DNV·GL

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Your reference	Your Letter of	Our reference	Extension	Date
	2016-10-21	014617-16/GuMi	+49 40 3 61 49-4865	2016-10-21

DNV GL Approval for Laminating Resins and Adhesives

GLAPP00232522H

We thank you very much for your interest and commitment to have your products certified by DNV GL.

We are happy to inform you that we are in a position to certify the below-listed products from your submitted documents:

Two Component Epoxy Resin System	**Elan-tech AS90 Series**	**WP 1640008 HH**
Two Component Epoxy Resin System	**Elan-tech EC 157.1 Series**	**WP 1620037 HH**
Two Component Epoxy Resin System	**Elan-tech EC 152 Series**	**WP 1620036 HH**

The certification is based on our Rules for Non-Metallic Materials and has a validity of four years. It can be prolonged further after expiry.

Our Approval is issued under the precondition, that the products meet the relevant requirements at any time.

Furthermore, we would like to inform you, that the afore mentioned products have been included in our GL-Index of approved Materials. Thereby you have a share in the worldwide safety of components and machinery.

You will find the "Approval Finder" on our Homepage with the following link:

https://app.gl-group.com/ApprovalFinder/home.de

116871

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ELANTAS Italia S.r.l. ALTANA
Research & Development

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Date: 21 September 2016

Test Report B040/16

Enclosed you will find the test report of IMA Dresden

B040/16 „Epoxy System GL Approval (II)".

If you have any questions, please do not hesitate to contact us:

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Thank you for your ordering!

Yours sincerely,

IMA Materialforschung und
Anwendungstechnik GmbH

i.A.

Dipl.-Ing. Frank Heinrich
Head of Department Plastics and Composites

Enclosures
Test Report B040/16

Enclosed please find our Certificates as well as the corresponding Annex.

We are looking forward to a productive partnership and wish you a lot of success with your products.

Yours faithfully,

for DNV GL SE

i.A. Guido Michalek

i.V. Joachim Rehbein

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Registergericht: Amtsgericht Dresden | HRB 5995
USt.-IdNr.: DE 155293995

IMA DRESDEN

Test Report

"Epoxy System GL-Approval (II)"

ilac-MRA

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-13119-02-00

Test Report No.: B040/16

Order No.: 402106034

Issued by Department Plastics and Composites

Laboratory for Plastic Testing

Test Report

Epoxy System GL-Approval (II)
Test Report No.: B040/16

Test Specimen:	2-components epoxy systems for infusion 2-components epoxy systems for lamination 2-components epoxy systems as structural adhesive
Customer:	ELANTAS Italia S.r.l. Strada Antolini 1 43044 Collecchio ITALY
Order no. of the Customer:	PO#4500030850 dated 23 February 2016 PO#4500034190 dated 17 June 2016
Test Specimen received on:	05.05.2015 Elan-tech® AW93 16.02.2016 Elan-tech® AS90 Elan-tech® AW91 Elan-tech® W152XLR 10.05.2016 Elan-tech® W152XLR Elan-tech® EC157.1 Elan-tech® EC152 Elan-tech® W152.1HR
Test Period:	February - August 2016
In Charge:	Mr. Dipl.-Ing. Frank Engelmann
Distribution List:	1 x ELANTAS Italia S.r.l., Mr. Dr. Marco Busi 2 x IMA Dresden, Department Plastics and Composites

Authorized
Dresden, 21 September 2016
IMA Materialforschung und
Anwendungstechnik GmbH

Dipl.-Ing. Frank Heinrich
Head of Department Plastics and Composites

Test Report

Epoxy System GL-Approval (II)

Test Report No.: B040/16

IMA DRESDEN

Document History

Issue	Date	Pages	Update purpose	Author
1	19 September 2016	All Pages	First Issue	F. Engelmann

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List of Abbreviations

Symbol	Unit	Value
b	[mm]	Width
t	[mm]	Bondline thickness
L	[mm]	Overlap length
F_m	[N]	Maximum load
τ_M	[MPa]	Lap shear strength at F_m

List of References

Short term	Reference
GL 2010	Germanischer Lloyd Industrial Services GmbH: "Guideline for the Certification of Wind Turbines", Edition 2010

1 Task

The company ELANTAS Italia S.r.l. assigned IMA Dresden with the manufacturing of test panels and the following material characterisation tests:

- Manufacturing of neat resin panels
- Manufacturing of a fibre-reinforced panel with infusion technology for specimen preparation for the single lap shear test following DIN EN 1465
- Heat deflection temperature (HDT) acc. to DIN EN ISO 75-2 with three specimens per series
- Single lap shear test following DIN EN 1465 on bonded joints with GFRP panels with seven specimens per series, determination of tensile lap-shear strength after water absorption for 1000 h, testing at standard atmosphere (23 ± 2 °C, 50 ± 10 % rel. humidity) acc. to DIN EN ISO 291 class 2
- Single lap shear test following DIN EN 1465 on bonded joints with GFRP panels with seven specimens per series, determination of tensile lap-shear strength, testing at + 50 °C

2 Test Preparation

2.1 State of Delivery

The test materials were delivered by the customer on 05.05.2015, 16.02.2016 and 10.05.2016. Every delivery except the reinforcement material was marked with type and batch. The material was in faultless state, no obvious defects were visible.

Table 1: Delivered test material

Material description	Delivery date	Purpose
Elan-tech® EC157.1	10.05.2016	Infusion resin
Elan-tech® EC152	10.05.2016	Lamination resin
Elan-tech® W152.1HR	10.05.2016	Infusion / lamination cure agent
Elan-tech® W152XLR	16.02.2016 / 10.05.2016	Infusion / lamination cure agent
Elan-tech® AS90	16.02.2016	Structural adhesive resin
Elan-tech® AW93	05.05.2015	Structural adhesive cure agent
Elan-tech® AW91	16.02.2016	Structural adhesive cure agent

Figure 1: Delivered resin material Elan-tech® EC152 and Elan-tech® EC157.1

Figure 2: Delivered hardener material Elan-tech® W152.1HR, Elan-tech® W152XLR (16.02.16) and Elan-tech® W152XLR (10.05.16)

Figure 3: Delivered structural adhesive material Elan-tech® AS90, Elan-tech® AW91 and Elan-tech® AW93

2.2 Manufacturing

The following tables show all fabrics, resin and adhesive materials used for the test program.

