Beyond Design Basis Analysis:

Developments in UK's Approach and Perspective

IAEA International Expert's Meeting on Severe Accident

Prof. Ali Tehrani

Principal Inspector – Nuclear Safety

March 2014

Office for Nuclear Regulation

An agency of HSE

Overview

- Brief overview of UK's post-Fukushima response
- Explore and compare UK's 3 types of Fault Analysis Methods: Risk assessment→ F/S→ PSA → Severe Accidents Analysis
- Focus of severe accident analysis and output of the analysis
- A methodology proposed for SAA
- Stimulate thinking and discussion!

Background

- From discussions with other International Regulators and ENSREG Stress Tests: It appears that we do not all have a common understanding
- Believe better Severe Accident Management (SAM) from better Severe Accident Analysis (SAA) will be the lasting legacy from Fukushima

UK Post-Fukushima Response

- Three “Weightman Reports”
  - Implications
  - Implementation
- ENSREG Stress Tests
  - Including for non-NPPs
- In present (SAA / SAM) context:
  - Has focussed minds on need for better SAA and SAM
  - New guidance (SAPs and TAGs) are being developed

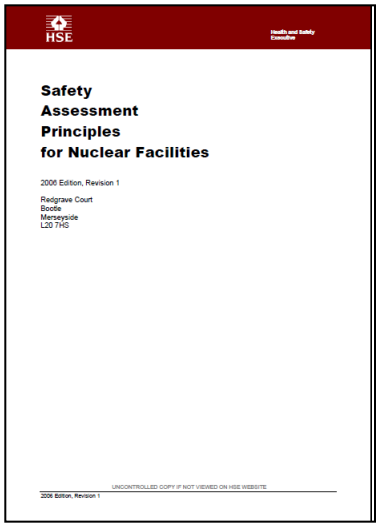
Office for Nuclear Regulation

An agency of HSE

UK's Three Fault Analysis Methods

- Guidance provided to Inspectors on risk assessment in Safety Assessment Principles (SAPs)

http://www.hse.gov.uk/nuclear/saps/



Safety assessment principles for nuclear facilities		
General		
Fault analysis: general	**Design basis analysis, PSA and severe accident analysis**	**FA.1**
Fault analysis should be carried out comprising suitable and sufficient design basis analysis, PSA, and severe accident analysis		

Complementary Approach - Fault Analysis

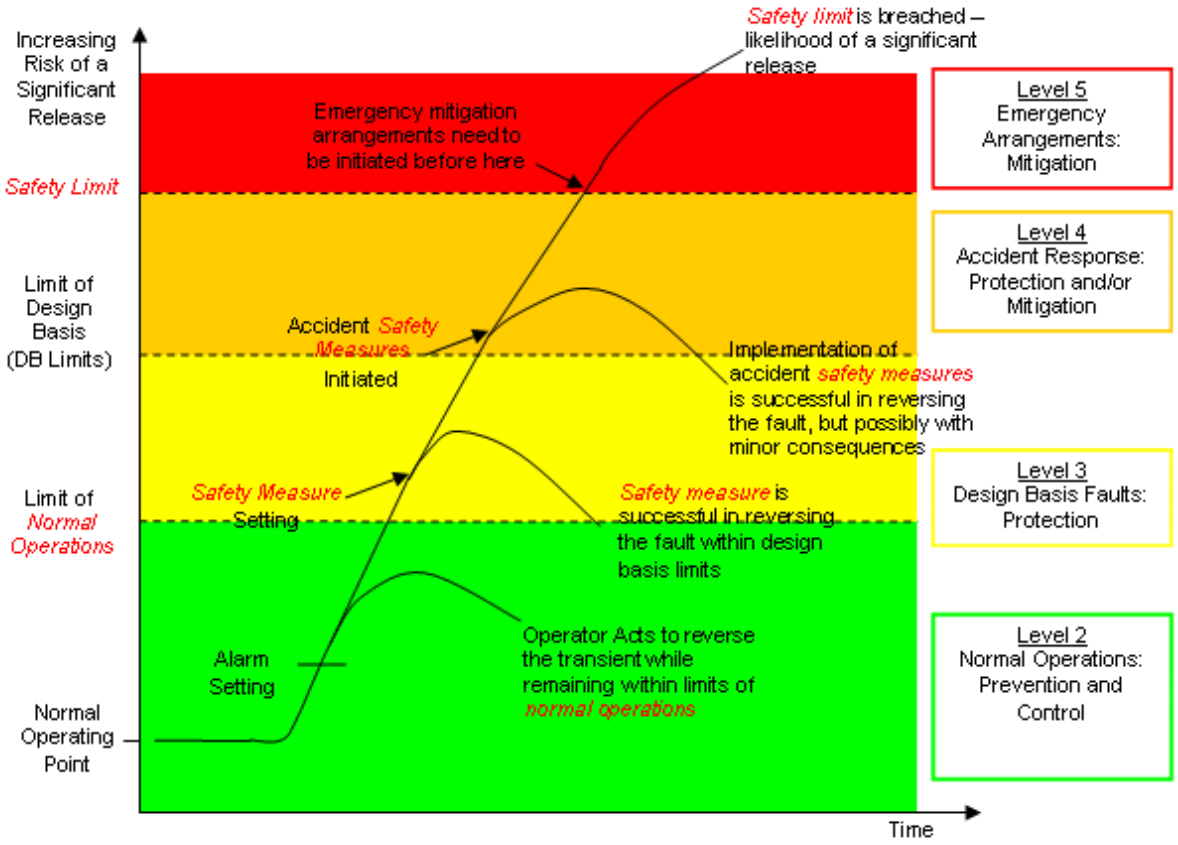
- Three complementary approaches designed to ensure nuclear Fault Analysis is adequate in its totality:
  - DBA: Design Basis Accident Analysis

