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Guidelines for quantified risk assessments at Ports and Wharves

**Explosives Regulatory Division
Explosives Safety and Security Branch**

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1. Purpose

Pursuant to s.203.1 (1) (b) of the *Explosives Regulations, 2013* a quantified risk assessment (QRA) that meets acceptance criteria is required to allow a Port or Wharf to conduct the activity of loading or unloading explosives. The purpose of this document is to provide guidance on the completion of a quantified risk assessment (QRA).

The ER, 2013 provides for the use of risk assessments to determine the quantity of explosives that may be loaded or unloaded at ports and wharves. This guideline outlines the methodology and procedures for conducting, completing, and submitting a risk assessment that will meet the regulations of ER, 2013, on a wharf or port.

2. Scope

This document applies to ports and wharves in Canada. In accordance with ER, 2013, this document describes the requirements for a quantified risk assessment.

This document covers the loading and unloading of containerized explosives only. The *Explosives Regulations, 2013* s.203.1 do not apply to vessels that are in-transit or to those which do not load or unload explosives.

3. Background, Methodology, and Criteria

Quantified risk assessment is intended to quantify the risk of harm to persons and property that result from loading and unloading of explosives at a port or wharf and compares that risk to the acceptance criteria. Quantified risk assessment is widely used in the explosives industry to determine the safety of an activity involving explosives.

Methodology Approval

In accordance with ER, 2013, s.203.1 (6) the Chief Inspector of Explosives is responsible for the approval of a methodology to be used in a quantified risk assessment. This entails ensuring that the methodology is capable of accurately calculating the risks to people and property resulting from loading and unloading of explosives at ports or wharves according to the criteria of s.203.1 (6). The approval of methodologies may include consultation with industry stakeholders, explosives specialists, and case studies.

An example of a quantified risk assessment methodology that is acceptable for use at ports and wharves and approved by the Chief Inspector of Explosives is IMESAFR, published by APT Research, Huntsville Alabama, USA.

Person conducting the Quantified Risk Assessment

A quantified risk assessment must be carried out by a qualified person. A qualified person must have knowledge of explosives properties and behaviors, their hazard classifications, and handling best practices. They must also have knowledge of the packaging methods of commercial explosives. A qualified person must have knowledge and experience in the conduct of quantified risk assessments for the handling of explosives and have training on the specific QRA methodology being used.

Risk Acceptance Criteria

In accordance with ER, 2013, s.203.1 (5) (d) the quantified risk assessment must demonstrate that the risk of harm to people and property is within acceptable limits. The risk associated with loading or unloading of explosives at a port is acceptable if it does not subject the general public to risks greater than those they might be otherwise subjected to in daily life. Consequently, risk criteria must be established. These risk criteria limits are established in accordance with widely accepted industry practice. The criteria is subdivided into individual risk or the risk to any one person and the societal risk or the group risk.

ERD accepts the individual risk criteria and group risk criteria recommended by the Institute Makers of Explosives (IME) in the document *Guidelines for IMESA FR-Based QRAs for Ports* published by the Institute Makers of Explosives (IME):

Annual Individual Risk: 1×10^{-6} , i.e. for the person most at risk, the fatality rate is less than 1 person per 1,000,000 years.

Annual Group Risk: 1×10^{-5} , i.e. the total fatality rate will be less than 10 people per million years.

These risk criteria agree with those published in the US Department of Defence (DoD) document DoD Ammunition and Explosives Safety Standards (DoD 6055.09). The IMESA FR User's Manual, and the IMESA FR Technical Manual provide additional information regarding the IME criteria.

These risk criteria are also in agreement with Canadian Society for Chemical Engineering publication *Risk Assessment – Recommended Practices for Municipalities and Industry*. Their criteria for annual individual risk 1.0×10^{-6} and was established from guidance of the Major Industrial Accidents Council of Canada (MIACC).

These risk criteria can be contextualized by comparing to the risks of common household activities and ailments whose risks are well known. The risk of fatality from drowning in the bathtub is 1.23×10^{-6} (1992-1994 USA).

Due to the conservative nature of quantity distance principles (QD) a survey conducted using QD would be deemed to meet this criteria.

Acceptance procedure

The quantified risk assessment is to be submitted to the Explosives Regulatory Division for review to ensure its proper completion. The assessment will be approved in accordance with ER, 2013, s.203.1 (7).

Upon approval of a QRA an Inspector of Explosives will communicate to the requestor the explosives limits denoted by berth and any additional safety measures relevant to the limits of explosives for ensuring public safety in accordance with ER, 2013, s.203.1 (2).

A similar communication will be issued where the submission is for a renewal.

4. Validity of assessment

An assessment is valid for a five-year period or until the circumstances change.

After a five-year period, the Port Authority or the municipality responsible for the wharf may reapply in writing for renewal. The renewal application must confirm that the circumstances have not changed and that the survey is still valid. A new assessment is not necessary where the circumstances have not changed. When the situation remains the same, the corresponding risk to persons and property is not changed and a new assessment is not necessary. A renewal will also be valid for a five year period.

An assessment conducted prior to the coming into force of ER, 2013 s.203.1 may be submitted for renewal to the Explosives Regulatory Division (ERD). Assessments that did not use the methodologies described in this document will not be renewed.

5. General

The risks presented in a QRA are typically evaluated on an annual basis, i.e. the risk to the public per year. In some cases there are few explosives handling operations at the site during the year. This low frequency of operations can dilute the results of an annual assessment. Where there are fewer than 1000 hours per year of explosives loading or unloading operations, an hourly QRA must be provided in addition to the annual-based QRA to ensure a proper review of limits.

