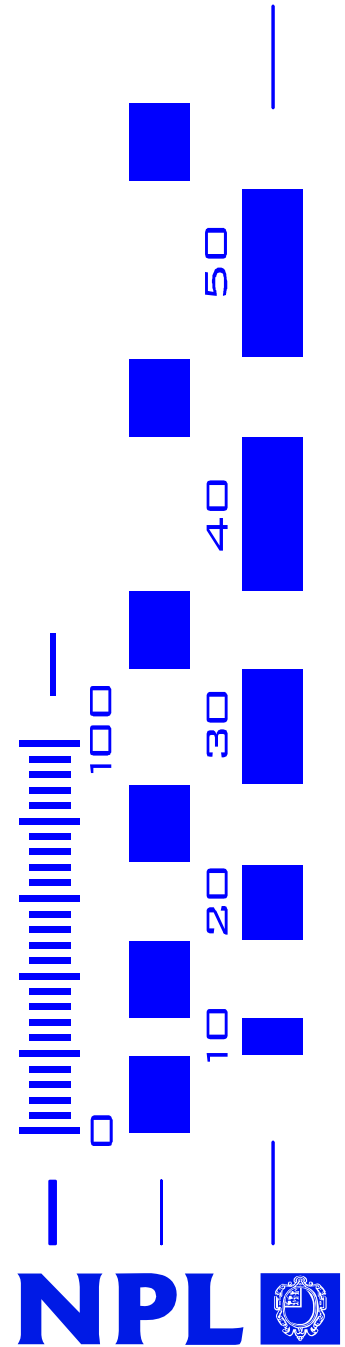


A database for adhesives

MMS IAG meeting

30 April 2003



Purpose of a database for adhesives

- ◆ To identify property data needed by the toolkit
- ◆ To include additional data of more general use
- ◆ To provide a format for the presentation of useful data on adhesives
 - Identify a test method
 - Define specimen dimensions
 - Test conditions
 - Comparable data

Contents

- ◆ The database guides the acquisition of selected property data
- ◆ The contents should not be too large
 - Burden on data supplier
- ◆ Nor too small
 - Limit the value of the database
- ◆ Identification needs support from adhesives suppliers and users

Classification of data

- ◆ Data needed for materials selection
 - Processing and short-term performance
 - Long-term performance
- ◆ Data needed for design
- ◆ Typical values for basic properties for different classes of adhesive
 - Specifically for the Toolkit

Typical values for basic data for different classes of adhesive

Property	1-part epoxy	2-part epoxy	Acrylic	Cyanoacrylate	anaerobic	Polyurethane
Tensile modulus (GPa)	2.5 - 3	1.5 - 2.25	1 - 2	0.5		0.05 - 0.1
Stress at failure (MPa)	40 - 60	30 - 45	20 - 25			10 - 15
Strain at failure (%)	5 - 10	3 - 10	10 - 30			50 - 100
Glass transition temperature (°C)	100-150	60-100	60-100	60-100	100	20 - 40
Lap shear strength (MPa)	20 - 35	10 - 30	10 - 30	10 - 25		
Viscosity (Pa.s)	100-1000	30-100	30-100	1 - 5	5 - 10	
Working life at 23°C (minutes)	stable	10 - 100	2 - 10	1	1	
Cure temperature (°C)	120-180	20 - 100	23	23	23	

Materials selection - typical values for a 1-part epoxy

<i>Property</i>	<i>Typical value</i>	<i>Units</i>	<i>Test method</i>	<i>Additional information</i>
Tensile modulus	3.0	GPa	ISO 527	Bulk specimens
Yield stress	55	MPa	ISO 527	For ductile behaviour (failure after yield)
Yield strain	4	%		
Nominal strain at failure	8	%		
Stress at failure		MPa	ISO 527	For brittle or rubbery behaviour (failure without yield)
Strain at failure				
Glass transition temperature	130	C	ISO 11357-2	<i>Consider alternative method by TMA ISO 11359-2</i>
DMTA curve	See fig.1	GPa	ISO 6721-4	From -40 to above T _g
Lap shear strength	35	MPa	ISO 4587	Aluminium adherends - specify surface treatment
	30			Steel adherends - specify surface treatment
				Other - specify material and treatment
T-peel strength				Aluminium adherends - specify surface treatment
				Steel adherends - specify surface treatment
				Other - specify material and treatment
Toughness	30	kJ/m ²	ISO 179	Charpy impact - from -40°C to 23°C <i>Consider fracture toughness using joint test</i>
Impact resistance			ISO 9653	<i>Is this used - consider block shear test ISO 13445</i>
Viscosity	500	Pa.s	ISO 3219	<i>Consider also ISO 2555. Test conditions need to be identified</i>
Density	1300	kg/m ³	ISO 1183	
Water absorption	5	%	ISO 62	Saturation value at 23°C
Volume resistivity	1.10 ¹²	ohm.m	IEC 60093	
Electric strength	20	kV/mm	IEC 60243	

