Nuclear energy in recent decades has grown into an important choice for producing electricity. As of 2011, about 12% of the total electricity produced worldwide was generated by nuclear power. New nuclear power plants are planned to be substantially safer than those of the previous generation (Chu and Majumdar 2012). In order to support rapid economic development, nuclear energy remains a significant element in India's energy arsenal. India is currently ranked sixth among nations with 20 operational NPPs and 4780 MWe nuclear installed capacity in terms of the number of nuclear power reactors in operation. There are also seven building/commissioning plants with a gross additional capacity of 5300 MWe (Bajaj 2013).

In order to maintain the plants in a safe and cost-effective way for as long as possible, the ageing of structural and mechanical components in the nuclear power plants (NPPs) must be kept under control. Different degradation processes in materials that lead to changes in mechanical properties and a deterioration of durability over service life must therefore be examined. Even if the initial design is faultless, by periodic inspections, we have to research material deterioration over time and plan for timely maintenance of the structure thus extending the lifetime of the structure.The structure of nuclear power plants (NPP) may be subjected to violent operation and environmental impacts on their service life. These structures can be susceptible to one or more damage-causing processes depending on their position and function: high-temperature creep, low-cycle fatigue, load-induced inelastic deformation, friction and fretting, radiation embrittlement, corrosion, etc. Irreversibility of cyclic slip, fatigue crack and, ultimately, growth of crack represents essential stages of fatigue damage production (Mughrabi 2013). Strain localization is regarded as a guide to crack initiation in classical fatigue reviews. Strain aggregation results in slip within the grains due to dislocation motion, which shifts irreversibly with each cycle as forward and reverse loads are applied.

Any of these damages can arise steadily and consistently (over a considerable portion of the service life); others may occur at unpredictable points in time and in vast numbers that correspond with extreme loads, injuries, etc. In either case, due to inconsistencies and variations in loading history, environmental factors, performance of components, structural reaction and boundary conditions. Therefore thedamage growth in nuclear power plants structures is essentially random in nature; consequently, a probabilistic description of damage and failure is more appropriate.

In-service inspection (ISI) of fluid retention limits is carried out in NPPs at regular intervals (ranging from 2 to 10 years) with complete or partial sampling (10 percent to 100 percent depending on criticality) because failure of NPP components/subsystems has the potential to cause serious public health hazards (IAEA 2000, AERB 1998). But with 100 percent precision, one would ideally like to provide constant monitoring in all spaces, it is not possible. There are different inspection costs - downtime, workers exposure to radiation, and shutdown introduced stressors. Moreover, there are inherent shortcomings and errors in each NDT process and operator, both systematic and random (Kurz et al 2013, USDOD 2009). All these variables make ISI findings ambiguous in nature. A risk based approach to ISI and decisions are therefore rational. A systematic technique for assessing the structural reliability of weld joints subject to thermal, seismic and other transient random loads was provided in this study. Experimentally developed crack growth data and crack detection curves were developed. Original crack size randomness, material properties, crack growth rate, result of inspection and loading were considered. Goal specifications have been discussed. The influence of key parameters on the risk of solder failure was evaluated.