Table 2: Fibre reinforcement and peel ply identification

Material description	Supplier	Material name
Peel ply	IMA Dresden	Lange & Ritter 98690 (02.26.150) 63g/m²
Glass UD-fabric	IMA Dresden	SAERTEX GmbH & Co. KG U-E-1200g/m²-1300mm, 7000079-08000167-1300

Table 3: Infusion and lamination resin system identification and mix ratio

Material description	Supplier	Material name	Mix ratio (by weight)	Batch
Infusion resin	ELANTAS Italia S.r.l.	Elan-tech® EC152, 100360	100 ± 2	0000070721
Lamination resin		Elan-tech® EC157.1, 5001821	100 ± 2	28 04 2016
Hardener		Elan-tech® W152XLR, 101443	30 ± 2	0000062972
Hardener		Elan-tech® W152.1HR, 104228	30 ± 2	0000069675

Table 4: Structural adhesive system identification and mix ratio

Material description	Supplier	Material name	Mix ratio (by weight)	Batch
Structural adhesive resin	ELANTAS Italia S.r.l.	Elan-tech® AS90, 100159	100 ± 2	0000063323
Hardener		Elan-tech® AW91, 100213	45 ± 2	0000059353
Hardener		Elan-tech® AW93, 5001832	45 ± 2	0000050793

2.2.1 Manufacturing of Neat Resin Panels

The manufacturing of the neat resin panels (thickness = 4 mm) was performed using a metal tool.

Table 5: Neat resin panels

Type of resin	Panel identification
Elan-tech® EC157.1 / W152XLR	B040/16-IV1
Elan-tech® EC157.1 / W152.1HR	B040/16-IV2
Elan-tech® EC152 / W152XLR	B040/16-WLV1
Elan-tech® EC152 / W152.1HR	B040/16-WLV2
Elan-tech® AS90 / AW91	B040/16-AV1, B040/16-AV1-2
Elan-tech® AS90 / AW93	B040/16-AV2, B040/16-AV2-2

2.2.2 Manufacturing of Single Lap Shear Specimens following DIN EN 1465

The glass fibre reinforced panel for the manufacturing of single lap shear specimens was manufactured at IMA Dresden by vacuum assisted resin infusion technology. The laminate was manufactured with peel ply on the bonding surface side.

Table 6: Panel configuration as substrate for single lap shear specimens

Panel description	No. of layers	Lay-up	Comment
B040/16-P1	6	[0, Stab./0, Stab./90, Stab.]$_s$	GFRP-panel for the manufacturing of single lap shear specimens

The manufacturing of the single lap bonding was performed with a capable bonding device for single lap joints with the adjustment of 0,5 mm and 3,0 mm adhesive thickness. The processing was carried out at room temperature. The adhesive was applied directly on the peel ply surface without further treatment.

2.2.3 Manufacturing Parameters

The following tables show all manufacturing parameters applied in the test program.

Table 7: Curing cycle of structural adhesive systems Elan-tech® AS90 / AW91 (AV1)

Parameters	Time [h:min]	Temp. [°C]	Ramp [K/min]
Curing cycle	24:00	RT	-
Heating rate	-	-	1
Post curing cycle	5:00	70	-

Table 8: Curing cycle of structural adhesive systems Elan-tech® AS90 / AW91 (AV1-2)

Parameters	Time [h:min]	Temp. [°C]	Ramp [K/min]
Curing cycle	2:00	RT	-
Heating rate	-	-	1
Post curing cycle	5:00	70	-

Table 9: Curing cycle of structural adhesive systems Elan-tech® AS90 / AW93 (AV2)

Parameters	Time [h:min]	Temp. [°C]	Ramp [K/min]
Curing cycle	24:00	RT	-
Heating rate	-	-	1
Post curing cycle	10:00	70	-

Table 10: Curing cycle of structural adhesive systems Elan-tech® AS90 / AW93 (AV2-2)

Parameters	Time [h:min]	Temp. [°C]	Ramp [K/min]
Curing cycle	8:00	RT	-
Heating rate	-	-	1
Post curing cycle	16:00	70	-

Table 11: Curing cycle of structural adhesive systems Elan-tech® EC152 / W152XLR (WLV1), Elan-tech® EC152 / W152.1HR (WLV2)

Parameters	Time [h:min]	Temp. [°C]	Ramp [K/min]
Curing cycle	24:00	RT	-
Heating rate	-	-	1
Post curing cycle	36:00	50	-

Table 12: Curing cycle of structural adhesive systems Elan-tech® EC157.1 / W152XLR (IV1), Elan-tech® EC157.1 / W152.1HR (IV2)

Parameters	Time [h:min]	Temp. [°C]	Ramp [K/min]
Curing cycle	24:00	RT	-
Heating rate	-	-	1
Post curing cycle	48:00	50	-

2.3 Specimen Machining

The specimen cutting was carried out on a precision saw MUTRONIC using a diamond saw blade. GFRP tabs were used for specimens following DIN EN 1465.

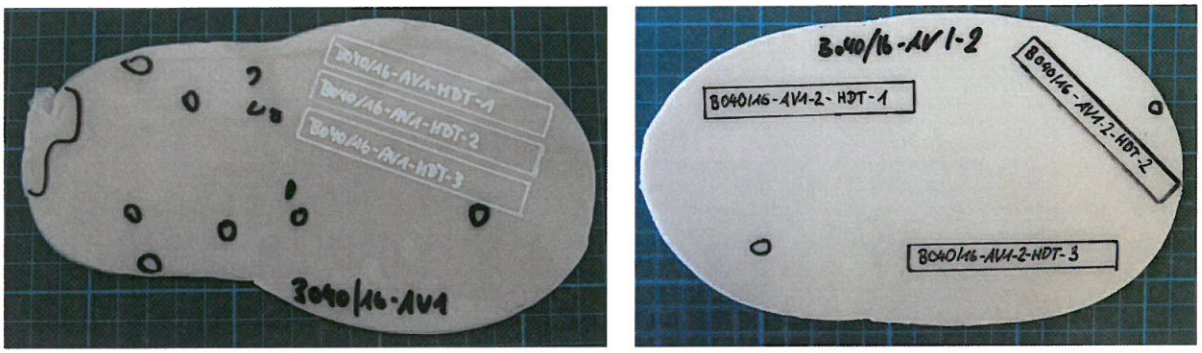


Figure 4: Place of sampling of test panel B040/16-AV1, B040/16-AV1-2 (from left to right)

