Environment Canada Environnement Canada

<u>Summary of Risk Evaluation Framework for Determining Quantity Thresholds and Concentrations for Substances under the *Environmental Emergency Regulations* Set under the *Canadian Environmental Protection Act, 1999* (CEPA 1999)</u>

1.0 INTRODUCTION

The *Environmental Emergency Regulations* (E2 Regulations), developed under Part 8 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999) (Government of Canada, 2011), establish a list of substances for which fixed facilities must notify Environment Canada that they store or use the substance on-site, by providing notices to Environment Canada, reporting when the substance is released into the environment, and developing an environmental emergency plan (E2 plan) for each substance stored or used at or above specified threshold quantities.

To determine if a substance is a candidate to be added to the E2 Regulations, Environment Canada has developed a risk evaluation methodology based on the following hazard categories:

- Physical: flammable and combustible or oxidizing substances, or those having a potential to cause vapour cloud explosions or pool fires.
- Human Health: substances that are toxic by inhalation, are carcinogenic, or are corrosive.
- Environmental Health: substances that are: corrosive, persistent, bioaccumulative, or aquatically toxic.

The following description is intended to guide the reader through the science of how the quantity thresholds and concentrations for substances are derived for the E2 Regulations. **For more information concerning Environmental Emergency authorities, see section 2.0 in the Implementation Guidelines 2011 (Environment Canada, 2011a)**.

2.0 PHYSICAL

2.1 Flammable Substances

The methodology used to determine the flammability threshold of a substance is based on the approach developed by the United States Environmental Protection Agency (U.S. EPA) (J.P. Lacoursière Inc., 2002). A vapour cloud explosion could occur if the flash point for a substance is less than 23°C and the boiling point is less than 35°C. A flammable substance meets both of these two criteria, and the threshold quantity is set at 4.5 tonnes.

Modeling indicated that, for a given quantity of a flammable material, vapour cloud explosions may have the greatest potential for offsite consequences. The probability of a vapour cloud exploding following a release is 7% when the weight of the flammable vapour in the cloud is 4.5 tonnes; this probability increases to 50% when the weight of the flammable vapour in the cloud is 90 tonnes (U.S. EPA, 1994b). The explosion of a flammable, combustible or oxidizing substance at the threshold quantity would result in an over-pressure of 21 kPa (3 psi) (approximately 166 km/hr wind speed) at 100 m (Ketcheson, 2012). This compression wave is sufficient to hurl a person to the ground and cause significant damage to buildings (e.g., broken glass) (Braise and Simpson, 1968; Glasstone and Dolan, 1977).

2.2 Combustible Substances

This category represents combustible substances that have a flash point less than 23°C or a boiling point less than 35°C. Substances that have these physical properties tend to fall into the category of National Fire Protection Association (NFPA) Level 3. Although combustible substances can cause a vapour cloud explosion within the given parameters, they require a higher quantity than flammable substances (i.e. 4.5 tonnes) in order for this to happen. However, combustible substances are nevertheless still dangerous to humans and the environment.

There are two methods used to calculate the threshold quantity for combustible materials:

- The threshold is estimated by modeling with Process Hazard Analysis Software Tools (PHAST) software; and
- The threshold is calculated using an equation.

The preference is to calculate the threshold via modeling, but where data for the substance is not available for modeling then the equation is used.

PHAST modeling Method

The PHAST software (version 6.7) is used to estimate the quantity necessary to reach 21 kPa (3 psi) at 100 meters. It assumes an outdoor catastrophic release of the entire contents whereby an ignition source causes the quantity to ignite and explode. The software is set to use the trinitrotoluene (TNT) explosion method at approximately 10% explosion efficiency compared to TNT at 25°C.

The following equation is used by the PHAST software to determine the threshold quantity necessary to cause a vapour cloud explosion for combustible substances. Some of the formulas came from the book *Loss Prevention in the Process Industries* (Lees, 1996).

Conditions:
Temperature = 25°C
Wind speed = 1.5 m/s
Release time = 10 minutes
Explosion efficiency = 0.1
Ground reflection factor = 2
Dike height = 0.5 m

$$Q_{threshold} = \frac{4.962293303 \times 10^{10} \times D}{H_{combustion} \times MW^{2/3} \times VP}$$

Where:
Density = kg/m^3
Vapour pressure = mmHg at 25°C
Molecular weight = g/mole
Heat of combustion = J/kg

Equation Method
The equation for estimating the evaporation rate of a liquid from a pool is modified from the *Technical Guidance for Hazards Analysis* (U.S. EPA, 1987). The same assumptions are made for determination of maximum pool area (i.e., the pool is assumed to be 1 cm deep).

2.3 Oxidizing Substances

Although oxidizing substances are not flammable or combustible, they behave as explosives in the sense that they have a fraction of the potential power of TNT to explode (ICF, 1993). These substances can explode under the right conditions (e.g., heated in confined spaces). Thresholds for oxidizing substances were set by expert opinion and were adopted from the *Conseil canadien des Accidents Industriels Majeurs* (CRAIM).

2.4 Pool Fires

The quantity threshold is set equal to the amount capable of traveling 100 m from the source and generating a heat radiation of 5 kW/m^2, according to computer modeling (e.g., PHAST software, version 6.7). This level of heat radiation is expected to produce second degree burns over the exposed skin when exposed for 30 seconds or more (Phani, 2008).