    to ensure the design is robust, fault tolerant and has effective safety measures
  - PSA: Probabilistic Safety Analysis

    to ensure overall risks are acceptable and balanced; and to understand strengths, weaknesses and inter-dependencies in the overall design
  - SAA: Severe Accident Analysis

    to ensure provision and planning for severe but unlikely faults (accidents)

DBA, PSA and SAA Compared



Schematic Illustration of Defence in Depth Approach to Operating Rules

DBA, PSA and SAA Compared

- Different Scopes:
  - DBA: All sequences with IEF>$10^{-5}y^{-1}$, excluding those that fail to meet consequence thresholds
  - PSA: All sequences down to very low IEFs (~$10^{-7}y^{-1}$)
  - SAA: States with offsite consequences > 100mSv (conservatively assessed)

What is a Severe Accident?

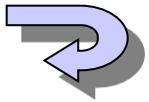
IAEA NS-G-2.15:

*A Beyond Design Basis Accident comprises accident conditions more severe than a design basis accident, and may **or may not** involve core degradation, such accidents are termed severe accidents.*

ONR's SAPS para. 543 ***(Guidance for ONR inspectors)***

' fault sequences beyond design basis that have the potential to lead to a severe accident … FA16'

Severe accidents are those faults that have the potential to lead **EITHER** *to consequences exceeding the highest radiological doses (>100 mSv to Public, >500 mSv to Workers)* **OR** *unintended relocation of radioactive material within the facility which places demand on the integrity of the remaining physical barriers.*

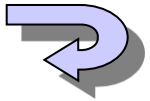


TECHNOLOGY NEUTRAL

Output of the Analysis: Safety Enhancement

WENRA, Harmonization of Reactor Safety

Principle: *Consideration shall be given … to selection of severe accidents, to determine those sequences for which reasonable practicable preventive or mitigatory measures can be identified (accident vulnerability study); combination of **engineering judgement** and **probabilistic methods** can be used and evaluations be made on a **best estimate basis***



(a) Instrumentation and hardware provisions

(b) Emergency operating procedures for management of severe accidents

- Equipment
- Instructions
- Training

DBA, PSA and SAA Compared

- SAA: Three types of states considered:
  1. High consequence scenarios of low frequency beyond the design basis;
  2. Design basis scenarios where the safety provisions are assumed to fail; and
  3. Scenarios traditionally not covered by UK safety cases such as malevolent acts, leading to high consequences.

DBA, PSA and SAA Compared

- Logic is that if you are operating a facility with a hazard where the accident consequences are of national (international) significance (e.g. affects GDP),
  - You should at least have a good plan for how you would address such a state.
  - Analogy is home (contents, fire …) insurance

DBA, PSA and SAA Compared

- Methodologies:
  - DBA: conservative according to strict, defined rules;
  - PSA: best estimate, probabilistic supported by deterministic calculations
  - SAA: best estimate deterministic calculations and research

DBA, PSA and SAA Compared

- Analysis Focuses on:

DBA

prevention and protection

PSA

protection (and mitigation)

SAA

mitigation (and protection)

DBA, PSA and SAA Compared

- Typical outputs to be implemented:

DBA

Limits instructions; and conditions, safety measures,

PSA

Numbers of safety measures, limits and conditions, maintenance schedules

SAA

Strategies, advance thinking, timings, plant / equipment, qualification requirements, supplies

DBA, PSA and SAA Compared

- Plant / equipment requirements - ENSREG demonstrated two types of fundamental philosophy being adopted:
  - Robust qualification approach (bunkered)
  - Diverse, redundant and flexible approach
  - Usually it's a mixture of the two

DBA, PSA and SAA Compared

- Overall message:

SAA is distinctly different from DBA and PSA – so our guidance (Safety Standards) are to reflect these differences

Where are we now?

1. New UK guidance is being updated.
2. UK licensees are in process of producing significantly improved SAA and implementing this through enhanced SAM
3. IAEA / WENRA guidance focuses mostly on procedural aspects of SAM and on research, to be complemented by SAA

Questions and Discussion