GRISPE

Guidelines and **R**ecommendations for **I**ntegrating **S**pecific **P**rofiled steel sheets in the **E**urocodes (**GRISPE**)

Test report of steel trapezoidal sheeting with and without embossments and outward stiffeners

Working Package 1

Deliverable D 1.3
(Rev02. 11. June 2015)

Guidelines and Recommendations for Integrating Specific Profiled Steels sheets in the Eurocodes (GRISPE)

Project co-funded under the Research Fund for Coal and Steel
Grant agreement No RFCS-CT-2013-00018
Proposal No RFS-PR-12027

Author(s)
C. Fauth, KIT

Drafting history	
Final Version	*31th October 2014*
Rev01.	*26th January 2015*
Rev02	*11th June 2015*

Dissemination Level		
PU	*Public*	
PP	*Restricted to the Commission Services, the Coal and Steel Technical Groups and the European Committee for Standardisation (CEN)*	
RE	*Restricted to a group specified by the Beneficiaries*	
CO	*Confidential, only for Beneficiaries (including the Commission services)*	***X***

Verification and Approval
Coordinator: ***x***
WP2 Leader: ***x***
Other Beneficiaries

Deliverable	
D 1.3 Test report	***Due date: 31th October 2014*** ***Completion date: 31th October 2014*** ***Rev02: 11th June 2015***

Content

1 Preliminary remarks

“Versuchsanstalt für Stahl, Holz und Steine” of the Karlsruhe Institute of Technology (KIT) investigated the load-bearing capacity of steel trapezoidal sheeting with and without embossments and outward stiffeners for the research project “Guidelines and Recommendations for Integrating Specific Profiled Steels sheets in the Eurocodes (GRISPE)” co-funded under the Research Fund for Coal and Steel. The trapezoidal steel sheeting profiles were produced by Bacacier (PCB 60 and PCB 80) and Tata Steel (ComFlor 80). The test program is specified in the deliverable D1.2 “Test program definition”.

2 Object of testing

The tested trapezoidal sheeting profiles from Bacacier and Tata Steel consist of steel sheeting according to EN 10346:2009, which are formed to profiles with the following section heights and overall widths by roll-forming:

Type of profile	Steel grade according to EN 10143:2006	height [mm]	width [mm]	thickness [mm]
PCB 60	S320GD	60	828	0.75 and 1.00
PCB 80	S320GD	77	750	0.75 and 1.00
ComFlor 80	S450GD	95	600	0.90 and 1.20

Table 1: Section heights and overall widths of the different tested profiles

The nominal cross-section geometry of the tested profiles is given in annex A.1 to A.3. Fifty percent of the profile types PCB 60 and PCB 80 had web embossments. The geometry of the profiles and embossments is given in the following table 2 and figure 1 and figure 2. The other part of the profiles PCB 60 and PCB 80 had no web embossments.

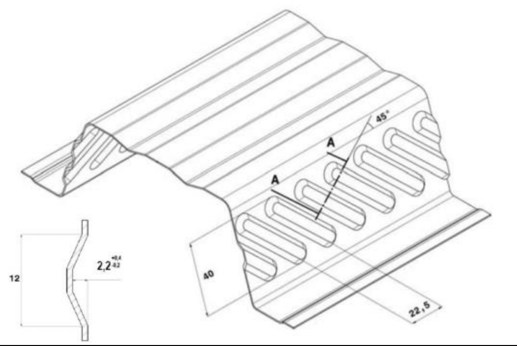
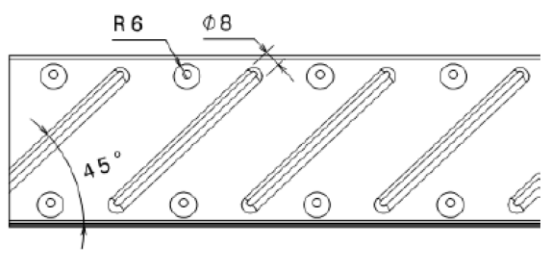
	
PCB 60	PCB 80

Table 2: Cross-section with embossments

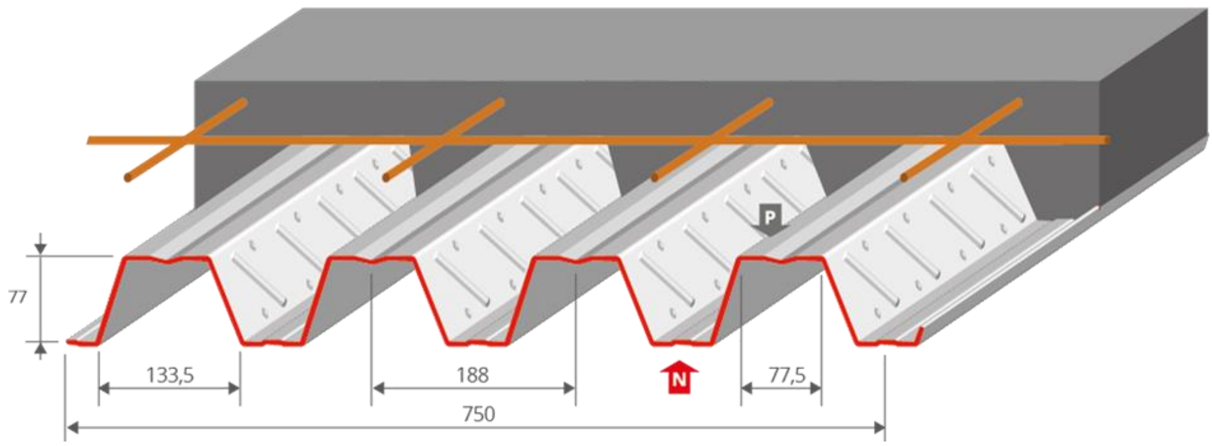


Figure 1: PCB 80 (incl. embossments)

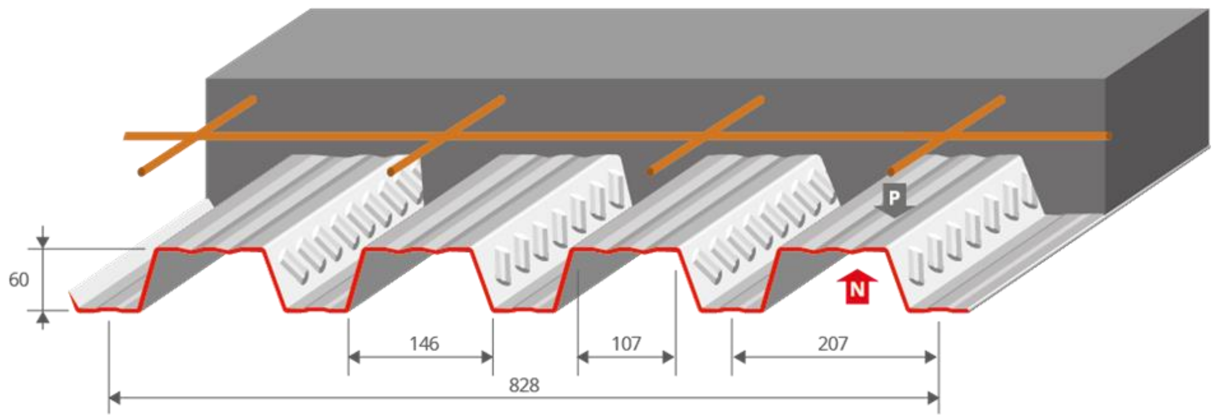


Figure 2: PCB 60 (incl. embossments)

The profile ComFlor 80 (Tata Steel) has outward stiffeners which are given in the following figure 3.

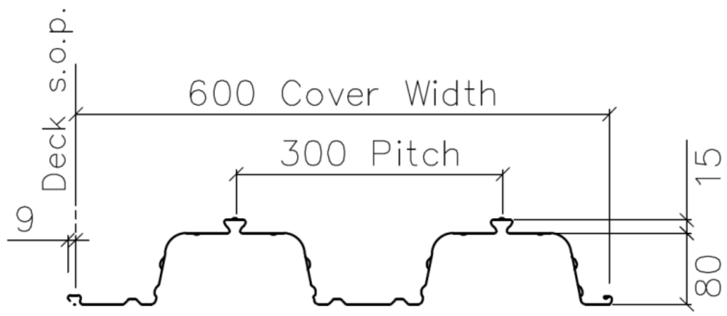


Figure 3: Outward stiffeners (ComFlor 80)

3 Scope of testing

The test performances for determination of the resistance values for bending, shear and web crippling were done according to EN 1993-1-3:2010. The tests performed are listed in the following table 3.

Profile	Type of test	Direction of loading	Thickness [mm]	Span [mm]	Number of tests
PCB 80 (profil 1)	Single span test	downward	0.75 and 1.00	3500	12
	Internal support test with b_u = 60 mm and b_u = 160 mm	downward		500	12
				1100	16
				1700	16
	End support test	downward		700	16
PCB 60 (profil 2)	Single span test	downward	0.75 and 1.00	3000	12
	Internal support test with b_u = 60 mm and b_u = 160 mm	downward		400	16
				950	16
				1500	16
	End support test	downward		650	12
ComFlor 80 (profil 3)	Single span test	downward	0.90 and 1.20	4000	8

Table 3: Tests performed

In addition, tensile tests on specimens taken from the sheeting according to EN 6892-1:2009 were performed to determine of the material properties. Furthermore the profile geometry was measured and tensile tests with embossments in the middle of the specimen were performed.

4 Test performance and results

4.1 General remarks

The test specimens were delivered June 18th, July 25th and August 06th, 2014. The tests were performed using calibrated testing machines of the “Versuchsanstalt für Stahl, Holz und Steine” of the Karlsruhe Institute of Technology (KIT). The specimens are all described by the following system:

System:	XX – X – XXX – X
First block (two char.):	Type of test
	PF = single span, positive flexion IS = internal support ES = end support
Second block:	Profile number
(one or two char.)	1 = PCB 80 without embossments
	1e = PCB 80 with embossments 2 = PCB 60 without embossments 2e = PCB 60 with embossments 3 = ComFlor 80
Third block (three char.):	Sheet thickness
	075 = 0.75 mm 090 = 0.90 mm 100 = 1.00 mm 120 = 1.20 mm
Fourth block:	Test number (running)

4.2 Single span tests

For the determination of the characteristic values of the mid-span moment resistance, single span tests for load case "gravity loading" (positive flexion) were performed with uniformly distributed load simulated by four line loads. These tests were performed using profiles of Bacacier PCB 80, PCB 60 and of Tata Steel ComFlor 80. The tests on PCB 80 and PCB 60 were performed on two sheet thicknesses (t_N = 0.75mm and t_N = 1.00 mm) on profiles with and without embossments. The overhang of each profile was 100 mm. The load was introduced into the small flanges via transverse steel sections and timber blocks. The profiles were prevented from spreading by transverse ties. At end supports timber blocks were used to avoid web crippling. The deflections were measured continuously in mid-span and at the end supports by each two cable extension transducers. At mid span, the deflections were measured under bottom flanges of edge ribs and at end support at the upper flanges, see Figure B.2 in annex B.

The structure of the specimens and the static systems are given in annex B. The load was applied deflection-controlled with a speed of 30 mm/min. The load was measured continuously using a load cell and was plotted as load-deformation curve.

In all single span tests a non-linear load-deflection behaviour appeared until the failure load was reached. In all tests failure occurred by buckling of the upper flange near the load applying traverse. The results including preload of the single span tests are listed in the following tables. Annex B shows the experimental setup, photos from the tests and the load deflection-curve (for PF-2-100-2 see annex E, there was an error by data storage).

