Nuclear Risk Research Center Workshop 2024
-Risk Informed Decision Making: Benefits and Obstacles-

CURRENT STATUS AND FUTURE EXPECTATIONS FOR SAFETY GOALS IN JAPAN

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November 13, 2024

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HISTORY OF SAFETY GOALS REVIEW

Timeline of Japan Nuclear Safety Commission, Nuclear Regulation Authority		Timeline of Academic conferences	
December 2003	Japan Nuclear Safety Commission, Special Committee on Safety Goals “Interim Summary on Survey and Review Status of Safety Goals”		
March 2006	Japan Nuclear Safety Commission, Special Committee on Safety Goals “Performance Metrics of Commercial Light Water Reactor Facilities – Performance Metrics Corresponding to Proposed Safety Goals”		
April 2013	Nuclear Regulation Authority “Key Topics Discussed Up to Previous Committee (April 3, 2013) Regarding Safety Goals”	September 2014	Science Council of Japan, General Engineering Committee, Report by Engineering System Safety/Security/Risk Review Subcommittee Regarding “Society’s Safety Goals Regarding Engineering System”
August 2016	Nuclear Regulation Authority “Principles of New Regulatory Requirements Regarding Commercial Power Reactors”	August 2016	Atomic Energy Society of Japan, Nuclear Safety Committee summer seminar, “Key Topics Regarding Use of Risk Information and Continuous Improvement”
		September 2016	Atomic Energy Society of Japan, Autumn session, Nuclear Safety Committee hosted session, “Current Status and Challenges Regarding the use of Safety Goals
August 2017	Nuclear Regulation Authority ”Safety Goals and New Regulatory Requirement (notes for discussion)”	2016	Central Research Institute of Electric Power Industry Report, “Development and Application of Nuclear Safety Goals in Japan – Lessons Learnt from Case of 2003 Draft Safety Goals –”
April 2018	Nuclear Reactor Safety Examination Committee, Nuclear Fuel Safety Examination Committee “Comparison Between Safety Goals of the Nuclear Regulation Authority and the Safety Standards Achieved by Conforming to New Regulatory Requirements (comprehensible explanation for the public)”	March 2018	Yayoi Research Group, research committee regarding safety goals, “Rethinking ‘Safety Goals’ Why is it Necessary?”
May 2018	Nuclear Regulation Authority 2018 8th Extraordinary Meeting, Report Regarding Response From the Nuclear Reactor Safety Examination Committee and Nuclear Fuel Safety Examination Committee	August 2018	Atomic Energy Society of Japan, Risk Science and Technology Division Symposium, “Rethinking ‘Safety Goals’ Why is it Necessary?”
July 2021	Review Team for Continuous Improvement of Safety, Critique of Discussion	November 2019	Atomic Energy Society of Japan, Risk Science and Technology Division/Tokyo University/NRRC Symposium “Rethinking ‘Safety Goals’ Why is it Necessary?-Part Two”

OVERVIEW OF "INTERIM SUMMARY ON SURVEY AND REVIEW STATUS OF SAFETY GOALS" BY THE JAPAN NUCLEAR SAFETY COMMISSION, SPECIAL COMMITTEE ON SAFETY GOALS

1. Purpose

- Safety goals quantitatively present the level of risk reduction required in activities involving nuclear power.

2. Position

- Apply first as reference for decision-making across regulatory activities, and apply to specific facilities only after experience has been gained.
- Facilities that do not satisfy safety goals are not immediately judged as being unsafe, and reviews are conducted to identify the reason for the gaps and any inappropriate entries in the corresponding part of regulations. The judgement regarding safety of specific facilities are based on such revised regulatory system.

3. Subject scope

- Nuclear power activities which could adversely impact the public through radiation exposure are the subject of safety goals.

OVERVIEW OF "INTERIM SUMMARY ON SURVEY AND REVIEW STATUS OF SAFETY GOALS" BY THE JAPAN NUCLEAR SAFETY COMMISSION, SPECIAL COMMITTEE ON SAFETY GOALS

4. Details

Proposed qualitative goals

The possibility of adverse impact on public health through the conduct of nuclear power activities which release radiation and disperse radioactive materials should be suppressed to levels which does not threaten to significantly increase health risk of the public in their daily life.

