

Test Method for the Measurement of Tensile and Shear Tack for Electronic Solder Pastes and Adhesives

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ABSTRACT

A test method is detailed for measuring the tack force exhibited by electronic solder pastes and adhesives. The test method describes the measurement of tack forces normal to, and in the plane of the circuit board surface (tensile and shear tack respectively).

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Approved on behalf of Managing Director, NPL, by Dr C Lea,
Head, Centre for Materials Measurement and Technology

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1 SCOPE

This document describes a test method that can be used for the testing of solder pastes and adhesives (conductive and non-conductive), which are used in electronics production. Historically tack testing has been performed in a tensile mode but NPL has proved that shear testing gives a better indication of material behaviour¹. It is recommended that shear tack testing be used to determine the component retention performance of these materials. Component retention is required, for example, in processing after placement and prior to reflow or cure.

2 TEST SPECIMENS

2.1 Test Substrate

The test specimen will be a flat copper surface at least 1mm thick, to ensure planarity.

2.2 Test Stencil

Previous work carried out at NPL^{1,2} has shown that the shape of the test probe did not significantly impact on results, and that larger probes gave the best differentiation between materials. It is therefore recommended that the screen used to deposit the paste or adhesive should have round apertures 2.7mm in diameter. The stencil should be stainless steel and 200µm thick.

3 APPARATUS

3.1 The Tack Tester

The equipment used for the NPL work^{1,2} was a prototype machine provided by Multicore-Loctite. The instrument uses load cells to measure the forces applied, and stepper motors to move the test probe and test plate. Figure 1 shows the tack tester, the broken arrows indicating the location of screw threads attached to stepper motors for the movement and positioning of the probe and sample plate. The full arrows indicate the load cells, which register the force acting on the probe.

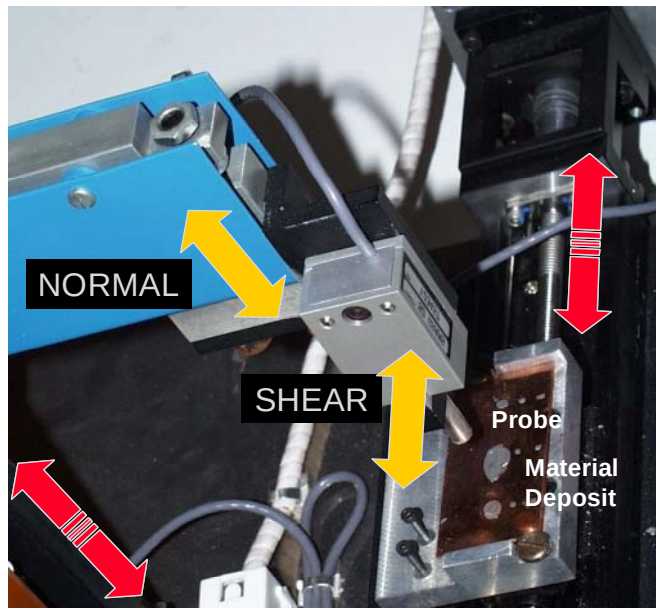


Figure 1. The Multicore-Loctite prototype tack tester

Equivalent systems can also be used, but they must be capable of measuring forces in directions both normal to, and in the plane of the PCB surface. They must also allow positioning of the probe over the paste or adhesive prior to commencing the test, and the facility to apply a known load into the material deposit. They must allow insertion and withdrawal speeds of 0.1mm/s and incorporate a 2 second delay after insertion before the probe is removed.

The equipment must be able to electronically store the force measurements taken over the test period.

3.2 The Test Probe

The test probe should be cylindrical, with a 6mm² contact area (2.7mm in diameter), and made from stainless steel.

4 PROCEDURE

1. Fix the test probe in the tack tester securely.
2. Screen the solder paste or adhesive onto the test substrate by hand, and clamp the sample beneath the test probe. Care must be taken not to smudge the prints. A stencil holder that releases away from the substrate is required.
3. Align the test probe over the material deposit.
4. Set the tack tester to use insertion and withdrawal speeds of 0.1mm/s and to apply a 50g load with a 2 second delay before removal of the probe.
5. Start the test. Once the test is started the probe is driven down into the paste deposit. As the probe enters the paste the vertical displacement load cell registers the vertical force on the test probe and once this reaches the

defined contact load the insertion is automatically halted. The machine then waits briefly before withdrawing the probe.

5 INTERPRETATION OF RESULTS

5.1 Tensile Tack

During a tack test the test probe is moved downwards into the paste material until a force of 50g is measured acting back on the probe. As the probe is withdrawn from the paste the downward force on the probe is recorded.

