# STRUCTURAL ANALYSIS AND STRUCTURAL INTEGRITY EVALUATION OF NUCLEAR COMPONENTS

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Steam Generator Tube Integrity Assessment. It is mandatory to perform a SG tube integrity analysis at every planned stop for refueling, when 100% of the tubes is inspected with Eddy-current techniques. To assure the assessment criteria are good and the SG operation is always within the regulatory safe limits, still when a defect has dimensions over the allowable limits, the tube/defect can be tested in situ. If the tube fails the test, the NPP owner should revise the criteria to assess the tube integrity. The regulatory specific in situ limits were investigated and the associated limits were obtained, using a Monte Carlo statistical approach to take into account all uncertainties, for almost all defects types observed in Angra 1 NPP. The actual defect profile is quite irregular and an algorithm was developed to obtain an idealized defect (uniform depth and length) that fails for the same pressure the actual one fails. This idealized defect dimensions are used in the selection of the tubes candidates to be tested in situ.

Nondestructive evaluation of equipment and structures. Development of experimental methods for nondestructive evaluation including: (i) Residual stresses evaluation in welded structures using Barkhausen noise measurements; (ii) Eddy current tests for PWR steam generator defects assessment; (iii) Eddy current tests for research reactor fuel elements claddings defects assessment (MTR and TRIGA fuel elements).

Numerical and analytical methods for structural integrity evaluation of cracked structures. Implementation of methodologies such as: (i) Finite elements J-integral evaluation for components structural integrity assessment with Elastic Plastic Fracture Mechanics tools; (ii) Engineering methods for colapse load evaluation of cracked piping systems using the Elastic Plastic Fracture Mechanics approaches (JxT method, DPFAD method).

Experimental and analytical methods for structural analysis of nuclear components. Several studies were developed as: (i) Thermal stresses evaluation using photoelasticty in thermal shock assessment of pressure vessels; (ii) Structural design criteria for PWR control rod drive mechanisms and evaluation of a study case; (iii) Assessment of stress corrosion cracking in PWR control rod drive mechanisms; (iv) Modeling of accelerated tests to obtain design fatigue curves.

IAEA BRA/4/050 project Structural Integrity of Nuclear Reactor Components. This project was coordinated by the CDTN Institute. The participation was a one month training (Feb/2003) in the Center D'Etude de L'Energie Nucleaire, SCK-CEN, Mol, Belgium. It took the AIAE code BRA/02013P. The training main scope was the degradation mechanisms in the NPP towards the structural integrity assessment by the characterization of the ferritic steels in the ductile-to-fragile transition region. This characterization was focused on the use of results obtained with small specimens of irradiated and non-irradiated material, the specimen (Charpy) reconstitution, the use of the Load Diagram technique and the Enhanced Surveillance program.

Composite Material Characterization. The goal of this research is to assess the thermal stress distribution in the SiC-aluminum composite, due to its cooling process: the mean and its most likely values, as function of the SiC particles distribution. As these thermal stresses increase the material resistance capacity is reduced. Greater resistance will be obtained as the particle distribution is uniform. As a first approach the material is supposed to behave linearly. A mathematical model was developed considering the non uniform distribution of particles and its relation with the material resistance using the Maxwell-Boltzmann distribution, the Eshelby stress and using statistics to determine of the most likely behavior of a particle system. The analytical results were validated by numerical analyses using the finite element method (FEM) using about thirty models a different SiC particle number, distribution and size quasi-randomly generated. Both results showed the strong effect of the non-uniform particle distribution in the matrix on the stresses with a strong dependency of the particle volumetric ratio. The analytical approach showed as efficient as the FEM to estimate the thermal stresses (the mean and the most likely value).