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
PF-1-075-1	3500	0.738	0.63	15.08
PF-1-075-2		0.743		15.21
PF-1-075-3		0.745		15.29
PF-1-100-1		0.984		22.62
PF-1-100-2		0.985		23.32
PF-1-100-3		0.982		23.11
PF-2-075-1	3000	0.749	0.73	10.73
PF-2-075-2		0.749		10.37
PF-2-075-3		0.750		10.50
PF-2-100-1		0.980		15.61
PF-2-100-2		0.980		15.58*)
PF-2-100-3		0.979		15.39

*) maximum load from graph in annex E plus preload

Table 4: Results of single span tests for profiles without embossments

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
PF-1e-075-1	3500	0.736	0.63	14.53
PF-1e-075-2		0.731		14.75
PF-1e-075-3		0.739		14.67
PF-1e-100-1		0.980		22.20
PF-1e-100-2		0.974		21.95
PF-1e-100-3		0.975		22.04
PF-2e-075-1	3000	0.741	0.73	9.57
PF-2e-075-2		0.740		9.22
PF-2e-075-3		0.743		9.67
PF-2e-100-1		0.977		15.23
PF-2e-100-2		0.976		14.54
PF-2e-100-3		0.976		14.64

Table 5: Results of single span tests for profiles with embossments

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
PF-3-090-1	4000	0.923	0.61	16.02
PF-3-090-2		0.926		16.12
PF-3-090-3		0.922		15.42
PF-3-090-4		0.920		16.20
PF-3-120-1	4000	1.216	0.61	26.28
PF-3-120-2		1.215		25.86
PF-3-120-3		1.211		25.41
PF-3-120-4		1.221		24.71

Table 6: Results of single span tests for profiles with outward stiffeners

4.3 Internal support tests

Instead of extensive investigations of the intermediate support area of continuous beams, internal support tests for the load case “gravity loading” (intermediate support downward load) were performed per sheet thickness with three different spans in negative position. Loading was effected in mid-span via a transverse steel plate with a width of b_u = 60 mm or b_u = 160 mm. The tests on PCB 80 and PCB 60 were performed on two sheet thicknesses (t_N = 0.75mm and t_N = 1.00 mm) on profiles with and without embossments. The profiles were prevented from spreading by transverse ties. At the supports the profiles were pivoted on timber blocks. The deflections were measured continuously in mid-span and near the end supports by each two cable extension transducers. For the profile PCB 80 the deflections were measured at the bottom flanges of edge ribs, see Figure C.2 in annex C. When testing the profile PCB 60, the deflections were measured at the upper flanges, see figure C.3 in annex C. The structure of the specimens and the static system are given in annex C.

The load applied deflection-controlled with a speed of 3 mm/min, after the failure load was reached the speed was increased to 10 mm/min. The load was measured continuously using a calibrated load cell.

In all internal support tests (intermediate support downward load) an approximately linear elastic load-bearing behaviour appeared until failure load was reached. Failure occurred by deformation of the webs (web-crippling). The results including preload of the internal support tests are listed in the following table.

Annex C shows the experimental setup, photos from the tests and the load deflection-curve (for IS16-2e-075-12 see annex E, there was an error by data storage).

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-1-075-11	500	0.738	0.16	13.43
IS6-1-075-12		0.726		13.37
IS6-1-075-21	1100	0.727		8.56
IS6-1-075-22		0.726		8.57
IS6-1-075-41	1700	0.733	0.19	6.04
IS6-1-075-42		0.734		6.03
IS16-1-075-11	500	0.741	0.16	19.57
IS16-1-075-12		0.735		19.97
IS16-1-075-21	1100	0.735		10.93
IS16-1-075-22		0.730		11.03
IS16-1-075-41	1700	0.731	0.19	7.38
IS16-1-075-42		0.732		7.37
IS6-1-100-11	500	0.979	0.16	23.16
IS6-1-100-12		0.975		23.06
IS6-1-100-21	1100	0.979		14.75
IS6-1-100-22		0.977		14.72
IS6-1-100-41	1700	0.974	0.19	10.30
IS6-1-100-42		0.973		10.45
IS16-1-100-11	500	0.978	0.16	35.00
IS16-1-100-12		0.980		35.68
IS16-1-100-21	1100	0.978		19.23
IS16-1-100-22		0.979		18.87
IS16-1-100-41	1700	0.970	0.19	12.47
IS16-1-100-42		0.973		12.30

Table 7: Results of intermediate support tests for PCB 80 without embossments

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-2-075-11	400	0.737	0.16	12.75
IS6-2-075-12		0.736		12.74
IS6-2-075-21	950	0.742	0.19	8.64
IS6-2-075-22		0.743		8.58
IS6-2-075-41	1500	0.743		5.97
IS6-2-075-42		0.738		6.03
IS16-2-075-11	400	0.737	0.16	19.95
IS16-2-075-12		0.735		19.97
IS16-2-075-21	950	0.745	0.19	11.84
IS16-2-075-22		0.742		11.84
IS16-2-075-41	1500	0.740		7.49
IS16-2-075-42		0.741		7.48
IS6-2-100-11	400	0.981	0.16	20.34
IS6-2-100-12		0.975		20.65
IS6-2-100-21	950	0.975	0.19	13.48
IS6-2-100-22		0.972		13.55
IS6-2-100-41	1500	0.982		9.73
IS6-2-100-42		0.977		9.78
IS16-2-100-11	400	0.975	0.16	33.39
IS16-2-100-12		0.974		33.27
IS16-2-100-21	950	0.972	0.19	18.79
IS16-2-100-22		0.976		18.74
IS16-2-100-41	1500	0.994		11.72
IS16-2-100-42		0.978		12.01

Table 8: Results of intermediate support tests for PCB 60 without embossments

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-1e-075-11	500	0.737	0.16	13.60
IS6-1e-075-12		0.730		13.34
IS6-1e-075-21	1100	0.737		8.73
IS6-1e-075-22		0.729		8.63
IS6-1e-075-41	1700	0.737	0.19	6.09
IS6-1e-075-42		0.733		5.93
IS16-1e-075-11	500	0.738	0.16	21.18
IS16-1e-075-12		0.734		21.29
IS16-1e-075-21	1100	0.729		11.54
IS16-1e-075-22		0.729		11.79
IS16-1e-075-41	1700	0.731	0.19	7.19
IS16-1e-075-42		0.730		7.01
IS6-1e-100-11	500	0.976	0.16	24.04
IS6-1e-100-12		0.978		24.15
IS6-1e-100-21	1100	0.975		14.85
IS6-1e-100-22		0.968		14.64
IS6-1e-100-41	1700	0.981	0.19	10.41
IS6-1e-100-42		0.975		10.42
IS16-1e-100-11	500	0.978	0.16	35.84
IS16-1e-100-12		0.976		37.54
IS16-1e-100-21	1100	0.972		19.34
IS16-1e-100-22		0.971		19.89
IS16-1e-100-41	1700	0.978	0.19	12.30
IS16-1e-100-42		0.972		12.31

Table 9: Results of intermediate support tests for PCB 80 with embossments

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]
IS6-2e-075-11	400	0.739	0.16	12.89
IS6-2e-075-12		0.738		12.75*)
IS6-2e-075-21	950	0.734	0.19	8.11
IS6-2e-075-22		0.737		8.28
IS6-2e-075-41	1500	0.731		5.73
IS6-2e-075-42		0.733		5.85
IS16-2e-075-11	400	0.732	0.16	20.76
IS16-2e-075-12		0.737		20.85*)
IS16-2e-075-21	950	0.733	0.19	10.71
IS16-2e-075-22		0.729		10.56
IS16-2e-075-41	1500	0.736		6.88
IS16-2e-075-42		0.735		7.04
IS6-2e-100-11	400	0.972	0.16	20.47
IS6-2e-100-12		0.970		20.61
IS6-2e-100-21	950	0.975	0.19	13.12
IS6-2e-100-22		0.973		13.15
IS6-2e-100-41	1500	0.976		9.23
IS6-2e-100-42		0.973		9.23
IS16-2e-100-11	400	0.976	0.16	33.97
IS16-2e-100-12		0.975		34.03
IS16-2e-100-21	950	0.972	0.19	17.54
IS16-2e-100-22		0.972		17.45
IS16-2e-100-41	1500	0.978		11.18
IS16-2e-100-42		0.970		11.00

*) maximum load from graph in annex E plus preload

Table 10: Results of intermediate support tests for PCB 60 with embossments

4.4 End support tests

For the determination of the characteristic values of the end support resistance, end support tests for the load case “gravity loading” were performed. The tests on PCB 80 and PCB 60

were performed on two sheet thicknesses (t_N = 0.75 mm and t_N = 1.00 mm) on profiles with and without embossments. The load was applied via a transverse steel plate with b = 300 mm and timber blocks attached to the bottom flanges of the profiles.
The profiles were prevented from spreading by transverse ties. At the tested end support there is a cutting edge (gradient of 1:20). At the opposite end support timber blocks were used to avoid web crippling. The deflections were measured continuously at the transverse steel plate and at the end support with the cutting edge by two cable extension transducers. At the end support the deflections were measured at the upper flanges, see Figure D.2 in annex D. The structure of the specimens and the static systems are given in annex D. The load applied deflection-controlled with a speed of 3 mm/min. The load was measured continuously using a calibrated load cell.
The results including preload of the end support tests and the failure modes are listed in the following tables. Annex D shows the experimental setup, photos from the tests and the load deflection-curve.

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]		Failure mode
ES-1-075-1	700	0.740	0.55	17.61	-	First load maximum: web-crippling Second load maximum: buckling of the upper flanges
ES-1-075-2		0.733		18.08	23.66	
ES-1-075-3		0.735		17.99	24.79	
ES-1-100-1		0.988		33.94	40.57	First load maximum: web-crippling Second load maximum: buckling of the upper flanges
ES-1-100-2		0.977		33.34	40.56	
ES-1-100-3		0.994		32.58	40.10	
ES-2-075-1	650	0.737	0.55	27.93	36.08	First load maximum: web-crippling Second load maximum: buckling of the upper flanges
ES-2-075-2		0.736		28.02	34.65	
ES-2-075-3		0.734		27.19	34.43	
ES-2-100-1		0.972		45.24	-	Web-crippling without buckling of the upper flanges
ES-2-100-2		0.967		46.02	-	
ES-2-100-3		0.975		46.11	48.63	First load maximum: web-crippling Second load maximum: buckling of the upper flanges

Table 11: Results of end support tests for profiles without embossments

Test	Span [mm]	Measured thickness including zinc coating [mm]	Preload [kN]	F_{max} [kN]		Failure mode
ES-1e-075-1	700	0.748	0.55	18.07	21.30	First load maximum: web-crippling Second load maximum: buckling of the upper flanges
ES-1e-075-2		0.734		19.51	25.71	
ES-1e-075-3		0.735		19.03	23.31	
ES-1e-100-1		0.982		34.24	40.48	First load maximum: web-crippling Second load maximum: buckling of the upper flanges
ES-1e-100-2		0.996		35.09	38.63	
ES-1e-100-3		0.984		35.95	40.13	
ES-2e-075-1	650	0.737	0.55	32.60	-	Load maximum: combination of web-crippling and buckling of the upper flanges
ES-2e-075-2		0.739		34.92	-	
ES-2e-075-3		0.738		32.48	-	
ES-2e-100-1		0.972		49.02	-	
ES-2e-100-2		0.974		49.26	-	
ES-2e-100-3		0.972		48.80	-	

Table 12: Results of end support tests for profiles with embossments

4.5 Measurement of the profile geometry

The geometry of the different profiles (PCB 80, PCB 60 and ComFlor 80) for both nominal thicknesses t_N = 0.75 mm and t_N = 1.00 mm (PCB 80 and PCB 60) or t_N = 0.90 mm and t_N = 1.20 mm (ComFlor 80) were measured. The results are documented in annex F.

