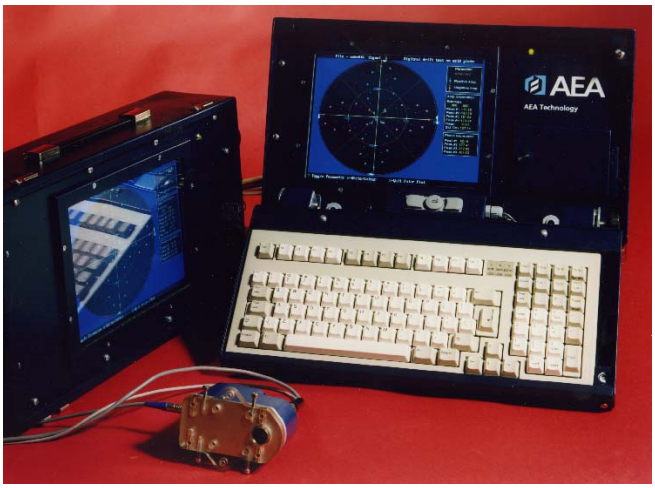
Magnetic Methods for Stress Measurement

The University of Manchester

STRESS & DAMAGE CHARACTERISATION UNIT

A variety of magnetic signals are sensitive to stress, and many of these are also sensitive to microstructure. By combining information from a range of signals it is possible to deduce - non-destructively - the in-plane stresses and their orientations in magnetic materials. Altering the search frequency allows scanning from near the surface to depths of approximately 10 mm.

FACILITIES



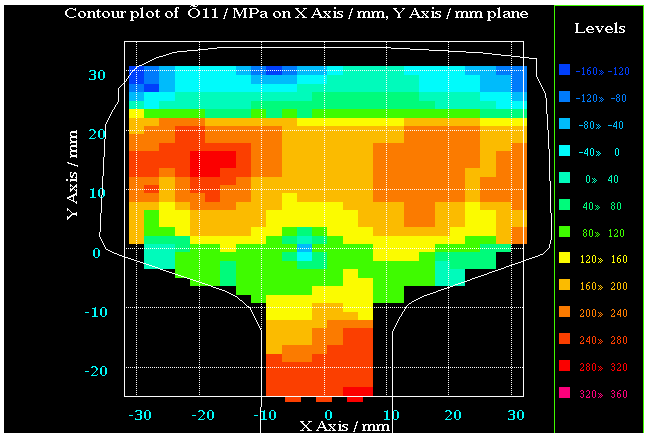
- MAPS (Magnetic Anisotropy and Permeability System). This equipment is shown above. Spatial resolution: 5.2 and 15.5 mm, depending on probe type, to a depth of 0.1 to 5 mm.
- MARSH (Magneto Acoustic Residual Stress & Hardness System), with a Barkhausen noise probe. Resolution of MARSH: 17 mm to a depth of 0.1 to 10 mm, and for Barkhausen: 12 mm to a depth of 20 to 300 mm.

Both are AEA Technology instruments. MAPS is a quick method, requiring under 2 minutes to make a bi-axial stress measurement, and is also a portable system. Marsh and Barkhausen noise are laboratory based techniques.

All ferromagnetic materials can be examined, including ferritic steel, cast iron, tool steel, some stainless steels and nickel super-alloys.
Each system enables several magnetic parameters to be measured. Complementary information allows a wide range of materials to be examined, and minimizes microstructural constraints. The table at the bottom of the page gives an indication of the sensitivity of the available techniques.

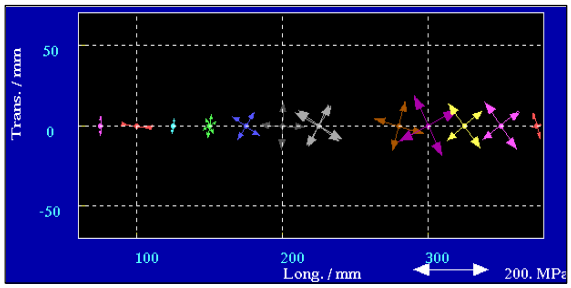
CASE STUDY – RESIDUAL STRESSES IN A SECTION OF TRAIN RAIL.

MAPS was used to make the following stress maps from a section of train rail.

