sensitivity of packaged or unpackaged articles – UN 4(b)(ii)	Must be "-" by the criteria in the UN Manual of Tests and Criteria (no fire or explosion in any of 3 trials of the test).
<b>Potential for mass explosion</b>	Determine potential for mass explosion of contents of package as a result of functioning of packaged article – UN 6(a)	Must be "-" by the criteria in the UN Manual of Tests and Criteria (no evidence that the entire contents exploded practically simultaneously).
<b>Potential for package-to-package propagation</b>	Determine potential for propagation from package to package as a result of functioning of packaged article – UN 6(b)	Must be "-" by the criteria in the UN Manual of Tests and Criteria (no evidence that propagation from package to package occurred).

Attribute	Test or tests	Criteria
<p><b>Effect of external fire on packaged product</b></p>	<p>Determine whether there is a mass explosion or a hazard from dangerous projections, radiant heat and/or violent burning or any other dangerous effect when explosives are involved in a fire – UN 6(c)</p>	<p>Assign to Division</p> <ul style="list-style-type: none"> <li>◆ 1.1, if mass explosion occurs</li> <li>◆ 1.2, if no mass explosion, but any of the following occurs:                             <ul style="list-style-type: none"> <li>a. perforation of any witness screen</li> <li>b. metallic projection(s) with kinetic energy exceeding 20 J</li> </ul> </li> <li>◆ 1.3, if no Division 1.1 or 1.2 events, but any of the following occurs:                             <ul style="list-style-type: none"> <li>a. fireball/jet of flame beyond witness screens</li> <li>b. fiery projection emanating from the product extends over 15 m from edge of packages or unpackaged articles</li> <li>c. a burning time of the product measured to be less than 35 seconds for 100 kg net explosive mass</li> <li>d. irradiance of the burning product exceeds that of the fire by more than 4 kW/m<sup>2</sup> at a distance of 15 m from the edge of the packages or unpackaged articles</li> </ul> </li> <li>◆ 1.4, (other than S) if no Division 1.1, 1.2, or 1.3 events, but any of following occurs:                             <ul style="list-style-type: none"> <li>a. a fireball or jet of flame which extends more than 1 m from the flames of the fire</li> <li>b. a fiery projection emanating from the product extends over 5 m from the edge of the packages or unpackaged articles</li> <li>c. an indentation in any of the witness screens of more than 4 mm</li> <li>d. a metallic projection with a kinetic energy exceeding 8 J</li> <li>e. a burning time of the product measured to be less than 330 seconds for 100 kg net explosive mass</li> <li>f. explosive mass</li> </ul> </li> <li>◆ 1.4S, if no Division 1.1, 1.2, 1.3, 1.4 (other than S) events</li> </ul>
<p><b>Potential for hazardous effect outside of package</b></p>	<p>Determine if hazardous effects outside of package occur as a result of accidental functioning – UN 6(d)<sup>5</sup></p>	<p>Must be "-" by the criteria in the UN Manual of Tests and Criteria – none of the following occurs:</p> <ul style="list-style-type: none"> <li>a. Denting or perforation of the witness plate beneath the package</li> <li>b. A flash or flame capable of igniting an adjacent material such as a sheet of 80 ± 3 g/m<sup>2</sup> paper at a distance of 25 cm from the package</li> <li>c. Disruption of the package causing projection of the explosive contents</li> <li>d. A projection which passes completely through the packaging.</li> </ul>

<sup>5</sup> Applies only to UN0441 and UN0323

<b>Attribute</b>	<b>Test or tests</b>	<b>Criteria</b>
<b>Resistance to water</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 5: Determination of resistance to water	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (must detonate in 3/3 trials - water temperature 0° to 40°C, pressure 0 to 0.3 MPa above atmospheric)
<b>Resistance to hydrostatic pressure</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 6: Determination of resistance to hydrostatic pressure	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (must detonate in 3/3 trials - water temperature 0° to 40°C - this test is used if the manufacturer claims the explosives can be used at pressures in excess of 0.3 MPa above atmospheric)
<b>Safety and reliability at extreme temperatures</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 7: Determination of safety and reliability at extreme temperatures	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (if the manufacturer claims that the explosive can be used at temperatures or pressures outside the ranges of validity of the standard tests, the tests shall be conducted at those temperatures).
<b>Transmission of detonation</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 11: Determination of transmission of detonation	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (Dmax shall not be less than 2 cm)
<b>Thermodynamic properties</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 15: Calculation of thermodynamic properties	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (no limits - data for manufacturer to quote, but values quoted by manufacturer should be within ±3% of those calculated by the procedure).
<b>Means of initiation</b>	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 10: Method for the verification of the means of initiation	CEN Standard EN 13631-1:2005: Explosives for civil uses - High explosives - Part 1: Requirements (the velocity of detonation shall be at least 90% of the value quoted by the manufacturer in 3/3 trials for each means of detonation claimed by the manufacturer).