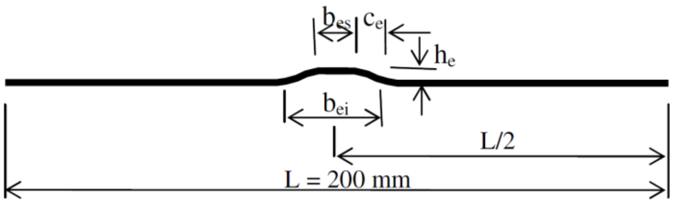
4.6 Coupon tests with and without embossments

For the determination of the material properties, 5 specimens per sheet (PCB 60, PCB 80 and ComFlor 80) and per thickness were worked out for tensile tests according to EN 6892-1:2009 with the specimen form 2 according to EN 6892-1:2009 table B.1. The determination of the yield strength $R_{p0.2}$ and the tensile strength R_m was based upon the measured sheet thickness exclusive of zinc coating. The results of the tensile tests are given in the following table.

For the determination of the influence of the embossment 3 tensile tests per configuration (see table 14 and 15) were performed according to EN 6892-1:2009 with the specimen form 2 according to EN 6892-1:2009 table B.1. The results of the tensile tests are given in annex G and table 14 and 15.

Profile	Nominal thickness t_N [mm]	Core thickness t_K [mm]	Yield strength $R_{p0,2}$ [N/mm²]	Tensile strength R_m [N/mm²]	Elongation at fracture $A_{L=80mm}$ [%]
PCB 80 (profile 1)	0.75	0.688	362	493	23.5
		0.686	363	494	25.5
		0.682	363	495	24.9
		0.682	362	495	24.1
		0.684	364	496	24.1
	1.00	0.962	378	474	25.4
		0.954	363	470	26.7
		0.961	360	469	27.0
		0.964	382	481	24.3
		0.962	366	469	27.2
PCB 60 (profile 2)	0.75	0.697	342	460	23.9
		0.698	341	458	23.7
		0.699	339	456	23.2
		0.698	340	457	23.2
		0.696	342	459	23.1
	1.00	0.931	362	480	24.8
		0.932	360	480	24.9
		0.933	369	482	25.3
		0.931	365	479	25.5
		0.931	364	480	25.3
ComFlor 80 (profile 3)	0.90	0.871	473	563	20.8
		0.875	470	560	20.5
		0.879	469	559	20.3
		0.874	470	558	20.6
	1.20	1.168	467	565	20.0
		1.161	465	568	19.8
		1.162	470	569	19.8
		1.164	468	567	20.5

Table 13: Results of tensile tests



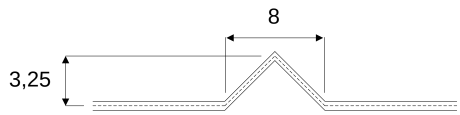
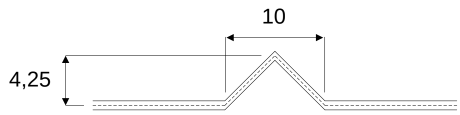
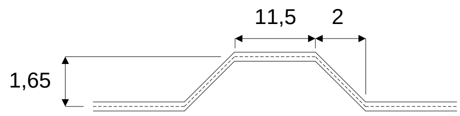
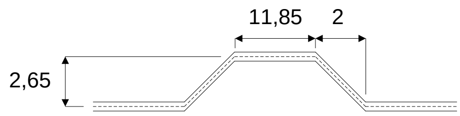
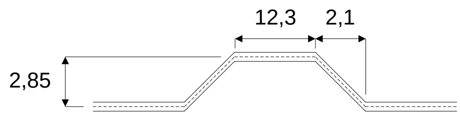
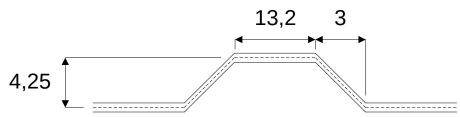
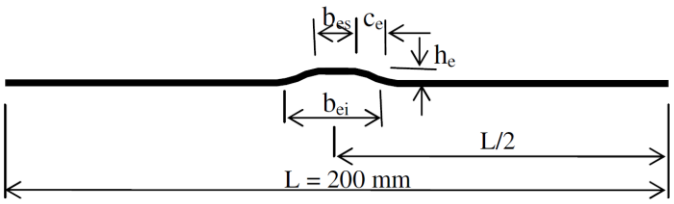
Test	Core thickness t_K [mm]	Measured height $h_e + t_N$ [mm]	Geometry according to Joris Ide [mm]
TT-e-075-0-0-0-1	0.698	-	
TT-e-075-0-0-0-2	0.701	-	
TT-e-075-0-0-0-3	0.702	-	
TT-e-075-1-1-0-1	0.701	2.14	-
TT-e-075-1-1-0-2	0.701	2.12	
TT-e-075-1-2-0-3	0.700	2.12	
TT-e-075-2-2-0-1	0.699	3.31	-
TT-e-075-2-2-0-2	0.705	3.25	
TT-e-075-2-2-0-3	0.702	3.30	
TT-e-075-3-3-0-1	0.694	4.00	
TT-e-075-3-3-0-2	0.698	3.96	
TT-e-075-3-3-0-3	0.679	3.94	
TT-e-075-4-4-0-1	0.701	4.85	
TT-e-075-4-4-0-2	0.700	4.85	
TT-e-075-4-4-0-3	0.696	4.91	
TT-e-075-1-1-10-1	0.693	2.40	
TT-e-075-1-1-10-2	0.699	2.41	
TT-e-075-1-1-10-3	0.695	2.40	
TT-e-075-2-2-10-1	0.699	3.39	
TT-e-075-2-2-10-2	0.699	3.35	
TT-e-075-2-2-10-3	0.700	3.34	
TT-e-075-3-3-10-1	0.698	3.57	
TT-e-075-3-3-10-2	0.698	3.57	
TT-e-075-3-3-10-3	0.702	3.56	
TT-e-075-4-4-10-1	0.691	5.06	
TT-e-075-4-4-10-2	0.699	5.11	
TT-e-075-4-4-10-3	0.698	5.10	

Table 14: Results of tensile tests with embossments, nominal thickness t_N = 0.75 mm



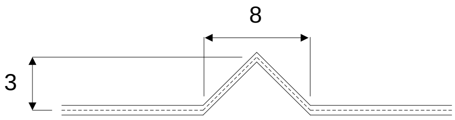
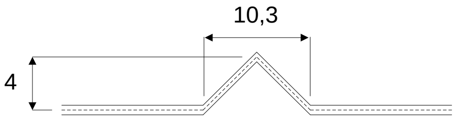
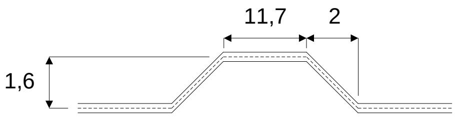
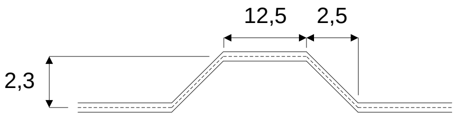
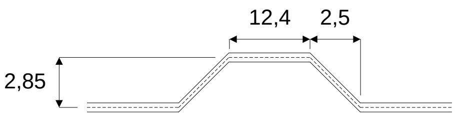
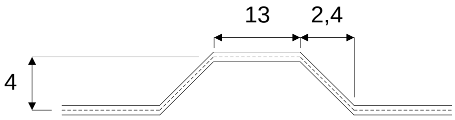
Test	Core thickness t_K [mm]	Measured height $h_e + t_N$ [mm]	Geometry according to Joris Ide [mm]
TT-e-100-0-0-0-1	0.698	-	
TT-e-100-0-0-0-2	0.701	-	
TT-e-100-0-0-0-3	0.702	-	
TT-e-100-1-1-0-1	0.935	2.31	-
TT-e-100-1-1-0-2	0.928	2.31	
TT-e-100-1-2-0-3	0.938	2.33	
TT-e-100-2-2-0-1	0.930	3.24	-
TT-e-100-2-2-0-2	0.933	3.25	
TT-e-100-2-2-0-3	0.935	3.24	
TT-e-100-3-3-0-1	0.694	4.00	
TT-e-100-3-3-0-2	0.698	3.96	
TT-e-100-3-3-0-3	0.679	3.94	
TT-e-100-4-4-0-1	0.701	4.85	
TT-e-100-4-4-0-2	0.700	4.85	
TT-e-100-4-4-0-3	0.696	4.91	
TT-e-100-1-1-10-1	0.693	2.40	
TT-e-100-1-1-10-2	0.699	2.41	
TT-e-100-1-1-10-3	0.695	2.40	
TT-e-100-2-2-10-1	0.699	3.39	
TT-e-100-2-2-10-2	0.699	3.35	
TT-e-100-2-2-10-3	0.700	3.34	
TT-e-100-3-3-10-1	0.698	3.57	
TT-e-100-3-3-10-2	0.698	3.57	
TT-e-100-3-3-10-3	0.702	3.56	
TT-e-100-4-4-10-1	0.691	5.06	
TT-e-100-4-4-10-2	0.699	5.11	
TT-e-100-4-4-10-3	0.698	5.10	

Table 15: Results of tensile tests with embossments, nominal thickness t_N = 1.00 mm

5 Summary

For the research project “Guidelines and Recommendations for Integrating Specific Profiled Steels sheets in the Eurocodes (GRISPE)” co-funded under the Research Fund for Coal and Steel the “Versuchsanstalt für Stahl, Holz und Steine” of the Karlsruhe Institute of Technology (KIT) made experimental investigations according to EN 1993-1-3:2010 on the load-bearing capacity of steel trapezoidal sheeting with and without embossments and outward stiffeners. Also tensile tests according to EN 6892.1:2009 and profile geometry measurements were accomplished.

In section 2 the trapezoidal sheeting are described with regard to application, geometry and material. Section 3 reflects the scope of testing. The description of the experimental set-up and the test performance and the documentation of the test results are included in section 4.

