

# **Application of X-Ray Diffraction for Residential Stress Analysis on Canadian Naval Platforms**

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## **ABSTRACT**

Residential stress are present in most engineered structures and arise during each processing step (ex., mechanical forming, heat treatment, joining, fitting) and maintenance and repair procedure (ex., cold-working, welding, straightening). The magnitude and distribution of residential stresses have a profound effect on mechanical behaviour (ex., distortion, fatigue, fracture) of materials and structures. This is a significant concern for the Canadian Navy, where the superposition of applied stresses on residential stresses may adversely affect the performance, safe operational envelope and service life of naval structures. The ability to elucidate residential stress distribution greatly improves the ability to conduct risk assessments of critical structures.

This presentation illustrates the influence of pressure hull weld repairs on the distribution of residential stress on Canada's VICTORIA Class Submarines. The experimental method for calibration of the portable miniature X-ray diffractometer is provided. An experimental X-ray elastic constant of  $195 \pm 6$  GPa (for the {211} crystallographic planes of bcc Fe) is derived for residential stress analysis on tempered Q1N steel. Several investigations of residential stress on Victoria Class submarines are discussed. This includes the residential stress redistribution during a recent pressure hull plate extraction/insertion/weld procedure. A post-weld residential stress survey had indicated highly variable and high magnitude tensile residential stresses that were beyond the measured elastic limit (590 MPa) for Q1N steels. The effect of these residential stresses on the mechanical behaviour of the pressure hull structure is still uncertain. Understanding residential stress redistribution has implications for present/future maintenance and repair recommendations and could potentially improve the operational safety and increase the service life of submarine structures.