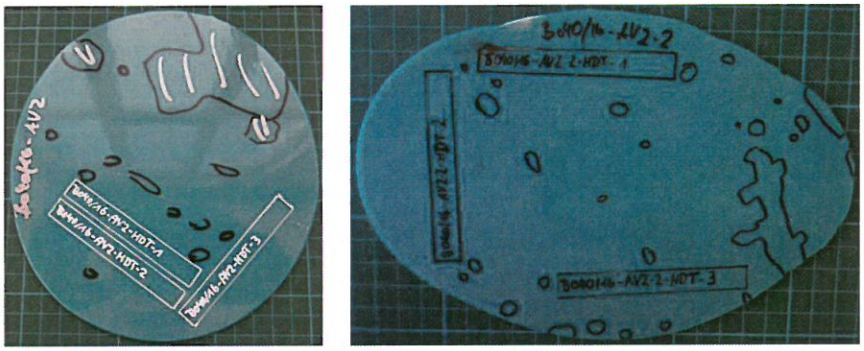


Figure 5: Place of sampling of test panel B040/16-AV2, B040/16-IV2, B040/16-AV2-2 (from left to right)

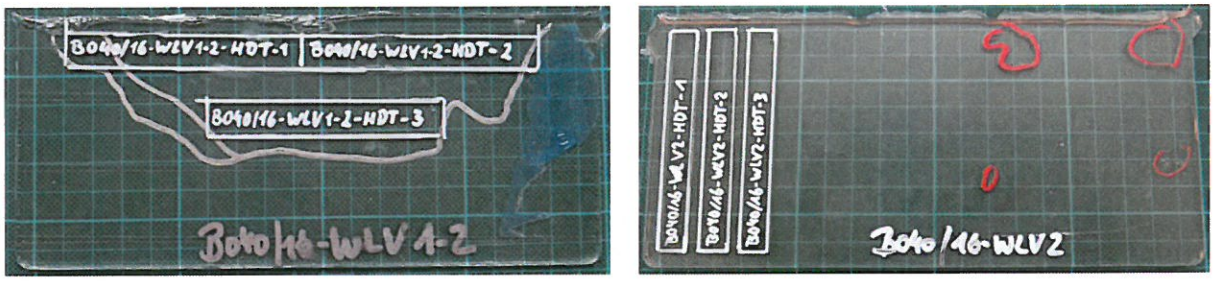


Figure 6: Place of sampling of test panel B040/16-WLV1 and B040/16-WLV2 (from left to right)

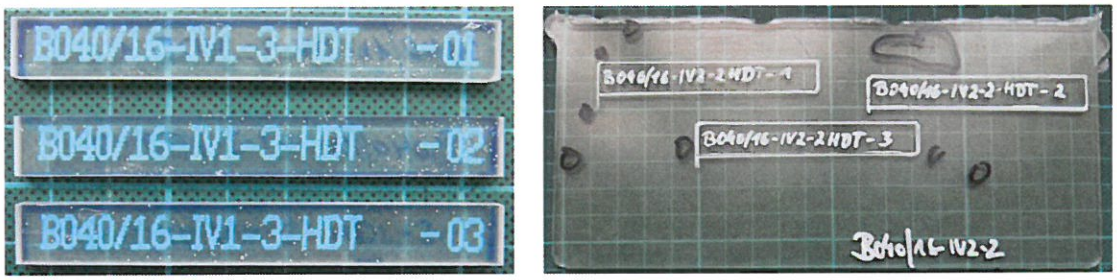


Figure 7: Place of sampling of test panel B040/16-IV1 and B040/16-IV2 (from left to right)

2.4 Storage

The storage of the raw material and the manufactured panels was carried out at room temperature. The marked specimens were stored at least 88 h at 23 °C, 50 % relative humidity.

2.5 Specimen Identification

Table 13: Specimen identification infusion resin system

Customer material	Panel description IMA	Specimen identification	Type of test
Elan-tech® EC157.1 / W152XLR	B040/16-IV1	B040/16-IV1-HDT-1...3	DIN EN ISO 75
Elan-tech® EC157.1 / W152.1HR	B040/16-IV2	B040/16-IV2-HDT-1...3	DIN EN ISO 75

Table 14: Specimen identification lamination resin system

Customer material	Panel description IMA	Specimen identification	Type of test
Elan-tech® EC152 / W152XLR	B040/16-WLV1	B040/16-WLV1-HDT-1...3	DIN EN ISO 75
Elan-tech® EC152 / W152.1HR	B040/16-WLV2	B040/16-WLV2-HDT-1...3	DIN EN ISO 75

Table 15: Specimen identification structural adhesive system

Customer material	Panel description IMA	Specimen identification	Type of test
Elan-tech® AS90 / AW91	B040/16-AV1	B040/16-AV1-HDT-1...3	DIN EN ISO 75
	B040/16-AV1-2	B040/16-AV1-2-HDT-1...3	DIN EN ISO 75
	B040/16-P1	B040/16-P1-AV1-0.5-SLS-HT-1...7	DIN EN 1465
	B040/16-P1	B040/16-P1-AV1-3.0-SLS-HT-1...7	DIN EN 1465
	B040/16-P1	B040/16-P1-AV1-0.5-SLS-WA-1...7	DIN EN 1465
	B040/16-P1	B040/16-P1-AV1-3.0-SLS-WA-1...7	DIN EN 1465
Elan-tech® AS90 / AW93	B040/16-AV2	B040/16-AV2-HDT-1...3	DIN EN ISO 75
	B040/16-AV2-2	B040/16-AV2-2-HDT-1...3	DIN EN ISO 75
	B040/16-P1	B040/16-P1-AV2-0.5-SLS-HT-1...7	DIN EN 1465
	B040/16-P1	B040/16-P1-AV2-3.0-SLS-HT-1...7	DIN EN 1465
	B040/16-P1	B040/16-P1-AV2-0.5-SLS-WA-1...7	DIN EN 1465
	B040/16-P1	B040/16-P1-AV2-3.0-SLS-WA-1...7	DIN EN 1465

3 Test Execution

3.1 Heat Deflection Temperature according to DIN EN ISO 75-2

The heat deflection temperature measurement was processed by KIMW Prüf- und Analyse GmbH Lüdenscheid (D-PL-19634-01-00). The original test report is stored by IMA Dresden.

