

Risk – How to Measure it and Evaluate it

....With an emphasis on process safety

Marcello Oliverio
Andy Ridpath
Angela Wong

*Presented at 2016 CShE Conference
Quebec City, Quebec, Canada
October 17 – 19, 2016*



Why do we need risk criteria?

Risk tolerance criteria help ensure prudent allocation of resources to adequately manage risk

Within the context of this statement,

- Adequately manage risk may mean reducing risks to conditionally tolerable or broadly tolerable levels rather than as far as possible
- Prudent allocation of resources means diverting time, effort and money towards acute risks from less pressing risks, particularly those already considered broadly tolerable

The aim is to better inform decisions by interpreting risk results

Structure of risk criteria

—

Terminology – 1 of 2

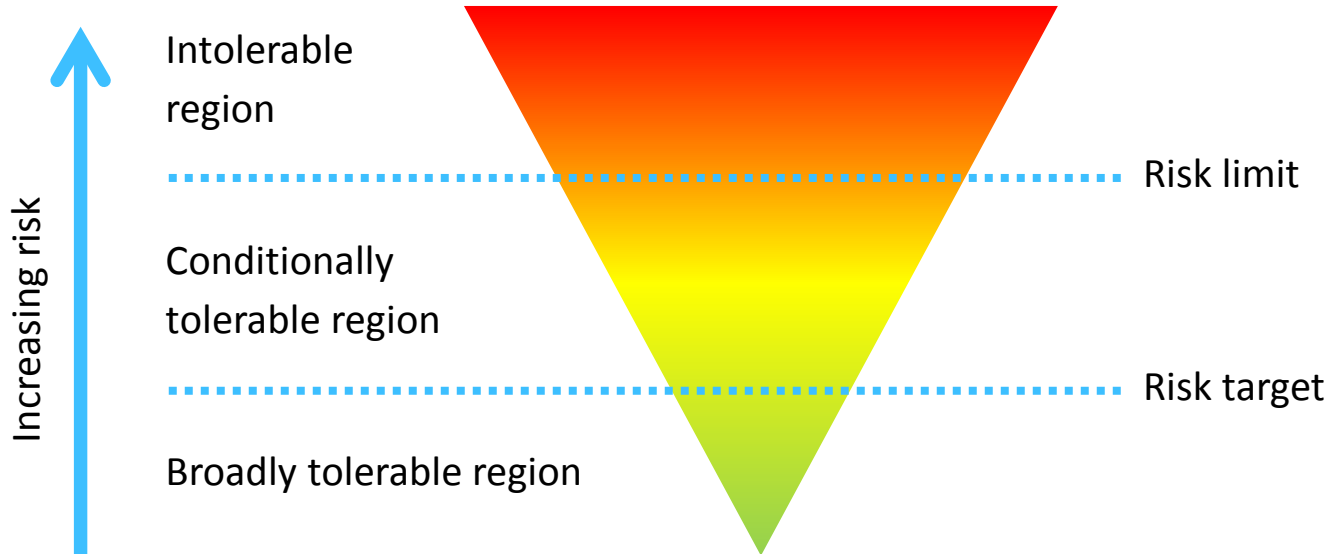
At what frequency would a given impact be a matter that we would feel *compelled* to act on?

This frequency represents our risk limit for this impact

At what frequency would a given impact become a concern *sufficient* for us to act?

This frequency represents our risk target for this impact

Terminology – 2 of 2



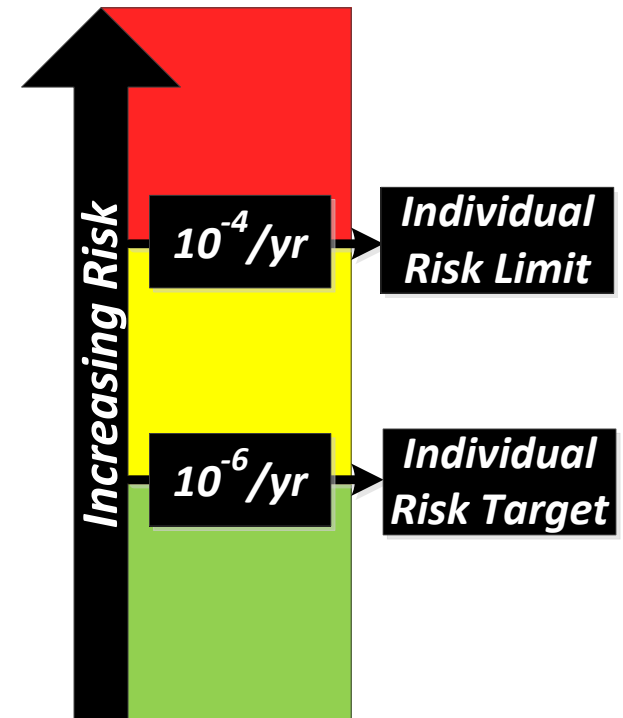
Risk limit the dividing line between intolerable and conditionally tolerable risks

