

# Quantitative Risk Assessment

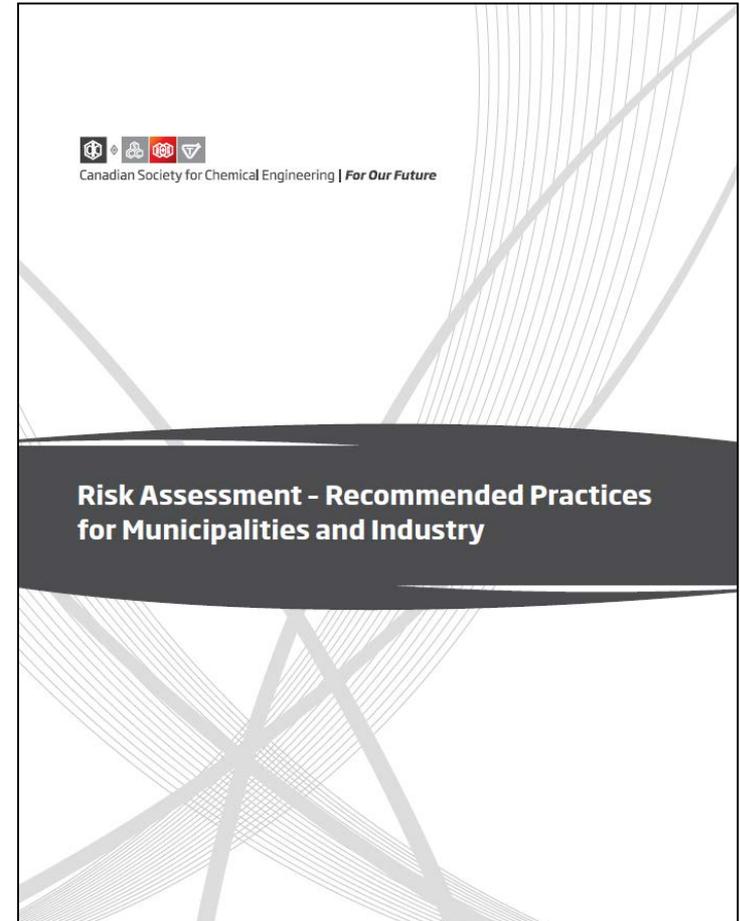
Creating QRA Scenarios to support **Recommended Practices for Municipalities and Industry**

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# History of this Guideline

- Originally prepared by the Risk Assessment Expert Committee of the former Major Industrial Accidents Council of Canada (MIACC).
- Focuses on managing risks from acute incidents, not chronic environmental risks
- Transferred to the Canadian Society for Chemical Engineering (CSCHE) as part of the work plan of the CSCHE's newly-formed Process Safety Management division
- Published in 2004
- Decision made to update it in 2013
- Guideline hiatus in 2016, pending CSA Z767



# 2016 Developments

- Z767 References 2004 QRA Guideline, which is out of date
- Impetus to “fast track” completion of updated/new “People Risk” guideline to support Z767
- 2016 Scope-influencing developments:
  1. Agreement by Z767 Technical Committee to including approaches to justify ALARP in this guideline
  2. Occupational risk criteria recommendation seen as a gap – approval to include at the October 2016 PSMD meeting in Quebec City
  3. Jean Paul Lacoursiere proposal to include detailed guidance to achieve consistent QRAs – also approved at the Quebec City meeting.