#### **4.2.1 Explosives properties**

CERL will prepare the sensitized product from unsensitized products. Instructions for sensitizing must be supplied with the application.

#### **4.2.2 Transport classification**

UN tests are used to determine compatibility group (for example, A versus D), and the compatibility group is assigned based on the table in the model regulations.

#### **4.2.3 Fume class (E-1 - blasting and bulk explosives)**

Fume class is not assigned by the Chief Inspector of Explosives. Instead, companies are required to submit an oxygen balance calculation for explosives intended for use underground, which will be required to meet the standard as detailed in Table 2. Commercial explosives must have an oxygen balance close to 0 in order to minimize the amount of toxic gases. This calculation is to be done for the formulation variances within the stated tolerance. Boosters will be exempt from this requirement, since their contribution to the total amount of explosives in a blast is small. When explosives are properly used, an oxygen balance close to 0 correlates well with low fume generation. The oxygen balance calculation is intended for explosives which are used underground where humans may be present after blasting. Packaging for packaged product must indicate if the product is suitable for use underground, based on the criteria as detailed in Table 2.

#### **4.2.4. Other classification – potential effects**

This is a supplementary requirement for products manufactured in Canada. In order to determine the appropriate potential effects (PE) needed to determine quantity-distance relationships for manufacturing facilities, additional testing may be required to determine the behaviour of explosives in intermediate forms other than their final form. In the case of most of the products being considered in this particular guideline, the expected PE is 1. More information regarding potential effects may be found in Directive Letter #59, *Classification by Potential Effects, June 2007*, which is available from the Explosives Regulatory Division upon request.



## Appendix – Definitions

<b>Term</b>	<b>Definition</b>
AN	See Ammonium Nitrate
ANFO	Ammonium nitrate fuel oil - an explosive material consisting of ammonium nitrate and fuel oil. 1.5D
ANFO-emulsion blends	See emulsion explosives
Ammonium nitrate	The ammonium salt of nitric acid represented by the formula $\text{NH}_4\text{NO}_3$ .
Authorization / Authorized	"Authorized explosive" means any explosive that is declared to be an authorized explosive in accordance with the <i>Explosives Regulations</i> by the Chief Inspector of Explosives. The procedure for obtaining authorization are described in the <i>Explosives Regulations</i> (current Regulations sections 15 to 24; new proposed modernized Regulations Part 3).
Base emulsion	See emulsion explosives
Binary explosive	A blasting explosive formed by mixing or combining two precursor chemicals, for example ammonium nitrate and nitromethane.
Blasting explosives	Detonating explosive substances used in mining, construction and similar tasks. Blasting explosives are assigned to one of five types. In addition to the ingredients listed, blasting explosives may contain inert components such as kieselguhr, and minor ingredients such as colouring agents and stabilizers.
Booster	An explosive charge, usually of high detonation velocity and detonation pressure, designed to be used in the explosive initiation sequence between an initiator or primer and the main charge.
Bulk ANFO	See bulk explosives.
Bulk explosives	A mass of explosive material prepared for use in bulk form without packaging.
Cap sensitivity	The sensitivity of an explosive to initiation by a detonator. An explosive material is considered to be cap sensitive if it detonates with a standard type of detonator. The standard used in Canada is a 0.780 g PETN base charge detonator.
Case	An outer shipping container used for the packaging and transport of Class 1 explosives.
Charge weight	The total weight in kilograms or pounds of an explosive charge (net explosives quantity or NEQ).

