

Neutron Radiography Tutorial

Introduction

Neutron radiography is a non-destructive testing technique that is widely used in the nuclear and aerospace industries. It is similar to X-radiography insofar as both techniques use beams of penetrating radiation to interrogate an object, and generate an image that allows visualization of areas that attenuate the beam differently than neighbouring areas. However, neutrons are attenuated very differently than are X-rays, and therein lie the differences.

Neutron Attenuation

In simplified terms, neutrons are attenuated by matter either by scattering from the nucleus of a target atom or through absorption by that nucleus. Unlike X-rays, which interact predominantly with the outer-shell electrons, there is no uniform increase in attenuation coefficient with atomic number. A plot of attenuation coefficient versus atomic number shows a nearly random structure. While clearer images are generated from samples where most of the attenuation is through absorption, meaningful neutron radiographs can be generated from scatterers as well.

Image Generation

Creation of images from the attenuated neutron beam can be accomplished in a variety of ways. Probably the most frequently used method today is the direct method using X-ray film and a suitable conversion screen. The conversion screen selected depends upon the application.

Indirect or Transfer Method

When radioactive materials are being inspected, thin foils of either Dy or In are generally used. These become radioactive in the neutron beam. After being exposed sufficiently, the foils are removed from the beam and placed in close contact with an X-ray film. The radioactive decay of the foil causes darkening of the X-ray film. Subsequent development of the film yields a radiograph. Since the film is never exposed to the beam itself, this method yields pure neutron radiographs and can be used when the beam contains contaminating radiations such as gamma rays or when the samples are themselves radioactive.

Direct Method

The direct method differs from the indirect method principally in that the film is placed in the beam with the conversion screen. Therefore, decay of the conversion screen must be either very fast or prompt. Since the film is exposed to the beam and to the sample, this method is not suitable for radioactive materials and cannot be used effectively when there are large amounts of contaminating radiations within the neutron beam. A commonly used conversion screen is a thin foil of Gd metal.

Track-Etch Imaging

If a plastic film in close contact with a material that yields heavy ions upon neutron absorption is exposed to a neutron beam, then the generated heavy ions will produce damage in the plastic film. These damaged areas will be more easily dissolved than other areas. Thus, etching of the plastic with a suitable reagent (KOH for example) will yield damage pits. Under suitable lighting these pits will be rendered visible.

This tutorial is growing. Please bear with us as we develop it.