Risk target the dividing line between conditionally tolerable and broadly tolerable risks

ALARP region the region between the risk limit and risk target in which risks may be considered tolerable on the condition that all reasonable and practicable measures to reduce risk have been implemented and they confer certain benefits (such as the provision of energy)

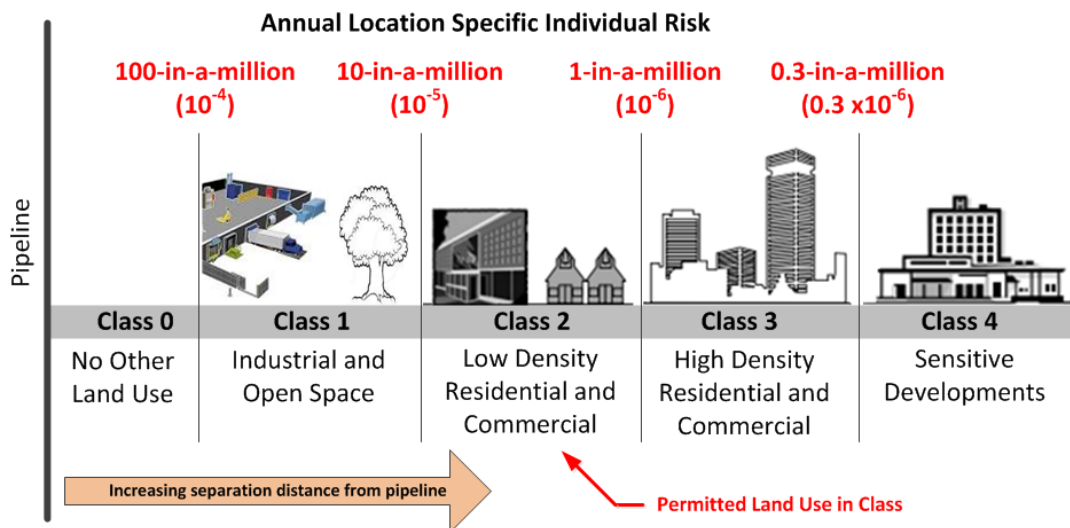
Canadian Public Risk Criteria – Current Proposal from the PSMD

- Retain Modified-MIACC Criteria for land use planning purposes
 - New public developments near existing hazardous facilities
 - New hazardous facilities
- UK HSE Individual Risk Criteria adopted for existing hazardous facilities
- New hazardous facilities must meet both the Modified-MIACC and the Individual Risk Criteria
- Societal Risk Criteria (possibly FN Curves) for existing hazardous facilities parked for future



Canadian Public Risk Criteria

- PSMD’s Risk Assessment Expert Committee working to update the **2004 Risk Assessment – Recommended Practices for Municipalities and Industry**
- 2004 Guideline had risk criteria that were (Modified-MIACC Criteria)
 - Based on **Total Risk**
 - Recommended for **land use planning purposes**
 - Specified allowable land uses for different levels of individual risk
 - Addresses Individual Risk and Societal Risk



Risk tolerance in a matrix

—

Why it's important

- While a good risk matrix won't solve all your problems, it will make them solvable
- It's the cornerstone of risk assessment, and allows
 - **targeting of action** to where it's most needed
 - **proportionality** of risk reduction measures
 - **consistency** between risk assessments by different groups and teams (internal and external)

