Methodology to Determine Requirements for Installation of Criticality Accident Alarm Systems

Jingjing Wang and Christine McNally

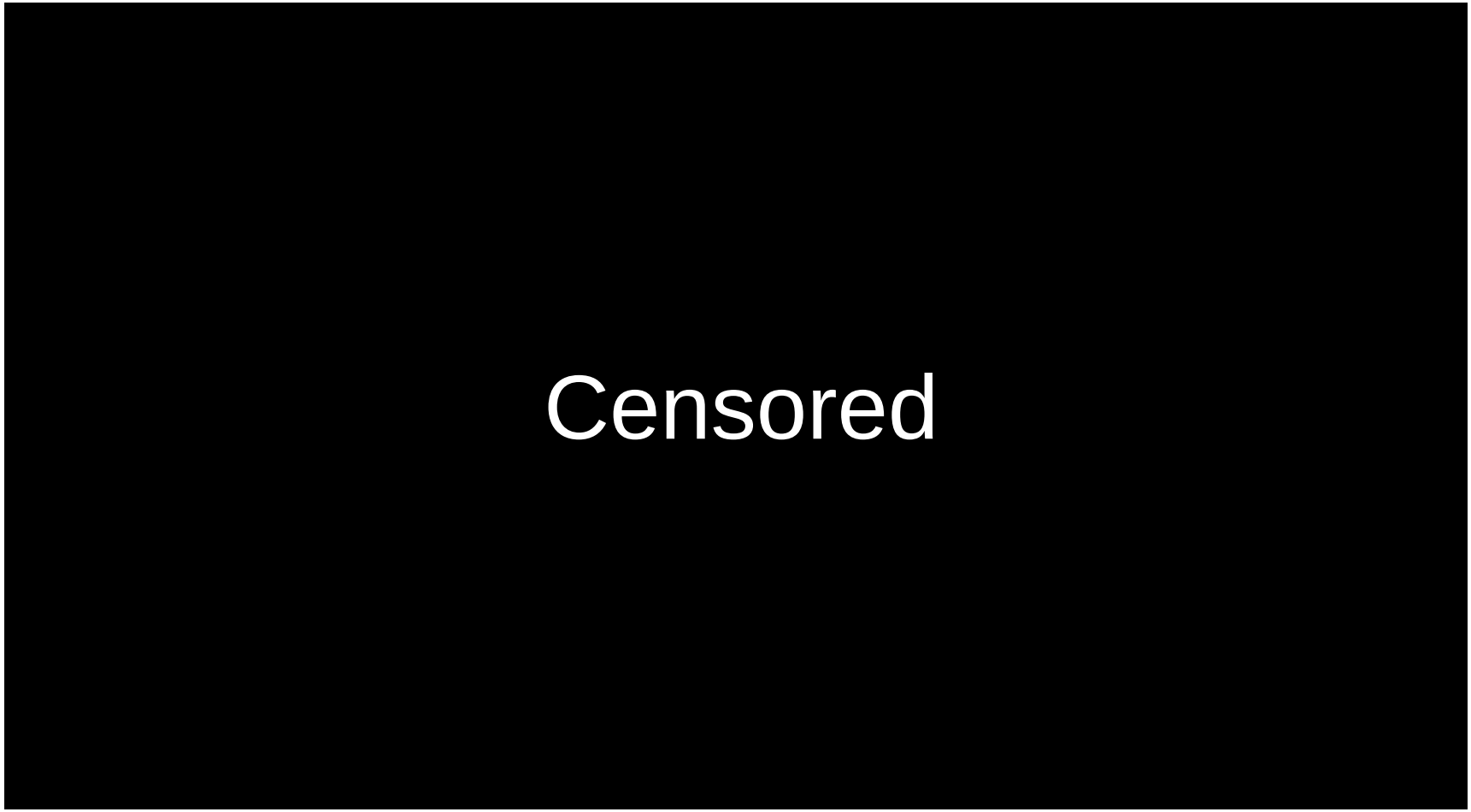
ANS NCSD 2013 – Criticality Safety in the Modern Era: Raising the Bar
Wilmington, North Carolina
Sept 29 – October 3, 2013

AECL EACL

AECL - Chalk River Site (CRL)

AECL EACL

Location and Layout of buildings



Outline

- Motivation
- Requirement
- Approach
  - Bands
  - Matrices
  - Evaluation
- Results
- Further work

Motivation

- AECL – Chalk River Laboratories have had Criticality Accident Alarm System (CAAS) installed - likely in the late 1960's and are aging
- Need to justify and document replacement locations for new alarms to meet regulator requirements
- Gap in lack of documentation related to the justification of the placement of current CAAS
- No predetermined industry best practice available for compliance with regulatory requirements

Requirements

- Canadian Nuclear Safety Commission (CNSC) Regulatory Document and Guidance Document (RD-327 and GD-327) requires for compliance :
  - Evaluation is required if the limits in the RD and GD documents are exceeded
  - Overall risk should be assessed
  - Consideration should be given to false alarms, sudden interruptions of operations and relocation of personnel

Approach – Risk Bands

- Since no detailed documentation available, a fresh start on approach to method for evaluation was developed
- Avoid equating dollars to lives
- Developed risk bands with Safety and Licensing group for assessment of criticality controlled areas based on four (4) key criteria.
  - Accident Frequency
  - Risk Reduction Severity
  - Operational Cost
  - Monetary Cost