Annex A: Object of testing

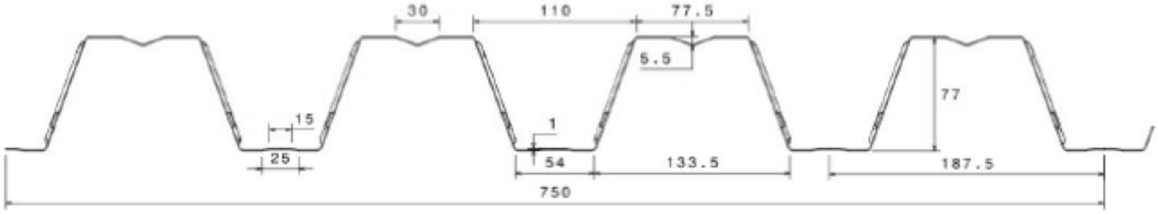


Figure A.1: Cross-section of PCB 80

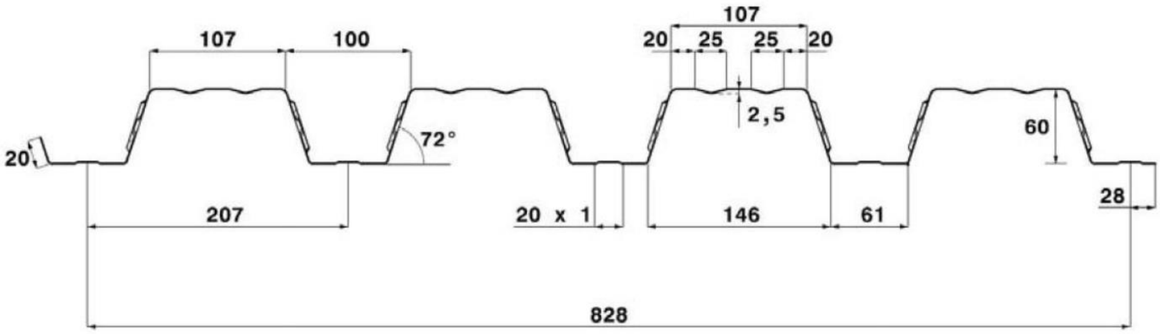


Figure A.2: Cross-section of PCB 60

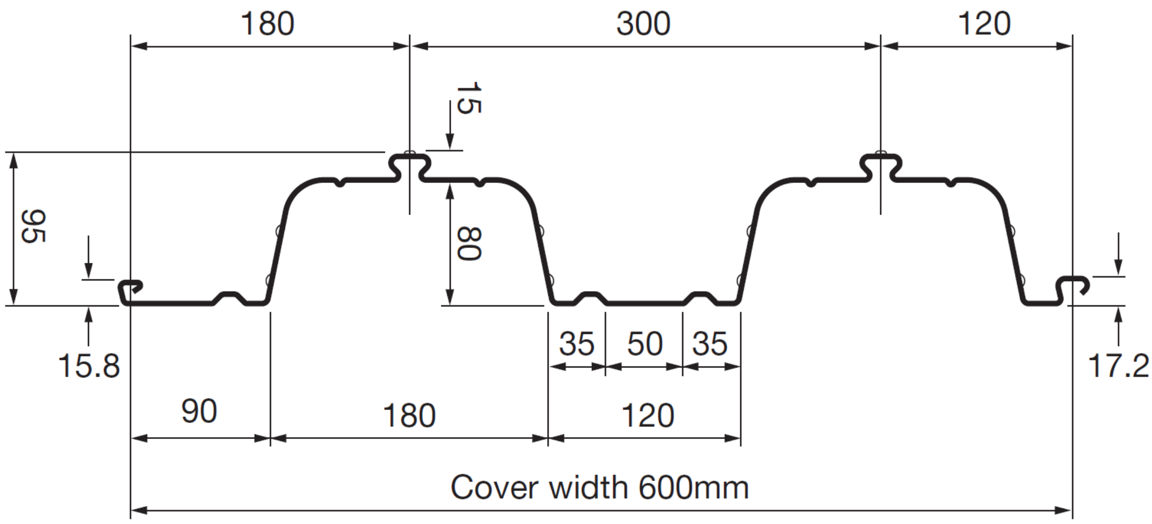


Figure A.3: Cross-section of ComFlor 80

Annex B: Single span positive bending tests

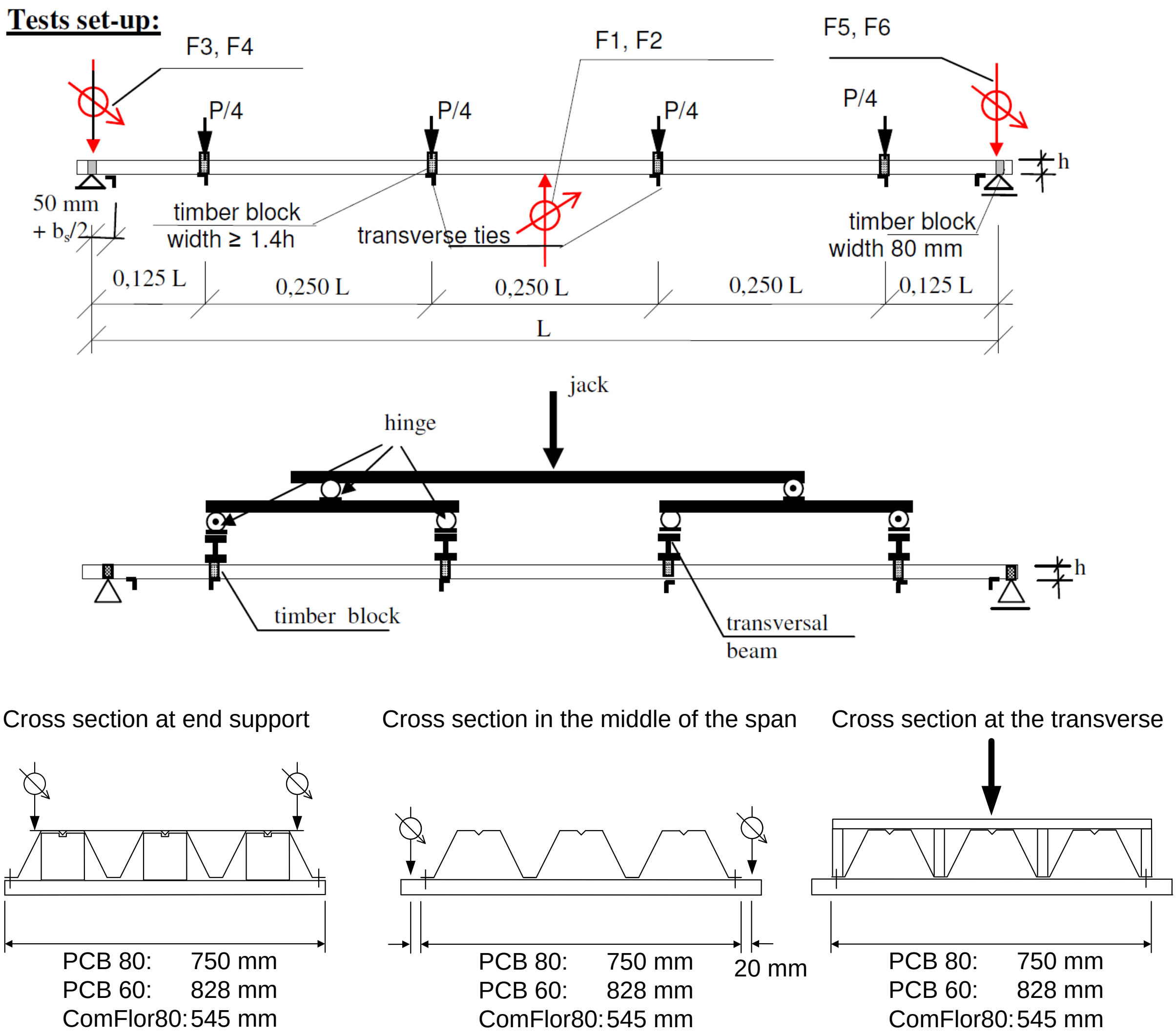


Figure B.1: Schematic test setup

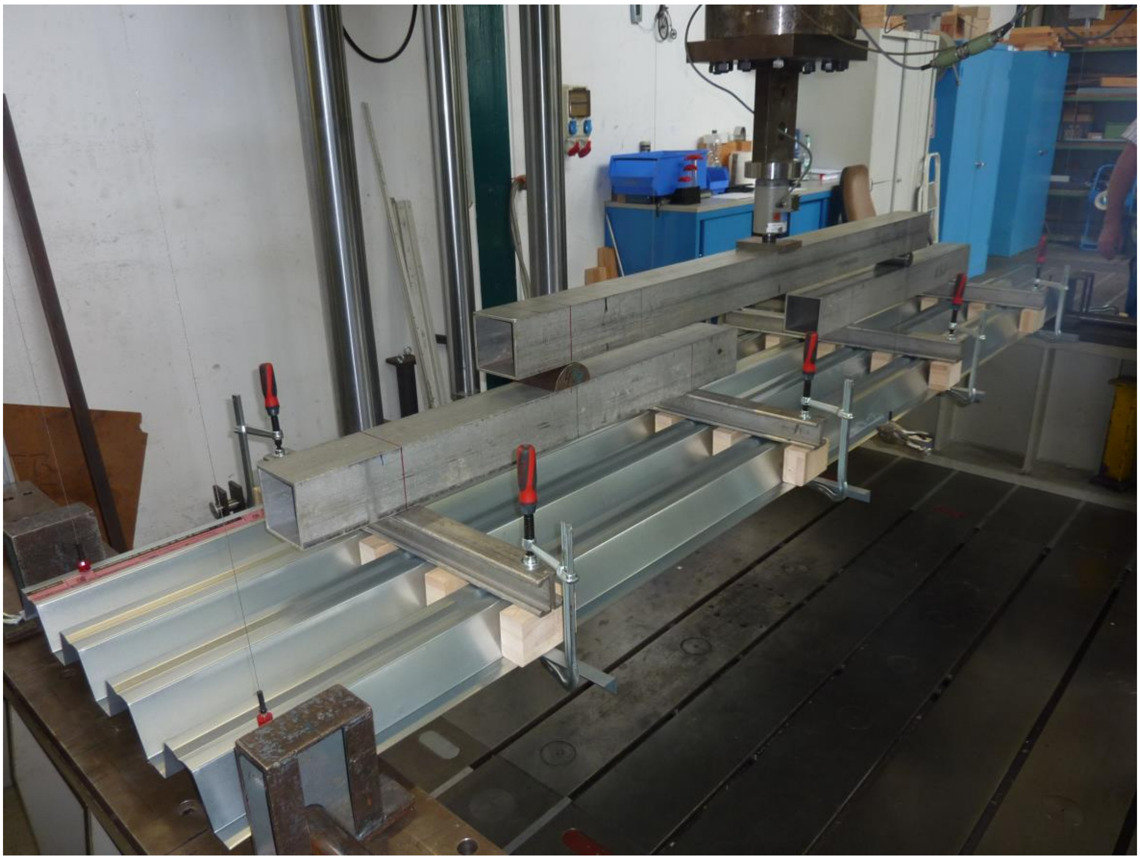


Figure B.2: Test setup (exemplary for PCB 80, t_N = 1.00 mm without embossments)

Figure B.3: Test setup (exemplary for PCB 80, t_N = 1.00 mm without embossments)

Figure B.4: Test setup (exemplary for ComFlor80, t_N = 0.90 with outward stiffeners)

Figure B.5: Failure mode (PCB 80 t_N = 0.75 mm without embossments)

Figure B.6: Failure mode (PCB 80, t_N = 0.75 mm with embossments)