3.1.1 Standard

- DIN EN ISO 75-2:2013-08 Plastics - Determination of temperature of deflection under load - Part 2: Plastics and ebonite

3.1.2 Personnel

- Technician: M. Grysko, Kunststoff-Institut Lüdenscheid

3.1.3 Test Conditions

- Number of specimens: 3 per series
- Test method: 3-point bending, method A
- Specimen dimensions: 80 x 10 x 4 [mm]
- Span length: 64 ± 1 [mm]
- Specimen position: flatwise
- Flexural stress: 1,8 MPa
- Test liquid: silicon oil
- Determination of: specimen deformation at elevating temperature

3.1.4 Test Execution

- Determination of temperature of deflection under load
- Statistical evaluation

3.2 Single Lap-Shear Test following DIN EN 1465

3.2.1 Standard

- DIN EN 1465:2009-07 Determination of tensile lap-shear strength of bonded assemblies; German version EN 1465:2009
- DIN EN ISO 10365:1995-08 Adhesives - Designation of main failure patterns (ISO 10365:1992); German version EN ISO 10365:1995

3.2.2 Personnel

- Technician: M. Schillig, A2100

3.2.3 Test Equipment

- Universal testing machine TIRA2, Type TIRAtest 2300, computer coupled, accuracy class 1 according to ISO 7500-1, load cell 10 kN, inventory-no.: 9023842
- Hydraulic fixture

3.2.4 Test Conditions

- Number of specimens: 7 per series
- Specimen dimensions: l = 212,5 mm
  b = 25 ± 0,25 [mm]
- Specimen type: single lap overlap joint with GFRP as joint material, with bonded doublers
- Overlap length: 12,5 ± 0,25 [mm]
- Free length between tabs: 112,5 ± 0,5 [mm]
- Adhesive thickness: 0,5 / 3,0 mm
- Test speed: 1 ± 0,2 [mm/min], test duration 65 ± 20 [s]
- Determination of: load, crosshead displacement
- Test atmosphere: standard atmosphere (23 ± 2 °C, 50 ± 10 % rel. humidity) acc. to DIN EN ISO 291 class 2

3.2.5 Test Execution

- 3 measurements of width and overlap length with an accuracy of ± 0,01 mm
- 2 measurements of adhesive thickness with microscope
- 2 measurements of overlap length with an accuracy of ± 0,1 mm
- Water absorption in deionised water at 23 ± 2 °C for 1000 ± 12 h
- Determination of maximum load, tensile lap-shear strength
- Statistical evaluation and estimation of failure mode

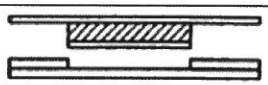
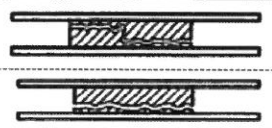
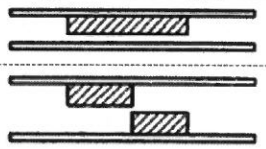
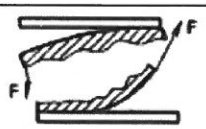
Failure Location	Failure pattern	Descpription	Failure mode
Adherend		Failure of at least one adherend (Adherend failure)	SF
		Failure of one adherend (Cohesive adherend failure)	CSF
		Failure due to delamination (Delamination failure)	DF
Adhesive		Cohesive failure	CF
		Cohesive failure adjacent to adherend	SCF
		Adhesive failure	AF
		Adhesive and cohesive failure with peeling	ACFP

Figure 8: Failure mode according to DIN EN ISO 10365

3.3 Single Lap-Shear Test following DIN EN 1465 at 50 °C

3.3.1 Standard

- DIN EN 1465:2009-07 Determination of tensile lap-shear strength of bonded assemblies; German version EN 1465:2009
- DIN EN ISO 10365:1995-08 Adhesives - Designation of main failure patterns (ISO 10365:1992); German version EN ISO 10365:1995

3.3.2 Personnel

- Technician: T. Jesche, A2100

3.3.3 Test Equipment

- Universal testing machine TIRA1, Type TIRAtest 2300, computer coupled, accuracy class 1 according to ISO 7500-1, load cell 10 kN, inventory-no.: 8004266
- Temperature chamber with computer controlled temperature control
- Mechanical wedge action fixture

3.3.4 Test Conditions

• Number of specimens:	7 per series
• Specimen dimensions:	l = 212,5 mm b = 25 ± 0,25 [mm]
• Specimen type:	single lap overlap joint with GFRP as joint material, with bonded doublers
• Overlap length:	12,5 ± 0,25 [mm]
• Free length between tabs:	112,5 ± 0,5 [mm]
• Adhesive thickness:	0,5 / 3,0 mm
• Test speed:	1 ± 0,2 [mm/min], test duration 65 ± 20 [s]
• Determination of:	load, crosshead displacement
• Test atmosphere:	50 ± 3 °C

3.3.5 Test Execution

- 3 measurements of width with an accuracy of ± 0,01 mm
- 2 measurements of overlap length with an accuracy of ± 0,1 mm
- 2 measurements of adhesive thickness with an optical microscope
- Determination of maximum load, tensile lap-shear strength
- Statistical evaluation and estimation of failure mode

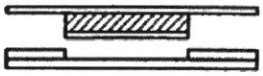
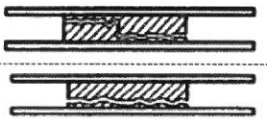
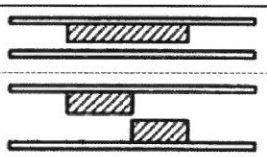
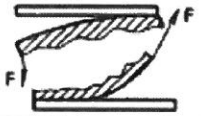
Failure Location	Failure pattern	Descpription	Failure mode
Adherend		Failure of at least one adherend (Adherend failure)	SF
		Failure of one adherend (Cohesive adherend failure)	CSF
		Failure due to delamination (Delamination failure)	DF
Adhesive		Cohesive failure	CF
		Cohesive failure adjacent to adherend	SCF
		Adhesive failure	AF
		Adhesive and cohesive failure with peeling	ACFP

Figure 9: Failure mode according to DIN EN ISO 10365

4.2 Single Lap Shear Test following DIN EN 1465

Table 24: Single lap shear test following DIN EN 1465 at standard atmosphere, adhesive thickness 0,5 mm, test series B040/16-P1-AV1-0.5-SLS-WA-1...7