Materials selection – durability in different environments

	Adherend material		Aluminium	
<i>Property</i>	<i>Typical value (MPa)</i>	<i>Test condition</i>	<i>Specimen conditioning prior to test</i>	
Lap-shear strength	40	-40°C	Dry	
	35	23°C		
	27	70°C		
	25	23°C	Expose for 30 days	At 70°C
	20			Under 95% RH at 70°C
	30			In water at 23°C
	17			In water at 90°C
	30			In alcohol at 23°C
	25			In dilute acid at 23°C
	25			In alkali at 23°C
				In solvent at 23°C
	20			In motor oil at 23°C
				In antifreeze at 23°C
				Other chemicals and temperatures that are optional
	<i>Include similar data for T-peel?</i>			



BASIC DATA REQUIRED FOR STRESS ANALYSIS

<i>Property</i>	<i>Typical value</i>	<i>Units</i>	<i>Test method</i>	<i>Additional information</i>	
Tensile modulus	3.2	GPa	ISO 527	-40°C	Tensile tests on bulk specimens Use a test speed of 1 mm/min. (or use TAST and a typical Poisson's ratio value)
	3.0			23°C	
	2.4			70°C	
Poisson's ratio	0.36		ISO 527	23°C	(or use typical value)
Engineering tensile stress vs strain data	See fig.2 and table1		ISO 527	-40°C	Tensile tests on bulk specimens Use a test speed of 10 mm/min.
				23°C	
				70°C	
Derived true tensile stress vs true plastic strain curve	See fig.3 and table 1	MPa		-40°C	
				23°C	
				70°C	

ADDITIONAL DATA FOR MORE ACCURATE STRESS ANALYSIS

<i>Property</i>	<i>Typical value</i>	<i>Units</i>	<i>Test method</i>	<i>Additional information</i>	
Shear stress vs shear strain data		MPa	ISO 11003-2 Or shear test on bulk specimen	-40°C	At a test speed of 0.05 mm/min. Bulk specimen test at a speed of 2 mm/min.
	See fig.4 and table 2			23°C	
				70°C	
Derived shear stress vs plastic strain curve		MPa		-40°C	
	See fig.5 and table 2			23°C	
				70°C	
Plastic Poisson's ratio	0.3		ISO 527	At 23°C	
Linear expansion coefficient	$50 \cdot 10^{-6}$	K ⁻¹	ISO 11359-2	Over temperature range between 23°C and T _g	