3.0 HUMAN HEALTH

3.1 Inhalation Toxicity
The methodology used to determine the thresholds of substances that are hazardous if inhaled is based on the approach developed by the U.S. EPA (J.P. Lacoursière Inc., 2002). The methodology takes into consideration the toxicity of a substance, as well as, its ability to become airborne and disperse in air. A substance must have a vapour pressure greater than 1.33 kPa (10 mmHg) to potentially cause inhalation toxicity in humans.

3.2 Carcinogenicity
A substance classified as a carcinogen or probable carcinogenic to humans (International Agency for Research on Cancer (IARC] / U.S. EPA) and having a half-life in any medium of at least five years is automatically assigned a high-risk threshold of 0.22 tonnes. The precautionary principle is implemented in this case to establish a timeline of five years in regards to those substances that may be carcinogenic in humans, specifically children. “These empirical results are consistent with current understanding of the biological processes involved in carcinogenesis, which leads to a reasonable expectation that children can be more susceptible to many carcinogenic agents.” (U.S. EPA, 2005).

3.3 Corrosiveness
Substances that are classified as strong acids or strong bases exhibit a pH solution equal to or less than 2, or equal to or greater than 11.5, respectively. The Organization for Economic Co-operation and Development (OECD, 2001) classifies these

substances as corrosive, and they are expected to produce significant effects on the skin and eyes. Extreme pHs are also harmful to aquatic life (Environment Canada, 2007, 2011b). At this pH, substances are considered corrosive, and they are assigned a high-risk threshold of 0.22 tonnes.

4.0 ENVIRONMENTAL HEALTH

The methodology used to determine the thresholds of substances that are aquatically toxic was developed by Environment Canada. For this category, the evaluation of risk to the environment is based on the persistence, bioaccumulation and aquatic toxicity of each substance. The following tables show the different thresholds for different values of persistence, bioaccumulation or aquatic toxicity. The threshold quantities were taken from the *Risk Management Plan of the United States* (U.S. EPA, 1994a), and the classification of aquatic toxicity for LC50 at 96-hours duration was based on the OECD (2001). The persistence and bioaccumulation levels for the High rating were taken from the *Persistence and Bioaccumulation Regulations* (Government of Canada, 2000) under CEPA 1999. The moderate bioaccumulation and persistent thresholds were incorporated from OECD (2001a). No thresholds are set based on persistence or bioaccumulation potential if the values are less than the moderate category. The lowest of all applicable thresholds is selected.

1st Step

Table 1: Threshold Based on the Acute (Short-term) Aquatic Toxicity (LC50) of the Substance

Potential of Environmental Harm	**96-hr Lethal Concentration (LC50) (mg/L)**	**Threshold (tonnes)**
Extreme	≤ 0.1	0.22
High	> 0.1 – 1	1.13
Moderate	> 1 – 10	4.5
Slight	> 10 – 100	9.1

2nd Step

Table 2: Default Settings of the Threshold for Persistent and Bioaccumulative Substances

Potential of Environmental Harm	**Bioaccumulation**		**Persistence (days)**	**Threshold (tonnes)**
	BCF	**Log Kow**		
High	≥ 5000	≥ 5	≥ 182	0.22
Moderate	500 – 5000	4 – 5	60 – 181	1.13

Important – Bioaccumulation and persistence are only considered for substances that have an acute lethal concentration equal to, or less than, 100 mg/L.

Where there are no empirical fish toxicity data, modeling was sometimes referenced from the Chemicals Management Plan (CMP) Final Screening Assessment Reports (SAR) from the website http://www.chemicalsubstanceschimiques.gc.ca/challenge-defi/index-eng.php.

5.0 CONCENTRATION PERCENTAGE

Concentrations are expressed as a weight percentage of the substance relative to the total weight in the case of mixtures. For substances that are solutions, the percent concentration refers to the dilution of the chemical in water (e.g., 30% hydrochloric acid). The concentration percentages are set in one of five ways:

1. If the substance is flammable or the substance is a carcinogen or probable carcinogen, the concentration is set at 1% (U.S. EPA, 1994a);
2. If the substance is not a carcinogen, the concentration is set at 10% (U.S. EPA, 1994a);
3. If the substance is a solution and toxic via inhalation, the concentration is based on the percent solution required to reach a vapour pressure of 1.33 kPa (U.S. EPA, 1994a);
4. If the substance is corrosive, the concentration is calculated such that the pH is either ≥ 11.5 or pH ≤ 2 (OECD, 2001);
5. The concentration for some substances are set by Environment Canada based on a case by case basis.

6.0 ASSIGNED THRESHOLD

Following the risk evaluation methodology developed under section 200 of CEPA 1999, the categories (flammability, combustibility, oxidizers, inhalation toxicity, aquatic toxicity, carcinogenicity, corrosiveness, pool fires) having the lowest scientific threshold will be compared against other risk management considerations. For example, the threshold will be compared to other provincial and federal legislation or voluntary programs that may already provide adequate management of the risk from an environmental emergency. Proposed thresholds may also be modified based on policy and other considerations as assessed during the preliminary public consultation period. For more information regarding the determination of thresholds, please refer to the *Implementation Guidelines for the Environmental Emergency Regulations 2011* (Environment Canada, 2011a).

7.0 REFERENCES

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