



Risk Evaluation Determining Whether Environmental Emergency Planning is Required Under the *Environmental Emergency Regulations* set under the *Canadian Environmental Protection Act, 1999* (CEPA 1999)

Styrene (CAS #: 100-42-5)

(Industry requested this substance to be assessed for possible addition to the Environmental Emergency Regulations)

Summary of Risk Evaluation Analysis

The Risk Evaluation Framework (REF), developed by Environment Canada, is applied to chemical substances in order to determine whether or not an environmental emergency (E2) plan should be required. For those substances that are evaluated as requiring an E2 plan, the next step is to determine a threshold quantity for the total quantity of the substance and the maximum storage container size on site. Within the REF, three categories are used to evaluate chemicals and assign threshold quantities. Shown below are the details within the three categories for *styrene*:

1. Environment Hazard

(Persistence, Bioaccumulation and Aquatic Toxicity Analysis)

- The Priority Substance List (PSL) report states: "*Hydroxyl radicals and tropospheric ozone are major reactants that rapidly degrade styrene in the atmosphere. Styrene can be biodegraded quite readily in water (...) and long-range transport of styrene is considered insignificant (...) the half-life for volatilization of styrene from soil surface was estimated to be approximately 1 minute*" (Government of Canada, 1993).
- According to the most sensitive species for bioaccumulation, goldfish, styrene is practically non-bioaccumulative (BCF less than 50) (HSDB, 2003).

- For aquatic toxicity, it was determined that styrene is moderately toxic (LC_{50} at 96 hrs between 1 and 10 mg/L) based on the most sensitive species, fathead minnow (Cushman et al., 1997).
- Styrene is also known as a marine pollutant (IMO, 1990).

2. Human Hazard

(Inhalation Toxicity and Carcinogenicity Analysis)

- Since *styrene* has a vapour pressure below 1.33 kPa at 20°C (NFPA, 2002), there is insufficient vapour from the substance to cause an inhalation problem.
- *Styrene* is categorized by the International Agency for Research on Cancer (IARC) as a carcinogen with a classification rating of '2B' (HSDB, 2003; IARC, 2002).

3. Physical Hazard

(Flammability and Combustibility Analysis)

- *Styrene* is considered to be a highly flammable, polymerizable, peroxidizable compound. It is highly susceptible to runaway reactions if cooling or mixing is interrupted during the polymerisation reaction. As Figure 1 demonstrates, runaway reactions could be catastrophic when the temperature reaches the point of no return (Lacoursière, 2004). For this reason, *styrene* has the potential to cause a BLEVE (Boiling Liquid Expanding Vapour Explosion).