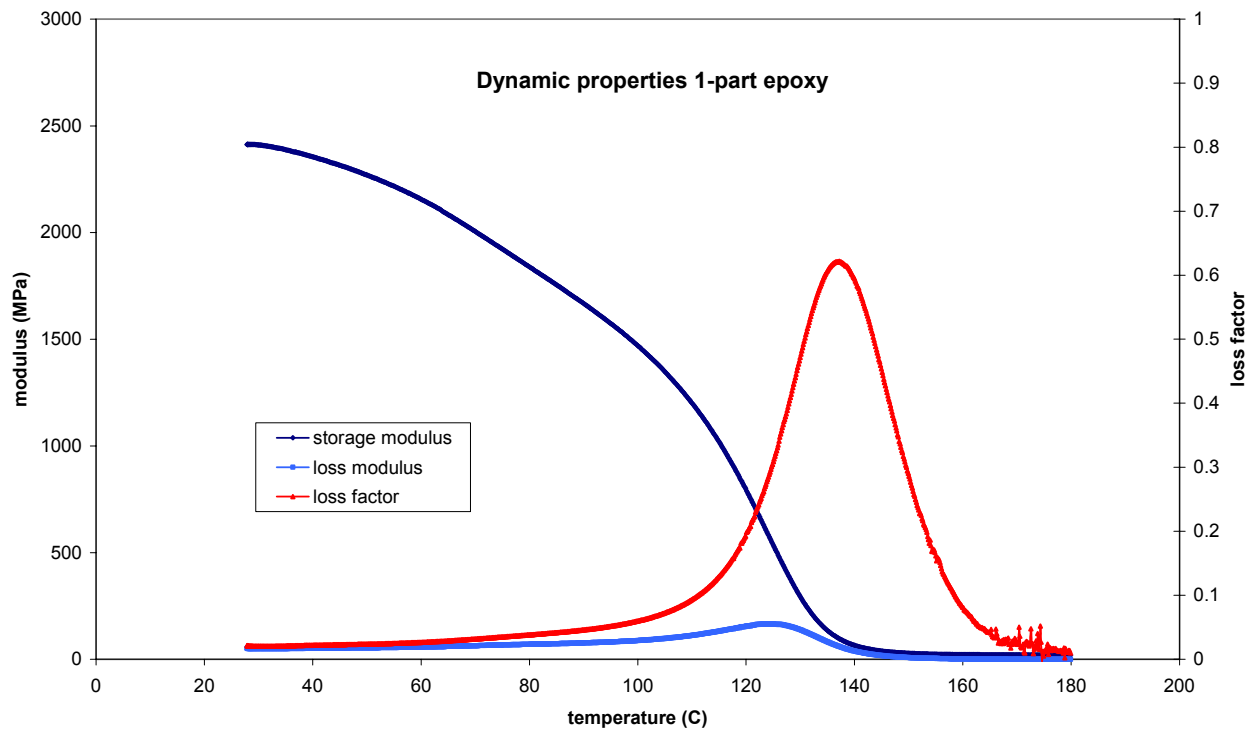


Figure 1 Temperature dependence of storage modulus, loss modulus and loss factor.

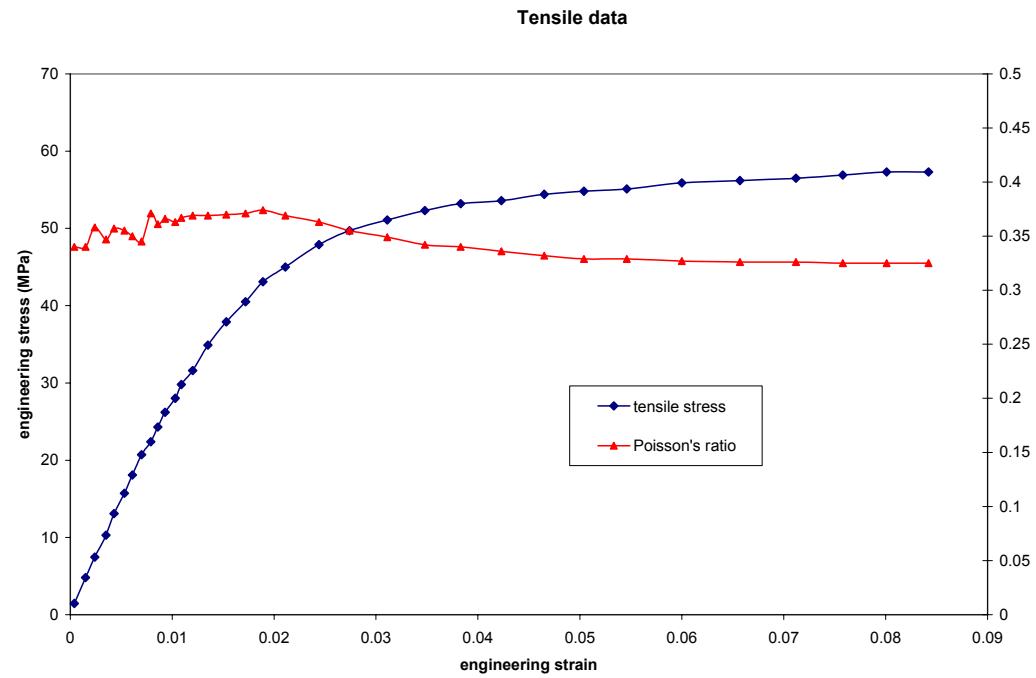


Figure 2 Measured tensile data for a 1-part toughened epoxy.

