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Risk Management

Consistency of Judgement in the Usage of Probabilistic Safety Goals

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Project overview

Nordic project "The Validity of Safety Goals"

NKS (Nordic Nuclear Safety Research)

NPSAG (Nordic PSA Group)

SAFIR (Finnish NPP safety research programme)

Co-operation with OECD/NEA WGRisk task 2006(2)

2006 — BASIS — PHASE 1

- Concepts
- Decision Theoretic Background
- Evolvement of Safety Goals
- Experiences from Application and Interpretation
- Limited International Overview
- Issues for Further Analysis
  - Use of Safety Goals in Decision Making
  - Ambiguities in Definitions of Safety Goals
  - Treatment of Uncertainties in the Application of Safety Goals
  - Ambiguities in the Scope of Safety Goals
  - Safety Goals on Different Levels
  - Safety Goals for New/Operating Plants

2007 — ELABORATION — PHASE 2

- Consistency in Usage of Safety Goals
- Criteria for Assessment of Results from PSA Level 2
- Safety Goals Related to Other Man-Made Risks in Society
- Expansion of International Overview
  - WG Risk Task on Safety Goals

2008 — GUIDANCE — PHASE 3

- Use of Subsidiary Criteria
- Use of Probabilistic Analyses in Support of Deterministic Safety Analysis
- Expansion of International Overview
  - WG Risk Task on Safety Goals
- Guidance for
  - Formulation
  - Application
  - Interpretation

OECD NEA WG Risk
"Probabilistic Risk Criteria for NPPs"

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What is a probabilistic safety goal?

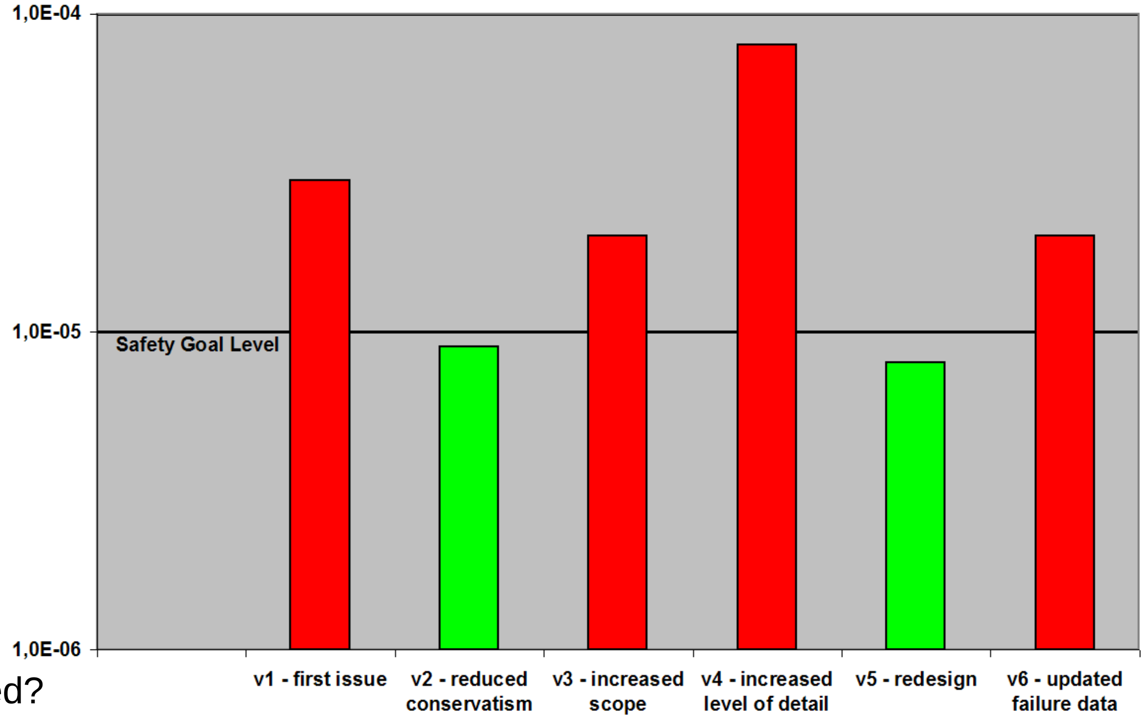
- **Lots of alternative formulations**
  - Risk/Safety limit/criteria/target/objective
  - … sometimes (but not always) synonyms
- **Main elements**
  - **Probabilistic**
    - The frequency or probability to be achieved/demonstrated/aimed for
  - **Safety**
    - The risk metric (fatalities, core melts, system failures, etc.)
  - **Goal**
    - ... vague... (voluntary/mandatory; limit/objective, etc.)
- **Also needed**
  - …but usually receiving less attention
  - Definition of **scope of plant model** and of procedure to calculate risk level to be compared ("Target PSA")
  - **Procedure for applying** the goal and acting on the outcome of the comparison (goal met / goal violated)