Proposed quantitative goals

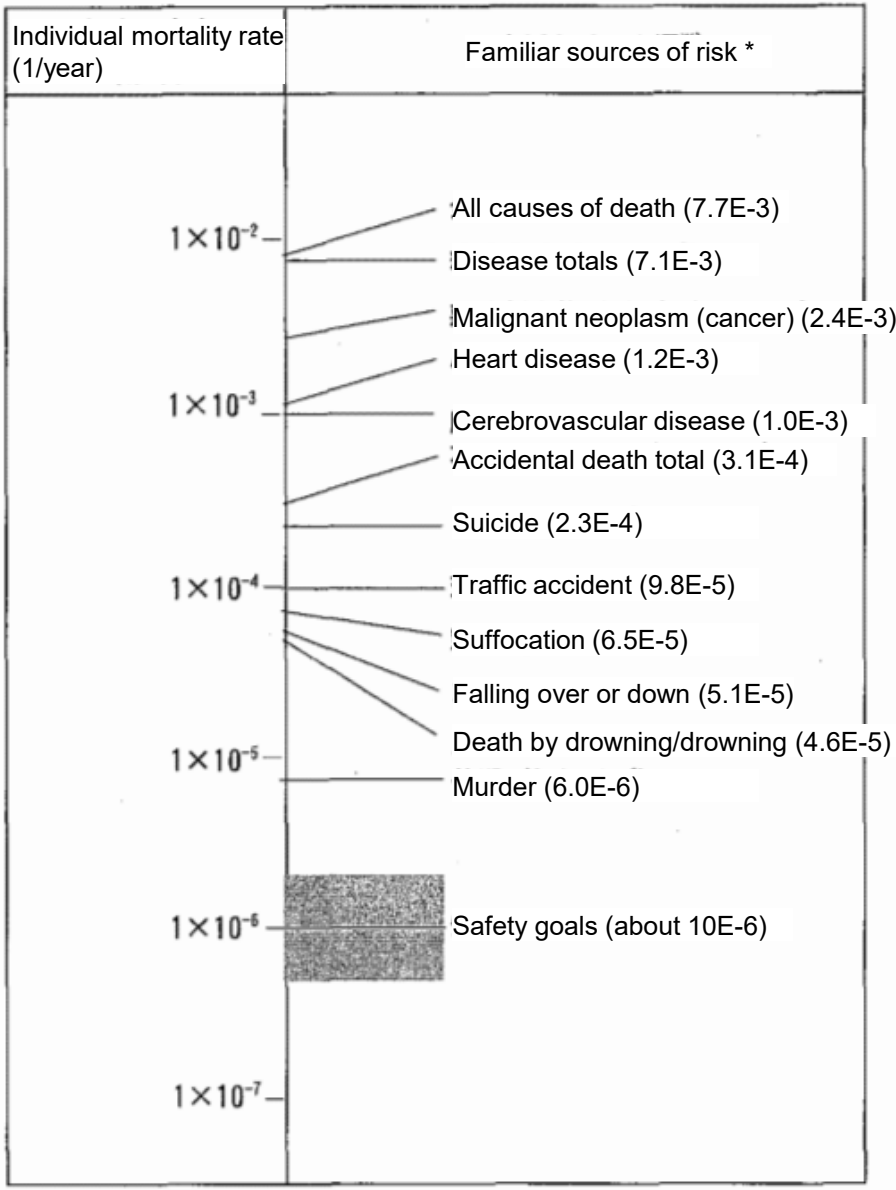
The average individual acute mortality risk of those in the proximity of site boundary caused by radiation exposure from accident at a nuclear facility should be suppressed to levels which does not exceed approx. one out of a million per year.

The average individual mortality risk of persons at set distance from the site caused by cancer from radiation exposure from accident at a nuclear facility should be suppressed to levels which does not exceed approx. one out of a million per year.

Explanation: "Should be suppressed to levels which does not exceed approx. one out of a million per year" implies that, "in the design, construction and operation of nuclear power facilities, risk reduction measures are planned and implemented as much as reasonably possible to prevent subject risk from exceeding one out of a million per year." This means that if necessary measures are planned and implemented, if the risk evaluation result exceeds the one out of a million per year, it does not immediately conclude that subject goals are not being conformed with.