Frequency Band

F0	**Inconceivable (less than 10^{-7} per year)** No sequence of credible events has been identified as leading to criticality.
F1	**Conceivable, but not credible (10^{-7} to 10^{-6} per year)** A simple operation with large criticality safety margin; event sequences that could lead to criticality have been identified, but are well below credibility.
F2	**Credible, but extremely unlikely (10^{-6} to 10^{-5} per year)** Operations with a few criticality safety controls that could fail; a few event sequences could lead to criticality in different ways.
F3	**Highly unlikely (10^{-5} to 10^{-4} per year)** Larger operations, which may not be complex, with several criticality safety controls that could fail; several different event sequences could lead to criticality in a few different work areas.
F4	**Unlikely (greater than 10^{-4} per year)** Complex operations with many criticality safety controls that could fail; many different event sequences could lead to criticality in any of several different work areas

Severity Band

S0	**Minor effect (less than 0.02 person-Gys cumulative dose)** Credible accidents require no mitigation, and are shielded such that there would not be a large dose to individuals present.
S1	**Moderate effect (0.02 to 0.2 person-Gys cumulative dose)** Credible accidents are self-terminating, and are located such that there would probably be nobody to benefit from the alarm during the event.
S2	**Serious effect (0.2 to 2.0 person-Grays cumulative dose)** Credible accidents are self-terminating, and alarms would allow some individuals to reduce radiation doses by 0.2 Gys or more.
S3	**Severe effect (2.0 to 20 person-Gys cumulative dose)** Prolonged criticality events are possible; alarms would allow many individuals to reduce their radiation doses by 0.2 Gys or more OR could save lives.
S4	**Very severe effect (greater than 20 person-Gys cumulative dose)** Prolonged criticality events are possible, and alarms could save several lives.

Operational Cost Band (OSH)

H0	**No impact (less than 1 hour per year)** Simple CAAS testing AND no impact from false alarms or maintenance, or other OSH issues.
H1	**Low impact (1 to 10 hours per year)** Regular CAAS testing and occasional maintenance (e.g. in areas that aren't regularly occupied) OR false alarms and other CAAS faults have minor risk consequences.
H2	**Minor impact (10 to 100 hours per year)** Regular CAAS maintenance and occasional group exercises OR false alarms and other CAAS faults have moderate risk consequences.
H3	**Moderate impact (100 to 1,000 hours per year)** Extensive CAAS maintenance and regular group exercises OR false alarms and other CAAS faults have serious risk consequences.
H4	**High impact (greater than 1,000 hours per year)** Full-time radiation monitor or CAAS maintainer OR false alarms and other CAAS faults have severe risk consequences.

Monetary Cost Band

M0	**Little or no cost ($1,000 per year or less)** Alarms exist and will last as long as needed for the duration of operation.
M1	**Low cost ($1,200 to $4,000 per year)** Alarms exist, but will need eventual replacement.
M2	**Moderate cost ($5,000 to $15,000 per year)** A basic redundant alarm set installed at a single location
M3	**High cost ($20,000 to $60,000 per year)** Diverse, redundant alarms at multiple locations, OR a basic redundant alarm set operating for three to ten years.
M4	**High cost ($80,000 per year or greater)** Diverse, redundant alarms at multiple locations operating for ten years or less, OR a basic redundant alarm set operating for less than three years.

Matrices – Risk Reduction Benefits

Severity	Frequency				
	F0	F1	F2	F3	**F4**
S0	B0	B0	B0	B0	B1
S1	B0	B0	B0	B1	B2
S2	B0	B0	B1	B2	B3
S3	B0	B1	B2	B3	**B4**
S4	B1	B2	B3	**B4**	**B4**

Matrices – Overall Cost

Monetary	Operational / OSH				
	H0	H1	H2	H3	**H4**
M0	C0	C1	C2	C3	**C4**
M1	C1	C1	C2	C3	**C4**
M2	C2	C2	C2	C3	**C4**
M3	C3	C3	C3	C3	**C4**
M4	**C4**	**C4**	**C4**	**C4**	**C4**

Evaluation

1. Simple questionnaire used.
2. The answers to the questionnaire were then related to a value between zero and four the values attributed to the Frequency, Severity, OSH, and Monetary.
3. The Frequency and Severity were combined to give a Risk Reduction Value
4. The OSH and Monetary combined to generate the overall Cost
5. The results of the risk reduction value and overall cost were then subsequently combined to determine the overall decision

Overall Decision Matrix

Cost	Risk-Reduction Benefit				
	B0	B1	B2	B3	**B4**
C0	NO*	YES	YES	YES	YES
C1	NO	NO*	YES	YES	YES
C2	NO	NO	YES*	YES	YES
C3	NO	NO	NO*	YES*	YES
C4	NO	NO	NO	NO*	YES*

Results

- Risk Matrices successfully assessed 36 criticality safety areas
- Flasks and packages were excluded
- One building/criticality controlled area received “ YES ”
- 5 buildings in the areas assessed received “ YES* ”
- 6 buildings in the areas assessed received “ NO* ”

Acknowledgement

- The authors gratefully acknowledge the help and assistance provided by fellow staff at AECL, The risk bands development team included the authors of this paper as well as Robin Corrigan, Susan Johnston, Graham Porter, Fred Adams, Ruxandra Dranga, and Nhu Tran.


AECL EACL