Contribution to the understanding of the creep mechanisms of 316L(N) austenitic stainless steel for 60 years of operation: link microstructural evolution (precipitates, dislocations) and damage

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Amphi de la Maison Jean KUNTZMANN

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Abstract: The components of Sodium-Cooled Fast Neutron Reactors (RNR-Na) located in the hot collector (pressure vessel, Core Cover Plug, Intermediate Exchangers,...) are subjected to temperatures ranging from 400°C to 575°C for an operating time of up to 60 years for non-replaceable components. At these temperatures, the austenitic 316L (N) stainless steel is a good candidate to be used and will be subjected to thermal ageing and various mechanical stresses such as creep, creep-fatigue. The material must also have sufficient residual ductility and tensile properties after ageing. The 60-year operating time of these components requires creep data for very long periods of time (up to 240,000 hours), which are not available, even under the previous programs of Phenix and SuperPhenix, and which will not be available until 2030 for the former.

Understanding and anticipating the evolution of 316L(N) steel during very long service life at operating temperatures is a major challenge in defining and justifying the components of RNR-Na but also more broadly for any austenitic stainless steel component operating at high temperature for long periods of time (flame thermal, AGR, etc.). Therefore we investigate the creep behaviour of two 316 L(N) with various compositions in minor elements (N, Nb, B, …) which present huge differences in creep rupture time. We performed multiscale microstructural characterization to understand the reason for these differences using optical microscope, SEM (EDX, EBSD), FIB, TEM (EDX, ASTAR), X-ray nano and microtomography and nanoindentation on post-mortem samples but also during interrupted creep tests. We observed strong differences in precipitation between the two steels highlighting the

combined effect of niobium, nitrogen and boron on the formation of carbides and thus on the induced damage.