Summary of Swedish safety goals

Authorities	Vattenfall	Sydkraft / EON
1985 Core damage - Release ”Extremely unlikely” release of more than 0,1 % of the inventory of the cesium isotopes Cs-134 and Cs-137 in a core of 1800 MWt. ➔ Often interpreted as f(LR) < 10^{-7}/year	1990 Core damage 10^{-5}/year with a high degree of confidence Release 10^{-7}/year for a release involving more than 0,1% of the core inventory of substances causing ground contamination.	1995 Core damage 10^{-5}/year Release 10^{-7}/year for release involving more than 0,1% of the core inventory excluding noble gases.
	2006 Core damage 10^{-5}/year for core damage Release 10^{-7}/year for a release involving more than 0,1% of the core inventory of substances causing ground contamination	2006 Core damage 10^{-5}/year for severe core damage Release Frequency of release involving more than 0,05-0,1% (depending on thermal effect) of the core inventory excluding noble gases shall be considerably lower than 10^{-5}/year.

Starting point

- **Long experience with PSA**
  - Gradual increase of scope and level of detail since early 1980:s
  - Today's PSA:s are more or less complete



- **Safety goals not possible to fulfill?**
  - Safety goals outlined in the 1980s hard to achieve for operating plants.
    - NRC/IAEA - 10^{-4} per year for CDF (Core damage frequency)
    - Swedish utilities - 10^{-5} per year for CDF
- **This has aroused confusion!**
  - What safety goals should be applied?
  - Is the risk level of the plants too high?
  - Are PSA:s too conservative?
  - Are safety goals applied in an incorrect way?

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Some conclusions so far...

- **Status of safety goals in decision making**
- Ambiguities in the definition of safety goals
- Ambiguities in the scope of safety goals
- **Relationship between goals on different levels**
- **Consistency in judgement when applying safety goals**

Status of PSA safety goals in decision making
Opinions about use of safety goals [interviews]

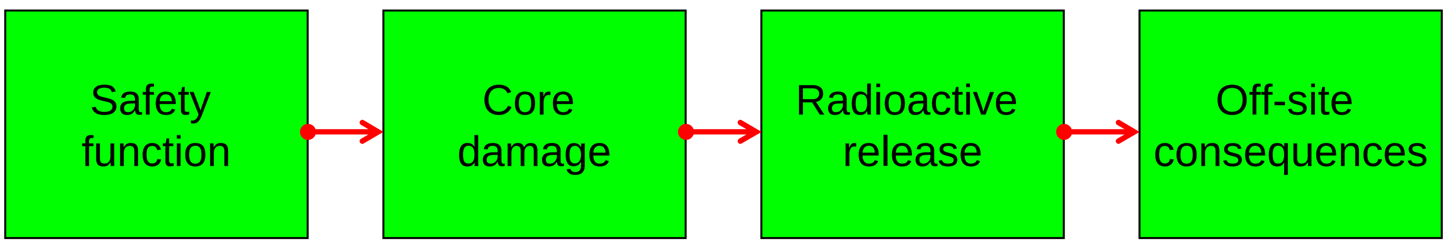
- **Most are in favor of informal use of safety goals**
  - uncertainties in the methodology
  - possibility for flexible handling of risk
- **Strict application of safety goals may switch attention to fulfillment of safety goals instead of open-minded assessment of safety**
- **Concern that very strictly applied safety goals could lead to**
  - unreasonable requirements on safety improvements
  - “manipulation” of results