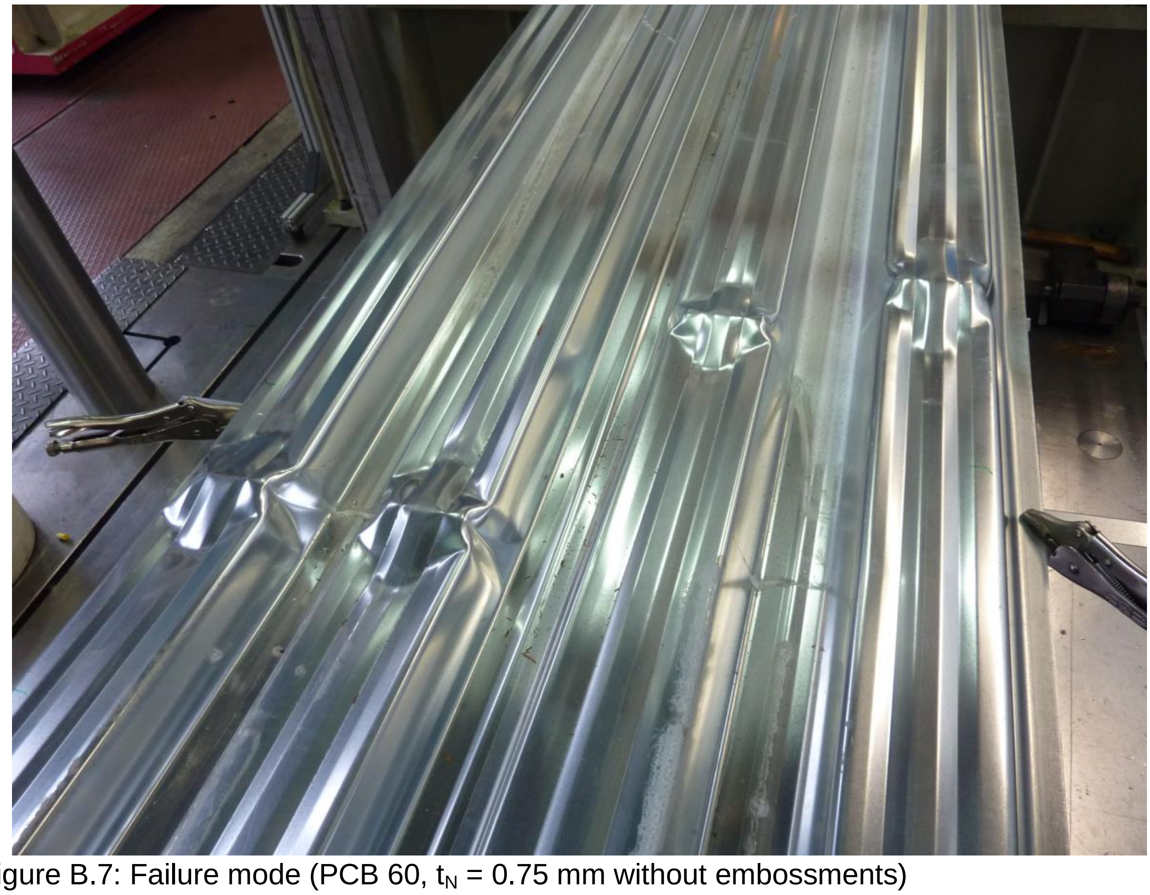


Figure B.7: Failure mode (PCB 60, t_N = 0.75 mm without embossments)

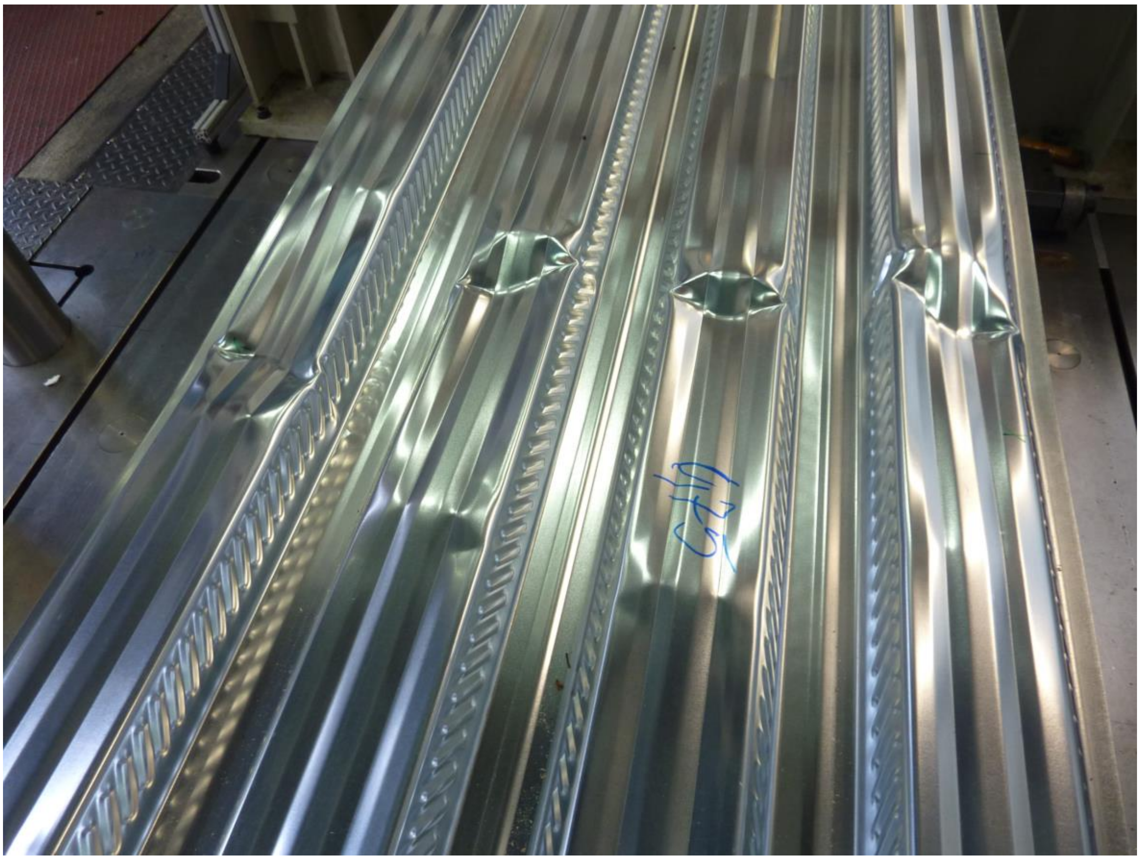
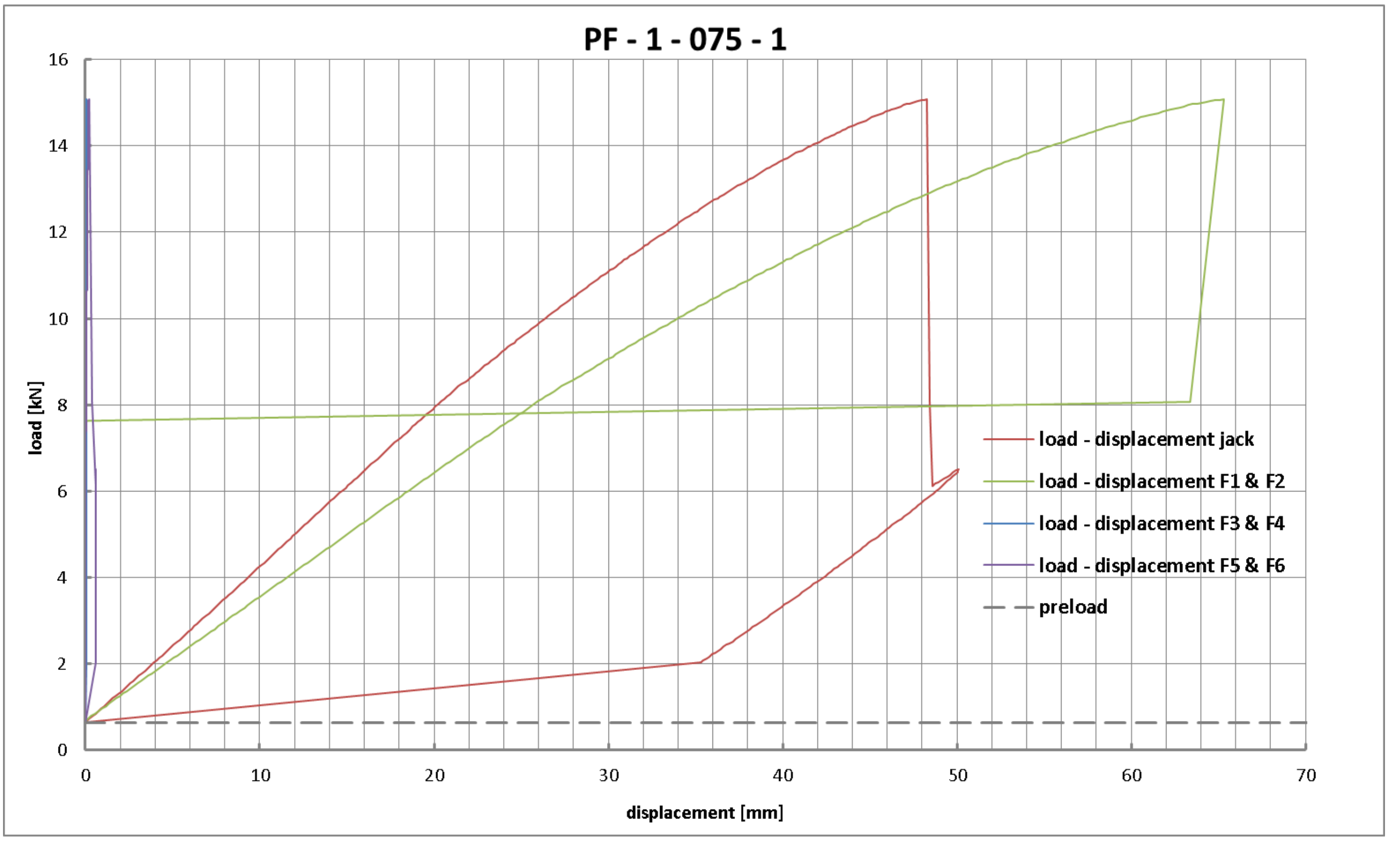
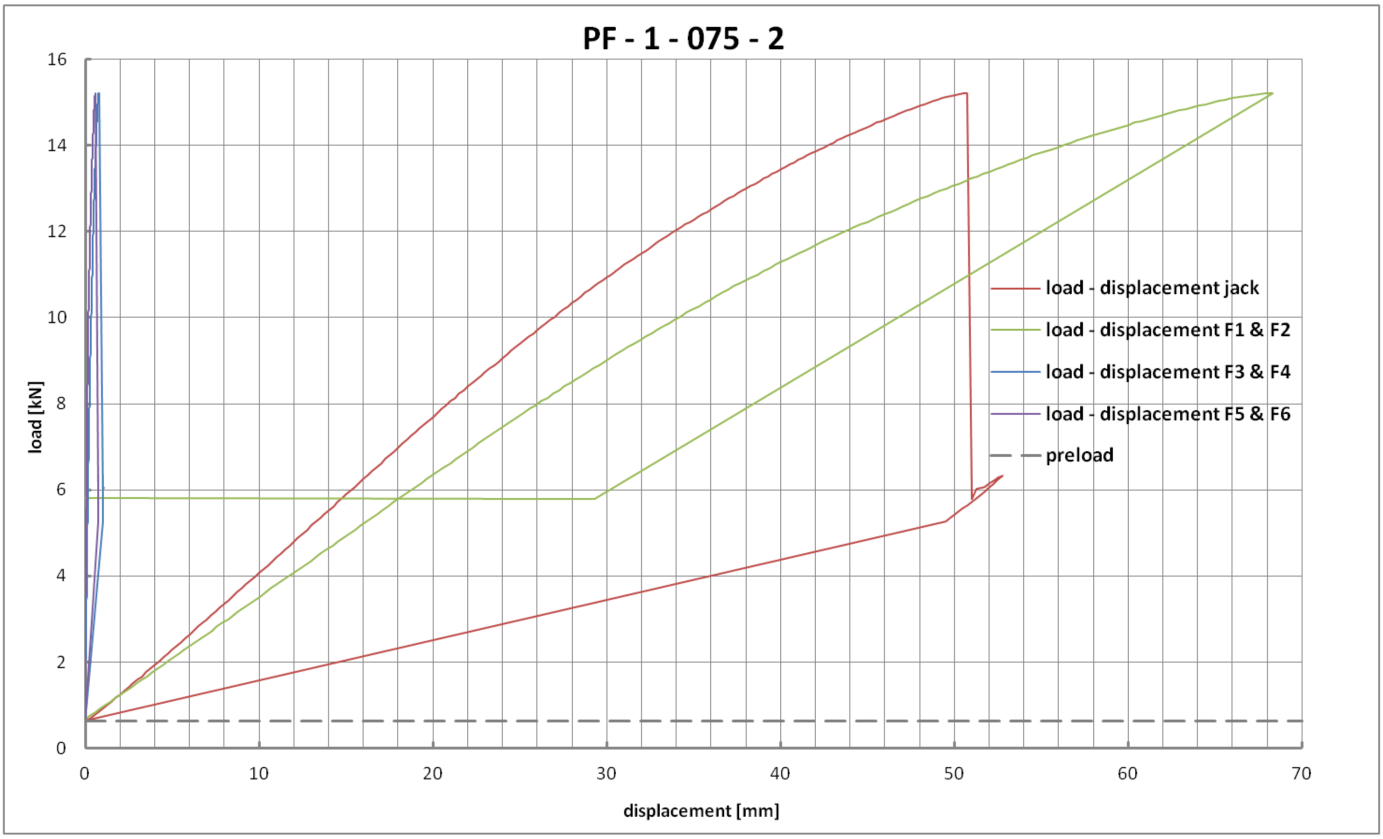


