



Standard Guide for Monitoring the Neutron Exposure of LWR Reactor Pressure Vessels¹

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INTRODUCTION

Light Water Reactor (LWR) power plant safety analysis reports and subsequent neutron exposure parameter calculations for the reactor pressure vessel (RPV) wall and critical welds need to be verified using modern codes and information from surveillance dosimetry. The location of critical welds relative to the axial and azimuthal fluence rate map should be taken into account, as well as changes in fuel loading during periods when surveillance capsules are exposed and beyond to the end of the reactor's operating license. For many reactors today this is a 60-year-long interval. In the nuclear industry, there is active consideration and evaluation of an 80-year-long operating interval. Most reactor surveillance programs were designed based on the guidance of Practice E185 with a 40-year operating life in mind. The Practice E185 surveillance programs are designed to select and irradiate the RPV material test specimens. The dosimetry in the surveillance capsule is there primarily to measure the neutron fluence to which the capsule's material specimens have been exposed.

In addition, those programs were based on the operating assumptions in place at the time; typically annual out-in core loading patterns and base load operation at a fixed reactor power level. Reactor operations have evolved so that low-leakage core loading patterns (L³P) are the norm as are 18- and 24-month-long fuel cycles and reactor power up-ratings of up to 20 %. Many reactors have now installed flux suppression features such as natural uranium fuel rods, full or part-length hafnium or B₄C rods, or stainless steel rods to minimize the neutron exposure of critical areas of the RPV. Such developments increase the need to comprehensively monitor the RPV accrued fluence through the extended operation period.

This guide is intended to be used together with other Standards to provide best estimates of the neutron exposure and exposure rate (together with uncertainties) at positions at the inner diameter and within the pressure vessel wall of a light water reactor. Also provided will be estimates of gamma-ray exposure and exposure rates to interpret dosimetry sensor photo-reaction and other gamma-ray induced effects. Information used to make these estimates is obtained from coupled neutron-gamma ray transport calculations and from neutron and gamma-ray sensors located in surveillance positions on the core side of the vessel and in the reactor cavity outside the vessel wall (1).² Benchmark field irradiations of similar monitors also provide valuable information used in the verification of the accuracy of the calculations (1).

Knowledge of the time-dependent relationship between exposure parameters at surveillance locations and selected (r , θ , z) locations within the pressure vessel wall is required to allow determination of the time-dependent radiation damage to the RPV. The time dependency must be known to allow proper accounting for complications due to burn-up, as well as changes in core loading configurations (2-5). An estimate of the uncertainty in the neutron exposure parameter values at selected (r , θ , z) points in the vessel wall (1) is also needed to place an upper bound on the allowable operating lifetime of the reactor vessel without remedial action (6-9). (See Guide E509.)