TASLIMAGE

A HIGH SENSITIVITY NVLAP-ACCREDITED NEUTRON DOSIMETRY SYSTEM

***Gary R Moss*, A Peter Fews, Denis L Henshaw, Maria F Hansen**

Track Analysis Systems Ltd (TASL), Napier House, Meadow Grove, Bristol, BS11 9PJ, UK, Tel: +44 117 9381172, Fax: +44 117 3720667, E-mail: info@tasl.co.uk, *www.tasl.co.uk*

We describe a US-NVLAP-accredited and UK HSE accredited fully-automated neutron dosimetry system with high sensitivity and ease of use. The system is based on TASTRAK CR-39 plastic, specifically formulated for nuclear track detection. Fast neutrons are detected by measurement of recoil proton tracks in the plastic using optical microscopy, image capture and highly sophisticated image analysis software.

TASTRAK detectors undergo conventional etching in 6.25 M NaOH, typically 3h at 85 °C. No methanol pre-etch is required because the readout software effectively removes all background alpha-particle tracks and effectively rejects other non-track background. Detectors, up to 56, are mounted in cells on a stainless steel frame on which etch processing and subsequent analysis is carried out. Following etch processing, the frame is mounted on the microscope stage and the detectors scanned at a rate of one per minute, 56 minutes for a complete frame. Subsequent calibration and dose analysis is carried out automatically. Separate analysis allows spectral information to be obtained where required.

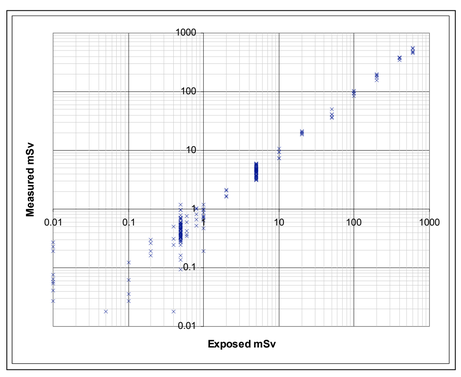
Key to achieving high quality recoil track recognition is the TASLIMAGE fully automated scanning and analysis software. The XY position of each detector is located. A software controlled autofocus locates and maintains focus on the plastic surface. The plastic code is read and a typical area of 1 cm^2 scanned. Track recognition is based on the measurement of up to 14 parameters on each candidate track. Sophisticated algorithms effectively remove all background alpha-particle tracks and minimize recognition of track-like features which may be confused with genuine recoil proton tracks. The neutron response can vary considerably between different exposure conditions in the working environment. Each detector or group of detectors, are characterized from their track response to allow individual automatic dose calibration. The normal range of this procedure allows for sensitivities between approximately 150 to 750 tracks per mSv.

We estimate a lower limit of unambiguous track detection of 20 cm^{-2}. How this translates to dose threshold depends on the neutron energy spectrum and individual plastic sensitivity, but values of 0.1 mSv (10 mrem) can be obtained. The system has been calibrated over an exposure range of 0.1 to 600 mSv and operates successfully to at least this upper value. The system automatically accounts for neutron spectra of lower energy such as moderated ^{252}Cf by evaluating the different track size distributions resulting from neutrons of lower energy. Equally, the track measurements allow spectral information to be obtained on individual or grouped detectors.

The TASLIMAGE Neutron dosimetry System

Our neutron dosimetry system is a complete system for measuring fast neutrons, comprising the TASL*IMAGE* microscope based analysis system, etch tank, drying cabinet, trays and a PC running the analysis software.

From the moment detectors are returned for analysis, they can be mounted in a tray which can be used for keeping them in place during the etching and afterwards be placed on the TASLIMAGE system for subsequent analysis.



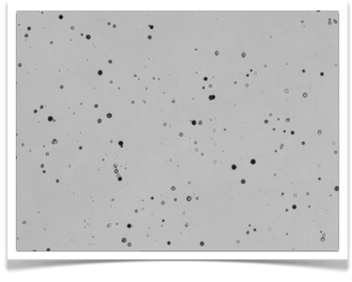
The TASLIMAGE neutron system is linear in its response to the measured dose as shown in above figure.

The TASL*IMAGE* analysis system is a fully automated microscope based track analysis system, based on ultra-fast 3-axis motorised control and high quality Nikon optics. It can be used as a fully automatic readout system for dosimetry services with a throughput of 30-60 seconds per detector or detectors can be scanned individually.

The scan data is automatically converted into a dose measurement and the measured dose and the track density are displayed in a database, indicating any issues which might have resulted in a poor result.