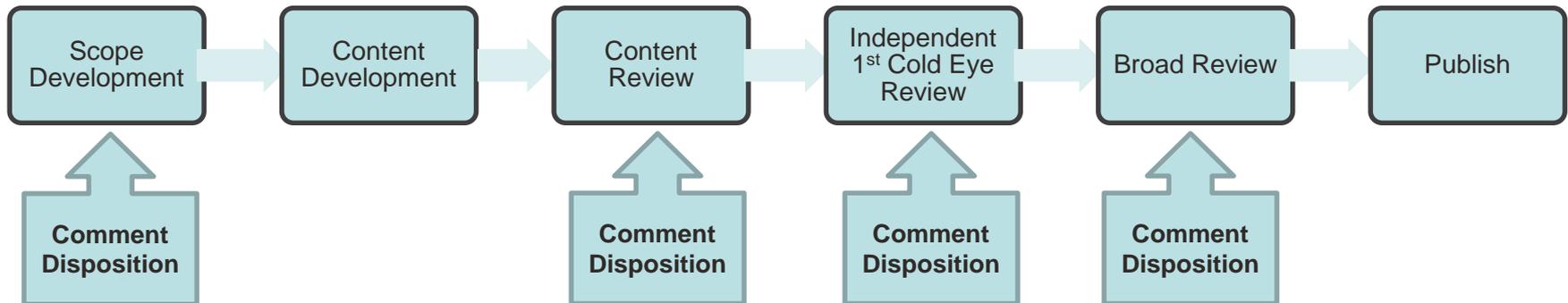
# Work done to date, following 2004 Guideline structure

TOC Section	Status
1. Introduction	Complete; 3 <sup>rd</sup> draft stage
2. General Risk Management Framework	Complete; 3 <sup>rd</sup> draft stage
3. Estimating Individual Risk In a QRA	Complete; ready for 1 <sup>st</sup> review
4. Hazard Identification	Complete; ready for 1 <sup>st</sup> review
5. Estimating Consequences	Being finalized
6. Estimating Frequency	Being finalized
7. Risk Reduction & Re-Iterating Risk	Not developed yet.
8. Appendix: Sample Scenarios / Methodology for Consistent Risk Assessments	Being finalized – <u>focus of this presentation</u>



# Proposed Development Plan (No Timeline) under review

- No timeline, other than to publish early 2018
- Participation open, but:
  - Content Developers and Cold Eye Reviewers are Subject Matter Experts
  - Broad review by users and other interested parties



# Purpose of developing sample scenarios

- Reproducibility in quantitative risk assessment is paramount.
- If we are to have engaged and informed discussion regarding facility design and operation – design engineers, risk assessors/consultants, regulators, municipalities, and other decision-makers must have a shared understanding of how risks are calculated and managed.
- Thus, the purpose of this appendix is to develop scenarios to demonstrate the analytic process, embedded assumptions, and modelling choices in:
  - identifying and using hazardous materials to represent the range of potential operational scenarios;
  - event tree analysis for modes of failure and loss of containment;
  - consequence analysis (source release, fire, explosion modelling, toxic cloud dispersion, and exposure modelling); and
  - frequency analysis (event tree quantification, loss of containment frequency and mitigation system modelling).

# Hazardous materials are ubiquitous, yet often taken for granted

- Three people in Fernie, B.C., died from possible exposure to ammonia after emergency crews were called to the Fernie Memorial Arena for reports of an ammonia leak just before noon on Tuesday, October 17, 2017.



# Hazardous materials are ubiquitous, yet often taken for granted

- Two people died as a result of Sunrise Propane Incident, in North York, Toronto, the morning of August 10, 2008.
- Thousands of people were evacuated, cleanup cost \$1.8M, and Sunrise propane was fined \$5.3M.
- Technical Standards and Safety Authority said that it had only inspected Sunrise once since it opened in 2005.
- TSSA have improved drastically and now are one the leading regulators in Canada for safety and risk



# Chosen materials for scenarios

- For most operations, the release of hazardous materials poses the greatest risk to workers and the surrounding community.
- For the purposes of illustration, we have chosen six materials that:
  - are on the MIACC (1994) list of hazardous substances;
  - represent the MSDS (Material Safety Data Sheet) chemical classes (explosives, gases, flammable liquids, flammable solids, oxidizers, poisons, corrosive) to demonstrate how to model their release, dispersion, and exposure modes;
  - are highly prevalent and diverse in use – from large industrial facilities (mining, refineries, processing plants) to small and medium sized enterprises (hotels, machine shops, construction yards, farm supply dealers) to institutional facilities (water treatment, colleges and universities, hospitals, medical labs); and, as a result,
  - are likely to transported via multiple modes (rail, road, pipelines) and stored in various manners and quantities.
  - For a comprehensive listing of hazardous materials, see MIACC (1994) Major Industrial Accidents Council of Canada, Lists of Hazardous Substances.



