Considerations on the Application of the IAEA Safety Requirements for Design of Nuclear Power Plants

Topical Meeting of NUSSC Members
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J. Yllera, B. Poulat
IAEA, Division of Nuclear Installation Safety
### Safety Glossary

The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems.

### Design Basis

#### Operational States

<table>
<thead>
<tr>
<th>NO</th>
<th>AO</th>
</tr>
</thead>
</table>

#### Accident Conditions

- **DBAs**
  - Safety systems
- **Severe Accidents**
  - Core melt

#### DECs

- No core melt
  - Optional safety features
- Safety features for SAs

#### Conditions Practically Eliminated

### General Plant Design

#### Design Basis

#### Non Permanent Equipment

### Beyond General Plant Design

Non permanent equipment (connections required)
Design extension conditions without significant fuel degradation are mostly reactor technology and design dependent,

They are additional safety features designed to prevent core melt. Their need depend on the reliability of the safety systems and are usually identified on the basis of deterministic and probabilistic assessment, operating experience, lessons learned from nuclear events and engineering judgement or prescribed by the regulator.

This general approach may be illustrated by a list of DECs already considered by some MS as examples.
## Plant States & Design Basis

<table>
<thead>
<tr>
<th>Operational States</th>
<th>Accident Conditions</th>
<th>Design Extension Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO, AO (AOOs)</td>
<td>DBAs</td>
<td>Conditions practically eliminated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No core melt, Severe Accidents (core melt)</td>
</tr>
</tbody>
</table>

**General plant design**

- **Operational States**: NO, AO (AOOs)
- **Accident Conditions**: DBAs
- **Design Extension Conditions**: No core melt, Severe Accidents (core melt)

**Criteria for the necessary capability, functionality, reliability and availability**
(for each plant state and SSC)

**Design Basis of equipment for Operational states**
- Design Basis of Safety Systems including those SSCs necessary to control DBAs and some AOOs

**Design Basis for each SSC (SSR 2/1, req.14)**

- **Design Basis of safety features for DECs** including those SSCs necessary to control DECs
  - Design Basis for preventive safety features
  - Design Basis of the containment systems

**Beyond general plant design**

- No plant equipment is designed for these conditions
### DiD approach from INSAG-10

- INSAG formalized the DiD approach in 5 levels.
- Scheme incorporated in several IAEA SSs
- DiD is more than design
- It was the basis for definition of levels in NS-R-1
- It is the basis for SSR- 2/1, but some changes have been introduced.
- SSR-2/1 only describe the levels. It doesn't describe provisions associated to the levels.

<table>
<thead>
<tr>
<th>Levels of defence</th>
<th>Objective</th>
<th>Essential means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Prevention of abnormal operation and failures</td>
<td>Conservative design and high quality in construction and operation</td>
</tr>
<tr>
<td>Level 2</td>
<td>Control of abnormal operation and detection of failures</td>
<td>Control, limiting and protection systems and other surveillance features</td>
</tr>
<tr>
<td>Level 3</td>
<td>Control of accidents within the design basis</td>
<td>Engineered safety features and accident procedures</td>
</tr>
<tr>
<td>Level 4</td>
<td>Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents</td>
<td>Complementary measures and accident management</td>
</tr>
<tr>
<td>Level 5</td>
<td>Mitigation of radiological consequences of significant releases of radioactive materials</td>
<td>Off-site emergency response</td>
</tr>
</tbody>
</table>

- INSAG-10 doesn’t assign explicitly DiD levels with plant states, but the text allows it with some interpretation.
- The description of INSAG-10 is for all NPPs in general. However, there is a section for future plants.
## Plant States & DiD

### NS-R-1

<table>
<thead>
<tr>
<th>Operational States</th>
<th>Accident Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>DBAs</td>
</tr>
<tr>
<td>(AOO) AO</td>
<td></td>
</tr>
</tbody>
</table>

#### Level 1
- Level 1

#### Level 2
- Level 2

#### Level 3
- Level 3

#### Level 4
- Severe Accidents (core melt)

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**Design basis**

**Beyond Design basis (Accident Management)**
### Plant States & DiD

**SSR-2/1**

<table>
<thead>
<tr>
<th>Operational States</th>
<th>Accident Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>DBAs (safety systems)</td>
</tr>
<tr>
<td>AO</td>
<td>DECs</td>
</tr>
<tr>
<td>No core melt (Optional safety features)</td>
<td>Safety features for SAs</td>
</tr>
<tr>
<td>Conditions practically eliminated</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3a</td>
<td>3b</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tecdoc**

- Since December 2014 (rev. 7c)
- Before December 2014

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**General plant Design**

**Beyond General plant design**
Defense in depth

- Clarity brought by the TECDOC:
  - Systems designed to mitigate the different plant state conditions are independent as far as reasonably achievable
  - **Specific** safety features for mitigation of a core melt accident should be independent from the safety systems
Practical Elimination of Early or Large Releases

• Originally introduced in the IAEA in INSAG-12 in 1999
• Used for the first time in the IAEA SS in NS-G-1.10 (containment), 2004

• The concept of practical elimination should not be misinterpreted or misused.
• It should be considered as part of a general approach to safety and, its appropriate application, as an enhancement of the defence in depth.
• The practical elimination of early or large releases is achieved by a strong prevention of the conditions that could lead to early or large releases
Practical Elimination of Early or Large Releases

- Option 1: Impossible (very limited cases)
- Option 2: High confidence that it is very unlikely

- There is a quite large consensus on the fact that the “practical elimination”, even involving probabilistic considerations, should always be based on solid design provisions and operational measures (e.g. in service inspections).

- The demonstration of practical elimination is based on the assessment of such provisions, that would necessarily include engineering, deterministic and probabilistic judgement.
Questions to NUSSC
to be discussed on Friday 3\textsuperscript{rd} of July

- Use of the Term Design Basis for the plant
- Association of Plant States with levels of DiD, in particular for DECs without core damage.
- Consideration of the use of non permanent equipment for new plants
- Concept of practical elimination
- List of DECs without core damage given as examples in the TECDOC
Thank you
for your attention!