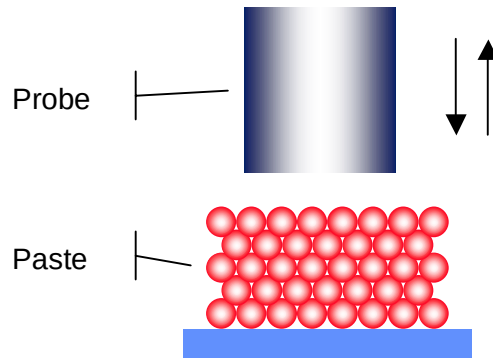


Figure 2. Schematic of tensile tack testing

The data should then be analysed using a plot of force against time, which will ideally have the shape of curve shown in Figure 3.

The probe is driven into the material until the required force is met at the point marked 'A'. The system dwells at this point and the paste relaxes with the force diminishing to point 'B'. At point 'B' the probe is withdrawn, the paste is extended and the maximum cohesive force in the paste is reached at point 'C'. After this the paste necks, and the neck breaks and the force falls to approximately zero at point 'D'.

The tensile tack force is defined as the peak force in the force curve shown, i.e. at point C.

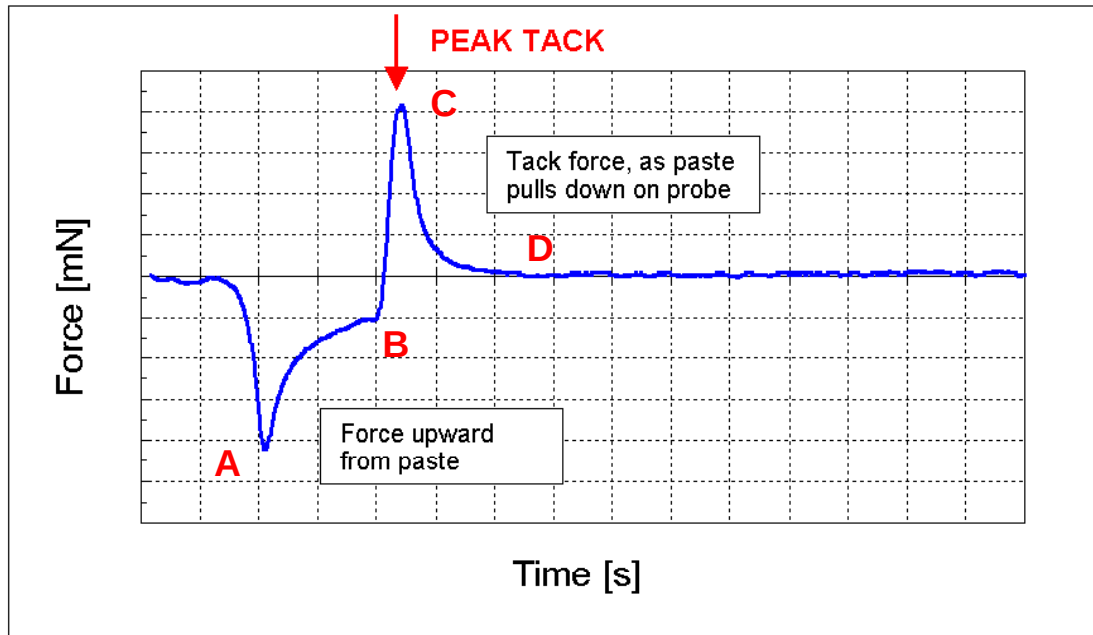


Figure 3. Idealised force - time plot for a tensile tack test

5.2 Shear Tack

When testing for shear tack the test probe is withdrawn horizontally from the material, although it is still inserted vertically. In practice this is often achieved by moving the paste sample plate horizontally. The force monitored during the process is the force on the probe in the y-horizontal axis, not the z-vertical axis, although the z-axis force is still used as the controlling parameter for limiting the insertion depth of the probe.

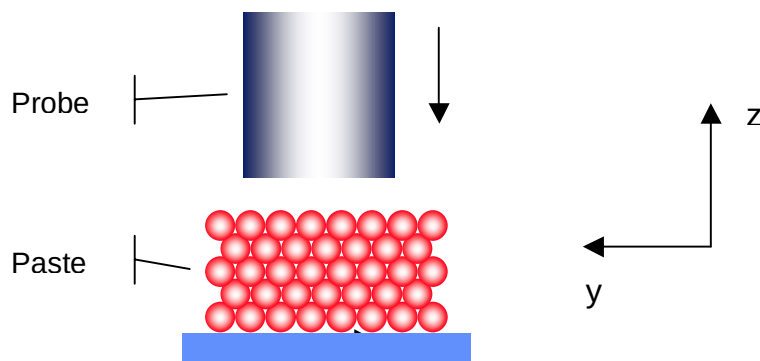


Figure 4. Schematic of shear tack testing

The force against time plot for the shear tack test (Figure 5) is different from that in the case of vertical withdrawal. There is no negative displacement due to the insertion force of the probe since this force is not in the horizontal plane. Only the force resulting from the shearing of the material is recorded, as the sample is pulled sideways. The maximum force at point 'A' is reached when the maximum cohesive force in shear is reached. Thereafter the paste necks and breaks, with a final residual

force being present with remnant paste on the probe being rubbed over the substrate, point 'B'.

