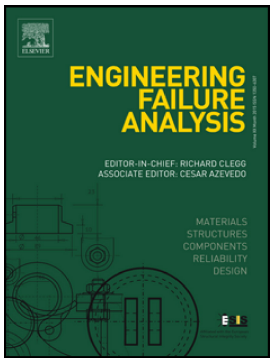

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Failure analysis of elbow pipe cracking in a residual heat-removal system of a nuclear power plant

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Abstract: Failure analysis of an elbow pipe in a nuclear power plant is conducted through non-destructive tests, chemical composition analysis, mechanical property tests, scanning electronic microscopy of fracture morphology, energy spectrum and micro-structure analyses, and cold-work elongation analysis. Results reveal the presence of many cold-worked slip bands in the micro-structures. The cold-work elongation is about 32% in the crack regime, the hardness is 390 $HV_{0.1}$, the crack presents embrittlement and propagates along the grain boundary, and the fracture presents crystal characteristics. The failure mode of the pipe is inter-granular stress corrosion crack, and the main reason for this failure is the high-cold-worked condition.

Keywords: elbow pipe failure, crack propagation, cold work hardening, IGSCC

1 Introduction

A leakage was discovered on an elbow pipe of a residual heat-removal system in a nuclear power plant (NPP) located in south China in October 2010. In situ ultrasonic and radiographic inspections revealed through-wall cracking in the elbow. The State Bureau of Nuclear Safety classified this event as class 1 according to the classification criteria for international nuclear events established by the International Atomic Energy Association.

The failure elbow was made of 316LN with a size of 355.6 mm × 40 mm. The coolant does not flow in this section during normal operations of the power plant. After in situ inspection, the elbow was cut from the pipe and sent to a laboratory for further investigation. The failure mode and mechanism were determined through various