Risk matrix colouring shows risk tolerance

Defining risk matrix scope and thresholds

- Where do we need to use the risk matrix?
 - For example
 - Process Hazard Assessment (PHA) to support Process Safety Management (PSM)
 - Project and program prioritization
- For each need,
 - Define scales
 - What *categories* of impacts are relevant? (H&S, environment, business and its subcategories)
 - What is the *worst foreseeable* event in terms of each impact category and subcategory?
 - What is the *least significant* event of each impact category/subcategory that we want to track? (May depend on reporting level)
 - Define risk tolerance
 - At what frequency is each worst foreseeable impact category broadly tolerable?
 - At what frequency are they intolerable?
 - Ditto for least significant impact category
 - Any distinct intermediate levels? If so, define their limits and targets

Testing risk matrix before use

This is just to double-check it reflects our values and intention across the full scope of its intended application before use

- Does the risk tolerance (red, yellow, green*) make sense against the impact severity ratings when combined with likelihood ratings?
 - against each need
 - against each impact category and subcategory within each need
 - particularly their extremes
 - including any distinct intermediate points
- This test report is what needs to be signed off by senior figures

* red = unacceptable (needs addressing)

yellow = address unless increasingly disproportionately costly or impractical

green = acceptable without further mitigation

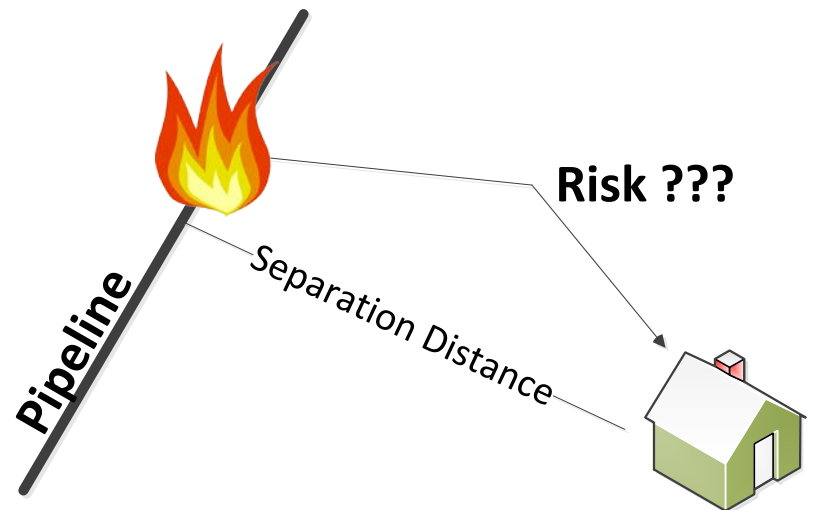
Issues and their solutions

—

Issue 1: “Total Risk” – 1 of 2

- People exposed to hazards from a hazardous facility care about the incremental **Total Risk** from those hazards
- Canadian regulators mostly concerned about **Total Risk**
 - TSSA (propane), BC Oil Gas Commission (LNG) provincial laws
- Other countries who have legislated risk criteria have done so using “Total Risk”

PHA risk assessment
using a risk matrix does
not use Total Risk



Issue 1: “Total Risk” – 2 of 2

PHA Risk Assessment using a Risk Matrix

- Total Risk criteria do not directly translate into likelihood categories for a risk matrix used in a PHA
 - A PHA evaluates single cause-consequence pairs
- Total Risk is based on **all** cause-consequence pairs that impact a risk receptor

Solutions

1. Sum risks from cause-consequence pairs before evaluating on matrix

OR

2. Reduce tolerance on risk matrix to rule of thumb 20% of limit and target and evaluate single cause-consequence pairs against it

Issue 2: Benchmarking against background risk – 1 of 2

Leisure / Everyday Risks



Technological Risks



Nature Risks



Issue 2: Benchmarking against background risk – 2 of 2

Do the Proposed Public Risk Criteria Make Sense?