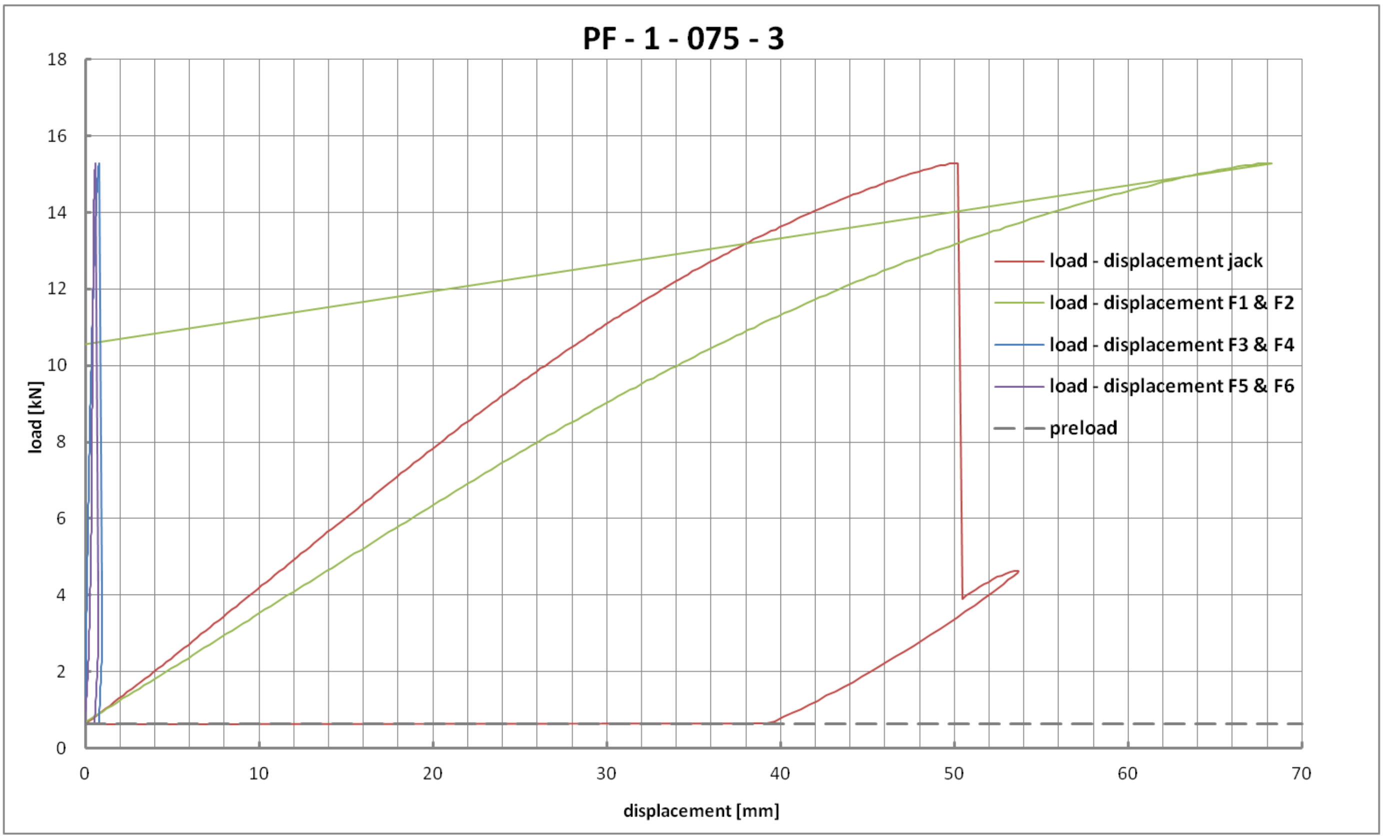
Figure B.8: Failure mode (PCB 60, t_N = 0.75 mm with embossments)

Figure B.9: Failure mode (ComFlor 80, t_N = 0.90 mm with outward stiffeners)

Load-deflection curves:






PF - 1 - 075 - 3
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
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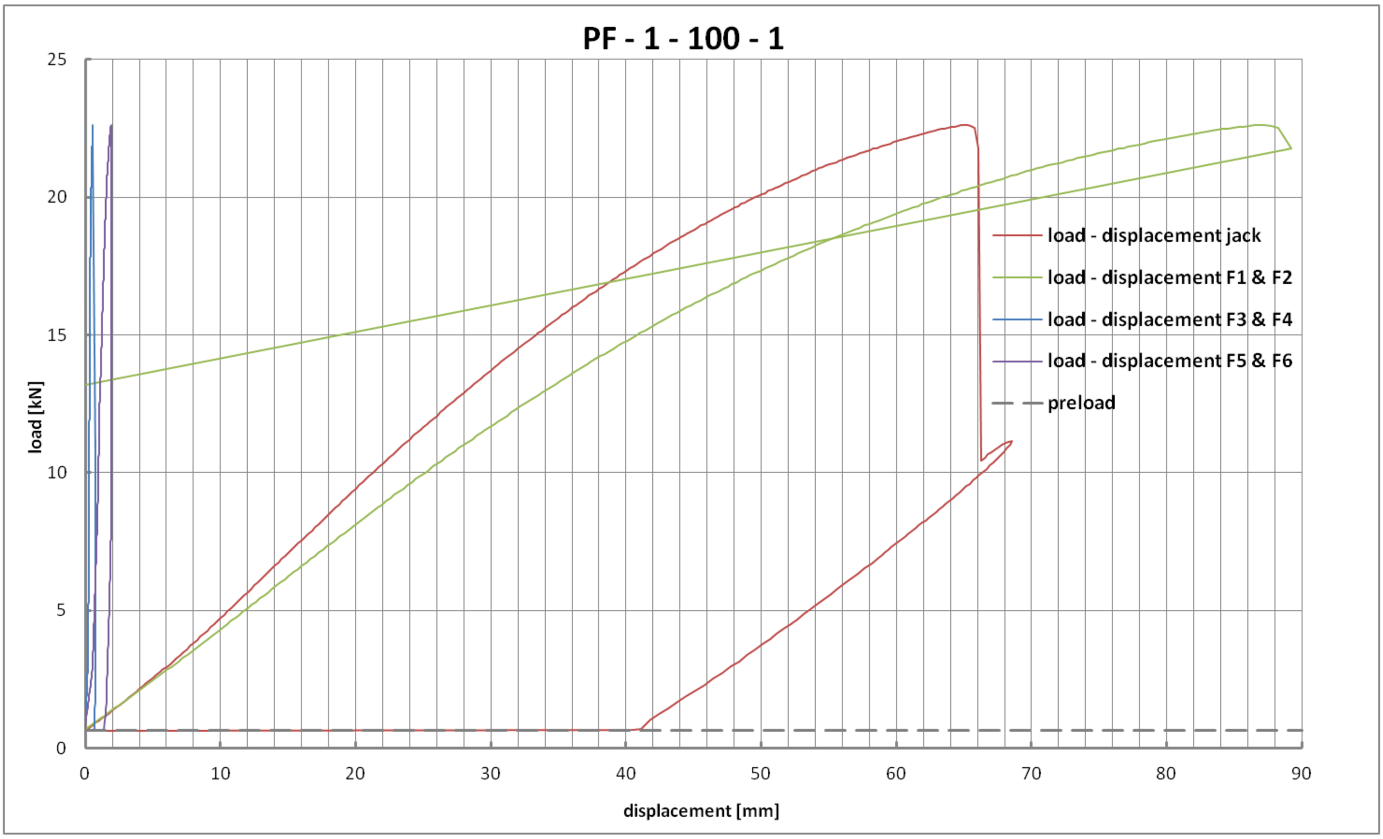
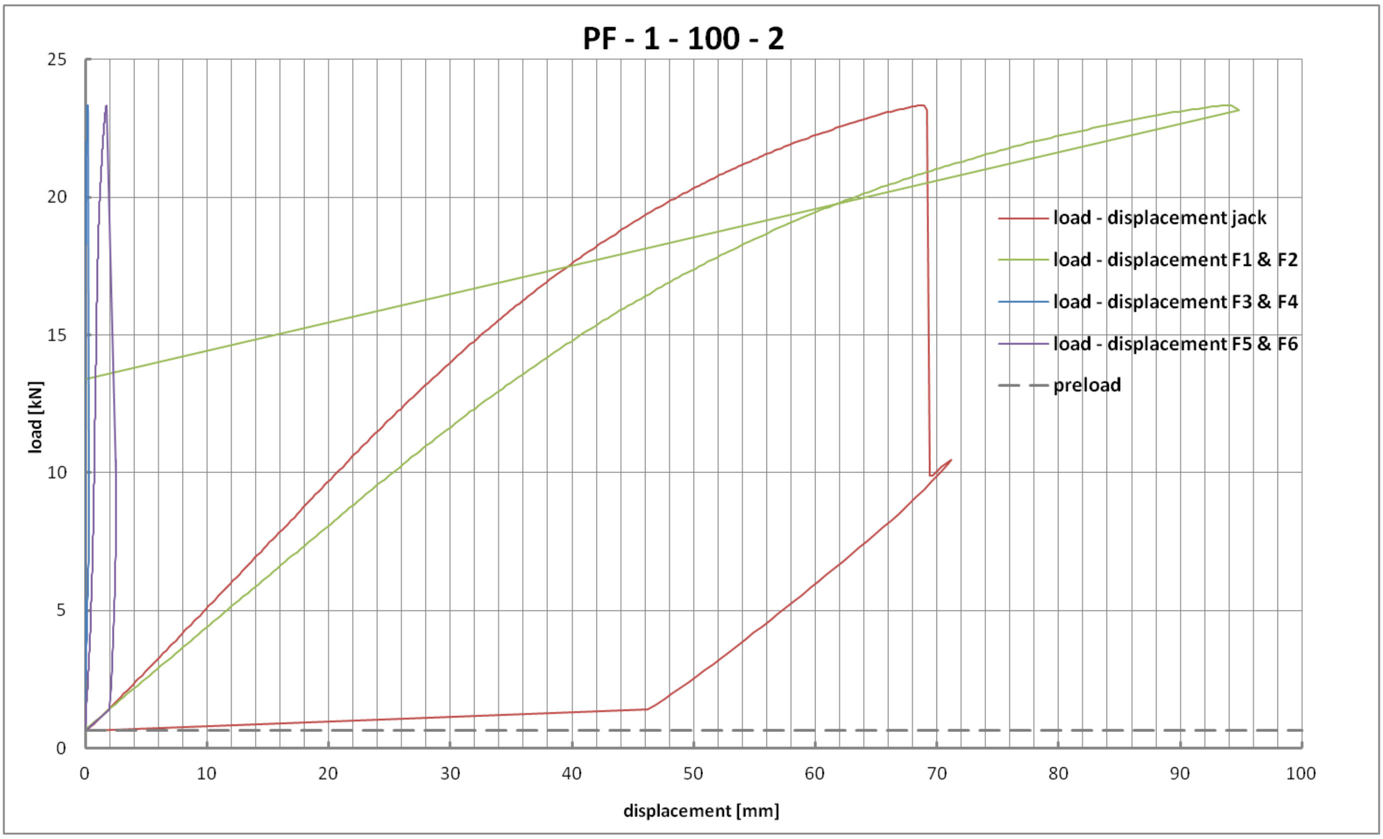
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
60
70