Specimen-no. **adhesive thickness 0,5 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV1-0.5-SLS-WA-1	12,66	24,96	0,6	8200	26,0	AF/(CSF)
B040/16-P1-AV1-0.5-SLS-WA-2	12,58	25,00	0,6	8693	27,6	
B040/16-P1-AV1-0.5-SLS-WA-3	12,58	25,02	0,6	8321	26,4	
B040/16-P1-AV1-0.5-SLS-WA-4	12,53	25,02	0,6	9568	30,5	
B040/16-P1-AV1-0.5-SLS-WA-5	12,50	24,98	0,6	9255	29,6	
B040/16-P1-AV1-0.5-SLS-WA-6	12,50	25,02	0,5	8882	28,4	
B040/16-P1-AV1-0.5-SLS-WA-7	12,51	25,00	0,6	8705	27,8	
				Average value:	**28,1**	
				Standard deviation:	**1,6**	
				Coefficient of variation:	**5,8 %**	
				Max:	**30,5**	
				Min:	**26,0**	
				R (5 %, 95 %, υ, n):	**24,4**	

Table 25: Single lap shear test following DIN EN 1465 at standard atmosphere, adhesive thickness 3,0 mm, test series B040/16-P1-AV1-3.0-SLS-WA-1...7

Specimen-no. **adhesive thickness 3,0 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV1-3.0-SLS-WA-1	12,56	25,00	3,0	6413	20,4	AF/(CSF)
B040/16-P1-AV1-3.0-SLS-WA-2	12,58	25,04	3,0	6390	20,3	
B040/16-P1-AV1-3.0-SLS-WA-3	12,58	24,99	3,0	6336	20,2	
B040/16-P1-AV1-3.0-SLS-WA-4	12,57	24,96	3,0	6255	19,9	
B040/16-P1-AV1-3.0-SLS-WA-5	12,55	24,95	3,0	6159	19,7	
B040/16-P1-AV1-3.0-SLS-WA-6	12,51	25,01	3,0	6574	21,0	
B040/16-P1-AV1-3.0-SLS-WA-7	12,51	25,01	3,0	6245	20,0	
				Average value:	**20,2**	
				Standard deviation:	**0,4**	
				Coefficient of variation:	**2,1 %**	
				Max:	**21,0**	
				Min:	**19,7**	
				R (5 %, 95 %, υ, n):	**19,2**	

Table 26: Single lap shear test following DIN EN 1465 at standard atmosphere, adhesive thickness 0,5 mm, test series B040/16-P1-AV2-0.5-SLS-WA-1...7

Specimen-no. **adhesive thickness 0,5 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV2-0.5-SLS-WA-1	12,53	24,99	0,6	6495	20,7	AF/(CSF)
B040/16-P1-AV2-0.5-SLS-WA-2	12,50	25,02	0,6	6646	21,3	
B040/16-P1-AV2-0.5-SLS-WA-3	12,49	25,03	0,6	7635	24,4	
B040/16-P1-AV2-0.5-SLS-WA-4	12,45	25,03	0,6	7066	22,7	
B040/16-P1-AV2-0.5-SLS-WA-5	12,47	25,00	0,6	7899	25,3	
B040/16-P1-AV2-0.5-SLS-WA-6	12,50	24,99	0,6	7894	25,3	
B040/16-P1-AV2-0.5-SLS-WA-7	12,52	25,02	0,6	8068	25,8	
				Average value:	**23,6**	
				Standard deviation:	**2,1**	
				Coefficient of variation:	**8,8 %**	
				Max:	**25,8**	
				Min:	**20,7**	
				R (5 %, 95 %, υ, n):	**18,9**	

Table 27: Single lap shear test following DIN EN 1465 at standard atmosphere, adhesive thickness 3,0 mm, test series B040/16-P1-AV2-3.0-SLS-WA-1...7

Specimen-no. **adhesive thickness 3,0 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV2-3.0-SLS-WA-1	12,55	25,00	3,0	3992	12,7	AF/(CSF)
B040/16-P1-AV2-3.0-SLS-WA-2	12,51	24,97	2,9	4183	13,4	
B040/16-P1-AV2-3.0-SLS-WA-3	12,53	24,99	2,9	4247	13,6	
B040/16-P1-AV2-3.0-SLS-WA-4	12,57	25,01	2,9	4189	13,3	
B040/16-P1-AV2-3.0-SLS-WA-5	12,57	25,01	2,9	4065	12,9	
B040/16-P1-AV2-3.0-SLS-WA-6	12,56	25,00	3,0	4229	13,5	
B040/16-P1-AV2-3.0-SLS-WA-7	12,55	24,98	3,0	4210	13,4	
				Average value:	**13,3**	
				Standard deviation:	**0,3**	
				Coefficient of variation:	**2,4 %**	
				Max:	**13,6**	
				Min:	**12,7**	
				R (5 %, 95 %, υ, n):	**12,6**	

4.3 Single Lap Shear Test following DIN EN 1465 at 50 °C

Table 28: Single lap shear test following DIN EN 1465 at 50 °C, adhesive thickness 0,5 mm, test series B040/16-P1-AV1-0.5-SLS-HT-1...7

Specimen-no. **adhesive thickness 0,5 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV1-0.5-SLS-HT-1	12,71	25,02	0,8	6807	21,4	AF/(CSF)
B040/16-P1-AV1-0.5-SLS-HT-2	12,59	24,99	0,7	6278	20,0	
B040/16-P1-AV1-0.5-SLS-HT-3	12,53	25,01	0,6	6985	22,3	
B040/16-P1-AV1-0.5-SLS-HT-4	12,52	25,02	0,6	7022	22,4	
B040/16-P1-AV1-0.5-SLS-HT-5	12,46	25,01	0,5	7000	22,5	
B040/16-P1-AV1-0.5-SLS-HT-6	12,63	25,02	0,6	7134	22,6	
B040/16-P1-AV1-0.5-SLS-HT-7	12,53	25,02	0,6	7320	23,3	
				Average value:	**22,1**	
				Standard deviation:	**1,1**	
				Coefficient of variation:	**4,9 %**	
				Max:	**23,3**	
				Min:	**20,0**	
				R (5 %, 95 %, υ, n):	**19,6**	

Table 29: Single lap shear test following DIN EN 1465 at 50 °C, adhesive thickness 3,0 mm, test series B040/16-P1-AV1-3.0-SLS-HT-1...7

