PSA applications

Development and Use of Probabilistic Safety Criteria

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Need for Probabilistic Safety Criteria

- If PSA results are to be used in a formal way for decision making, then it is necessary to establish a formal process for using those results
- This process will depend on
  - the purpose of the particular PSA application,
  - the nature of the decision,
  - and the PSA results to be used.
- where the application involves judging whether a calculated risk value is acceptable, then a judgement on the significance of the calculated value can only be made by comparing it with some reference value.

Need for Probabilistic Safety Criteria (Cont.)

- These reference values and their associated rules are called probabilistic safety criteria (PSC)
- Internationally it is more usual to identify PSC as *targets, goals*, *objectives*, *guidelines* or *reference values for orientation, etc*...
- The meaning of the numerical value of the PSC and the decision making rule itself will depend very much on its use.

PSC and PSA applications

- Design, design modifications
  - The PSA applications to the design of new plant, upgrades, backfits and other modifications may make use of criteria and targets for the full range of long term average risk measures, from system reliability to public health effects
  - The criteria for new plant will generally be more stringent than those for backfits
  - Note: Where an old plant needs widespread upgrading to bring it up to an acceptable safety standard, and money is short, the main use of PSA is to assist in prioritizing the potential modifications, and no specific criteria are needed for this.

PSC and PSA applications (Cont.)

- PSC for plant in operation
  - PSC for limiting the operational risk for both short term and long term applications
  - typical applications potentially involving PSC:
    - *Configuration control*
    - *Evaluation of operational events*
    - *Modifications to AOTs in the TS*
    - *Modifications to STIs in the TS*
    - *To support maintenance planning, etc...*

Comparison of numerical results with PSC

- The PSA will be an essential part of the decision making process
- Rules depending on the consideration of uncertainties:
  - If the PSA result X is greater (or less) than reference value Y, do Z
    - *If the mean value (of X is greater (or less) than Reference value Y, do Z.*
    - *Do Z, If the probability that X is greater (or less) than Y is greater than or equal to α (or X is greater (or less) than Y at a confidence level α).*

Risk Measures for use in Decision Making

- Two types of measures:
  - long term measures
    - *Absolute time averaged risk measures*
      - the unreliability or unavailability of particular safety systems/functions (Level 0)
      - the frequency of core damage (Level 1)
      - the frequencies of radioactive releases and their associated magnitudes (Level 2)
      - the frequency of specified public health effects (Level 3).
  - short term measures
    - *Instantaneous measures of risk*
      - Instantaneous CDF
      - Core damage probability (CDP)

Methods of determining PSC

- Top-down method
  - Determination of high level goals, and derivation of the lower level criteria from the high level goals
- Bottom-up method
  - Determination of the PSC on lower level (like CDF) linked to a clearly specified scope for the PSA, and these form higher level goals

PSC in the world

- INSAG-3 has proposed the following objectives:
  - *PSC for CDF*

    - 10^{-4} per reactor year for existing plants.
    - 10^{-5} per reactor year for future plants.

  - *PSC for LERF*
    - 10^{-5} per reactor year for existing plants
    - 10^{-6} per reactor year for future plants
- Health effects to members of the public: INSAG have given no guidance on the targets for health effects for members of the public. In some countries, the target for the individual risk of death is taken to be 10^{-6} per reactor year for members of the public.

Risk Matrix (IEC Standard example)

Frequency of occurrence	1/year	Severity of consequences			
		Catastrophic	Major	Severe	Minor
Frequent	> 1	H	H	H	I
Probable	10e-1 - 1	H	H	I	L
Occasional	10e-2 – 10e-1	H	H	L	L
Remote	10e-4 – 10e-2	H	H	L	L
Improbable	10e-6 – 10e-4	H	I	L	T
Incredible	10e-6 <	I	I	T	T

H	-	High risk
I	-	Intermediate risk
L	-	Low risk
T	-	Trivial risk

Catastrophic	Virtually complete loss of plant or system Many fatalities
Major	Extensive damage of plant or system. Few fatalities
Severe	Significant damage to plant or system. Severe injuries, severe occupational illness.
Minor	Minor system or plant damage. Minor injuries, minor occupational illness