PF - 1 - 100 - 1
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90


PF - 1 - 100 - 2
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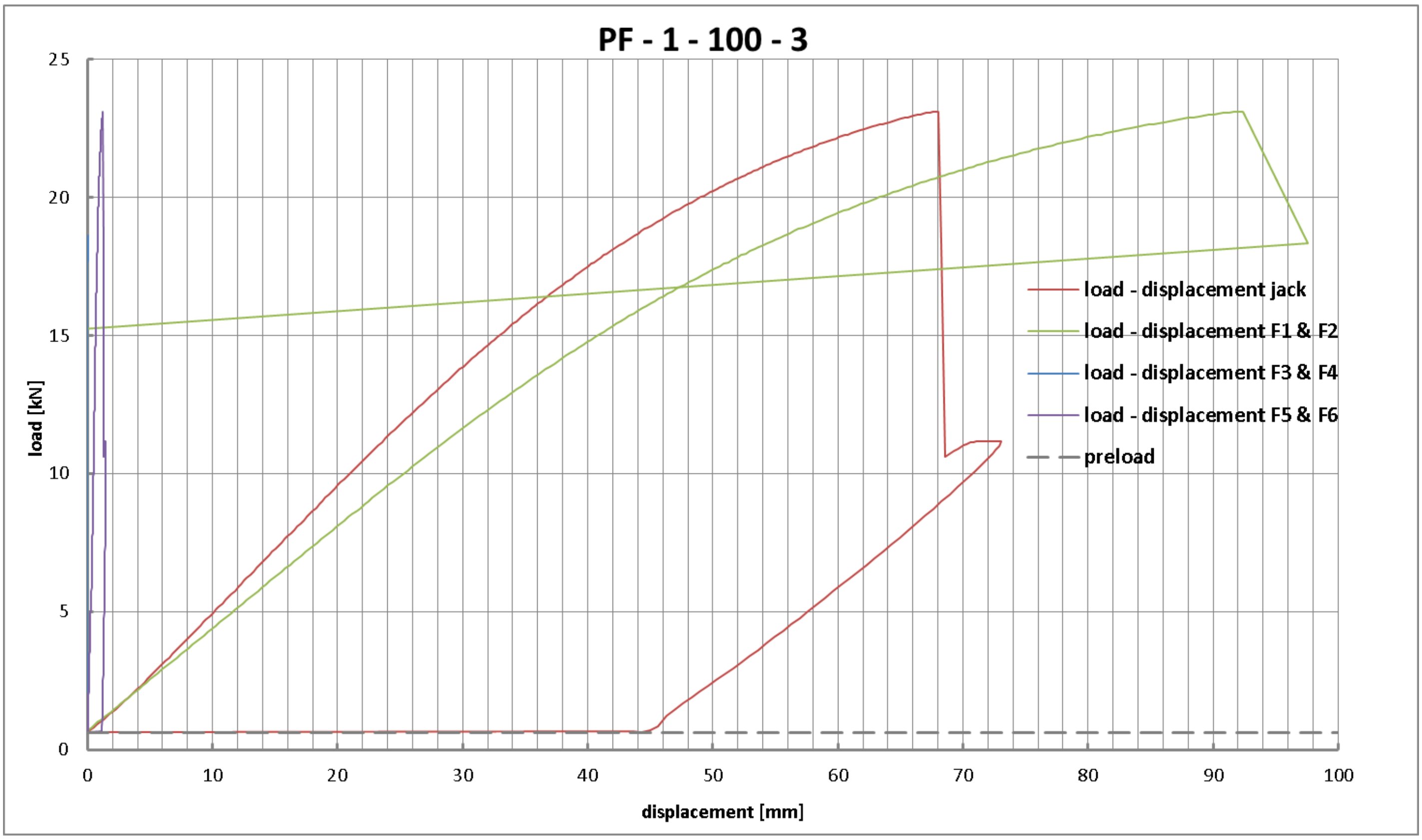
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
