Workshop on Evaluation of Uncertainties in relation to severe accidents and level 2 PSA

Severe Accident Research Network (SARNET)
Level 2 PSA work package: comparison of partners’ methods for uncertainties assessment

Bernard Chaumont & all
Summary

SARNET general presentation
General objectives of SARNET level 2 PSA WP
Status of work already performed
Global comparison of partners’ approaches
Some results of the comparison
  Level 1 PSA uncertainties propagation
    Uncertainties considered in the APET and for the releases assessment

Conclusions & future work
Severe Accident Research NETwork of excellence

EURATOM 6th Framework Programme (FP-6) 2002-2006
18 Countries, 49 organizations
- 18 Research Organizations
- 10 Universities
- 11 Industry Organizations
- 4 Utilities
- 6 Safety Authorities or Technical Supports

Programme started in April 2004
SARNET: themes of interest

**Integrating Activities**
- WP 1: ACT
  Development on an Advanced Communication Tool
- WP 6: IED
  Implementation of Experimental Database
- WP 7: SARP
  Definition of Severe Accident Research Priorities
- WP 8: IA
  Integration Assessment
- WP 2: USTIA
  ASTEC Users Support and Training, Integration, and Adaptation
- WP 3: PHYMA
  ASTEC PHYsical Model Assessment
- WP 4: RAB
  ASTEC Reactor Application Benchmarking
- WP 5: PS2
  Level 2 PSA methodology and advanced tools

**Joint executed research activities**
- WP 9, 10, 11: CORIUM
  Early phase core degradation
  Late phase core degradation
  Ex-vessel corium recovery
- WP 12, 13: CONTAINMENT
  Hydrogen behaviour
  Fast Interaction in Containment
- WP 14, 15, 16: SOURCE TERM
  FP Release and Transport
  Aerosol Behaviour impact on Source Term
  Containment Chemistry impact on Source Term

**Spreading of excellence activities**
- WP 17: ET
  Education and Training
- WP 18: BOOK
  Book on severe accident phenomenology
- WP 19: MOB
  Mobility programme
- WP 20: Management
SARNET PSA 2 WP content

Part of Joined Programme Activities / Integrating Activities

Organization in three main tasks

Task 5.1: Comparison of level 2 PSA approaches and identification of improvement needs

Task 5.2: Comparison of methodologies for assessment of uncertainties and identification of improvement and harmonization needs

Task 5.3: Improvement of event tree methodology using dynamic reliability techniques

Detailed specific programme defined for these tasks for the two first years (JPA1 and JPA2)
## Participants

<table>
<thead>
<tr>
<th></th>
<th>WP 5.1: methods</th>
<th>WP 5.2: uncertainties</th>
<th>WP 5.3: dynamic reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRSN (France) Coordinator</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AVN (Belgium)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEA (France)</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CSN (Spain)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EDF (France)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>FRAMATOME (Germany)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>GRS (Germany)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>INR (Romania)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JRC (Belgium)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>LEI (Lithuania)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NNC (United Kingdom)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI (Switzerland)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>SWP (Sweden)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TUS (Bulgaria)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ULB (Belgium)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>UJV (Czech Republic)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>VEIKI (Hungary)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
WP5.2: status of work performed

Description, comparison of partners methods concerning uncertainties assessment

- Propagation from level 1 PSA
- Uncertainties considered in the APET and associated methods
- Uncertainties for releases assessment and associated methods
- Sensitivity studies performed in the frame of the level 2 PSA

Review of complementary possible methods

- To propagate uncertainties
- To perform sensitivity studies
- To assess that a probability exceeds a threshold
- Surrogated methods (including surface response methods)

Identification of some improvement needs
WP5.2 : method used

First general questionnaire including some questions about the general approach for uncertainty assessment
- Different sources of uncertainties considered
- Methods used to assess them (qualitative description expected)

Second specific questionnaire on uncertainties (quantitative data expected)
- Uncertainties treatment for the different steps of the level 2 PSA

Answers to the questionnaires provided by the partners, compiled and then compared for the different subjects of interest
WP5.2: Some elements of the global comparison

Criteria defined for global methods comparison

Criteria for « quantification » methods
1. None or very coarse
2. Mathematical - assignment of arbitrary distributions
3. Physical-mathematical - process/phenomenon oriented