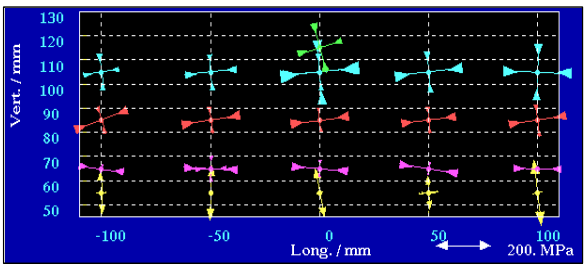


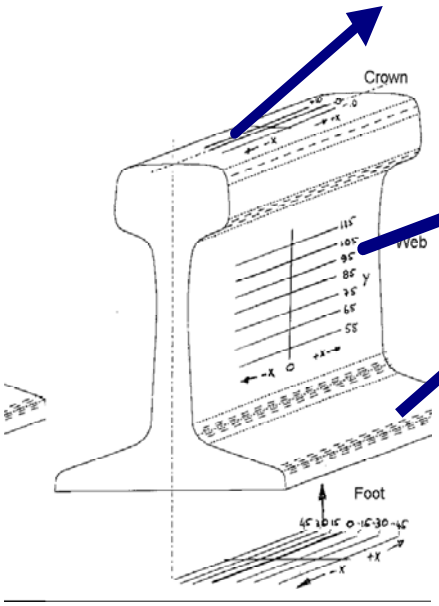
Coercivity Hysteresis loss Remanence	Field strength permeability	Barkhausen emission	Magneto acoustic emission Impedance Coercivity	Stress induced magnetic anisotropy

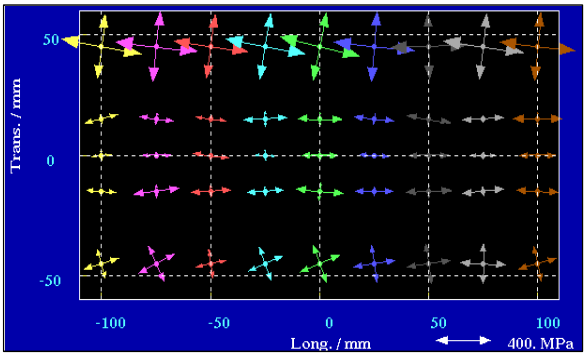
High microstructural sensitivity — High stress sensitivity



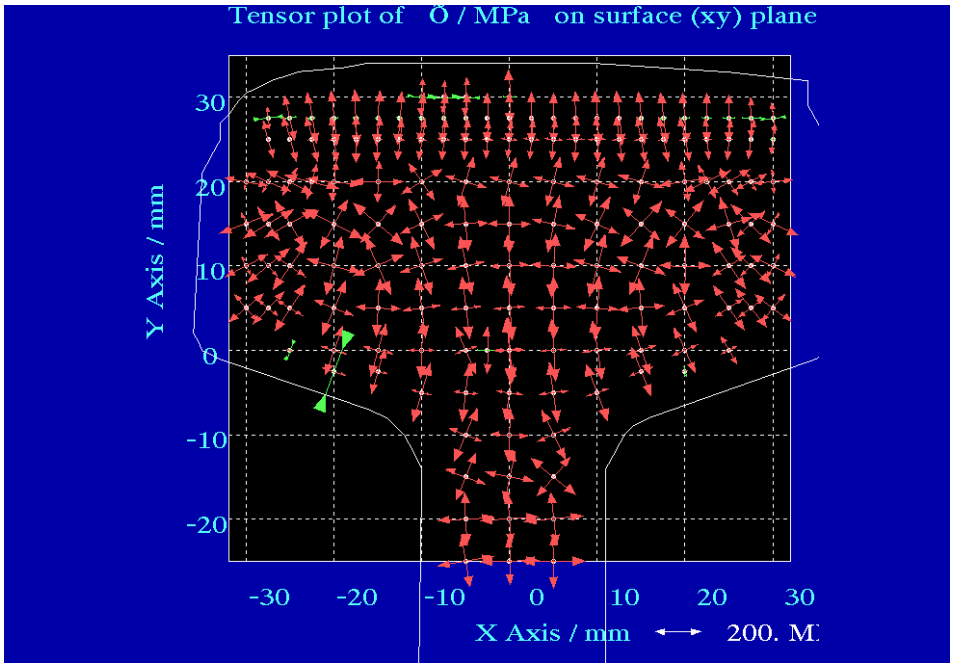
These three stress plots are courtesy of Dr D Buttle, AEA Technology.







Tensor plot corresponding to colour contour map of rail section shown overleaf



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