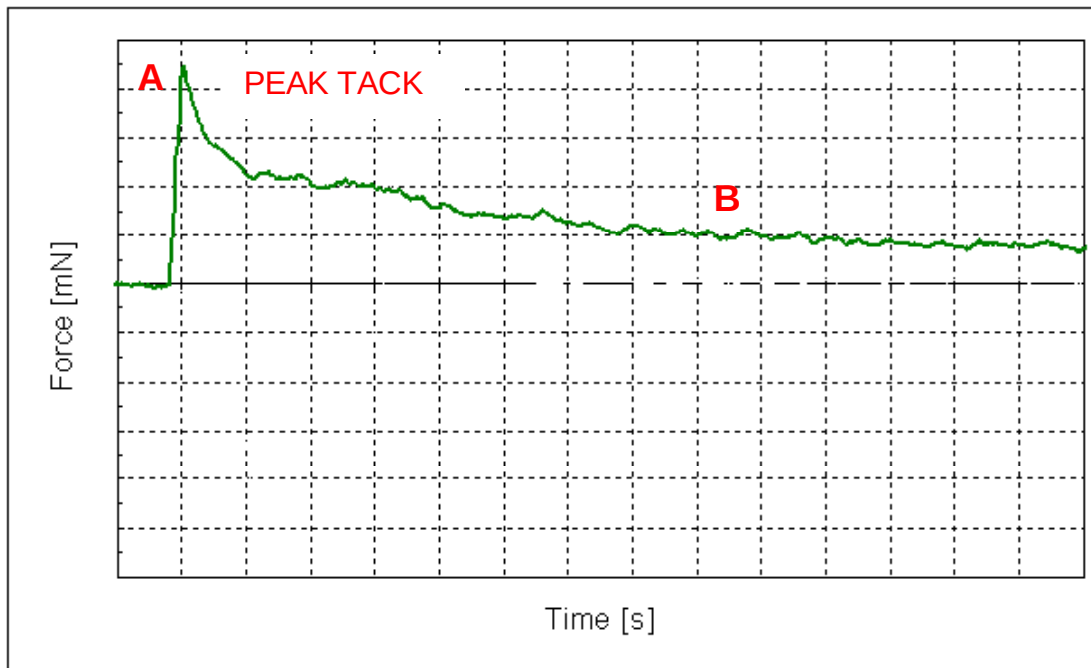


Figure 5. idealised force against time plot for a shear tack test

The shear tack force is defined as the peak force in the force curve shown, i.e. at point A.

5.3 Ageing of Materials

Normal and shear tack tests can be used to monitor the ageing of pastes and adhesives. Following previous NPL work^{1,2} it is recommended that shear tack is the best indicator for ageing of both pastes and adhesive materials.

Examples are presented in Figures 6 and 7. Figure 6 shows typical data collected for rosin-based solder paste over 8 hours of ageing. It can be seen that the shear tack of the paste decreases over time, whereas the tensile tack increases, then begins to decrease. Hence shear measurements provide a better indication of ageing, as well as being more relevant to performance in production. Tensile tack data does not give a useful indication of ageing.