Chemical formula	This is a way of expressing information about the atoms that constitute a particular chemical compound.
Chemical properties	Properties that involve changing the chemical nature of matter. Examples of chemical properties include heat of combustion, reactivity in water, pH.
Commercial explosives	Explosives designed, produced and used for commercial or industrial applications rather than for military purposes.
Compatibility	Different types of explosives are considered to be compatible if they may be stored or transported together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of an effect of an accident.
Compatibility group	In the United Nations Classification System for Dangerous Goods, Class 1 is divided into 13 compatibility groups denoted by letters (A-H, J, K, L, N and S). (See <i>Authorization of Explosives Regulations</i> for definitions).
Competent authority	A national agency or body responsible under its national law for the control or regulation of a particular aspect of the transportation of hazardous materials.
Critical diameter	The minimum diameter for propagation of a detonation wave at a stable velocity. Critical diameter is affected by conditions of confinement, temperature, and pressure on the explosive.
Deflagration	An explosive reaction where rapid combustion moves through an explosive material at a velocity less than the speed of sound.
Density	The mass of an explosive per unit of volume, usually expressed in grams per cubic centimetre or pounds per cubic foot.
Detonating cord	A flexible cord containing a centre core of high explosive and used to initiate other explosives.
Detonation	A violent and complete chemical reaction proceeding at supersonic velocity within an explosive, generating gases at extremely high pressure and temperature. The sudden and enormous pressure of hot gases violently disrupts the surroundings, and a shock wave is propagated at supersonic velocity.
Detonation wave	See shock wave.
Detonator	Any device containing any initiating or primary explosive that is used for initiating detonation.
Doped emulsion	See emulsion explosives.
Dynamite	A high explosive used for blasting, consisting essentially of a mixture of, but not limited to, nitroglycerine, nitrocellulose, ammonium nitrate, sodium nitrate, and carbonaceous materials.

Emulsion explosives	An explosive material containing substantial amounts of oxidizers (most frequently ammonium nitrate) dissolved in water droplets, surrounded by an immiscible fuel (most frequently fuel oil). The emulsion is stabilized by various emulsifiers. Sensitivity is achieved by adding voids such as small nitrogen bubbles (by using a gassing mixture) or micro-spheres made of glass or plastic. Prior to sensitization, the product is sometimes called the "base emulsion". The characteristics of the explosive may be varied by adding solids such as AN prills. Emulsions with less than 50% AN prills are known as "doped" emulsions; if the prills make up more than 50% of the explosive, it is known as "heavy ANFO".
Explosive	A substance manufactured to produce an explosion, detonation, pyrotechnic or propulsive effect, and includes articles containing such substances.
Flashpoint	The lowest temperature at which vapours from a volatile combustible substance ignite in air when exposed to a flame, as determined in an apparatus specifically designed for such testing.
Fume class	A measure of the amount of toxic gases, primarily carbon monoxide and oxides of nitrogen, produced by the detonation of an explosive.
Fume classification	See IME Fume classification.
Fumes	The gaseous products of an explosion. For the purposes of fume classification, only poisonous or toxic gases such as carbon monoxide, hydrogen sulphide, and nitrogen oxides are considered.
Gap sensitivity	The maximum length of air gap across which a detonation wave will travel.
Gassed density	The density of an emulsion or water gel explosive after sensitization by a chemical reaction resulting in gas.
Gelatin dynamite	A type of highly water-resistant dynamite characterized by its gelatinous consistency.
Hazard classification	A system of hazard classification for dangerous goods based on the international system of classification as devised by the United Nations. Explosives are assigned to the appropriate hazard division and compatibility group in this system using a recognized UN test series.
Hazard division	The classification of an explosive into numbered divisions according to the hazards they present.
Heavy ANFO	See emulsion explosives.

High explosives	An explosive that reacts by detonation rather than deflagration when used in its normal manner (also known as detonating explosive). High explosives are characterized by a very high rate of reaction, high pressure development, and the presence of a detonation wave in the explosion.
Hydrocarbon	A fuel containing only carbon and hydrogen.
Hydrostatic pressure	The pressure at any point in a column of fluid caused by the weight of the fluid above that point.
IME	Institute of the Makers of Explosives. A non-profit association dedicated to safety and security, representing producers of commercial explosive materials in the US and Canada and dedicated to safety in the manufacture, transportation, storage, handling and use of explosive materials.
IME fume classification	A classification indicating the amount of carbon monoxide and hydrogen sulphide produced by an explosive or blasting agent. Explosives with positive oxygen balances are not considered as being acceptable in these classifications.
Initiation	The act of causing an explosive material to detonate or deflagrate.
Initiator	A detonator or detonating cord used to initiate detonation in an explosive material.
Jet perforating gun	A device used to perforate oil and gas wells in preparation for production. Containing several shaped explosive charges, perforating guns are available in a range of sizes and configurations. The diameter of the gun used is typically determined by the presence of wellbore restrictions or limitations imposed by the surface equipment.
Mass explosion hazard	An explosion which affects virtually the entire quantity of explosives under consideration practically instantaneously. The term usually relates to detonation but also applies to deflagration when the practical effects are similar, for example, the mass deflagration of black powder or propellants under very strong confinement so as to produce a burst effect and a serious hazard from debris.
NG	See nitroglycerine.
Nitrate ester products	Organic molecules containing nitrate groups.
Nitroglycerine	An explosive chemical compound used as a sensitizer in dynamite and represented by the formula $C_3H_5(ONO_2)_3$ .
Oxygen balance	The theoretical percentage of oxygen in an explosive material or ingredient that exceeds (+) or is less than (-) what is needed to produce ideal reaction products.