OVERVIEW OF "INTERIM SUMMARY ON SURVEY AND REVIEW STATUS OF SAFETY GOALS" BY THE JAPAN NUCLEAR SAFETY COMMISSION, SPECIAL COMMITTEE ON SAFETY GOALS

- When comparing the individual annual mortality rate from Japan's 2001 data on vital statistics mortality rate with the risk standards in the proposed quantitative goals, risk levels presented in the quantitative goals is about 1/8,000 of the public individual mortality rate (mortality rate of all causes of death).
- The acute mortality risk is about 1/300 (0.3%) of the mortality rate due to accidental death, and the cancer mortality risk is about 1/2000 (0.05%) of the mortality rate due to cancer.
- Proposed quantitative goals are at adequately low levels compared to risk involved in daily life.



*Source: 'Vital Statistics' (Ministry of Health, Labour and Welfare) 2001 data

JAPAN NUCLEAR SAFETY COMMISSION, SPECIAL COMMITTEE ON SAFETY GOALS OVERVIEW OF PERFORMANCE METRICS (PART 1)

Regarding performance metrics of commercial light water reactor facilities －Performance metrics responding to proposed safety goals － 2006

- Performance metrics are defined as supplementary goals to determine conformance with safety goals, and for indicators of performance metrics, indicators with focus on characteristics of power reactors shall be selected.
- The two items below shall be used jointly.
  - Indicator 1. Core Damage Frequency (CDF): It is rational to consider the core damage frequency (CDF) which would release radioactive material housed in the core as the risk source
  - Indicator 2. Containment Failure Frequency (CFF): It is rational to consider CFF because release of radioactive material into the environment can be suppressed to extremely low levels if the most outer protective function of power reactors, such as CV, can be secured.

JAPAN NUCLEAR SAFETY COMMISSION, SPECIAL COMMITTEE ON SAFETY GOALS
OVERVIEW OF PERFORMANCE METRICS (PART 2)

- The condition for applying performance metrics to power reactor as indicator is for both items below to be satisfied simultaneously.
  - Indicator value 1. CDF approx. 10^{-4}
  - Indicator value 2. CFF approx. 10^{-5}
- Comparison between performance metrics and results of risk assessment shall implement the mean value derived from assessing size of uncertainty.
- Using CFF as an indicator would prevent reduction effect of source term such as deposits in the CV from being applied; therefore, CFF would be a largely conservative and strict indicator. Also, it would include LERF and LRF, making the indicator easy to understand.

JAPAN NUCLEAR SAFETY COMMISSION, SPECIAL COMMITTEE ON SAFETY GOALS
OVERVIEW OF PERFORMANCE METRICS (PART 2)

- Derivation
  - A source term was assumed for a large-scale accident involving loss of containment functions of C/V which could cause acute mortality or mortality by cancer to the surrounding population. Furthermore, meteorological data and population distribution data of the assumed site is used, conservative assumption is established regarding emergency preparedness measures, its effectiveness evaluated and a conservative conditional mortality rate equivalent to upper limit was estimated.
  - Conservative bias was confirmed based on conditional mortality rate assumed from L3PRA results (JNES) of domestic representative plant. Based on this conditional mortality rate (approx. $2\text{-}3 \times 10^{-2}$), a CFF indicator value of approx. 10^{-5}/year was derived which accounts for further margin of (10^{-1}).
  - CFF=CDF×CCFP (Conditional Containment Failure Probability). If risk to the public is the same, it is preferable for accident frequency resulting in core damage to be lower, and based on the principle of not placing excess dependency on the C/V, the CDF indicator value shall be approx. 10^{-4}/year.

DISCUSSION IN THE NUCLEAR REGULATION AUTHORITY

[2013 Nuclear Regulation Authority]

- Detailed results of review conducted by the former Japan Nuclear Safety Commission, Special Committee on Safety Goals is adequate for serving as a foundation for discussion of safety goals by the Nuclear Regulation Authority.
- Safety goals are to be achieved while the Nuclear Regulation Authority conducts regulation of nuclear power facilities.
- The "CDF approx. 10^{-4}/year" and "CFF approx. 10^{-5}/year" discussed in details at the Japan Nuclear Safety Commission, Special Committee on Safety Goals is adequate for serving as a foundation for discussion of safety goals by the Nuclear Regulation Authority.
- However, considering the Fukushima Daiichi Accident, there is a need to incorporate the perspective of environmental contamination of radioactive materials into safety goals to minimize the environmental impact in the unlikely event of an accident. Specifically, it shall be added for nuclear reactors that the frequency of an accident which releases amount of Cs137 exceeding 100TBq should be suppressed to not exceed approx. once/one million reactor years, excluding terrorist attacks, with reference to examples from other countries around the world.