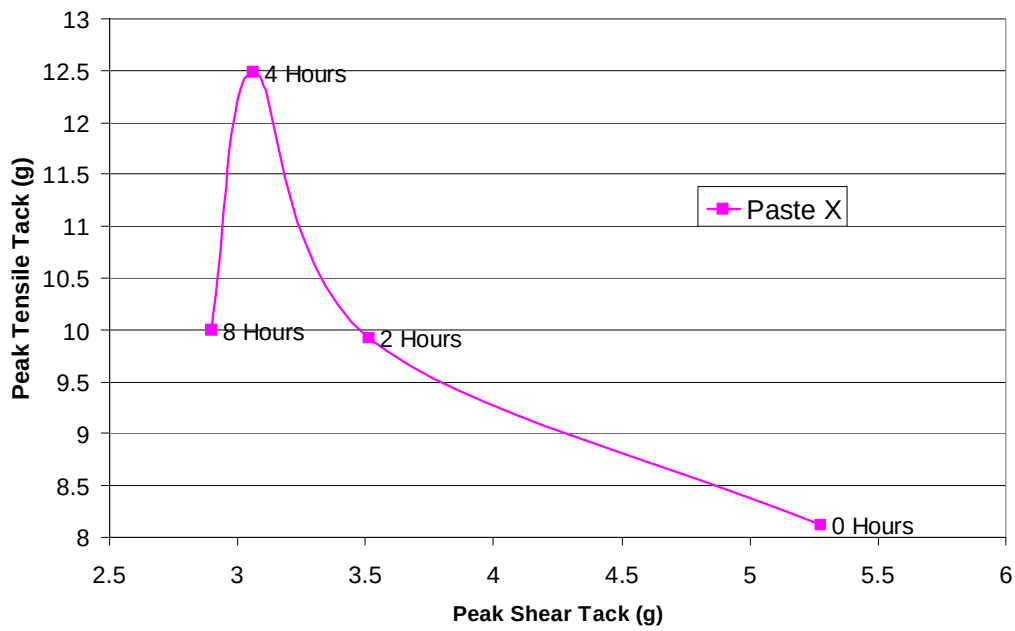


Figure 6. Correlation between tensile and shear peak tack for ageing a typical solder paste

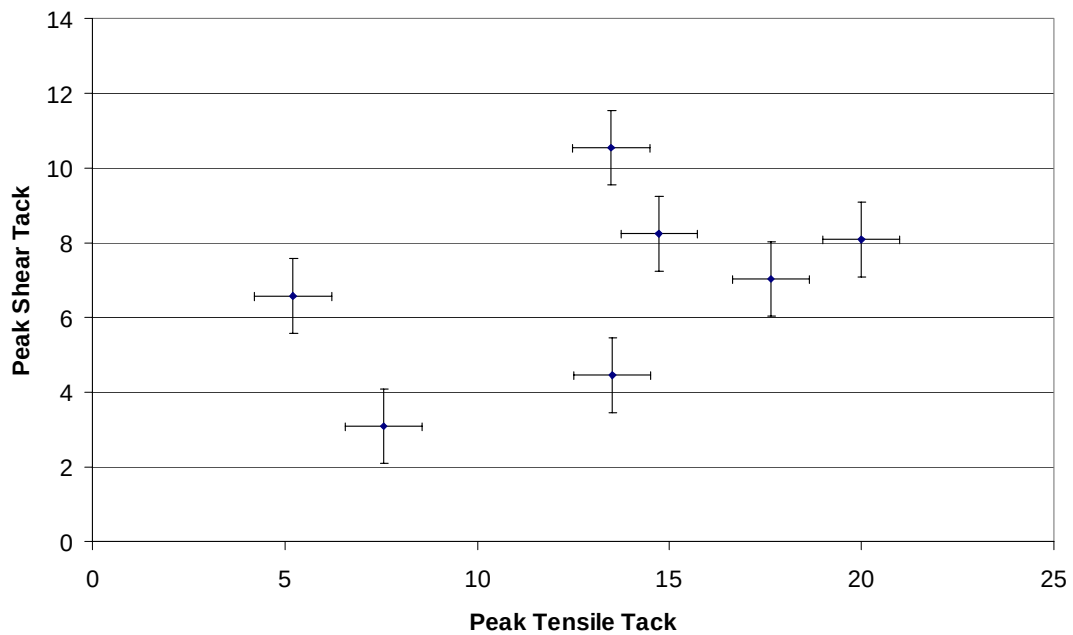


Figure 7. Tensile and shear peak tack for a SM adhesive over a range of test conditions

NPL work^{1,2} has shown a similar lack of correlation between tack behaviour in tensile and shear modes for adhesives. Figure 7 presents data for a surface mount adhesive, tested under a variety of conditions. If the same mechanism were being measured in tensile and shear modes one might expect a linear relationship, or some element of proportionality between the results obtained when measuring tack in each direction. It is clear that there is not a strong correlation between shear and tensile

measurements. There may be a general trend of shear and tensile tack increasing in magnitude together, but there is significant scatter.

5.4 Quality Assessment

Shear tack has been shown to be more sensitive and follow the deterioration of materials in a progressive fashion, when compared to tensile tack measurements. This work recommends the use of shear measurements for characterising the tack and retention properties of materials.

6 REFERENCES

1. 'Measurement of Solder Paste Tack in Tension and Shear', NPL Report MATC(A)29, A Brewin, L Zou, & C P Hunt
2. 'Tack of Electronic Adhesives in Tension and Shear', NPL Report MATC(A)30, A Brewin, L Zou, & C P Hunt

7 ACKNOWLEDGEMENTS

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