Criteria for « propagation » methods
1. Not addressed
2. Uncertainties discussed but not quantified or dismissed as of little consequence or interest
3. Treatment implicit, i.e. uncertainties discussed but not quantified, but rather addressed with sensitivity studies
4. Explicit, quantification performed for PDS frequency
5. Explicit, quantification performed for PDS frequency and magnitude of source terms
WP5.2: Some elements of the comparison

<table>
<thead>
<tr>
<th>Partner</th>
<th>« Quantification » method</th>
<th>« Propagation » method</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVN</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>EDF</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>FRAMATOME</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>GRS</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>IRSN</td>
<td>3</td>
<td>2 &amp; 5</td>
</tr>
<tr>
<td>LEI</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NNC</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>SWP</td>
<td>1</td>
<td>2 &amp; 3</td>
</tr>
<tr>
<td>TUS</td>
<td>1</td>
<td>2 &amp; 3</td>
</tr>
<tr>
<td>UJV</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>VEIKI</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>INR</td>
<td>To be defined</td>
<td>2</td>
</tr>
<tr>
<td>PSI</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>
Some conclusions of the global comparison

Diversity of partners’ approaches

No requirement, in most of the countries, for uncertainties assessment in level 2 PSAs
Partners’ approaches depend on level 2 PSA objectives and also on available ressources
Apparent contradiction of partners’ practices with existing AIEA guidelines stressing the importance of uncertainty assessment in level 2 PSA
Clearer evidence of the benefit of an uncertainty assessment in a level 2 PSA probably to be provided
Propagation of uncertainties from level 1 PSA to level 2 PSA

Uncertainties generally assessed in the partners’ level 1 PSA

- Uncertainties on input data (initiating events frequency, systems or components reliability, sometimes human actions)
- Uncertainties on physical phenomena not considered

Agreement on a propagation method based on distribution functions of Plant Damage State (PDS) frequency

Uncertainties generally not propagated to level 2 PSA

Binning uncertainty not assessed (relevant choice of PDS attributes considered as a way to limit the corresponding uncertainties)

Nevertheless great variations in the number of interface variables, in the choice of these variables, in the number and meaning of variables modalities
Accident Progression Event Tree (APET) uncertainties

Some physical phenomena omitted or neglected but associated uncertainties not assessed

- Lists of corresponding phenomena may vary between the different partners
- Different consequences of the same physical phenomenon may be investigated

Some physical phenomena considered sometimes as aleatory (and sometimes as deterministic)

- Triggering of steam explosion
- Hydrogen ignition of a flammable mixture

No assessment of the uncertainties resulting from the "coarse" structure of the APET

- Decisions necessary on the level of APET complexity according to limited time and knowledge available
- May be assessed using dynamic reliability methods (WP5.3 task)
Accident Progression Event Tree (APET) uncertainties

Partners’ interest on the uncertainties related to physical phenomena

But no estimation of the relative importance of uncertainties on human actions, systems reliability and physical phenomena

Uncertainties related to cut-off frequency during APET quantification estimated - and sometimes demonstrated - to be negligible

Uncertainties propagated during the APET quantification using the Monte Carlo method

Feasibility of a rather systematic assessment of uncertainties for recently developed level 2 PSA using

Systematic severe accident code calculations
Some complementary expert judgement interpretation
Uncertainties on releases assessment

Few partners assess the uncertainties on releases
As for the APET, some physical phenomena omitted or neglected but associated uncertainties not assessed
  Lists of corresponding phenomena may vary between the different partners

Quite different number of releases categories (from 8 to 1000)
  Binning uncertainty not assessed separately (excepted partly in one case) but probably dependant on the number of RCs

Both uncertainties due to binning process or to source term assessment estimated very high (at least more than one order of magnitude)
Lack of knowledge on gaseous iodine behaviour estimated to be the most important contributor to the source term uncertainty (estimated unquantifiable for some partners)
Conclusions / future work

Very high difficulty to correctly address all sources of uncertainties notably due to
- The lack of completeness of the study
- The lack on knowledge on some subjects
- The limitations of classical methodologies

Feasibility of a rather systematic assessment of uncertainties on physical phenomena on the basis mainly of severe accident codes calculations

Probable difficulty to achieve globally a certain level of harmonization due to the complexity of the subject and to the diversity of initial partners’ approaches

Future work concentrated on recommendations of best estimate method(s) to assess in a level 2 PSA the uncertainties on some physical phenomena (tasks now on going):
- Hydrogen distribution and combustion
- Melt corium and concrete interaction
- Iodine releases