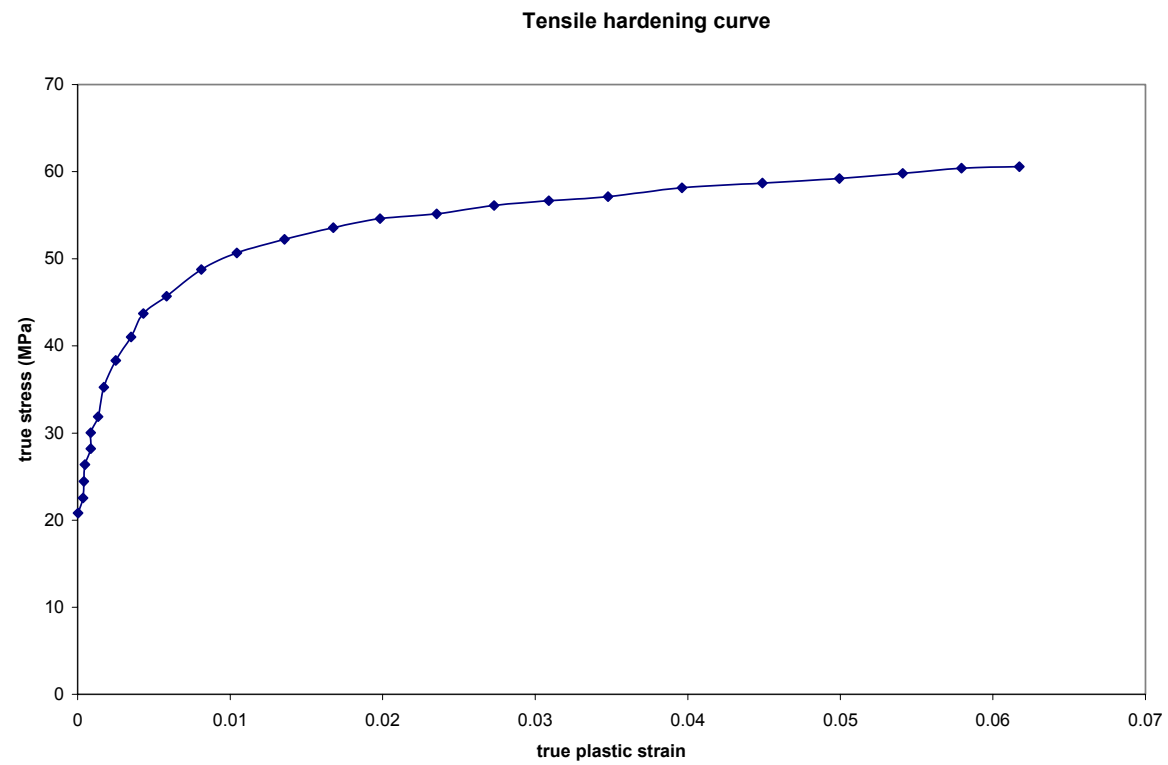


Figure 3 Tensile hardening curve derived from the data in figure 2.

Table 1. Tensile data for a 1-part toughened epoxy

Young's modulus $E = 2970$ MPa

Engineering (tensile) strain ε'

Engineering (tensile) stress σ'

Poisson's ratio ν

True strain $\varepsilon = \ln(1 + \varepsilon')$

True stress $\sigma = \sigma' / (1 - \nu \varepsilon')^2$

True elastic strain $\varepsilon_e = \ln(1 + \sigma/E)$

True plastic strain $\varepsilon_p = \varepsilon - \varepsilon_e$

Tensile strain	Tensile stress MPa	Poisson's ratio		true strain	elastic strain	plastic strain	true stress
0.0004	1.45	0.34		0.0004	0.0004881	-8.81763E-05	1.4503945
0.0015	4.8	0.34		0.001499	0.0016149	-0.000115981	4.8048997
0.0024	7.44	0.358		0.002397	0.0025019	-0.000104793	7.4528014
0.0035	10.3	0.347		0.003494	0.003462	3.18755E-05	10.325064
0.0043	13.1	0.357		0.004291	0.0044011	-0.000110294	13.140312
0.0053	15.7	0.355		0.005286	0.0052723	1.3732E-05	15.759246
0.0061	18.1	0.35		0.006081	0.0060758	5.68922E-06	18.177535
0.007	20.7	0.345		0.006976	0.0069455	3.00928E-05	20.800344
0.0079	22.4	0.371		0.007869	0.0075138	0.00035517	22.531884
0.0086	24.3	0.361		0.008563	0.0081485	0.000414702	24.451589