Status of PSA safety goals in decision making
Handling of violations [interviews]

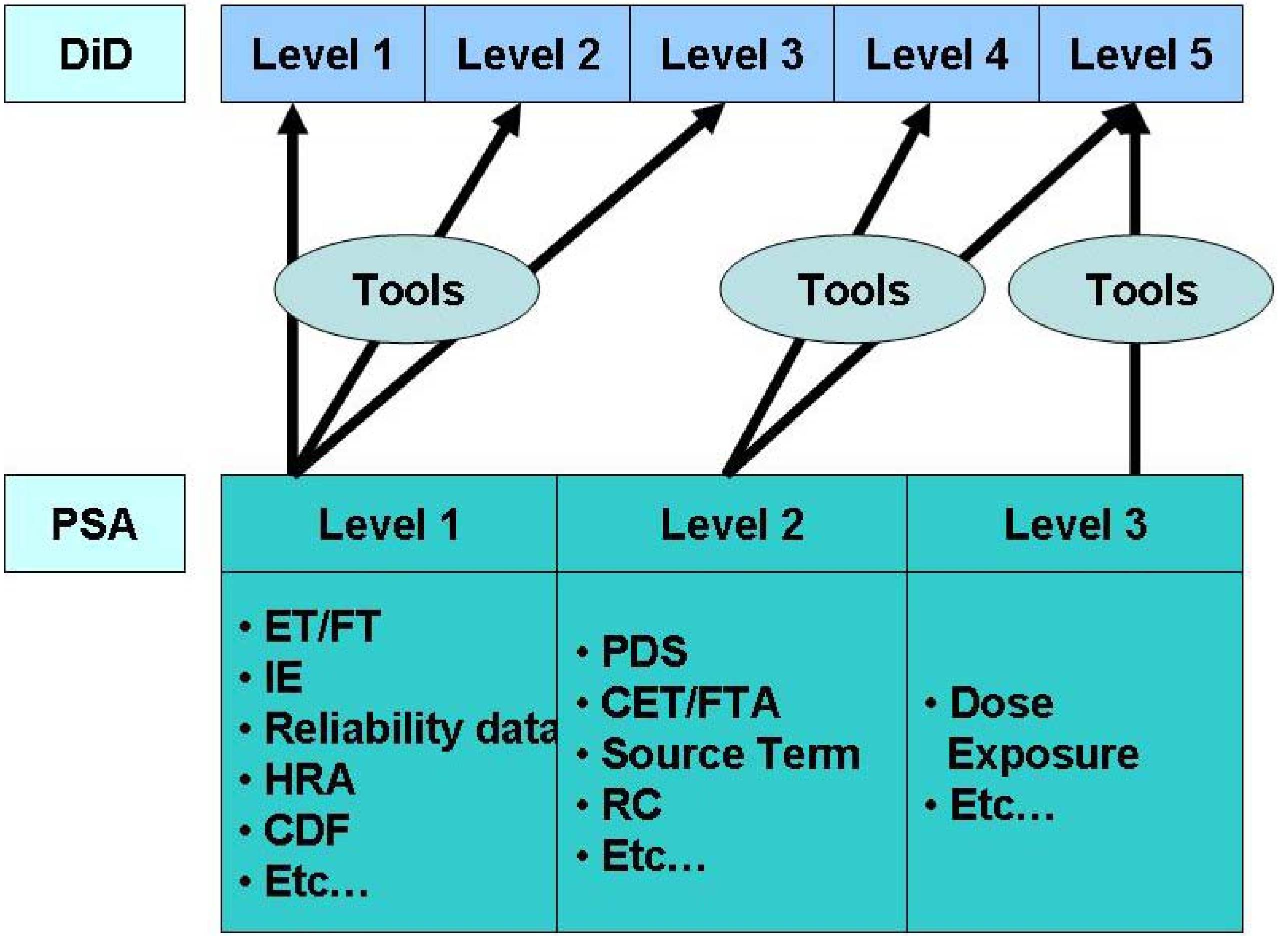
- **If goals are used, rules for violations should be defined/discussed**
- **Quite formal procedures for PSA safety goals in place at all Swedish plants, but not strictly enforced**
  - PSA results have often exceeded safety goals
  - Implicitly, a graded approach has been applied
    - the IAEA-goal CDF = 1E-4/yr is a limit
    - the own goal CDF = 1E-5/yr is a target
- **In Finland, utility goals for operating plants are informal and desired targets**
- **Exceedence of safety goal is a trigger for investigation and prioritisation.**