Note: Total amount of Cs137 (half-life approx. 30years) released during 1F accident was evaluated at approx. 10,000TBq.

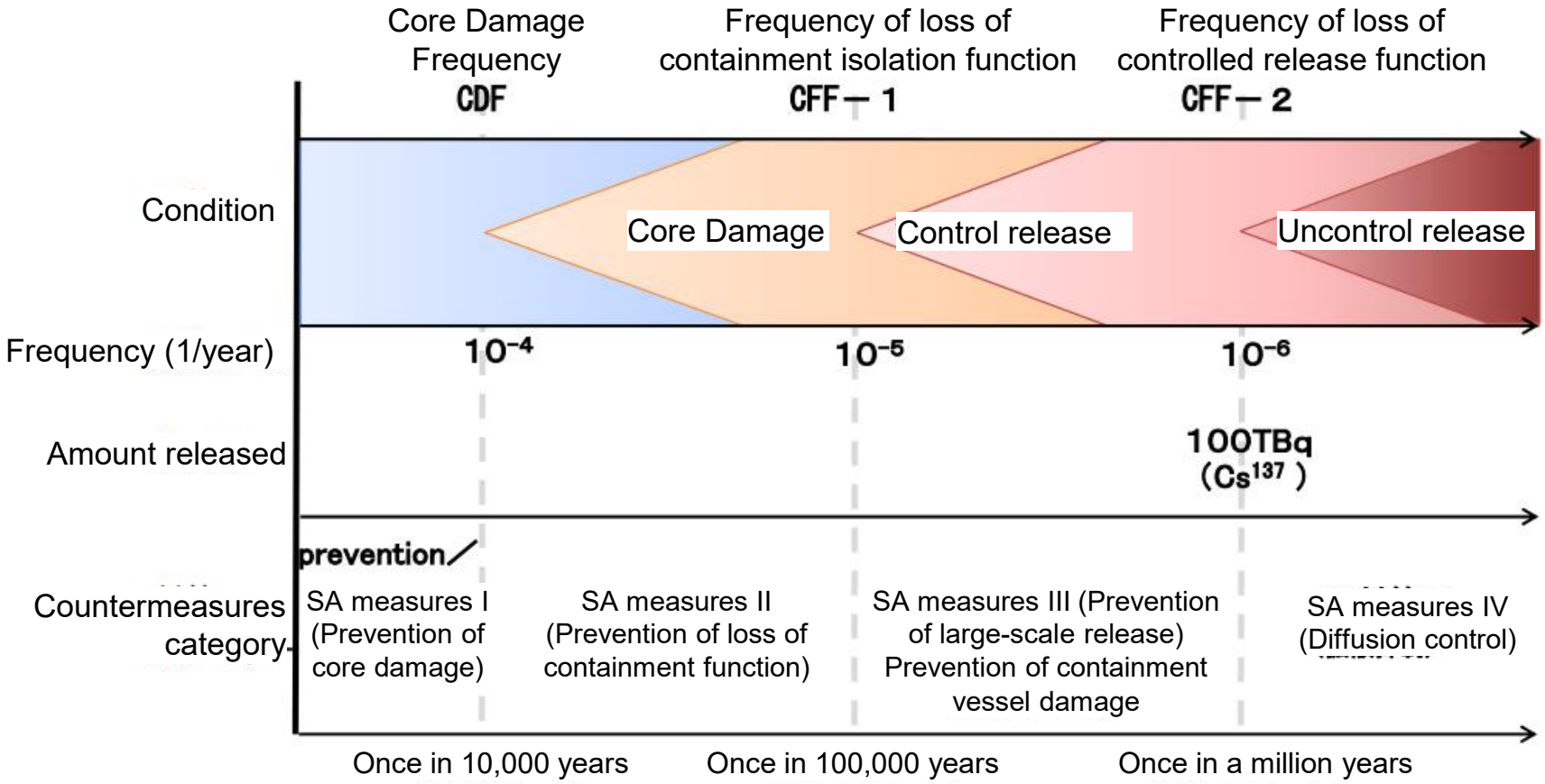
DISCUSSION IN THE NUCLEAR REGULATION AUTHORITY