# Chosen materials

Material	Toxic – airborne inhalation only	Flammable	Fixed Plant	Transportation		
				Rail	Road	Pipeline
Propane / LPG / NGL, C <sub>3</sub> H <sub>8</sub>		X	X	X	X	X
Methane / natural gas, CH <sub>4</sub>		X				X
Gasoline, C <sub>4</sub> -C <sub>12</sub>		X	X		X	
Chlorine, Cl <sub>2</sub>	X		X	X	X	
Sodium Cyanide, NaCN	X					
Hydrogen Sulfide, H <sub>2</sub> S	X	X	X			
Ammonia, NH <sub>3</sub>	X		X	X	X	

# Hazard identification

- Hazardous material properties
  - Physical properties
  - Flammability
  - Reactivity
  - Toxicology
    - Inhalation toxicity only
    - Probit equation
  - Combustion/decomposition products
- Loss of Containment (LoC) Scenarios
  - Method to identify
    - HAZOP, What if, FMEA, Process Review
  - Categories – by hole size or by release rate
  - Number and location per site



# Hazard identification

- Event Tree Analysis
  - From LoC to Hazard Outcome
  - Fires
    - Pool fire
    - Jet fire
    - Fireball
    - Trench fire
  - Explosions
  - Toxic Clouds (Inhalation)



# Consequence Analysis, Source Term

- Liquid release
  - Below normal boiling point
  - Above normal boiling point - flashing
- Gas/vapor release
- Pooling / Evaporation
  - Confined pool
  - Unconfined pool
- Indoor / confined explosions
- Vapour cloud explosion (VCE)



# Consequence Analysis, Modelling

## ■ Fire Modelling

- Liquid release
- Pool fire
- Jet fire
- boiling liquid expanding vapor explosion (BLEVE)  
Fireball
- Trench Fire - pipelines
- Point source model
- Dispersion & Flash Fire

## ■ Explosion Modelling

- Vapor Cloud Explosion (VCE)
- BLEVE Blast
- Confined – vessel, building
- Deflagration to detonation transition (DDT)
- Computational fluid dynamics (CFD)



# Consequence Analysis, Modelling

- Toxic Cloud (Inhalation)
  - Dispersion modelling
    - Heavy gas
    - Neutrally buoyant
    - Plume rise – toxic combustion products
    - Surface roughness
    - Averaging Time
  - Indoor infiltration
- Effects Modelling
  - Fire
    - Thermal radiation
    - Fire surface emissive power
    - Flame contact
    - Probit model
    - Exposure time
  - Explosion
    - Overpressure
    - Missiles / debris
  - Toxic cloud inhalations
    - Probit model
  - Exposure time

# Frequency Analysis

- Event Tree Quantification
  - Quantifying post-LoC events
    - Immediate ignition
    - Delayed ignition
    - Meteorology, including wind direction
    - Time-at-risk
    - Spatial/directional probabilities
    - Mitigation system failure
- LoC Frequency Modelling
  - Equipment LoC events
  - Frequency Data sources
  - Fault Tree Analysis
    - Prevention systems
  - Ageing / end of life / bathtub curve



# Mitigation System Modelling

- Equipment Probability of Failure on Demand (PFD)
  - Fractional dead time
  - Repair time
- System PFD
  - Fault Tree Analysis
- Frequency/PFD Data sources
- Common mode failure modelling
- Dependencies
- Redundant equipment
- Ageing / end of life / bathtub curve
- Process control modelling
- Electrical / pneumatic / lube oil sub systems



# THANK YOU!

Questions?  
Comments?  
Feedback?

Interested in being  
involved?