Packaged explosives	These include traditional dynamite, packaged ANFO, emulsion and water gel explosives. The explosives are packaged in tubes, cardboard or other materials, or in polymer film resulting in sausage-like products.
Perforating gun	A device used to deploy shaped charges down cased well holes for cutting radial holes through the steel casing and into the surrounding formation structure. A device used to perforate oil and gas wells in preparation for production. Containing several shaped explosive charges, perforating guns are available in a range of sizes and configurations. The diameter of the gun used is typically determined by the presence of wellbore restrictions or limitations imposed by the surface equipment.
PETN	An abbreviation for the name of the explosive pentaerythritol tetranitrate.
pH	This is a measure of the acidity or alkalinity of a solution.
Physical properties	These are properties that can be observed or measured without changing the composition of matter. Physical properties include appearance, texture, colour, odour, melting point, boiling point, density, solubility, polarity and many others.
Plastic explosive	An explosive that is formulated with one or more high explosives that in their pure form have a vapour pressure of less than $10^{-4}$ Pa at a temperature of 25°C, is formulated with a binder material, and is, when mixed, malleable or flexible at normal room temperature.
Potential effects (classification by)	(PE) - a system of classification to determine appropriate quantity-distance principles for manufacture, storage and handling, based on the behaviour of the explosives in intermediate forms and containment it may encounter during manufacturing.
Primary explosive	A sensitive explosive that nearly always detonates by simple ignition from such means as spark, flame, impact, friction, or other primary heat sources of appropriate magnitude.
Primer	A unit, package, or cartridge of explosives used to initiate other explosives or blasting agents, and which contains, 1) a detonator, or 2) detonating cord to which is attached a detonator.
Propellant	An explosive material that normally functions by deflagration and is used for propulsion purposes.
Quantity-distance principles	The quantity-distance principles and tables published by the Explosives Safety and Security Branch, Natural Resources Canada.
Sensitiveness	(ISEE definition): A measure of an explosive's cartridge-to-cartridge propagating ability under certain test conditions. It is expressed as the distance through air at which a primed half-cartridge (donor) will detonate an unprimed half-cartridge (receptor). Also see gap sensitivity.

Shaped charge	An explosive with a shaped cavity, specifically designed to produce a high-velocity cutting or piercing jet of product reaction; usually lined with metal to create a jet of molten liner material.
Shock wave	A transient pressure pulse that propagates at supersonic velocity.
Slurry explosive	An explosive material containing substantial portions of a liquid, oxidizers, and fuel, plus a thickener.
Specific gravity	The ratio of the weight of a volume of substance to the weight of an equal volume of pure water.
Tolerances	Permissible limits of variation in a measured value or physical property of a material. Variation within these limits will not significantly affect the functioning of a product or process.
Transport classification	See UN classification.
Transportation temperature	The temperature at which a bulk explosive is transported, usually referring to a bulk emulsion explosive product, prior to sensitization or partially sensitized.
Type E explosives	High explosives. E.1 - blasting and bulk explosives; E.2 - perforating explosives; E.3 - special application explosives.
UN classification	The UN system consists of nine classes of dangerous materials, with explosives designated as Class 1. The explosives hazard class is further subdivided into six divisions, which are used for segregating ammunition and explosives on the basis of similarity of characteristics, properties, and accident effects potential.
Velocity of detonation (VOD)	The detonation velocity of an explosive material, for example, a charge fired in the open.
Virgin oil	An oil that has never been used.
Viscosity	A property of fluids and slurries that indicates their resistance to flow, defined as the ratio of shear stress to shear rate.
VOD	Velocity of detonation, usually measured in metres per second. It is the speed at which the detonation front moves through a column of explosives.
Waste lubricating oil	See waste oil.
Waste oil	Used oil.
Water gel explosive	An explosive material containing substantial portions of water, oxidizers, and fuel, plus a cross-linking agent.