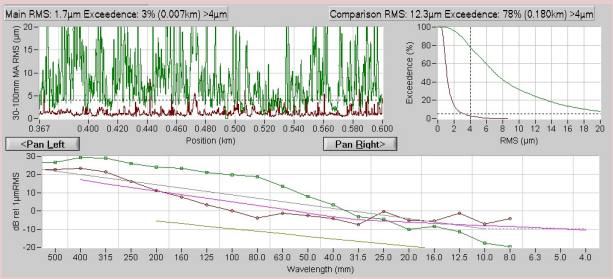
Manual Corrugation Measurement: CAT

CAT 3 in use on embedded rail: this equipment can be used on heavily worn, deeply embedded rails as well as on conventional Vignole rails

RailMeasurement's **CAT** (Corrugation Analysis Trolley) is used for manual measurement of rail corrugation and acoustic roughness. Typical uses are Quality Assurance of rail grinding; short- and long-term monitoring of corrugation development e.g. on test sites; corrugation surveys of small railway systems; demonstration that a site satisfies the requirements for acoustic testing of vehicles; and corrugation research. We have supplied CATs to Alstom, Banverket, Hong Kong MTRC, Loram, Metronet (London Underground), Portec, Queensland Rail, Schweerbau, Sumitomo, SNCF, Toronto Transit Commission, Wiener Linien and many others.

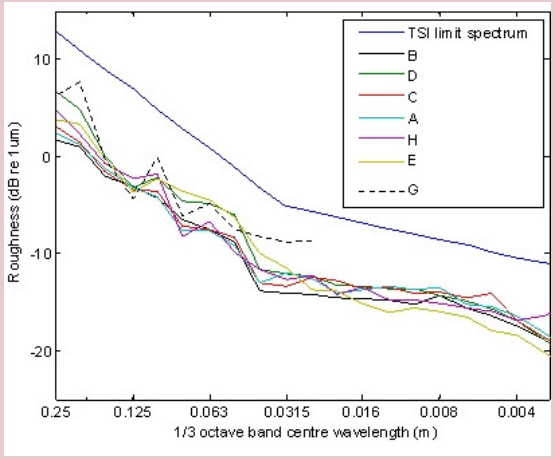


CAT measurements showing sporadically severe corrugation in the 30-100mm wavelength range, that has been reduced by grinding to within the requirements of EN I3231-3:2006. Note the periodic irregularities at 12.5mm and 25mm from grinding "signature" and that short wavelength irregularities (<30mm) are more severe after grinding.

Measurements can be made at a comfortable walking speed of 1m/s (3.6km/h) for essentially an unlimited length of track. The CAT operates with a USB lead to a laptop computer, so only the laptop needs to be charged to run the equipment.

Although the CAT is an extremely accurate instrument, it is also robust and very reliable. Many CATs have had years of trouble-free use for quality assurance of rail grinding and corrugation surveys.

Equipment that is used to measure "acoustic roughness" must be accurate to sub-micron levels. It has been demonstrated by independent tests that the CAT is a satisfactory instrument to measure acoustic roughness on rails to the requirements of standards EN ISO 3095:2005 and EN 15610:2009. In 2006 RailMeasurement Ltd participated fully in a so-called "road test" of the measuring protocol in EN 15610:2009, from which it was concluded that similar measurements of acoustic roughness were provided by the CAT and by conventional straight-edge based instruments. However, one person with a CAT can make a continuous measurement of hundreds of metres in the time that two or more people take selected measurements of 1m length with a straight-edge device.



Measurements of "acoustic roughness" made using different instruments. CAT is instrument H. A-E are measurements made using straight-edge instruments. G was made using another trolley (not a CAT).