[2018 Discussion at Nuclear Reactor Safety Examination Committee, Nuclear Fuel Safety Examination Committee]

- Safety goal is to be referred to for establishment of regulatory requirements by the Nuclear Regulation Authority, and changes according to the social situation.
- The relationship between safety goals and safety levels must be discussed regarding various safety related perspectives such as safety margin, results of effectiveness evaluation of defense in depth using deterministic methods, operation experience, organizational factors, etc., in addition to the results of probabilistic risk assessment.
- Initiatives should be continued for establishing a regulatory system based on graded approach which is consistent with risks.
- In view of the implementation of back-fitting rules, safety goals currently should be applied to all power reactors without distinction.
- It is necessary to discuss safety goals while including nuclear fuel cycle facilities in addition to nuclear reactors.

SAFETY GOAL OF THE JAPANESE NUCLEAR SAFETY COMMISSION AND THE NUCLEAR REGULATION AUTHORITY

Relationship between the amount of radioactive material released and the frequency of occurrence (conceptual diagram)



Source: Nuclear Regulation Authority, "FY2013 1st Nuclear Regulation Authority Material 6-2, Relationship Between Amount of Radioactive Material Released and Frequency of Occurrence (Concept Figure)", April 3, 2013

REGULATORY POSITION REGARDING SAFETY GOALS IN JAPAN

- Safety goals have not yet been officially established in Japan.
- Performance metrics were reported to the Japan Nuclear Safety Commission, and performance metrics were reviewed and recognized as being important for manifesting activities for risk informed approach.
- The Nuclear Regulation Authority agrees to the following points.
  - Safety goals are to be achieved while the Nuclear Regulation Authority conducts regulation of nuclear power facilities.
  - Results of review conducted by the Japan Nuclear Safety Commission, Special Committee on Safety Goals are adequate for serving as a foundation for discussion of safety goals by the Nuclear Regulation Authority.
  - “The frequency of an accident which releases amount of Cs137 exceeding 100TBq should be suppressed to not exceed approx. once/one million years”, shall be added.

    →Safety improvement assessment submission
  - Should be applied to all power reactors without distinction.
  - Other topics (distinction between newly constructed plants and existing plants) shall continue to be reviewed in the future.

PROBABLE REASONS WHY SAFETY GOALS HAVE NOT BEEN OFFICIALLY ESTABLISHED IN JAPAN

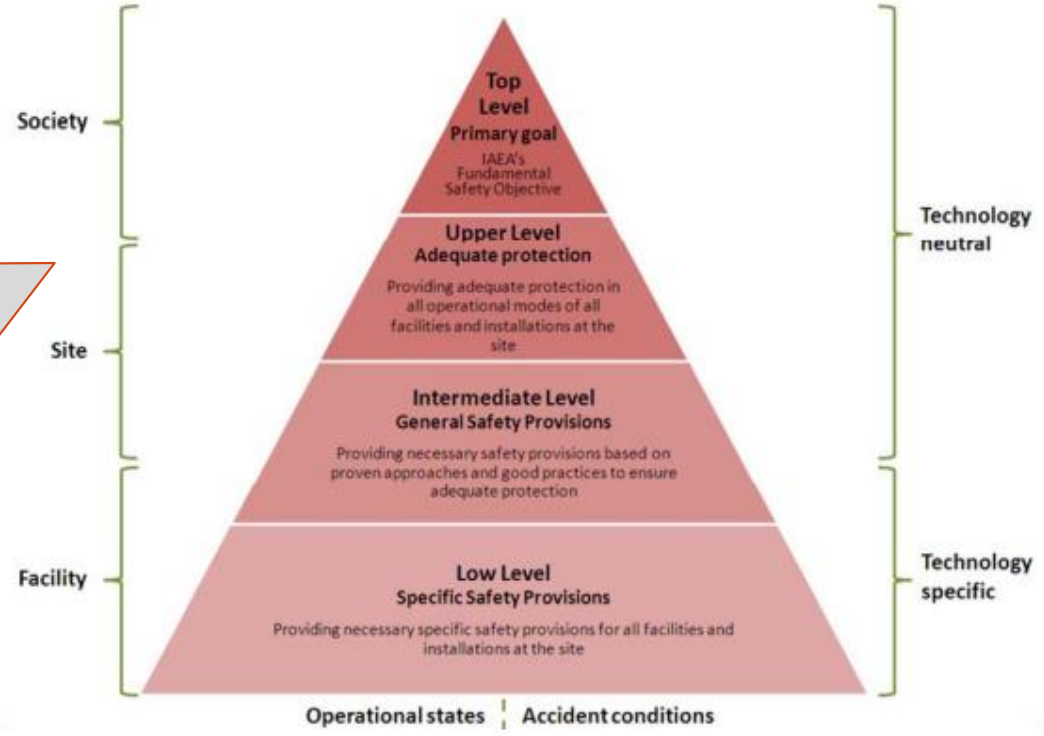
Items necessary for future discussion which reflects individual opinions based on past domestic comments and documents.