CR-39 plastic detectors can be used to measure fast neutrons by means of detecting the knock-on protons from a polyethylene radiator. Etching of the plastics will reveal conically shaped tracks in the detectors which can be analysed for dose determination.

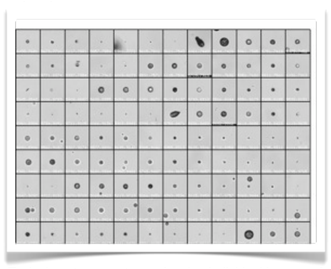
The size of the tracks left behind in the detector is dependent on the detector sensitivity and the subsequent etch conditions, which our system takes into account via a self-calibration procedure. This automatic procedure calibrates the plastics, since the track density varies, allowing for a variation in sensitivity of between 150 to 750 tracks per mSv. A further 31 parameters are used to characterise each track to discriminate the signal from background.



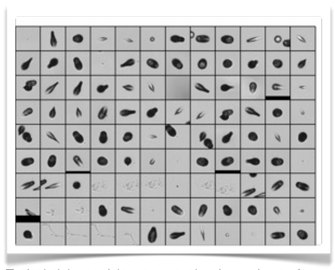
Typical image of an etched piece of TASTRAK dotted with proton recoil tracks.

TASL has developed extra sensitive CR-39 plastic which allows for efficient discrimination from alpha background tracks. The system can in addition to reading our own proprietary TASTRAK format detectors also read the “Autoscan” style plastics or be configured for any size plastic, including automatic ID reading.

The system has various user options available for research applications, such as a montage feature which gives a compact display of the recorded tracks.

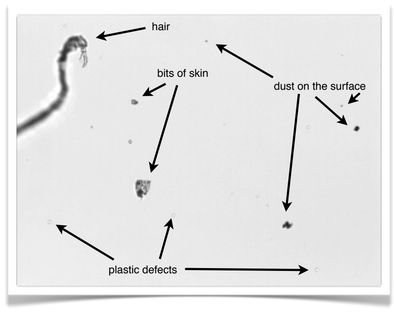


Typical neutron montage, showing individual images of the different tracks.



Typical alpha particle montage, showing an image for each detected track.

When working with higher energy neutrons (>10 MeV), an alternative way to distinguish the neutron signal can be via carbon triple alpha breakup. This leaves a very distinct signature and this is something we are currently working on, to develop a method of reporting the dose of the high energy components.



This image has 22 features of various sizes, none of which are real tracks. Amongst the features are hair, dust, skin and defects in the plastic, with the smaller pieces of dust corresponding to the size of a typical neutron track. Labelled defects are easily distinguishable, the most demanding features are small circular pieces of dust.

Background and limitations

Tracks from recoil protons are typically 3-15 microns. The track sizes overlap with the alpha particle region at large track sizes, where shape differences are used to discriminate particle species. At the small track sizes, it is difficult to discriminate between noise (primarily dust on the surface) and genuine tracks. A variety of shape characterisations are used to achieve the successful discrimination of tracks against backgrounds for up to 2000 background features per cm^2 without compromising the measurement accuracy. Even a low energy fast neutron signal(~200 keV), which is almost identical to that of the background, is distinguishable by use of a variety of complex shape detection algorithms. This enables the system to work in normal laboratory environments

Typical backgrounds are alpha particles from the natural radon background, surface dust and hair, dirt and finger prints from the handling of the detectors. The image on the left shows a typical dirty piece of CR-39, showing no real tracks, but background features which the system will all identify and reject.

TASLIMAGE system specifications

Dimensions (WxHxD): 486 x 440 x 640 mm

Stage area: 203 x 203 mm

Throughput: The analysis time for a tray of 56 detectors is less than 1 hr

Optics: Nikon CFI LU Plan Epi 20x objective, Nikon L-IM focusing unit and Nikon standard sextuple nosepiece

Neutron energy range: 200 KeV to 14 MeV.

Calibration range: 0.1 mSv to 600 mSv.

TASL has a number of these systems operating in the field. For sales enquiries about neutron dosimetry systems, radon dosimetry systems or TASTRAK CR-39 plastic, please contact TASL, Napier House, Meadow Grove, Bristol, BS11 9PJ,UK or Tel: +44 117 9381172, Fax: +44 117 3720667, E-mail: info@tasl.co.uk

In the Americas and Asia, the TASL*IMAGE* neutron dosimetry system is distributed by the Radiation Detection Company (RDC), 8095 Camino Arroyo, Gilroy, CA 95020, USA. Contact: ron.smith@radetco.com