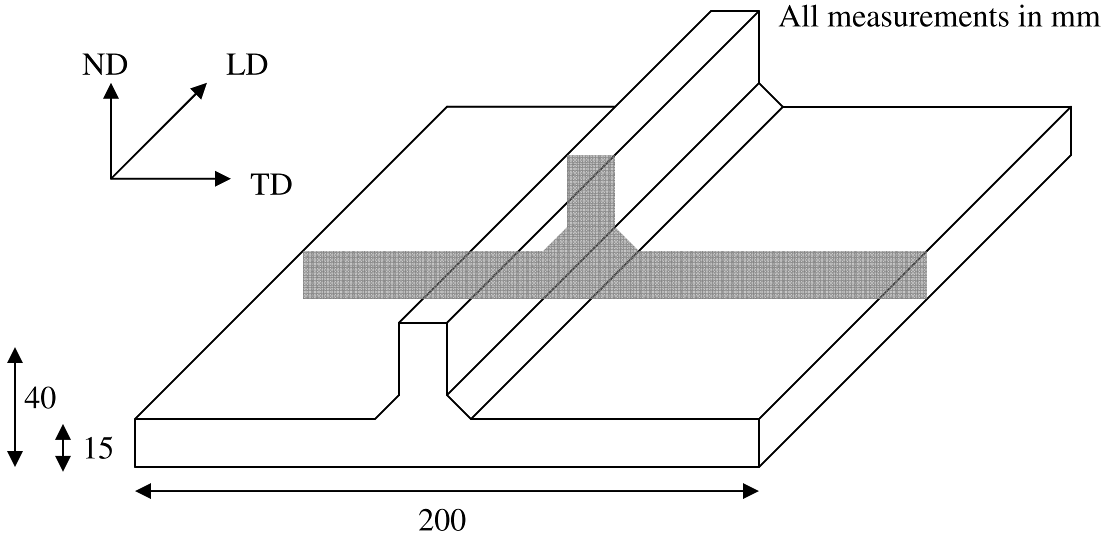
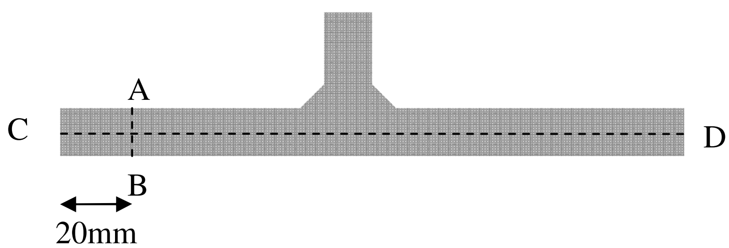
ENGIN-X strain scanning training exercise

Ed Oliver, September 2008



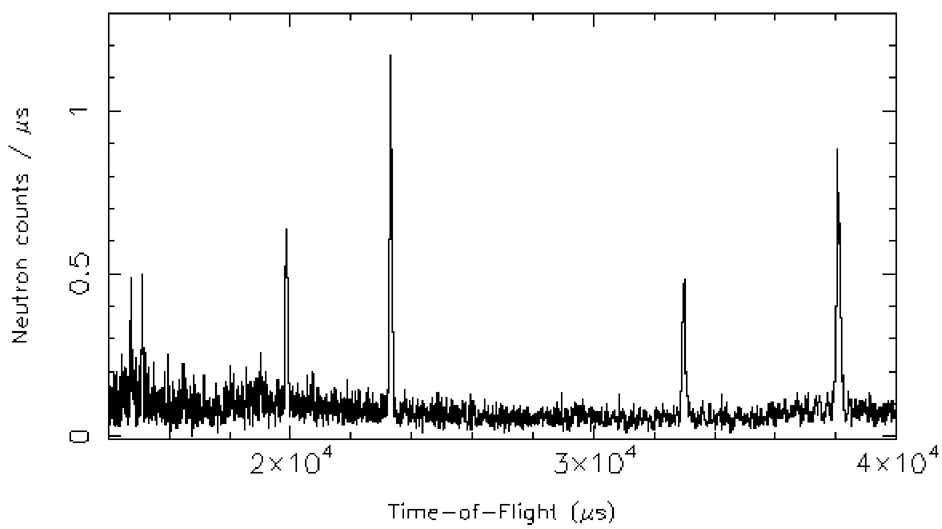
You have been assigned the task of planning residual stress measurements on the above T-butt weld at ENGIN-X. The sample is entirely composed of austenitic stainless steel. Two line scans are required within the middle cross section (shaded above), along lines AB and CD as shown below. The strain components along each of the directions LD, TD and ND should be measured at each measurement location.



1. Sketch a plan view to show how you would orient the sample to measure the ND and TD strain components along line AB.
2. What is the path length through the material for the TD measurement at the centre of line AB? How does this vary as the measurement location moves towards points A and B? (Note: for this question and the remainder of the exercise, assume all neutrons measured by the detector scatter at an angle of exactly 90º).
3. Repeat question 2 for the ND direction. What can you do to ensure that the path length never exceeds that for the point at the centre? Does this alter your answer to question 1 at all?
4. You plan to use a 2mm wide incident beam and radial collimators which also define a 2mm field of view on the outgoing beam. What is the closest distance to points A and B that you can measure without having to worry about surface pseudostrains (geometrical diffraction peak shifts due to the gauge volume intersecting the surface)?

5. The instrument scientist has performed a trial measurement with a path length of 10mm and a gauge volume of $3x3x3mm^3$. Acceptable counting statistics were achieved in a time of 30s. Given that the exponential attenuation length for stainless steel is 8.3mm (i.e. the neutron beam intensity falls by a factor 1/e in this length), estimate the time required for each of the above measurements using a $2x2x2mm^3$ gauge volume (HINT: it should be the same for all points along line AB). If you assume that the strain state does not vary along LD within +/- 10mm of the plate, what can you do to reduce this time, and by approximately what factor can you reduce it?

6. The spectrum measured by the instrument scientist during the trial is plotted below as a function of time-of-flight. Given that the ENGIN-X flight path is L=51.5m, approximately calculate the d-spacings in Angstroms of the 4 highest d-spacing diffraction peaks shown. Given that the lattice parameter is a=3.61Å, give the hkl indices of each diffraction peak (note that for face-centred cubic structures, $d=a/\mathrm{sqrt}(h^2+k^2+l^2)$, and diffraction peaks only arise when h, k, l are either all odd or all even. For face-centred cubic symmetry, the order of h, k and l does not matter, i.e. hkl is equivalent to khl and so on).



7. Thanks to your meticulous planning, the measurements are successful. At a particular location, the lattice parameter measurements are a_{LD}=3.61433Å, a_{TD}=3.60762Å, a_{ND}=3.61041Å. The stress-free lattice parameter is found to be a_0=3.61050Å. Assuming a Young's modulus E=210GPa and Poisson's ratio ν=0.3, calculate the residual stress resolved along the three directions. What assumptions have you made?

8. Sketch diagram(s) of how you would orient the sample for TD and ND measurements along line CD. Comment on how many sample orientations you would need and whether there are any possible experimental/calibration issues which arise from your choice.

9. Sketch a diagram of how you would orient the sample for LD measurements along line CD.

10. Comment on how you would measure the stress free lattice parameter. What considerations would you need to make in the vicinity of the weld?