Specimen-no. **adhesive thickness 3,0 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV1-3.0-SLS-HT-1	12,60	25,02	3,0	4735	15,0	AF/(CSF)
B040/16-P1-AV1-3.0-SLS-HT-2	12,65	24,97	3,0	5178	16,4	
B040/16-P1-AV1-3.0-SLS-HT-3	12,66	25,01	3,0	5281	16,7	
B040/16-P1-AV1-3.0-SLS-HT-4	12,67	24,98	3,0	5169	16,3	
B040/16-P1-AV1-3.0-SLS-HT-5	12,66	24,98	3,0	5277	16,7	
B040/16-P1-AV1-3.0-SLS-HT-6	12,68	25,00	3,0	5290	16,7	
B040/16-P1-AV1-3.0-SLS-HT-7	12,72	25,01	2,9	5367	16,9	
				Average value:	**16,4**	
				Standard deviation:	**0,6**	
				Coefficient of variation:	**3,8 %**	
				Max:	**16,9**	
				Min:	**15,0**	
				R (5 %, 95 %, υ, n):	**15,0**	

Table 30: Single lap shear test following DIN EN 1465 at 50 °C, adhesive thickness 0,5 mm, test series B040/16-P1-AV2-0.5-SLS-HT-1...7

Specimen-no. **adhesive thickness 0,5 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV2-0.5-SLS-HT-1	12,57	25,02	0,6	6751	21,5	AF/(CSF)
B040/16-P1-AV2-0.5-SLS-HT-2	12,58	25,00	0,6	6796	21,6	
B040/16-P1-AV2-0.5-SLS-HT-3	12,50	24,99	0,6	6846	21,9	
B040/16-P1-AV2-0.5-SLS-HT-4	12,53	25,00	0,6	6832	21,8	
B040/16-P1-AV2-0.5-SLS-HT-5	12,53	25,00	0,6	6821	21,8	
B040/16-P1-AV2-0.5-SLS-HT-6	12,43	25,00	0,6	6877	22,1	
B040/16-P1-AV2-0.5-SLS-HT-7	12,60	24,99	0,6	6947	22,1	
				Average value:	**21,8**	
				Standard deviation:	**0,2**	
				Coefficient of variation:	**1,1 %**	
				Max:	**22,1**	
				Min:	**21,5**	
				R (5 %, 95 %, υ, n):	**21,3**	

Table 31: Single lap shear test following DIN EN 1465 at 50 °C, adhesive thickness 3,0 mm, test series B040/16-P1-AV2-3.0-SLS-HT-1...7

Specimen-no. **adhesive thickness 3,0 mm**	L [mm]	b [mm]	t [mm]	F_m [N]	τ_M [MPa]	Failure Mode
B040/16-P1-AV2-3.0-SLS-HT-1	12,66	25,01	3,1	4532	14,3	AF/(CSF)
B040/16-P1-AV2-3.0-SLS-HT-2	12,64	24,96	3,1	4508	14,3	
B040/16-P1-AV2-3.0-SLS-HT-3	12,60	24,97	3,1	4378	13,9	
B040/16-P1-AV2-3.0-SLS-HT-4	12,59	24,99	3,0	4621	14,7	
B040/16-P1-AV2-3.0-SLS-HT-5	12,53	24,98	3,0	4431	14,2	
B040/16-P1-AV2-3.0-SLS-HT-6	12,54	25,00	3,0	4807	15,3	
B040/16-P1-AV2-3.0-SLS-HT-7	12,53	25,02	3,0	4393	14,0	
				Average value:	**14,4**	
				Standard deviation:	**0,5**	
				Coefficient of variation:	**3,4 %**	
				Max:	**15,3**	
				Min:	**13,9**	
				R (5 %, 95 %, υ, n):	**13,3**	

4.4 Failure Figures

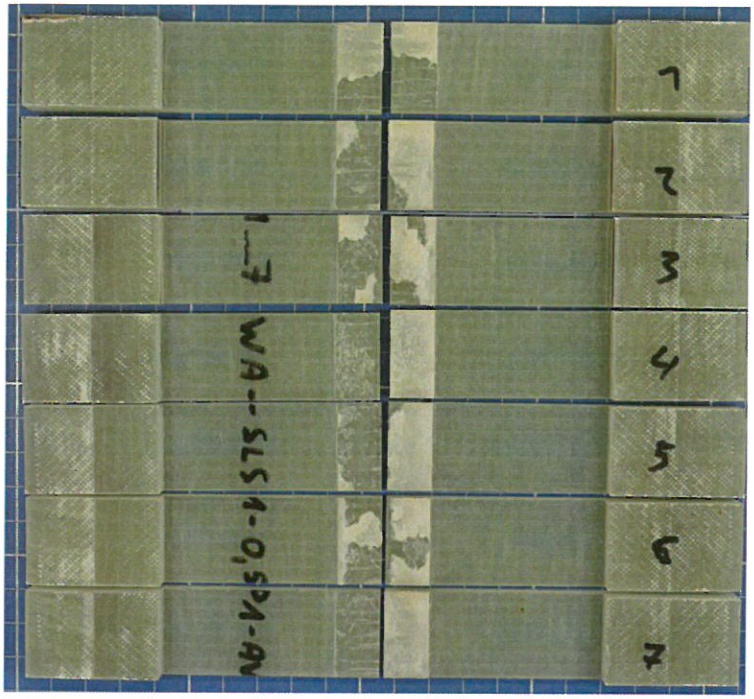


Figure 10: Failure figures of single lap shear test at standard atmosphere, test series B040/16-P1-AV1-0.5-SLS-WA-1...7

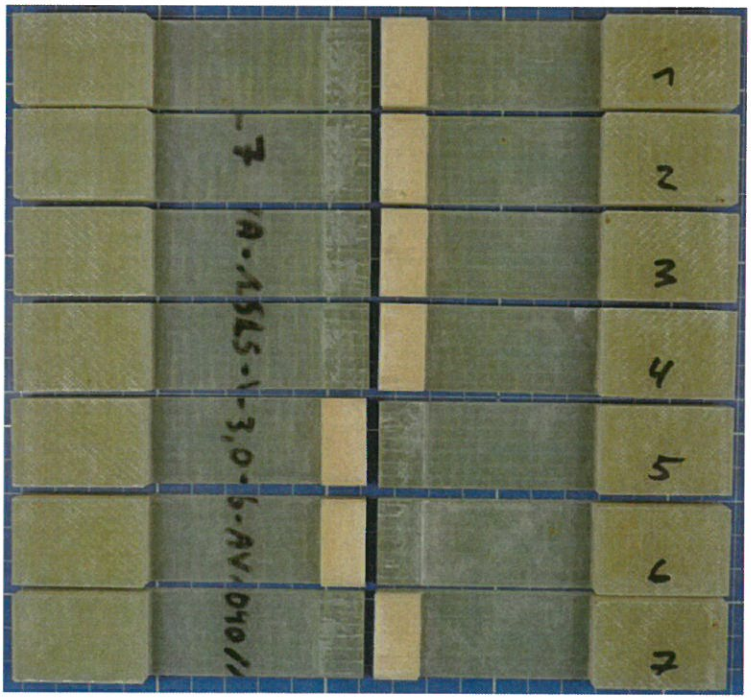


Figure 11: Failure figures of single lap shear test at standard atmosphere, test series B040/16-P1-AV1-3.0-SLS-WA-1...7

