EU SMR PARTNERSHIP – WS5
Topic 4 : Severe Accidents

Sustainable Nuclear Energy Technology Platform (SNETP) FORUM
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Philippe Dejardin

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General

- SMR Design should
  - Include advanced inherent safety features, reinforcing Defence in Depth (DiD)
  - Aim to drastically reduce Severe Accidents (SA) likelihood and to strengthen mitigation measures
  - Aim to practically eliminate the need for offsite emergency response, linking with Emergency Planning Zones (EPZ)

- Need for efficient quantifications of mitigation feature to address timely regulatory requirements and allow completion of proper safety demonstration
  - Notably via risk assessment approaches
  - Validation of numerical tools based on dedicated experimental data

- Wide variety of SMR is a challenge
  - Some common considerations (e.g. integral concepts, increased modularity, shared SSCs)
  - Some specific considerations (e.g. different technologies, different phenomena)

  - Need to focus on a limited number of designs (ongoing)
  - First identification of “R&D Needs” split between Light Water SMR (LWSMR) and non-LWSMR

EC1 – Needs for LWSMR

- #1 - Identification of potential or postulated SA scenarios
  - Available knowledge on LWR would support this need in a straightforward manner
  - Specific efforts needed to select more finely potential scenarios with impact of
    - Integral designs
    - Smaller containments
    - Increased use of passive systems *(link with Topic 3)*
  - Combination of deterministic and probabilistic tools along with engineering judgment
  - Emphasis set on dedicated PSA tools and methods
    - Need to have access to detailed designs as far as possible

EC1 – Needs for LWSMR

- #2 - Identification of specific needs for the potential / postulated scenarios

  - 3-step approach to reach “net” specific needs for LWSMR research on SA
    - Step 1 : Experimental and code development needs (“comprehensive” list of needs)
      - Aiming at ensuring efficient and timely safety demonstration in line with regulatory requirements
    - Step 2 : Applicability and transfer of large-LWR knowledge (credited needs)
    - Step 3 : Achieve a list of “net” needs

  - Identify feasibility studies for existing and new experimental facilities
    - Including modelling and specification of the measurement tools to allow future validation of numerical tools that would support the licensing process

  - Existing numerical tools and methods to be used already
    - Improve the estimate of the calculation uncertainties *(e.g. link with H2020 MUSA)*
    - Characterize fields where a better knowledge is necessary

    - To be applied primarily on 3 areas : RPV integrity, Containment integrity and EPZ

EC1 – Needs for LWSMR

- #2 - Identification of specific needs for the potential / postulated scenarios

  - RPV integrity
    - Mostly related to sound demonstration of In-Vessel Retention (IVR)
      - Considering latest state-of-the-art & applicability to LWSMR designs
      - Even if lower decay heat is favorable, EU H2020 IVMR showed that other important parameters exist
    - Integral design and compaction might call for specific research needs
      - E.g. impact on RPV inner structures of an in-vessel steam explosion and/or other thermal effects in SA
  - Containment integrity
    - Integral design and compaction might impact SA progression and containment integrity
    - Phenomenological issues mostly expected to derive from large LWR knowledge to be transposed
      - E.g. hydrogen generation, recombiners, containment filtered venting, aerosols behavior
  - Emergency Planning Zones
    - Identified given SMR goal to limit the EPZ to the site boundary and as it relates to radiological releases
    - Not SA-phenomenology but important to assess acceptability of SMR designs
    - EPZ limited to site-boundary might be challenging for existing tools & methodologies due to closer range

EC1 – Needs for Non-LWSMR

- /!\ Prerequisite needed in terms of “Severe Accident” definition
  - Link to WS2 Licensing
  - “Conventional” definitions (core degradation/melting) are inadequate for some technologies

- Same generic two high-level research needs identified

  - #1 - Identification of potential or postulated SA scenarios
  - #2 - Identification of specific needs for the potential / postulated scenarios
    - Vessel integrity, Containment integrity, Emergency Planning Zones

  - Specific contents to be adapted given the wide variety of concepts (HTGR, SFR, MSR, …)

  - At least for HTGR-SMR, first needs related to
    - Uncertainties in accidental source term determination, e.g.:
      - graphite adsorption/desorption, different core degradation, effect of depressurization, …
    - EPZ is reinforced for heat applications given the closer distance

EC2 – Gaps

- Past and ongoing initiatives related to SMR SA appears very limited
  - SMR SA safety assessments with best estimate methods is still not addressed

- SA-related topics of current high interest for SMR
  - Systematic analyses of applicability and transfer of the current available SA experimental database for SMR safety assessment studies
  - Analyses of current codes capabilities to simulate SA phenomena
  - Identifications of experimental and code validation gaps
  - Large-LWR scalability to LWSMR
  - Subsequent definition of action plans to address these gaps

- H-Europe SASPAM-SA is proposed accordingly for integral PWR (iPWR)

EC2 – Gaps

- SASPAM-SA (Safety Analysis of SMR with PAssive Mitigation strategies – Severe Accident):
  - Submitted in the HORIZON-EURATOM2021-NRT-01-0
  - Grant Agreement preparation on-going

- Project main objective: to investigate the applicability and transfer of the operating large-LWR reactor knowledge and know-how to the near-term deployment of integral PWR (iPWR), in the view of SA and EPZ European licensing analyses needs

- Expected outcomes: help speeding up the licensing of iPWRs in Europe, as well as the siting processes of these reactors in light of their possible use near densely populated areas

- 4 years duration
- Coordinated by ENEA
- 23 participating organizations
- More info : fulvio.mascari@enea.it

EC4 – Infrastructures

- Identification of infrastructures to support SA research for SMR

  - Start with the existing test facilities dedicated to SA research, e.g.
    - From the H2020 SAFEST (Severe Accident Facilities for European Safety Targets) project, regarding European corium experimental laboratories with a focus on LWR
    - From containment test facilities
    - From non-LWR test facilities (?)

  - List to be established and consolidated depending on the actual specific needs identified

Conclusions

- SMR should include inherent safety features to drastically reduce SA likelihood

- For all SMR (i.e. LWSMR and non-LWSMR), 2 high-level needs identified
  - #1 - Identification of potential or postulated SA scenarios
  - #2 - Identification of specific needs for the potential / postulated scenarios
    - Vessel integrity, Containment integrity, Emergency Planning Zones

- For LWSMR, specific needs to identify, crediting applicability of large-LWR knowledge
  - SASPAM-SA proposal aims at addressing it for iPWR

- For (some) non-LWSMR, prerequisite needed in terms of “Severe Accident” definition

- Need for efficient quantifications of mitigation feature to address timely regulatory requirements and allow completion of proper safety demonstration
  - via risk assessment approaches & proper validation of numerical tools
  - Link with WS2 related to Licensing