- When assessing the impact of the human body for mortality risk, etc., collective dose evaluation was considered difficult 20 years ago, but does this still apply?
- Setting mortality as the goal may cause misunderstandings in society.
- While countries like the U.S. and the U.K. clearly sets, presents and implements safety goals, some countries like France uses PRA results without setting safety goals.
- Safety goals not included in legislation cannot be used in legal matters.
- Misunderstanding safety goals/performance metrics as criteria for judging pass/fail of plant will not result in normal safety activity.
- Is practical application of L3 PRA and external event PRA really difficult?
- Discussions regarding safety goals tend to focus on acceptability of evaluations, etc., but discussions should focus on ”what is safety” and the ideal state for the use of nuclear power.

OVERVIEW OF RESEARCH PAPER BY THE YAYOI RESEARCH GROUP, ATOMIC ENERGY SOCIETY OF JAPAN

- Reference for answering the question “How safe is safe enough?” from a technical and social perspective.
- IAEA SF-1 requires ”safety to be secured without unreasonably limiting operation and activity of facilities with risk of radiation exposure.
- Hierarchal structure of IAEA TECDOC-1874

  - Thinking of safety goals for practical indicators for the purpose of nuclear safety as hierarchal structure is feasible.
  - Qualitatively clarify relationship between goals between levels.



IAEA HIERARCHAL STRUCTURE OF SAFETY GOALS

Relevant scope	Level	Overall Objective	Description	Relationship to Technology
Society	Top Level Primary goal Unambiguous safety goals	Protecting people and environment from the harmful effects of ionizing radiation	Fundamental safety objective as set out in IAEA SF-I and society level safety goals as defined in national legislation or regulations. The safety goals at this level are society-wide and technology neutral.	Not dependent on technical aspect
Power station	Upper Level Upper goals Adequate protection	Ensuring adequate protection in all states for all facilities and installations at the site	Interpretation of the Top Level safety goal in terms that are defined in more detail at the Intermediate and Low Level. The safety goals at this level are typically technology neutral and have a site-wide scope. They cover operational states and accident conditions. E.g. Risk in society; for example, expressed in comparison with mortality risk of other energy sources.	
	Intermediate Level General safety provisions	Providing general safety provisions including technical and organizational measures based on proven approaches and good practices to ensure adequate protection	Formulation of proven approaches and good practices to achieve the higher level safety goals as well as definition of general requirements on site level. The safety goals at this level are still largely technology neutral and site-wide. E.g. • Overall power station LERF(Large early release frequency) • Capabilities on the power station level regarding external hazards	
Facility	Low Level Specific safety provisions	Providing specific safety provisions for each facility and installation at the site to ensure adequate protection	Formulation of technology and facility specific safety goals aimed at assuring that each nuclear facility at the site effectively contributes to meeting the higher level safety goals. E.g. • Deterministic safety goals: Such as DBA cladding max temperature control value, etc. • CDF, LRF(Large release frequency) • SSC (Structure, System, Component) reliability	Dependent on specific technical aspects.

