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Executive Summary

Studsvik is launching SMILE (Studsvik Material Integrity Life Extension), a project that will support Light Water Reactor (LWR) operators and authorities worldwide in plant ageing management. The objective of SMILE is to provide critical data and mechanistic understanding of materials ageing in support of plant ageing management, life extension programmes and operating licence renewals.

SMILE is a 5-year Studsvik/OECD/NEA project that will also connect experts from all over the world. It will create a forum for knowledge transfer between organisations and age generations based on experimental examinations and testing of aged materials harvested from LWRs decommissioned after up to 40+ years of operation.

Ageing degradation of structural materials in LWRs is a significant challenge for their continued safe and reliable operation. It is all the more important for plant life extension beyond the original 30 to 40-year design objective that is being pursued in many countries. Several international studies over the last two decades have identified, categorized and prioritized the main causes of LWR structural materials degradation due to metal fatigue, corrosion-related mechanisms, thermal ageing and neutron irradiation damage. This has led to guidelines from national and international safety organizations for establishing detailed plans for plant ageing management, life extension programmes and operating licence renewals.

Aging management relies on models of the kinetics of the various mechanisms of degradation as well as validated replacement materials/components where necessary. This proposal aims to support LWR plant operators and national nuclear safety regulators by improving knowledge of materials ageing phenomena and their kinetics. It will leverage a near-unique opportunity to harvest various components from three Swedish BWRs and one Swedish PWR that have recently been shut down or will soon be withdrawn from service. The data obtained will form the basis for improved mechanistic understanding for the development of models capable of predicting materials and LWR component properties for projected life extensions to 60 years and possibly up to 80 years envisaged in some countries.

The proposal is organized into three main tasks that address specific material classes and/or generic primary coolant system components, as follows:

- Low alloy pressure vessel steels:
 - Irradiation embrittlement;
 - Thermal ageing embrittlement;
 - Stability in service of casting and forging anomalies;

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- SCC and corrosion fatigue properties of irradiated RPV steels.
- Stainless alloy core support structures and internals:
 - Irradiation embrittlement including stainless steel welds;
 - IASCC and corrosion fatigue susceptibility;
 - CASS thermal ageing with irradiation effects.
- Austenitic pressure boundary alloys without significant irradiation effects:
 - Stainless steel and nickel-base alloy weld SCC resistance in BWRs and PWRs;
 - Alloy 690/152/52 PWSCC resistance and thermal stability in PWRs;
 - Low cycle corrosion fatigue in BWR and PWR reactor coolants and high cycle fatigue and wear.

Since SMILE is initially scheduled as a 5-year project, it was necessary for participating organizations to prioritize those tasks and sub-tasks described herein in order to identify those that can be accomplished within this period with the resources available. This third revised version¹ of the proposal includes a summary of the priority choices made by organizations who have expressed a firm intention to participate in SMILE, as well as additional feedback received since Rev. 1 of this document was issued. It also describes the associated experimental plans that take these views into account. It should be noted that these priority choices will likely evolve in future as the SMILE project proceeds. Such decisions will be the responsibility of the SMILE Management Board that will take into account the funding balance between BWR and PWR interests as well as negotiating compromises between divergent views of technical priorities among funding members.

¹ Draft issued on October 24, 2019, Rev 0 issued on April 9, 2020, and Rev. 1 issued on July 2, 2020.