Levels of Safety Goals

- **Important aspects of risks from nuclear power plants**
  - Health risk to people (individual/collective)
  - Risk of long-term contamination (evacuation, land use)
- **Accidents with significant off-site damage are extremely rare**
- **Levels of safety goals**
  - Off-site consequences (corresponds to PSA level 3)
  - Radioactive release from plant (corresponds to PSA level 2)
  - Core damage in plant (corresponds to PSA level 1)
  - Loss of important safety function (ECCS, RHR, scram, containment isolation)



Assessing DiD levels with PSA?



Consistency in judgement when applying safety goals

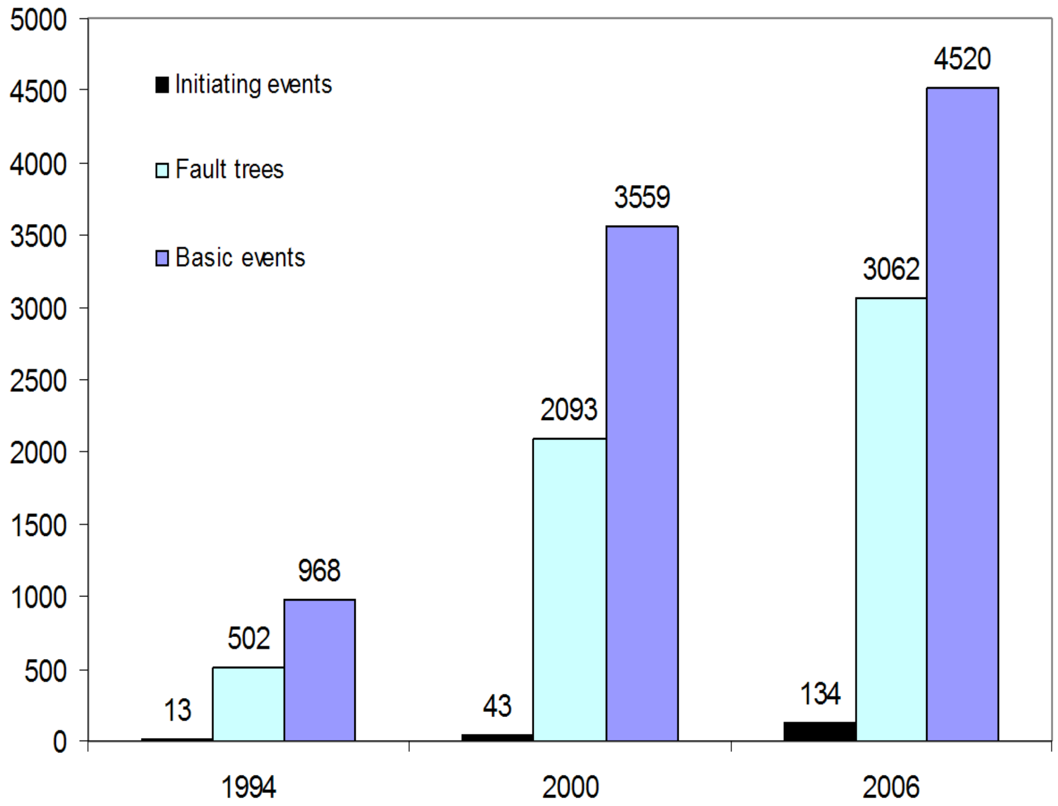
Consistency over time

- **Same safety goals applied to specific plant at different points in time**
- **Perceived to be one of the main problems in the usage of safety goals**
- **Limited comparative review performed of three generations of the same PSA**
  - Forsmark 1 (ASEA-Atom BWR commissioned in 1980)
  - PSA versions from the years 1994, 2000 and 2006
  - During these years, the PSA increased considerably in scope and level of detail.
  - Comparison restricted to a scope corresponding to the 1994 PSA (mainly internal events)