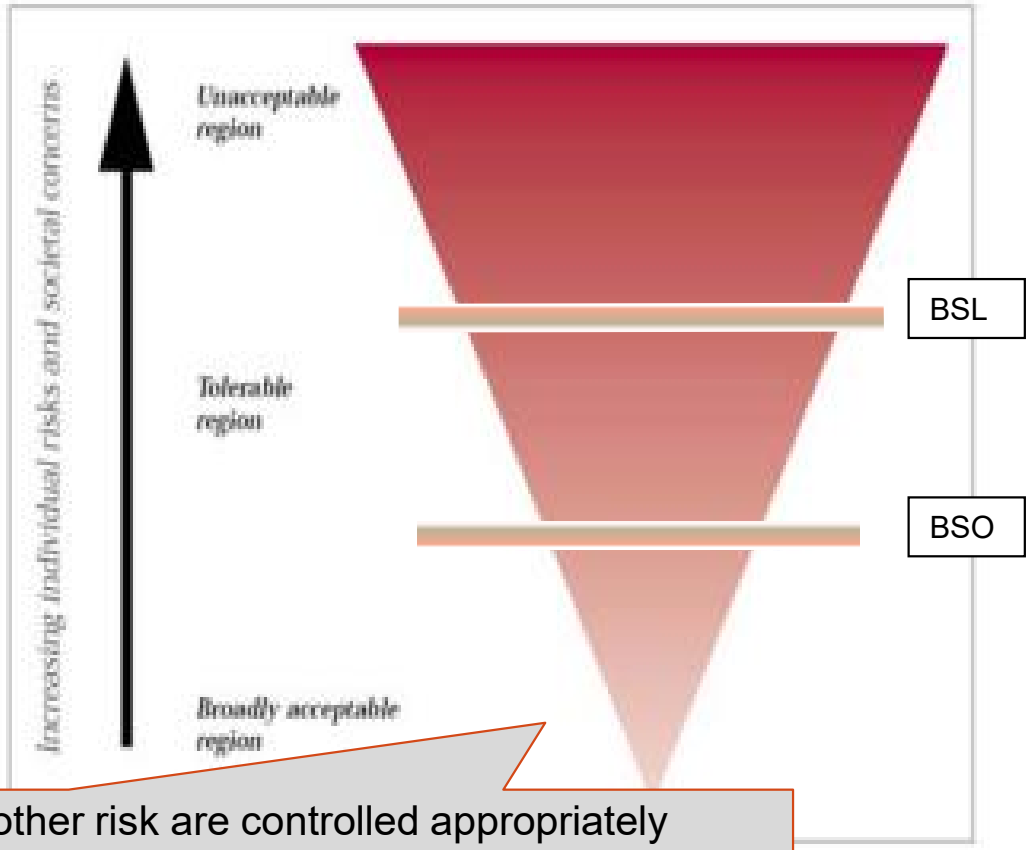
RISK CRITERIA

Framework presented by the U.K. Health and Safety Executive (HSE)

Framework consists of following three regions:

① Unacceptable region
② Tolerable region
③ Broadly acceptable region

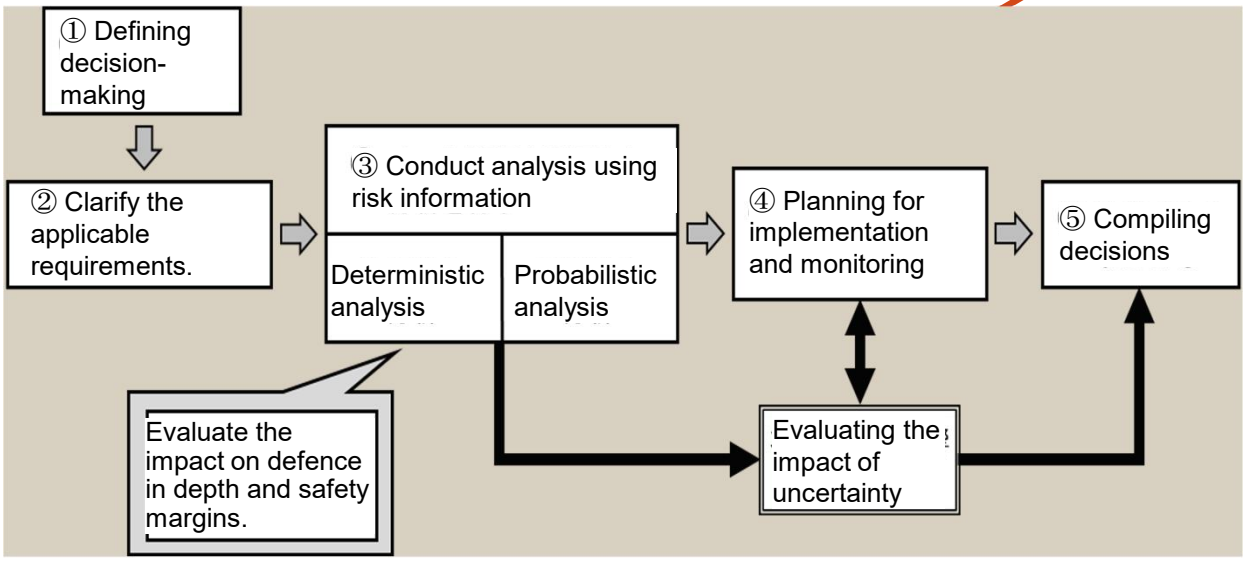
- Upper limit where further risk is unacceptable under any circumstance (boundary between ① and ②) Basic Safety Level (BSL)
- Lower limit where risk below subject level is broadly acceptable (boundary between ② and ③) Basic Safety Objective (BSO)
- Tolerable levels in between are decided based on the principle of "As low as reasonably practicable (ALARP)"