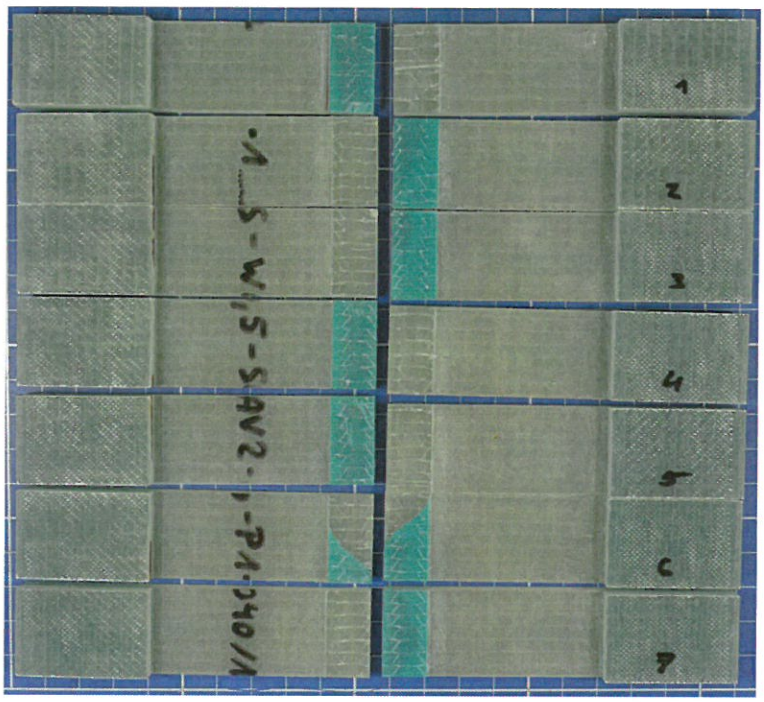


Figure 12: Failure figures of single lap shear test at standard atmosphere, test series B040/16-P1-AV2-0.5-SLS-WA-1…7

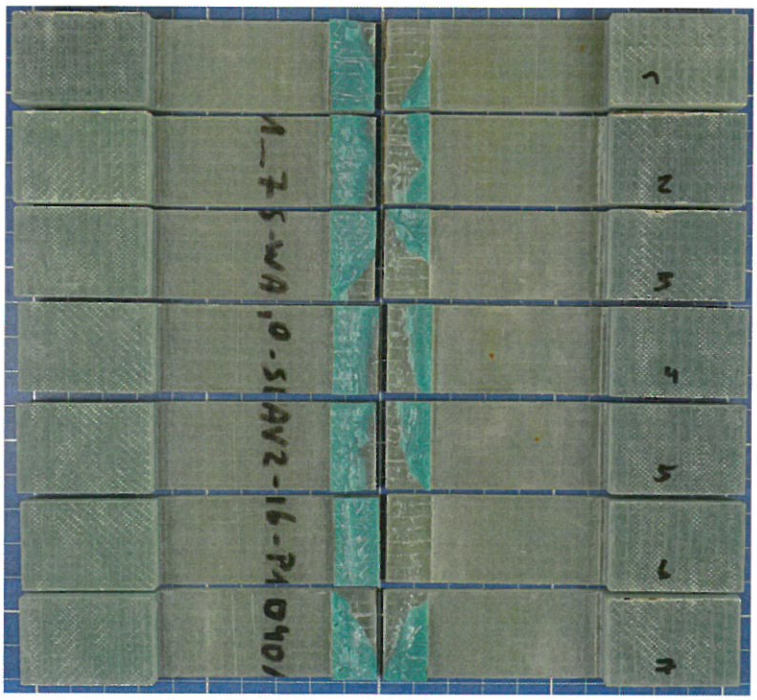


Figure 13: Failure figures of single lap shear test at standard atmosphere, test series B040/16-P1-AV2-3.0-SLS-WA-1…7

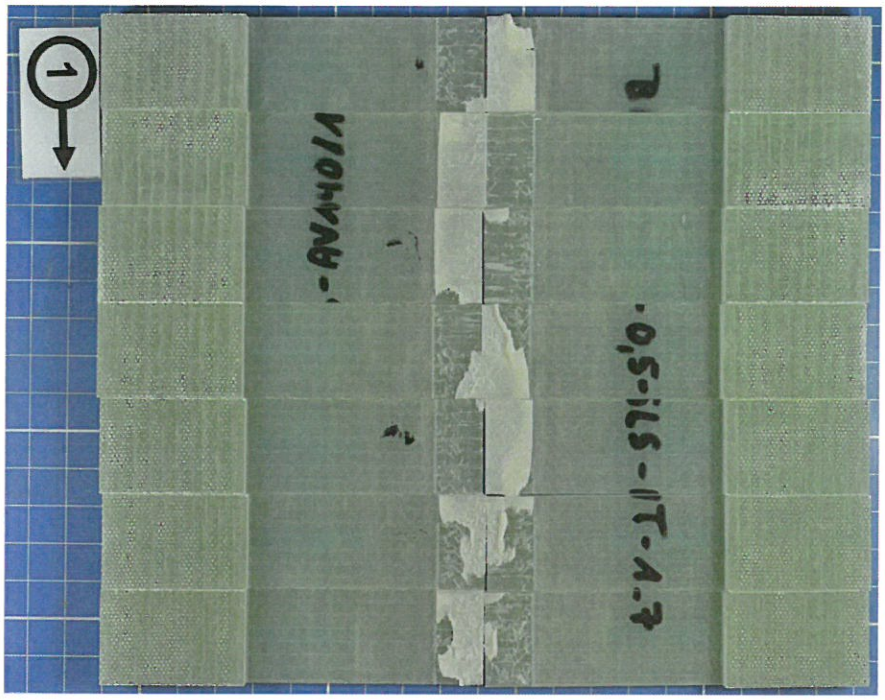


Figure 14: Failure figures of single lap shear test at 50 °C, test series B040/16-P1-AV1-0.5-SLS-HT-1…7

