Implementation DEC Standalone or Considered within the Scope of Risk Management Regulatory Framework

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1. Conflict about DEC

2. Challenges of DEC
   1) Identification of DEC
   2) Acceptance criteria of DEC
   3) Survivability of equipment for DEC

3. Conclusion
1. Conflict of DEC

**IAEA’s Position about DEC:** Design Extension conditions (DEC) was adopted in SSR2/1 with TECDOC-1791 supplemented

- Both a set of DBAs and DECs should be considered.
- Analyses of DBAs & DECs
  - DBAs: performed by conservative approach
  - DECs: performed by best estimate approach for DECs identified with engineering judgment, deterministic assessments and probabilistic assessments.
1. Conflict of DEC

IAEA’s Position about DEC (cont.)

• Measures for DBAs & DECs
  ✓ Engineering Safety Features (ESFs) for DBAs
  ✓ Safety features for DECs.

• Equipment capability for DBAs and DECs
  ✓ ESFs: Equipment Qualification for DBAs
  ✓ Safety features: Survival in the environmental condition of DECs
1. Conflict of DEC

**US NRC’s Position about DEC:** DEC was not considered by NRC as the statement of SECY-15-0168

- A set of DBAs and the selected BDBAs should be considered.
- Analyses of DBAs & BDBAs
  - DBAs, SBO and ATWS: Deterministic methodology applied
  - Most of BDBAs: Probabilistic methodology applied
- Measures for DBAs & BDBAs
  - Engineering Safety Features for DBAs
  - Preventive & mitigative measures for significant BDBAs based on PSA insight.
- Equipment capability for DBAs and BDBAs
  - Equipment Qualification for DBAs
  - Equipment survivability for BDBAs
2. Challenges of DEC

Identification of DEC:

- Complex sequences: not limited by single failures
- Frequency of occurrence cannot be neglected
- Determination based on engineering judgment, deterministic approach and probabilistic approach
- DEC sub-category
  - DEC-A: conditions without significant fuel degradation
  - DEC-B: conditions with core melting
Identification of DEC:

- **DEC-A**
  - Very unlikely events for the situation out of safety systems
  - Multiple failures of safety systems due to common failures
  - Multiple failures that cause the loss of a safety system while this system is used to fulfill the fundamental safety functions in NO.

- **DEC-B:** severe accident, no further difference
  - Europe: Performed severe accident analyses in deterministic methodology based on the engineering judgment, PRA/PSA and experiences. Limited typical sequences
2. Challenges of DEC

Acceptance Criteria of DEC: without unacceptable radiological consequences

- Acceptance criteria of DEC-A
  - Limited damage of fuel with integrity of containment
  - The radiological acceptance criteria is similar to that of the most unlikely design basis accidents

- Acceptance criteria of DEC-B
  - Maintaining containment integrity and limited emergency action needed
  - Effective dose on the site boundary in the first 2 and 7 days is 10mSv and 50 mSv, respectively
## 2. Challenges of DEC

<table>
<thead>
<tr>
<th>Level of defence</th>
<th>Objective</th>
<th>Associated plant state</th>
<th>Criteria for maintaining integrity of barriers</th>
<th>Criteria for limitation of radiological consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Prevention of abnormal operation and failures</td>
<td>Normal operation</td>
<td>No failure of any of the physical barriers except minor operational leakages</td>
<td>Negligible radiological impact beyond immediate vicinity of the plant. Acceptable effective dose limits are bounded by the general radiation protection limit for the public (1 mSv/year commensurate with typical doses due to natural background), typically in the order of 0.1 mSv/year.</td>
</tr>
<tr>
<td>Level 2</td>
<td>Control of abnormal operation and detection of failures</td>
<td>Anticipated operational occurrence</td>
<td>No failure of any of the physical barriers except minor operational leakages</td>
<td>Negligible radiological impact beyond immediate vicinity of the plant. Acceptable effective dose limits are similar as for normal operation, limiting the impact per event and for the period of 1 year following the event (0.1 mSv/year).</td>
</tr>
<tr>
<td>Level 3a</td>
<td>Control of design basis accidents (DBAs)</td>
<td>Design basis accident</td>
<td>No consequential damage of the reactor coolant system, maintaining containment integrity, limited damage of the fuel</td>
<td>No or only minor radiological impact beyond immediate vicinity of the plant, without the need for any off-site emergency actions. Acceptable effective dose limits are typically in the order of few mSv.</td>
</tr>
<tr>
<td>Level 3b</td>
<td>Control of DECs without significant fuel degradation (prevention of accident progression into severe accident)</td>
<td>Design extension condition without significant fuel degradation</td>
<td>No consequential damage of the reactor coolant system, maintaining containment integrity, limited damage of the fuel.</td>
<td>The same or similar radiological acceptance criteria as for the most unlikely design basis accidents</td>
</tr>
<tr>
<td>Level 4</td>
<td>Control of DECs with core melt (mitigation of consequences of severe accidents)</td>
<td>Design extension condition with core melt (severe accident)</td>
<td>Maintaining containment integrity</td>
<td>Only emergency countermeasures that are of limited scope in terms of area and time are necessary.</td>
</tr>
<tr>
<td>Level 5</td>
<td>Mitigation of radiological consequences of significant releases</td>
<td>Accident with releases requiring implementation of emergency countermeasures</td>
<td>Containment integrity severely impacted, or containment disabled or bypassed</td>
<td>Off-site radiological impact necessitating emergency countermeasures</td>
</tr>
</tbody>
</table>
2. Challenges of DEC

Survivability of equipment for DEC: Five-step approach

- Step 1: Determine the accident progression time frame
- Step 2: Screen the sequences leading to DECs
- Step 3: Establish bounding environmental conditions, including temperature, pressure, radiation and etc.
- Step 4: Identify the equipment used for DECs mitigation;
- Step 5: Verify the reliability and/or capability of those identified equipment by analysis or test
谢谢！
THANK YOU！