- Reasonable safety is when BSL is satisfied and other risk are controlled appropriately based on ALARP.
- The carrot diagram of the three regions allows review of measures against excess investment of resources despite levels being below BSO.
- Public individual mortality risk BSL 10^{-4}/year, BSO 10^{-6}/year
- BSL and BSO are not thresholds of nuclear safety.

RISK INFORMED DECISION MAKING

- RIDM is not about comparing PRA results with performance metrics.
- As in indicated in IAEA INSAG 25 and Atomic Energy Society of Japan IRIDM standards, RIDM/IRIDM is decision making based on multiple perspectives which includes regulatory requirements, experience, deterministic knowledge, probabilistic knowledge, economic elements, etc.



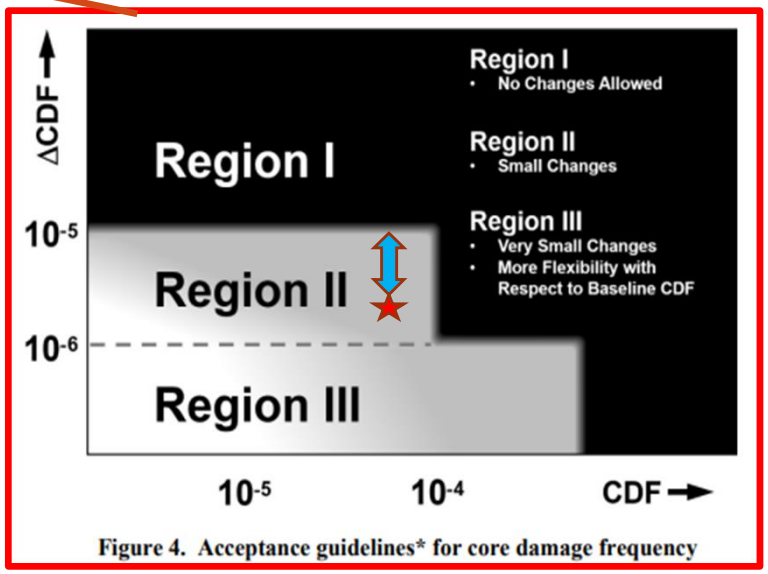


Figure 4. Acceptance guidelines* for core damage frequency

R.G.1.174 Rev3

Risk informed approach is not determined only from PRA results

NRC NUREG-1855 Rev1"Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision-making Final Report"

WHAT'S NEEDED IN FUTURE SAFETY GOAL DISCUSSIONS

Topics to be reviewed.

- Are safety goals necessary?
- If necessary, for what purpose?
- Who should establish it and how? What changes will be made from the current status?
- Can it be used in regulation, safety activities of operators, in legal matters?
- What are the current issues? (resulting from interim report of the Japan Nuclear Safety Commission and discussion with Nuclear Regulation Authority)
- What is the relationship between safety goals (including performance metrics) and the risk informed approach?

- Discussion of safety goals should not only consist of mortality risks and risk evaluation methods, but also on how to reasonably achieve nuclear safety and how to set metrics and standards for achieving this.
- Discussion of nuclear safety goals requires healthy communication with society. Communication should not only be for gaining understanding from the society, but also for receiving criticism and comments, and providing explanations which could also include countering arguments.

THANK YOU FOR YOUR ATTENTION