- How do they compare to background **Accident** risk from every day life.
- Proposed Individual Risk Target of $10^{-6}/\text{yr} = 0.4\%$ of background accident risk
- Proposed Individual Risk Limit of $10^{-4}/\text{yr} = 40\%$ of background accident risk

Summary Calculations - Background Public Accident Risk (Canada)	
Total annual accident fatalities [public+occupational] (2003-2012 average)	9853 [1]
Total annual occupational fatalities (2011-2013 average)	933 [2]
Estimated annual public accident fatalities	8920
Canadian population (2003 - 2012 annual average)	33,125,431
Average Public Accident Risk (chance of fatality per year)	2.7E-04

[1] Statistics Canada

[2] Association Of Workers Compensation Boards Of Canada

Issue 3: Public vs. worker risk – 1 of 4

– Voluntary

- Willingly expose oneself to
- Receive a benefit
- Have control over
-

– Involuntary

- Don't want exposure to
- Don't receive a direct benefit from
- Have no control over
-

Issue 3: Public vs. worker risk – 2 of 4

Occupational Risk (Total Risk)

- Regulatory disdain for the development of quantitative risk criteria for workers
- Leaves organizations up to themselves to develop
- So what makes sense?
 - Approach could be to develop such criteria in relation to historical individual risks that may be generally accepted.
 - This should not deter from continuous safety improvement, but provides a risk-informed basis for justifying such improvement.

Issue 3: Public vs. worker risk – 3 of 4

Historical Occupational Individual Risk (Canada)

Occupational Individual Risk - Selected Industries

[2011 to 2014]

	Average Annual Worker Population [1]	Average Annual Fatalities [2]	Average Annual Individual Risk
Iron and Steel Mills and ferro-alloy manufacturing	15,644	18.3	1.2E-03
Basic chemical manufacturing	11,585	8.8	7.6E-04
Metal ore mining	31,135	21.3	6.8E-04
Coal mining	8,517	4.3	5.0E-04
Petroleum and coal product manufacturing	19,413	7.3	3.7E-04
Pulp, paper and paperboard mills	27,566	9.0	3.3E-04
Forestry / logging	38,760	12	3.1E-04
Truck transportation	185,067	49.5	2.7E-04
Sawmills and wood preservation	34,057	8.5	2.5E-04
Construction	943,321	221	2.3E-04
Electric power generation, transmission and distribution	93,733	16.0	1.7E-04
Pesticide, fertilizer and other agricultural chemical manufacturing	6,646	0.8	1.1E-04
Oil and gas extraction	59,720	6.5	1.1E-04
Petroleum and petroleum product merchant wholesalers	14,567	1.5	1.0E-04
Natural gas distribution	16,237	1.3	7.7E-05
Pharmaceutical and medicine manufacturing	26,651	1.0	3.8E-05
Retail Trade	1,913,982	24	1.3E-05



[1] Statistics Canada

[2] Association Of Workers Compensation Boards Of Canada

Issue 3: Public vs. worker risk – 4 of 4

Historical Occupational Individual Risk in Perspective

- Broad Industry range: $10^{-3}/\text{yr}$ to $10^{-5}/\text{yr}$

For hazardous facilities:

- A Risk Limit of $10^{-4}/\text{yr}$ (same as public) doesn't make sense as a broad guideline
- A Risk Limit of $10^{-4}/\text{yr}$ (same as public) can make sense for individual organizations – your choice.
- A Risk Target of $10^{-6}/\text{yr}$ (same as public) does make sense as a broad guideline
 - Drives continuous improvement
- A Risk Target of Zero (as some have suggested) doesn't make sense
 - Potential to spend money on negligible risks that would not be available to reduce higher risks

Summary - PHA Risk Assessment using a Risk Matrix

- Organizations should ensure that Total Risk is used to develop risk matrices
 - Risk matrices could differentiate between public risk and occupational risk
 - Risk matrices could differentiate between individual risk (single fatality) and societal risk (multiple fatalities)
- **In developing a risk matrix, some accounting is required of the number of cause – consequence pairs that impact a risk receptor such that there is alignment with Total Risk criteria.**

What's next?

—



Regulatory Future ??

- CSA Z767 – Process Safety Management
 - Due to be published end of 2016
- UL2984 – risk management guideline for regulators
 - Due to be published in 2017
- The ask is that organizations identify hazards and evaluate risks
- A consistent, fair and robust method for doing so is required, including risk tolerance criteria
- CSCChE PSMD is updating the 2004 risk assessment guideline to help organizations do this

Q&A