Development of the F1 PSA over time

- **CDF differed quite considerably over the years:**

  1994 8,2E-06/year
  2000 2,4E-05/year
  2006 7,8E-06/year



Consistency in judgement – Aspects analysed

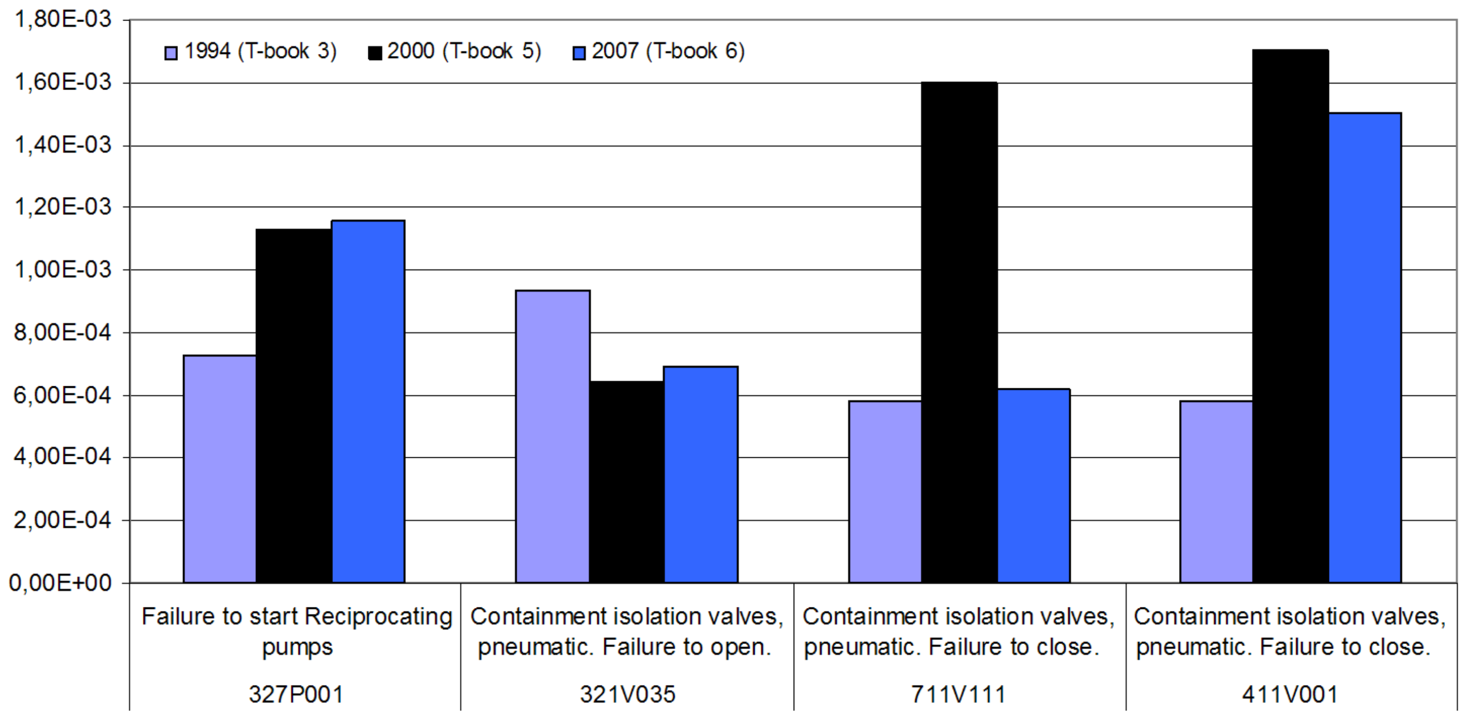
- Cut-off in PSA quantification
- Changes in component failure data
- Changes in initiating event frequency
- Conditional CDP (disregarding IE frequency)
- Changes in modelling of the plant, including plant changes and changes in success criteria