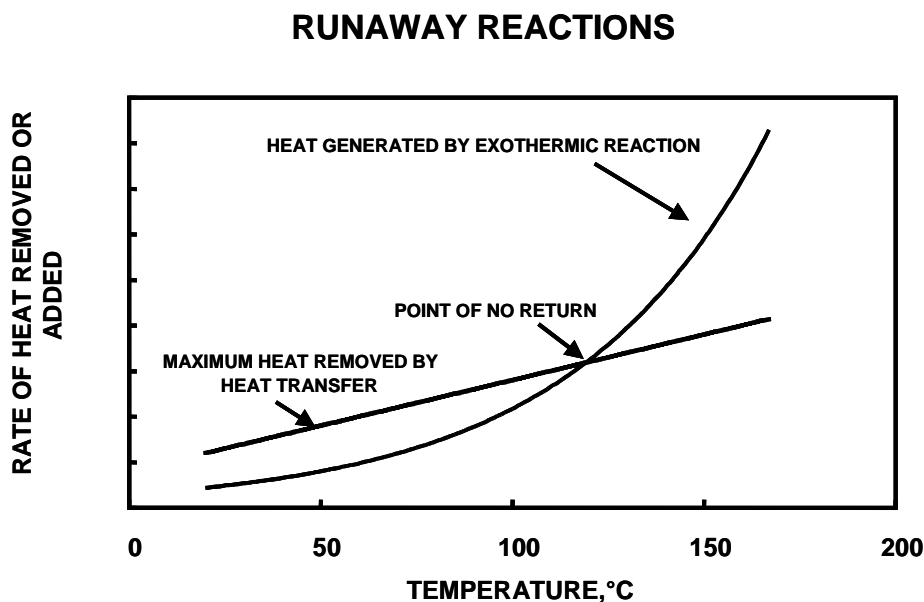


Figure 1: Runaway reaction as a function of temperature (J.P. Lacoursière Inc., 2005)

Accidents

The worst industrial accident in Canada was caused by the runaway reaction of a polystyrene reactor at a Monsanto Plant in Ville-de-LaSalle, Québec, on October 13, 1966, that caused 11 fatalities and 7 injuries. Runaway reactions in polystyrene plants continue to occur with the potential for highly severe consequences. Four additional runaway reactions occurred in Canada between 1987 and 1998 (Lacoursière, 2004). Each of these accidents could have had an impact on the neighbouring population.

A number of accidents involving *styrene* have resulted in threshold quantities being specified in various regulations. In Europe, *styrene* is regulated under the Seveso Directive, while in the United States, it is regulated under OSHA 1910.119 as a flammable substance with a threshold quantity of 4.50 tonnes (J.P. Lacoursière Inc., 2005).

Flammability and Combustibility Analysis Table

	Value	Vapour Cloud Explosion (Yes/No)	Combustible (Yes/No)	References
Boiling point (°C)	145	No	No	(Genium, 2004; HSDB, 2004)
Flash point (°C)	34.4			(Genium, 2004; HSDB, 2004)

Threshold

The data from the above mentioned categories were used to determine the various environmental/human thresholds. The threshold quantities relate to: carcinogenicity, aquatic toxicity, inhalation toxicity, vapour cloud explosion, combustibility, and reactivity.

The threshold quantity for carcinogenicity is defaulted to 0.22 tonnes, if it meets the following criteria:

- 1) have an IARC rating of 1, 2A or 2B, or have a US EPA rating of A, B1, or B2;
- 2) be persistent in any media for greater than 5 years.

Threshold quantities assigned as a result of aquatic toxicity are based on the following table:

Threshold Quantities Assigned as a Result of Aquatic Toxicity

Criteria	Extremely Toxic	Highly Toxic	Moderately Toxic	Slightly Toxic
Persistence (water)	≥ 6 months	≥ 2 months to < 6 months	N/A	N/A
Bioaccumulation	BCF ≥ 5000 or Log Kow ≥ 5	BCF ≥ 500 to < 5000 or Log Kow ≥ 4 to < 5 (unless BCF < 500)	N/A	N/A
Acute Aquatic Toxicity (96 hrs LC ₅₀ – mg/L)	≤ 0.1	> 0.1 to ≤ 1	> 1 to ≤ 10	> 10 to ≤ 100
Threshold Quantity Tonnes (lbs)	0.22 (500 lbs)	1.13 (2 500 lbs)	4.50 (10 000 lbs)	9.10 (20 000 lbs)

A substance is a candidate for a vapour cloud explosion if its flash point is < 23°C and its boiling point is < 35°C. A substance is considered combustible if its flash point is < 23°C or its boiling point is < 35°C. In accordance with the precautionary principle, the category with the lowest threshold will be used. For further explanation, please refer to the *Implementation Guidelines for Part 8 of the Canadian Environmental Protection Act, 1999 – Environmental Emergency Plans* (<http://www.ec.gc.ca/ee-ue/>).

Conclusion

For *styrene*, the E2 hazard threshold was triggered by:

1) Reactivity – capable of causing a BLEVE, threshold set at 4.50 tonnes.

Therefore, *styrene* is recommended for addition to Schedule 1 of the *Environmental Emergency Regulations* under Part 1 with a threshold quantity of 4.50 tonnes.

References

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