

# Effect of temperature on the behaviour of adhesive joints for automotive industry

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## Introduction

In recent years there has been an increasing interest in the automotive industry in applying adhesive bonding in structural components of vehicles. When adhesive joints are used in this area, some factors such as impact loading and temperature variation have a decisive role. Under these conditions, the joint must provide enough strength to transmit the load without fracturing, and thus assure the car's integrity. Although several studies have characterized adhesives under both situations separately, very few have considered them at the same time [1]. In this study the impact strength of single lap joints using a new crash resistant epoxy adhesive and ductile adherends was characterized as a function of temperature. Drop impact tests were successfully conducted at -20, 23 and 80 °C by developing a cooling system and a heating system. The results obtained were discussed and analyzed, and a failure prediction was developed. At room temperature failure was dictated by the adherends yielding due to the high strength of the adhesive. At high and low temperatures, a high decrease in the adhesive strength was found with an increase of ductility and brittleness, respectively. Thus, in this case it was the adhesive which determined the joints strength. Failure prediction at room temperature gave accurate values due to the low sensitivity of the steel adherends to the high strain-rate. At +80 °C the adhesive was much more sensitive to the high strain-rate, since the values obtained for the prediction using the static properties of the adhesive were far below the experimental results.

## Experimental details

### Materials:

- Adhesive: XNR6852-1, one-component epoxy adhesive [2];
- Steel: DIN St33, mild steel

### Cure process:

- 150 °C during 3 hours.

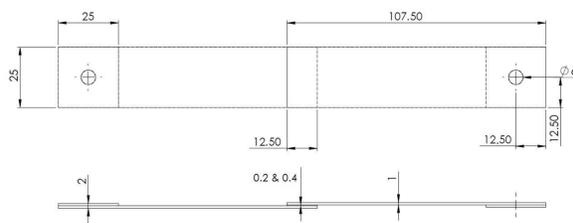


Figure 1 – SLJs geometry.

## Impact tests procedure

The impact tests were conducted in the machine Rosand® Instrumented Falling weight impact tester, type 5 H.V.. The energy applied in the impact is controlled by the weight of the falling mass, and the speed can be set by the height.

### - Room temperature tests

The room temperature tests were performed following the procedure explained in the past section. After fixing the specimen, the mass was set to provide an impact energy of 320 J, which was the maximum capacity available with the specified machine. The height was set to give an impact speed of 4.55 m/s.

### - High temperature tests

Heating through electromagnetic induction was used to reach the temperature of +80 °C in the SLJs overlap. The system implemented heated the specimen once it was assembled to the holding device. When the temperature was slightly above the +80 °C, the system was removed and the mass was dropped to provide an impact of 150 J energy and 4.47 m/s speed.



Figure 2 – Heating system used.

### - High temperature tests

The solution found to reach the -20 °C was to throw gas nitrogen directly to the specimen overlap. The energy and speed used for the tests were also 150 J and 4.47 m/s respectively.



Figure 3 – Cooling system used.

## Experimental results

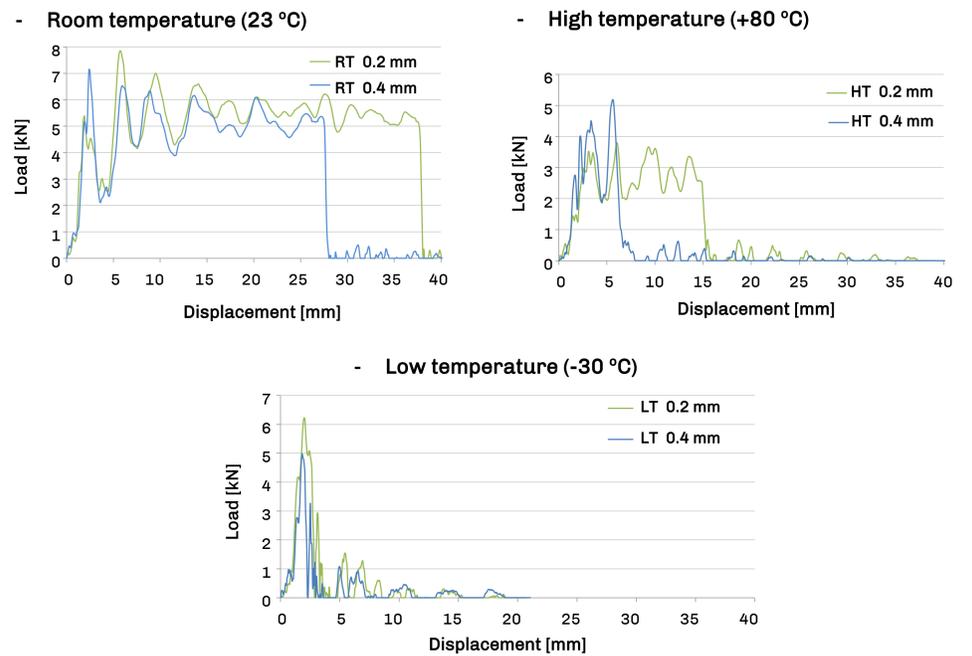


Figure 4 – Typical load vs. displacement curves as a function of temperature.

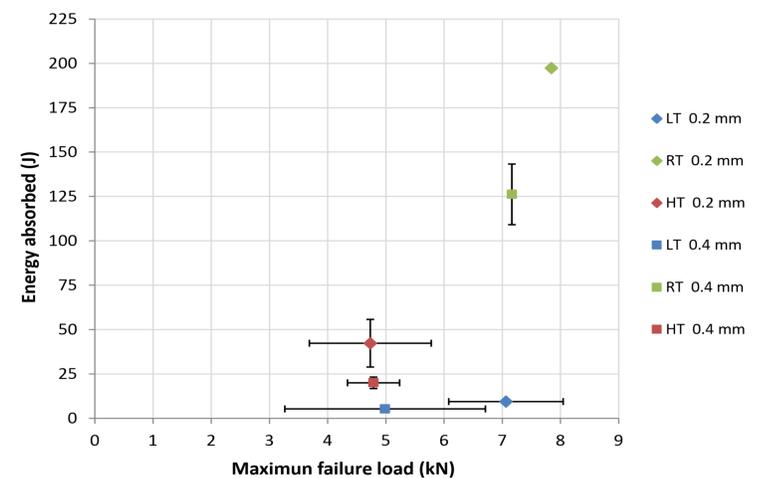


Figure 5 – Energy absorbed vs. max. failure load results summary for the impact tests.

## Conclusions

- The adhesive showed high resistance under impact load, withstanding deformation and damage without brittle behaviour. Failure was dictated by the adherend yielding and could be predicted accurately considering static conditions due to the low sensitivity of the steel to the high strain-rate.
- The resistance of the adhesive is strongly reduced, fracturing in a ductile manner before the steel adherends yield. The strong sensitivity of the adhesive to high strain-rate gives higher results for failure load than the prediction using static properties of the adhesive.
- The adhesive shows low resistance under impact load as at high temperature, showing a brittle behaviour in the fracture mode. Static properties at -20 °C could not be obtained and therefore no failure prediction was developed.

## References

- [1] L.F.M. da Silva, A. Öchsner, and R.D. Adams. Handbook of Adhesion Technology, 2nd Edition (Springer-Verlag, Berlin, 2018).
- [2] D. F. S. Saldanha, C. M. S. Canto, L. F. M. da Silva, R. J. C. Carbas, F. J. P. Chaves, K. Nomura and T. Ueda, "Mechanical characterization of a high elongation and high toughness epoxy adhesive," Int. J. Adhesion Adhes., vol. 47, p. 91–98, 2013.

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