When a quantity of explosives is being loaded or unloaded from a vessel, that vessels entire cargo of explosives must be considered as part of the limits for a given berth.

In accordance with ER, 2013, s.203.1 (d) additional safety measures can include, but are not limited to:

- The presence of a well defined and established Emergency Response Action Plan (ERAP); and
- The limitations of activities to coincide with reduced traffic i.e. loading does not occur during rush hour.

Safety measures will be predominantly location specific. For further guidance, contact ERD.

The quantity distance principles (QD) are highly conservative when applied at ports and wharves for hazard divisions 1.1/1.5 and 1.2. This conservatism was a factor in adopting quantified risk assessments for the loading and unloading of explosives at ports and wharves.

This is not the case for hazard division 1.3 and 1.4. The behavior of 1.3 and 1.4 closely follows QD described in National Standard of Canada CAN/BNQ 2910-510/2015 *Explosives - Quantity Distances* published by the *Bureau de Normalisation du Québec*. Quantity distance principles meet the current commercial needs of port authorities for the loading and unloading of 1.3 and 1.4.

Appendix A

The following section is intended for use by third party contractors conducting quantified risk assessment for port authorities or a municipality responsible for a wharf and describes some of the specific inputs required.

Quantity Distance Principles Method

The quantity distance principles method can be used with the following port/wharf specific considerations.

- i. The explosives container on the vessel must be considered the potential explosion site (PES).
- ii. The exposed sites (ES) for the port include all of the buildings, public traffic routes and places people are likely to gather (further defined in the BNQ manual).

Conduct the assessment following the procedure laid out in the standard to determine the allowable explosives, by berth, by explosives hazard division, in NEQ for the port/facility.

IMESAFR Assessment Details

The following section details the specific considerations required for conducting a risk assessment using the IMESAFR software. Additional guidance is provided by the IMESAFR User's Manual, and the IMESAFR Technical Manual. Also, a very helpful document is *Guidelines for IMESAFR-Based QRAs for Ports* published by the Institute Makers of Explosives (IME).

Model set-up considerations

The recommended background image type for a model is a Registered Image. These include metadata that the software will use for measuring distances within the model.

Alternatively, an aerial open-source photo may be imported as a base image. The calibration of the base image is important and evidence the calibration was done accurately must be provided.

Potential Explosion Site (PES) considerations

Table 1 shows inputs for the PES. The building identifier is up to the stakeholder, in most cases this would correspond to the berth identifier.

The building category is ISO Container, the maximum NEQ considered reasonable for a single container is 20 000 kg. This may be lower based on explosives with less-dense packaging.

Building Identifier	Up to the stakeholder
Building Category	ISO Container
Building Type	ISO Container
Number of Containers	Based on 20 000 kg each
Soil Type	Use either Rock/Hard Clay or Concrete
Operating hours	# of hours the explosives are present at the port annually
RBED	Risk Based Evaluation Distance (RBED) Should be enlarged to include each area of interest
Hazard Division	Pick appropriate
Maximum NEQ	Based on activities
Expected NEQ	Should match Max
Storage Compatibility Group	Based on Explosives
Activity Type	Commercial Loading/Unloading
Environmental Factors	Pick as appropriate

Table 1 – Potential Explosion Site IMESA FR inputs

Table 1 are recommended inputs. There are likely instances where these inputs are not suited to the situation at the port. In each case, detailed explanations must be provided.

The hours of operation must include all hours, on an annual basis, explosives are present at the port or wharf. This value may be subdivided to show hours where explosives are present but not being loaded or unloaded i.e. explosives remaining-on-board (ROB).

It is recommended to include photos of the site and PESs. An aerial photo as well as a berth layout are helpful. It is incumbent on the applicant to ensure that the assessment is clear and easily understood what berth is under consideration.

It may be necessary to repeat the analysis for more than one desired hazard division as the software is limited to one-hazard division per model. This should be made clear where the applicant wishes to establish a unique limit for multiple hazard divisions.

Special consideration should be given to hazard division 1.2. Details on the specifics of the explosives and how they will be treated by the model must be provided.

Exposed Site (ES) considerations

Table 2 are input recommendations for ESs. The table provides some of the required inputs. In each case, the input selected must be justified and the report must clearly explained how it represents the situation. As an example, an open-source street view or photo of a residential building would help justify the input selection for the % of glass.

Traffic data must be supplied by a competent authority where the ES is a public traffic route i.e. provincial or municipal highway authority if available.

The building identifier is largely up to the stakeholder however, whatever is chosen must be made clear in the report. A plan view of the site or a legend should be used for clarity.

Vulnerable buildings are buildings of particular importance, historical significance, or weak construction. An example includes a hospital or glass facade high-rise residence. Specific care and attention should be provided as to how those buildings are modelled.

Building Identifier	Up to the stakeholder
Building Category	Pick appropriate
Building Type	Pick appropriate
Roof Type	Pick appropriate
Floor Area	Pick appropriate
Window Type	Pick appropriate
% Glass on ES	Pick appropriate
Debris Arrival Time	Default is likely appropriate
Number of People	Pick appropriate
Hours Present	Pick appropriate – 8760 for houses
Exposure Confidence	Pick appropriate
Exposed persons upper limit	Pick appropriate
Exposed persons lower limit	Pick appropriate
Exposed persons correlation	Pick appropriate

Table 2 – Exposed Site IMESA FR inputs

Provide details on how any buildings greater than 3 stories were modelled. Specifically how their storey height and occupants’ were considered in the model, including the relative distance differences to the PES given their additional height.

Building occupancy data must be justified in each case. The complexity of the exposed site dictates how detailed the occupancy inputs must be. For example, residential occupancy should be assumed to be continuous. Alternatively a commercial occupancy can be based on business hours.