Adhesion in Hostile Environments

London, UK, 12 December 1991

Organized by: The Plastics and Rubber Institute Adhesives Group

Thirty six people registered for this one-day symposium and most were able to attend on the day. The hostile environments ranged from aerospace to marine to dental.

The day began with Tony Maddison of Stoke Golding Applied Research who discussed the topic of 'Stress testing of adhesive joints using a travelling test bed'. He emphasized the importance of testing representative joints under realistic conditions of temperature, environment and also time. He described a range of miniature stress tubes, each one instrumented, which are now being carried on a heavy, long-distance goods vehicle (commonly, and rightly, called 'road trains') in Australia. This vehicle is operated from North to South Australia and consequently encounters mountainous, rain forest, marine and very dry desert conditions on each journey. The remote detection of spontaneous bond failures facilitates early intervention and specimen recovery. Temperature and humidity data are continuously recorded. The eventual comparison of these results with laboratory testing is expected to prove extremely useful.

The second paper by Steve Shaw from the Defence Research Agency (RAE) Farnborough, previously from RARDE, Waltham Abbey, was entitled 'Problems of adhesive bonding in the aerospace industry'. For this paper, which spent some time on the history of Waltham Abbey, its original title of The Royal Gunpowder Factory was used. This title was used from 1787 to 1948. RARDE closed in summer 1991.

The hostile environments of moisture, temperature extremes, stress and radiation were discussed. Moisture was considered one of the greatest problems, causing reversible effects such as plasticization and T_g reduction and irreversible effects such as hydrolysis of the adhesive/resin, generation of micro-cavities, disruption of specific interactions at the substrate/adhesive interface and attack on the substrate (primarily on the oxide layer). The solutions offered to these problems were the use of hydrophobic polymers as adhesives and matrix resins and the use of organosilane coupling agents together with good adhesive primers. Some time was spent on discussion of trials using silanes and the effects of solvent type, solution age and drying conditions were covered. It was concluded that an aqueous solution was the best when dried at 20°C and bonded between 30 and 80 min after application.

Hydrophobic adhesives mentioned were fluoro-epoxies using silicone amines or fluoroanhydrides as curing agents. Some fluoro-epoxies were quoted as having water uptakes at saturation as low as 0.25–1.5%.

High temperature adhesives were also mentioned. Phenolics, polybenzimidazoles, condensation polyimides, bis-maleimides and suitable primers for them were discussed.

The third paper, 'Environmental durability of elastomer to polymer composite bonding', was presented by Mark Priest of Materials Engineering Research Laboratory Ltd. This paper covered some interesting trials of polymer-to-composite bonds subjected to immersion in seawater and a hydrocarbon fluid. Such bonds exist in, for example, automotive engine mounts, sub-sea flex elements, civil engineering bridge supports and captive seals. The results showed that the temperature sensitivity of bond strength is generally lower using polymer composite substrates than when using steel structures. An interesting graph of bond energy versus time was presented for a range of test temperatures. This work indicates that an advantage may be obtained by replacing conventional steel substrates by polymer composite substrates when durability under extreme environments is required.

The fourth paper, 'Adhesives for the marine environment', appropriately continued the theme of the previous one. Presented by Mike Cowling of the Glasgow Marine Technology Centre, this contribution described how adhesive bonding was being considered for marine use as an alternative to the more traditional process of welding. One objective was to avoid the residual stresses set up by welding. The surface preparation studied was the use of an air-driven rotary abrasive belt followed by dust removal and the application of a silane primer. It was found that the silane primer provided an indication of the immediate surface condition because residual surface contamination was seen to prevent wetting of the surface by the primer. Immersion tests for 18 months showed a strength reduction of 12%. Examination of the fracture surfaces showed no evidence of corrosion at the adhesive-to-steel interface. Immersion tests under load are continuing. Some of the early tests from this series showed only a 10% loss of strength after two years' immersion. Tests on fire resistance were also mentioned.

The fifth paper, entitled 'Factors affecting the performance of polysulphide aviation sealants', was presented by Mercia Gick of the British Plastics Federation and was based on her PhD thesis completed in 1988 at the Polytechnic of North London. She found that it was difficult to obtain a diffusion coefficient for these materials. Modulus was drastically reduced by moisture uptake, the first 1% of uptake