Dr Stuart Grassie, a Director of RailMeasurement Ltd, has consulted in the area of rail corrugation for railway systems and suppliers worldwide, and some of his work is standard reference material in the area e.g. [1],[2]. The CAT is one outcome of his long involvement with rail corrugation and particularly with the need that he identified to have an instrument of excellent and traceable accuracy with which measurements could reliably be made of residual irregularities on rails after

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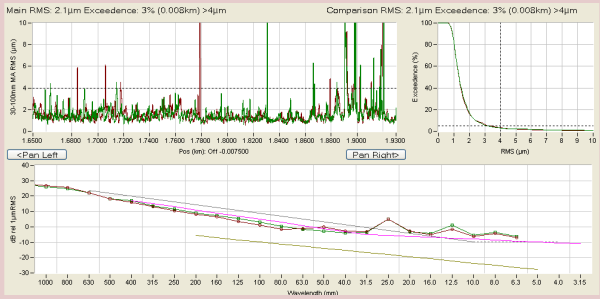
grinding. A second key use for the CAT is to calibrate other corrugation equipment e.g. [3],[4].



Correlation of measurements from two CATs over 280m of a grinding site: RMS moving average (30-100mm); percentage exceedence; one-third octave spectra

When the first CAT was made in the late 1990s, there was no accepted, objective and "traceable" method of demonstrating the accuracy of such equipment. We developed such a test, which is described in ref [5]. This is the basis of the procedure adopted for testing so-called "reference" equipment in the European Standard for reprofiling of rails, EN13231-3:2006. All CATs are calibrated using this test and issued with a calibration certificate stating the accuracy thus obtained in different wavelength ranges.

CATs are available for hire.

The CAT software is continually being improved to satisfy the requirements of users. Grinding reports can be produced routinely that summarise areas where corrugation exceeds a specified limit for more than a specified length of track. Some success has also been achieved using the CAT to highlight excessively dipped or peaked welds.

References

1. Grassie SL and Kalousek J, "Rail corrugation: characteristics, causes and treatments", *Journal of Rail and Rapid Transit, Procs of I mech E*, 1993, 207F, pp57-68
2. Grassie SL, "Rail corrugation: characteristics, causes and treatments", *Journal of Rail and Rapid Transit, Procs of I mech E*, 2009, 223F, pp581-596
3. Gullers P, Andersson Land Lunden R, "High-frequency vertical wheel-rail contact forces: field measurements and influence of track irregularities", *Wear*, 2008, 265, pp1472-1478
4. Berggren E, Li M and Spännar J, "A new approach to the analysis and presentation of vertical track geometry quality and rail roughness with focus on train-track interaction and wavelength content", *Procs. of 7th Intnl. Conference on Contact Mechanics and Wear of Rail/Wheel Systems*, Brisbane, 2006, pp563-572
5. Grassie SL, Saxon MJ and Smith JD, "Measurement of longitudinal rail irregularities and criteria for acceptable grinding", *Journal of Sound and Vibration*, 1999, 227, pp949-964

Technical Data: CAT			
interval at which data are saved	1mm or 2mm	Output compatible with requirements of	• EN 13231-3:2006 • EN ISO 3095:2005 • EN 15610:2009
Measuring speed (within +/-25%)	• 0.5m/s (1mm interval) • 1m/s (2mm interval)	Output	• raw and filtered displacements • moving average amplitudes (RMS and peak-to-peak) vs. distance • percentage exceedences • one-third octave spectra • exceedence reports (to assist grinding) • ASCII data
Precision of measurements (displacement)	0.01µm		
Repeatability	Better than • 0.5µm RMS 10-30mm • 1µm RMS 30-100mm • 2µm RMS 100-300mm	Filters, built-in	• 10-30mm, 30-100mm, 100-300mm, 300-1000mm, 1000-3000mm • 30-300mm, 300-3000mm • 30-150mm, 150-1500mm • 150-1000mm, 1000-1500mm
Accuracy (measurement of 1m calibration beam)	Better than • 2µm RMS 10-30mm • 2µm RMS 30-100mm		
Data storage requirements	< 2MB per kilometre of rail	Filter, user-selectable	• band-pass, high-pass or low-pass • wavelength of 5-5000mm
Weight	• 20kg in carrying case • 8kg for instrument with laptop on rail	Options	• measurement of track with different gauge • software to concatenate data files • training course

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