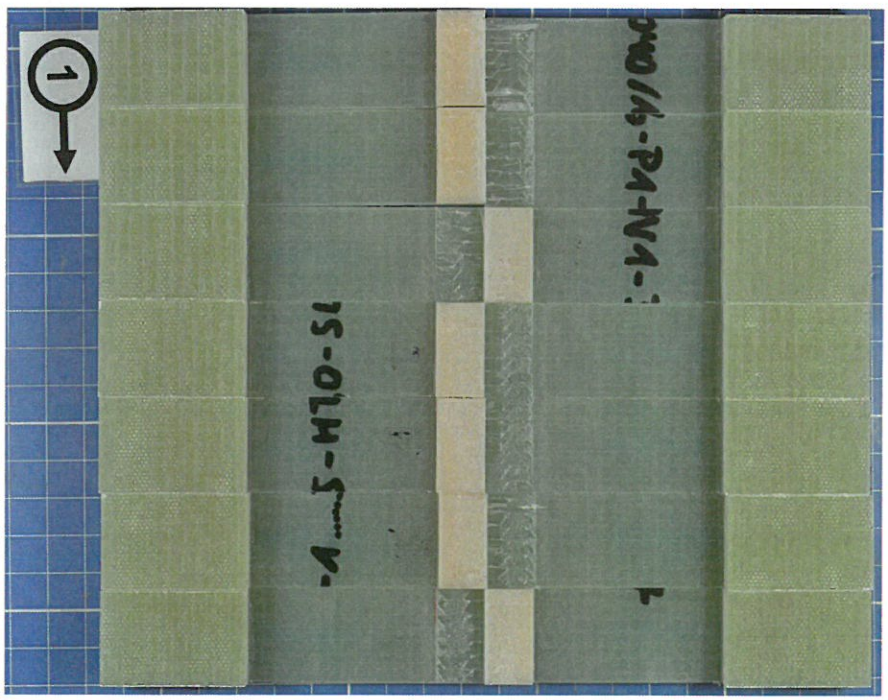


Figure 15: Failure figures of single lap shear test at 50 °C, test series B040/16-P1-AV1-3.0-SLS-HT-1…7

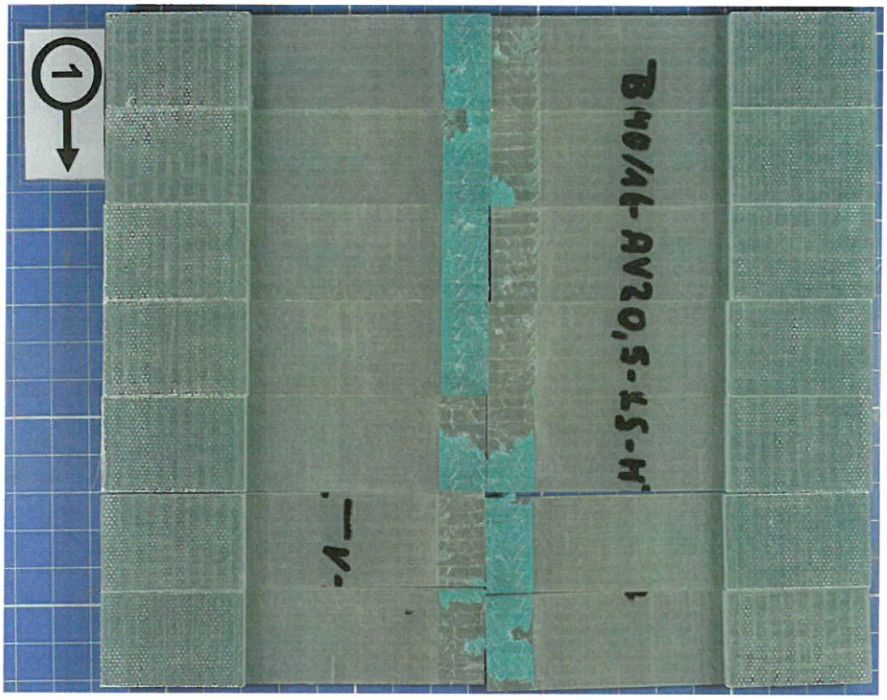


Figure 16: Failure figures of single lap shear test at 50 °C, test series B040/16-P1-AV2-0.5-SLS-HT-1…7

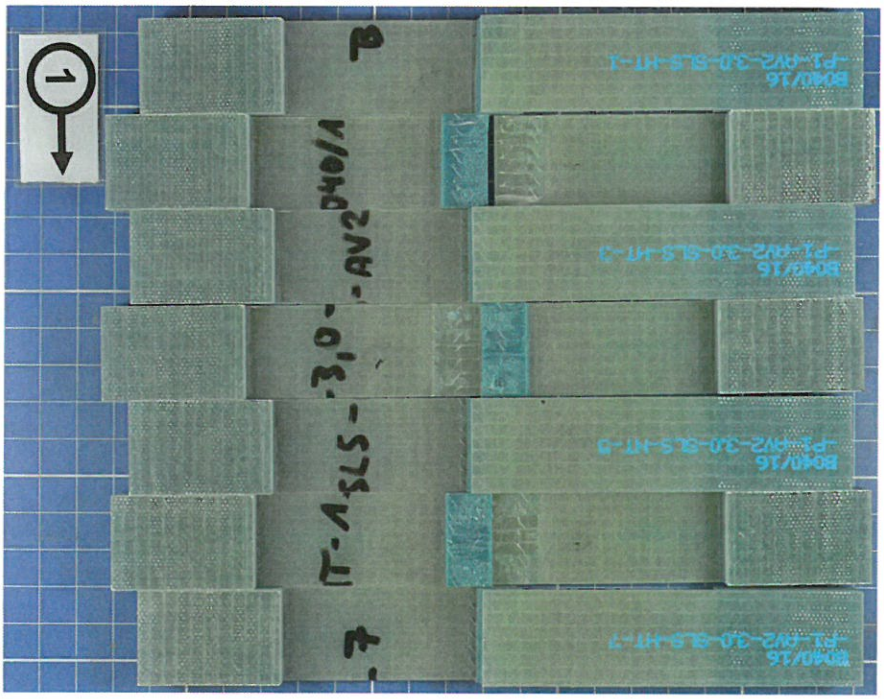


Figure 17: Failure figures of single lap shear test at 50 °C, test series B040/16-P1-AV2-3.0-SLS-HT-1…7

Reviewed	Created
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