Cut-off in PSA quantification

- **Comparison of quantification results with original cut-off and new cut off was performed**
  - Absolute cut-off 1E-12 and relative cut-off 1E-6
- **In some cases this had a noticeable influence**
  - Mainly cases with CDF results close to the cut-off limit
- **On total level the CDF influence is less than 1%**

Changes in component failure data

- **Data derived from T-book (Nordic Reliability Data Book)**
  - T-book versions 3, 5 and 6
- **Data for a number of components were compared**



Changes in initiating event frequency

- **Transient frequencies**
  - Largely based plant operating experiences, i.e., differed only slightly between the years.
  - Part of the transients were modelled as CCI events in the 2000 and 2006 versions of the PSA, and some of these made large contributions to the total CDF.
- **LOCA frequencies**
  - Based on WASH 1400 in all three PSA:s
  - PSA results differed considerably because LOCA events were split up into more and more detailed break locations, with more specific damage modelling.
- **Loss of external power modelled in all three PSA:s with very differing total impact**
  - Basis for modelling the event different in all three PSA:s.

Conditional CDP (disregarding IE frequency)

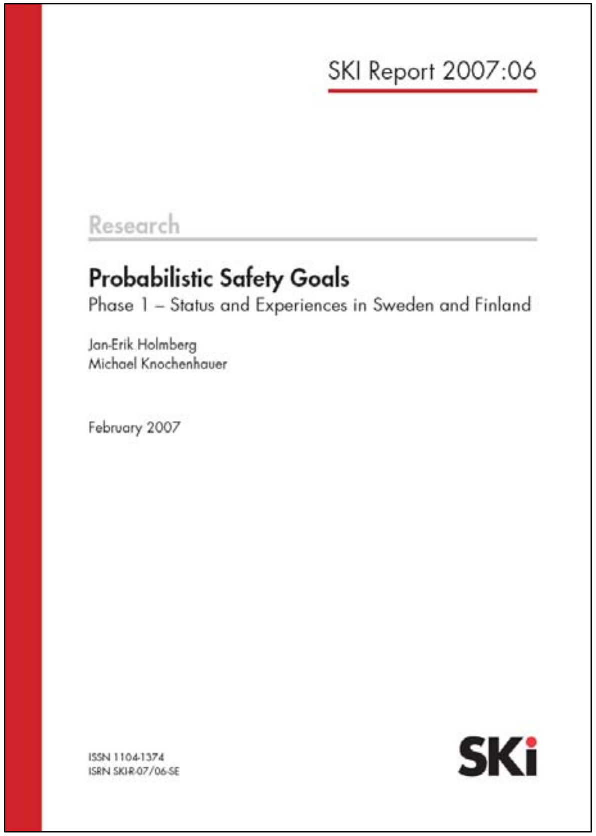
- **Eliminates the impact from differences over time in IE frequency**
- **Comparison made of CCDP for every group of initiating events.**
- **Large differences were identified, due to e.g.**
  - Data changes
  - Changes in success criteria for safety systems
  - More realistic modelling of the impact of failures
  - More realistic modelling of the impact of initiating events (CCI).

Conclusion from comparison

- **Very time-consuming to correctly identify the basic causes for changes in PSA results**
  - A multitude of different sub-causes were combined and difficult to differentiate.
- **Rigorous book-keeping needed to keep track of how and why results change**
  - Especially important in order to differentiate “real” differences (plant changes, new component and IE data) from differences that are due to general PSA development (scope, level of detail, modelling issues).
  - This is becoming part of normal updating procedures.
- **Insufficient book-keeping for the analysed PSA**
  - PSA as a technique was quickly developing over the studied time period
  - Previous PSA version was always considered to be kind of a draft version of the PSA that was currently being developed

Project reports

- **Phase 1 (2006)**
  - Issued as SKI report 2007:06
- **Phase 2 (2007)**
  - Interim report issued by NKS (May 2008)
- **Phase 3 (2008)**
  - To be issued as SKI report (May/June 2009)


SKI Report 2007:06

Research

Probabilistic Safety Goals

Phase 1 – Status and Experiences in Sweden and Finland

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