Development and Use of Probabilistic Safety Criteria

Use of risk information in NRC and US industry programs

<table>
<tr><th>CDF/ DCDF</th><th>RG 1.174 Low CDF/LERF</th><th>RG 1.174 High CDF/LERF</th><th>EPRI PSA Application Guide</th><th>EPRI Temp. Change</th><th>OL 803</th><th>Oversight Process SECY-99-007</th><th>RAG Screening Criteria</th><th>NEI 91-04 Severe Accident Guidelines</th><th>LERF/ DLERF</th></tr>
<tr><td>10^{-3}</td><td rowspan="2">“Not Normally Allowed”</td><td rowspan="3">“Not Normally Allowed”</td><td>“Unacceptable”</td><td rowspan="2">“Potentially Risk Significant”</td><td rowspan="2">“Substantial Risk Significance”</td><td>“RED” “Unacceptable”</td><td>“Proceed to Value Impact Analysis” (PRIORITY)</td><td>“Cost Effective Admin. Procedure or Hardware Change” or “Treat in EOP” or include in SAMG</td><td>10^{-4}</td></tr>
<tr><td>10^{-4}</td><td rowspan="3">“Further Evaluation Needed”
↓
“Non-Risk Significant”</td><td>“YELLOW” “Required Reg. Response”</td><td>“Proceed to Value Impact Analysis”</td><td>“Cost Effective Admin. Procedure or Hardware Change” or include in SAMG</td><td>10^{-5}</td></tr>
<tr><td>10^{-5}</td><td>“Small Changes” (Acceptable w/Management Attention</td><td>“Assess Non-Quantifiable Factors”</td><td>“Low to Moderate Risk Significance”</td><td rowspan="2">“WHITE” “Increase Reg. Response”
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“GREEN” “Routine Reg. response”</td><td>“Value Impact Analysis upon Management Decision”</td><td>“Include in SAMG”</td><td>10^{-6}</td></tr>
<tr><td>10^{-6}</td><td>“Very Small Changes” (Acceptable)</td><td>“Very Small Changes” (Acceptable)</td><td>“Non-Risk Significant”</td><td>“Very Low Risk Significance”</td><td>[No Action]</td><td>“No Specific Action Required”</td><td>10^{-7}</td></tr>
<tr><td>10^{-7}</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>10^{-8}</td></tr>
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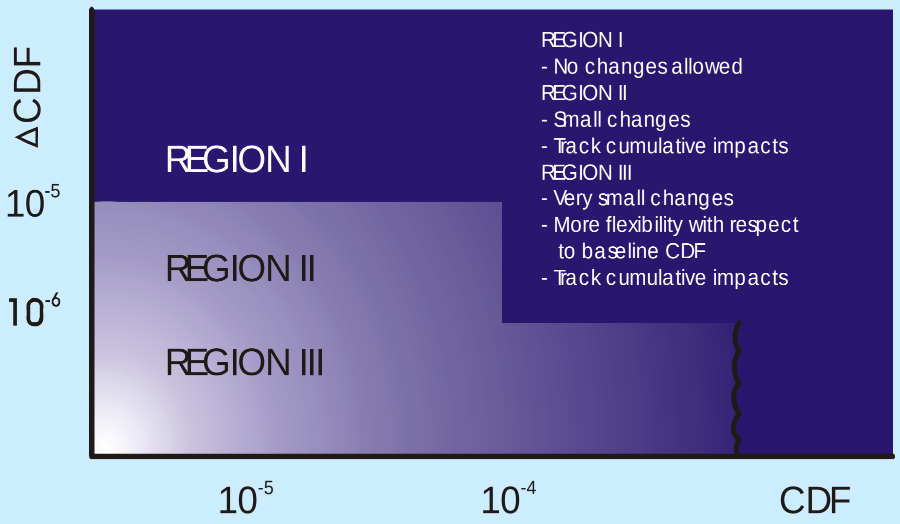
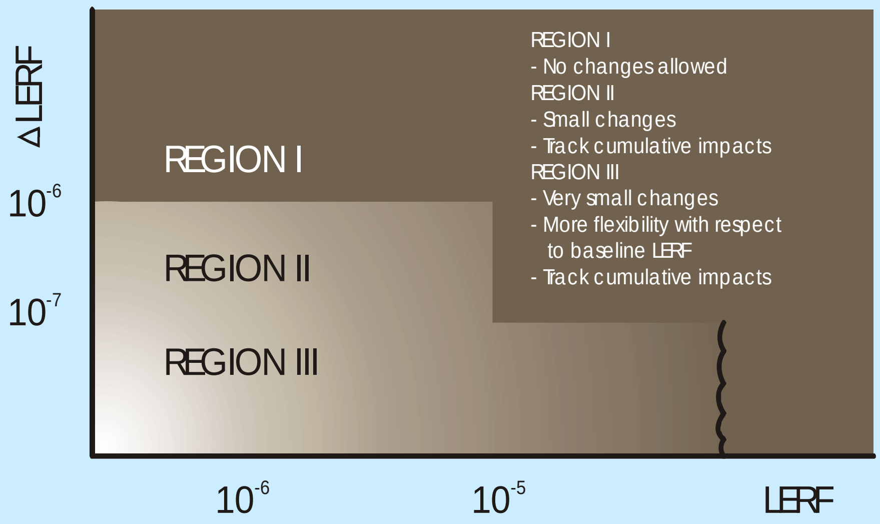
Risk-Informed Decision Making (NRC RG 1.174) - Acceptance Criteria



Acceptance guidelines for CDF.



Acceptance guidelines for Large Early Release Frequency (LERF)

References

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