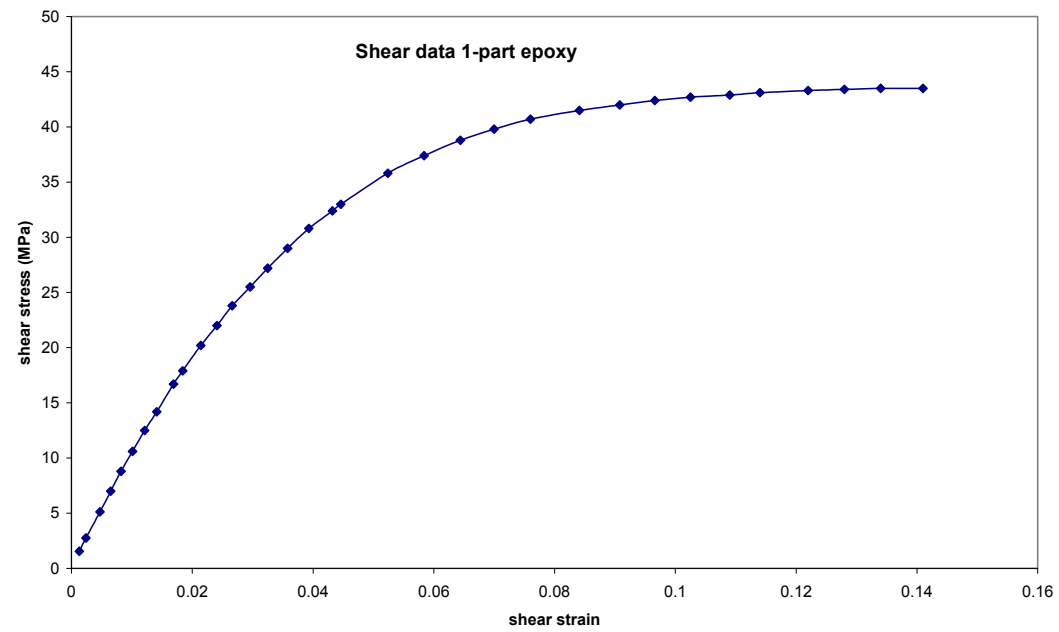


Figure 4 Measured shear data

Table 2 Shear data for a 1-part epoxy

Shear modulus $G=1100$ MPa

Shear stress τ (MPa)

Shear strain γ

Elastic shear strain = τ/G

Plastic shear strain = $\gamma - \tau/G$

Effective shear stress = $\sqrt{3} \cdot \tau$

Effective shear strain = $\gamma/\sqrt{3}$

shear strain	shear stress MPa	elastic strain	plastic strain	eff.pl.strain	eff.shear stress MPa
0.0013	1.56	0.001485	-0.000185	-0.000107	2.70192
0.0024	2.75	0.002616	-0.000216	-0.000124	4.763
0.0047	5.12	0.004864	-0.000164	-9.49E-05	8.86784
0.0065	7	0.006645	-0.000145	-8.35E-05	12.124
0.0082	8.8	0.008346	-0.000146	-8.43E-05	15.2416
0.0101	10.6	0.010045	5.538E-05	3.2E-05	18.3592
0.0121	12.5	0.011834	0.0002655	0.000153	21.65
0.0141	14.2	0.013433	0.0006668	0.000385	24.5944
0.0169	16.7	0.01578	0.0011204	0.000647	28.9244
0.0184	17.9	0.016904	0.0014961	0.000864	31.0028

Concluding remarks

- ◆ We need some feedback from adhesive users and suppliers to decide
 - Property selection
 - Test method
 - Test conditions
- ◆ Scope for standardisation
- ◆ More information can be included illustrating the use of data by the different modules