100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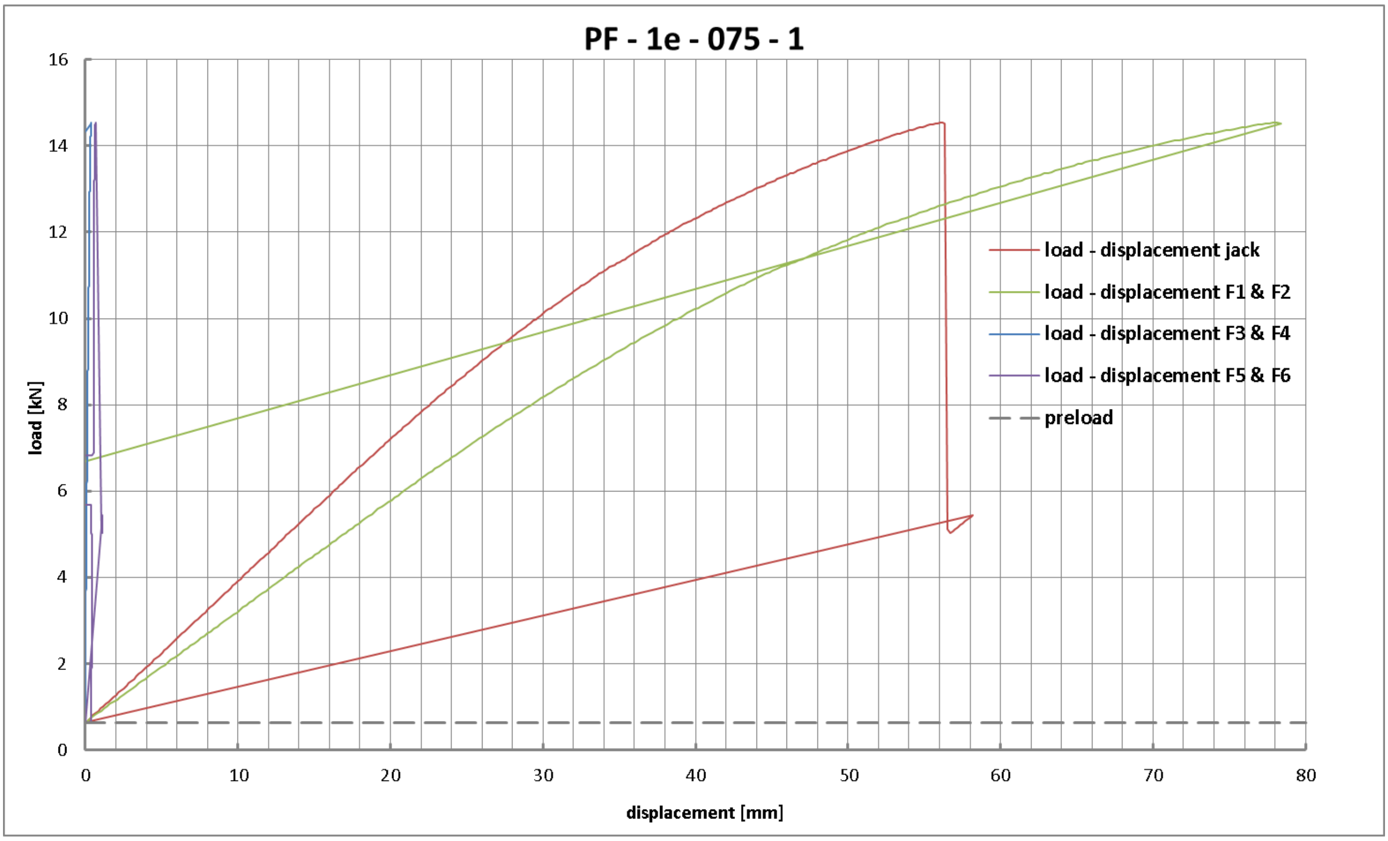
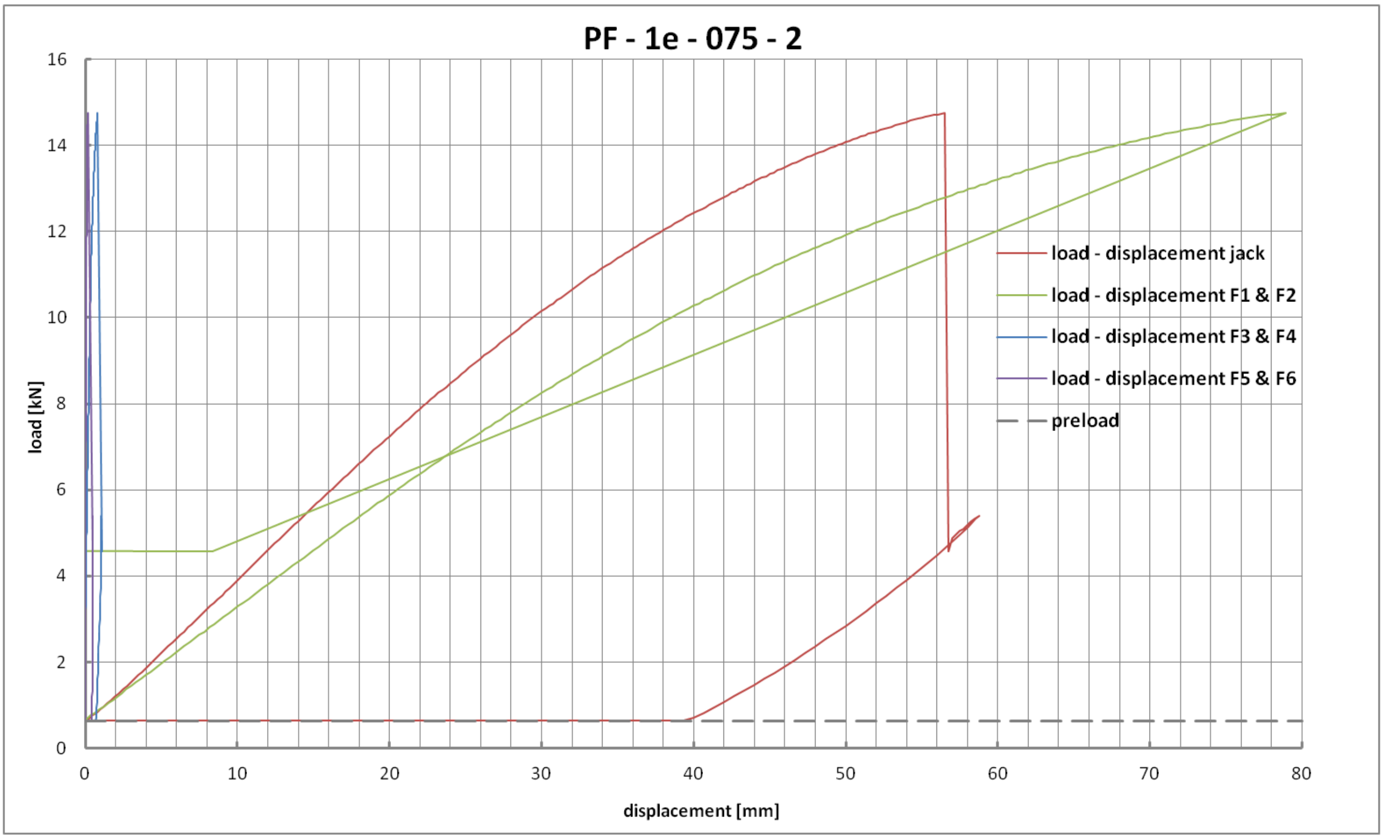
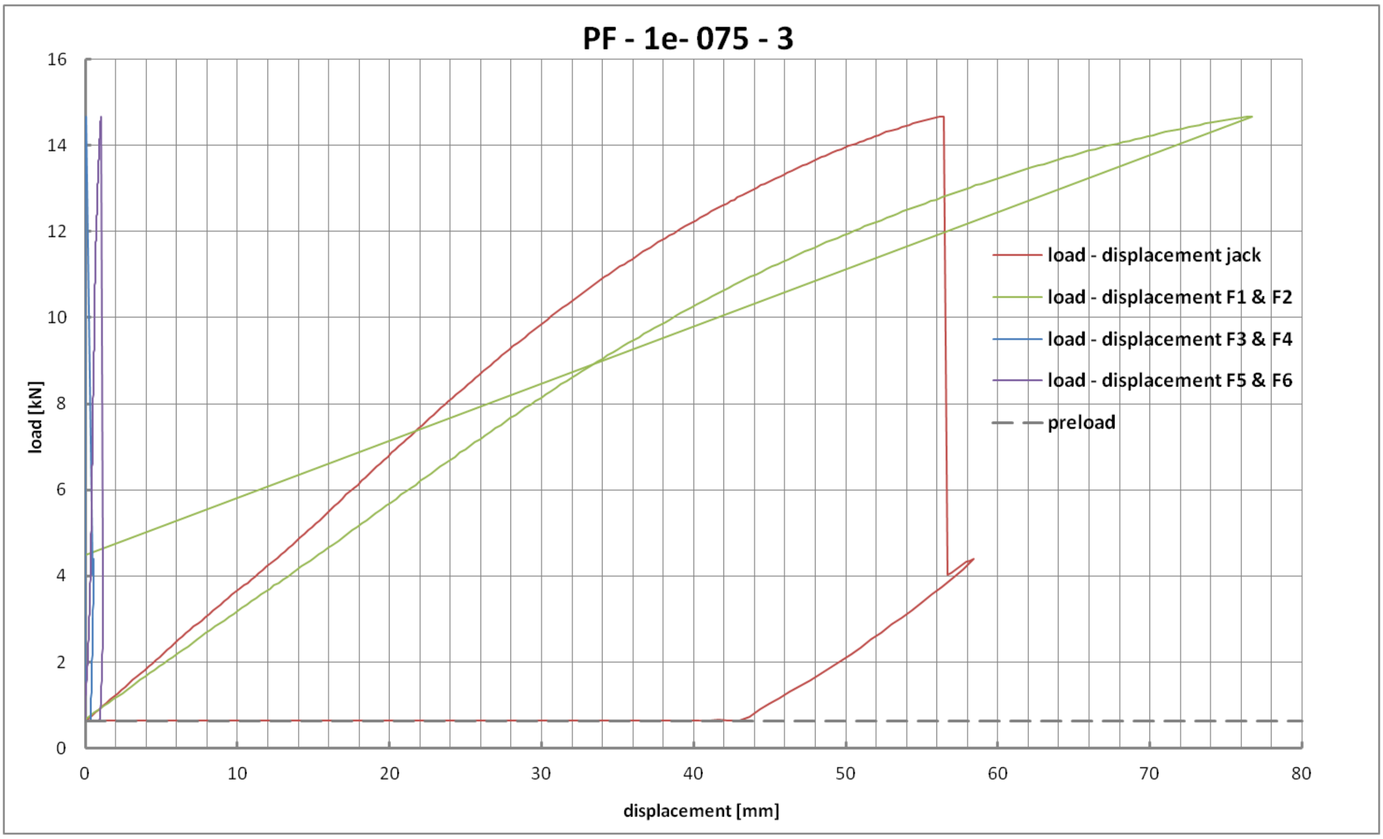
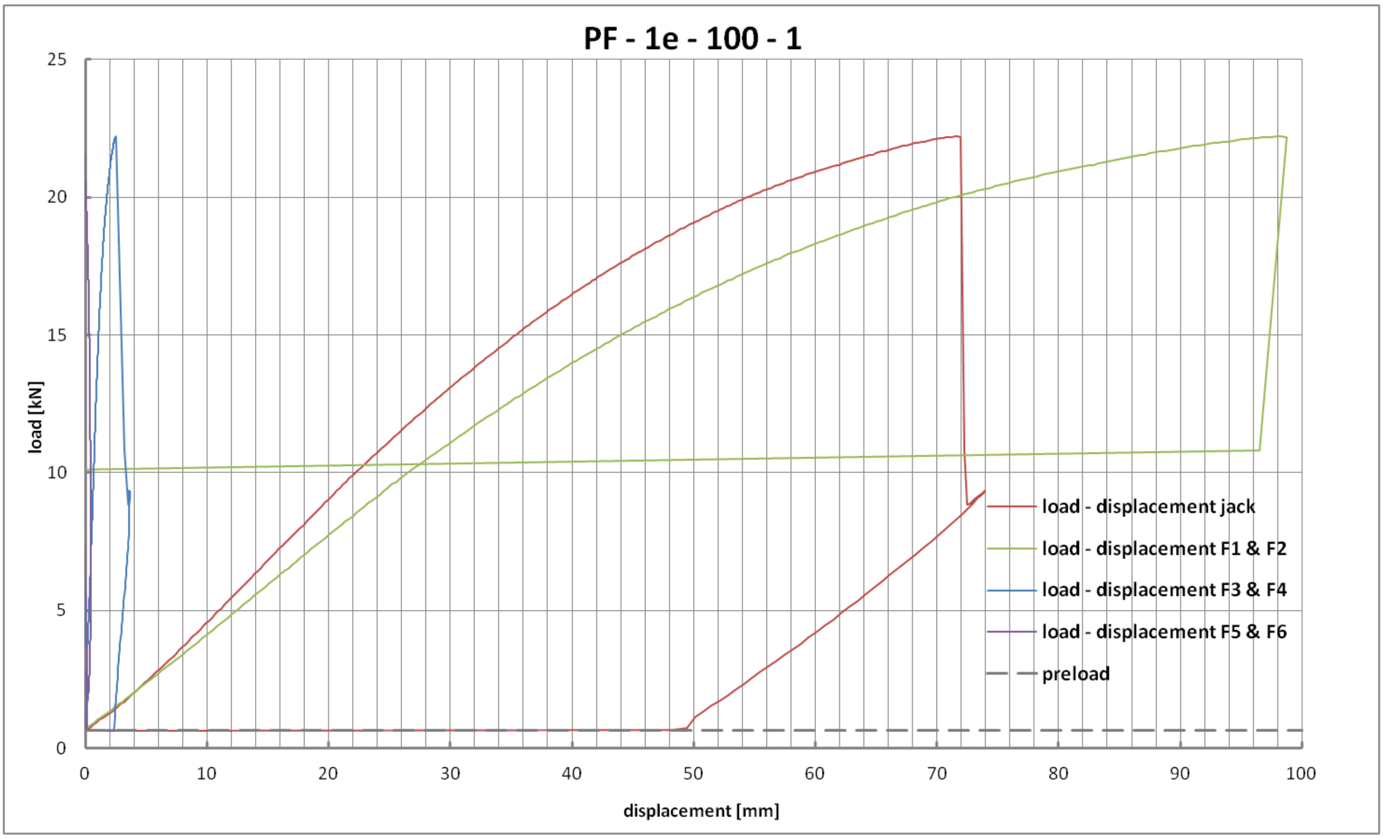
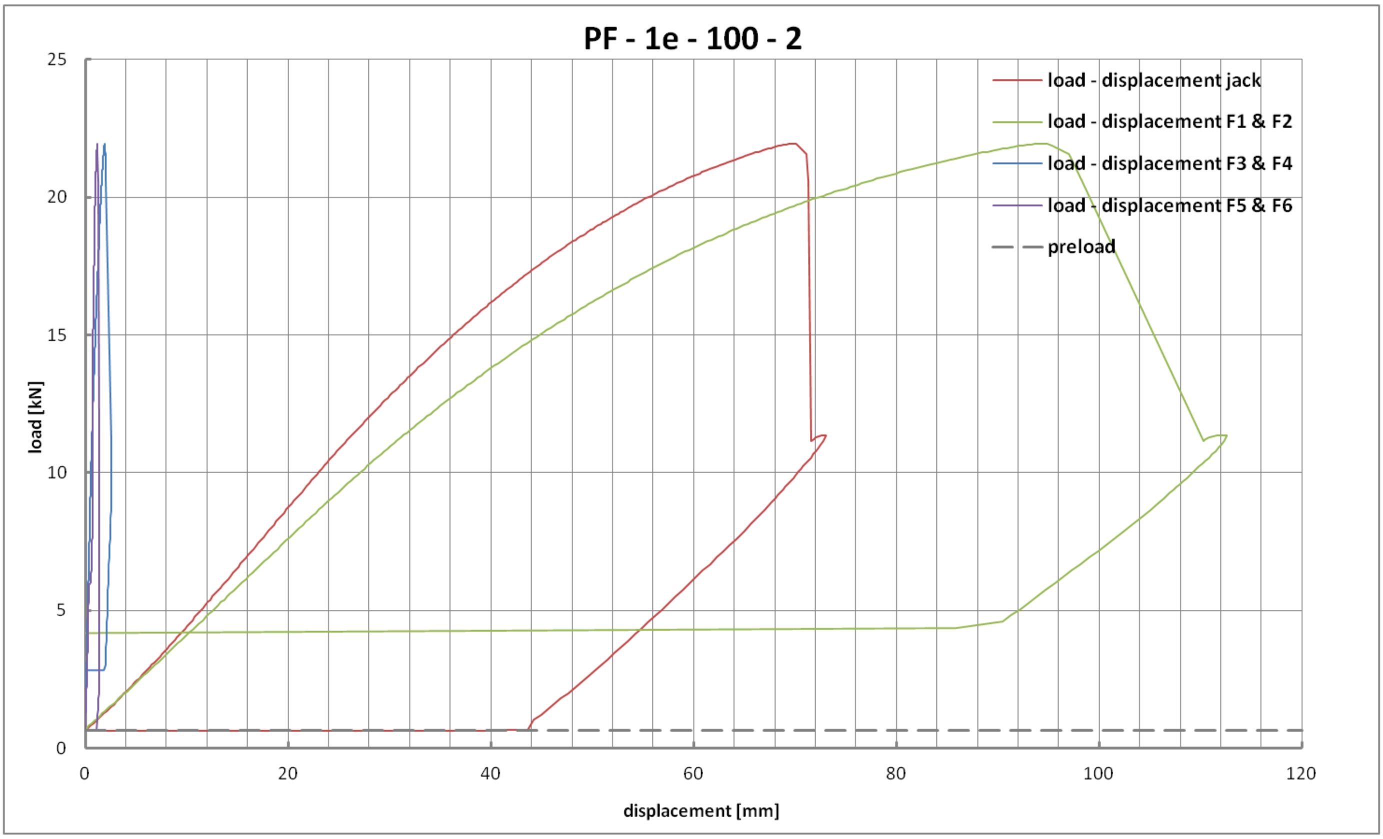
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
100

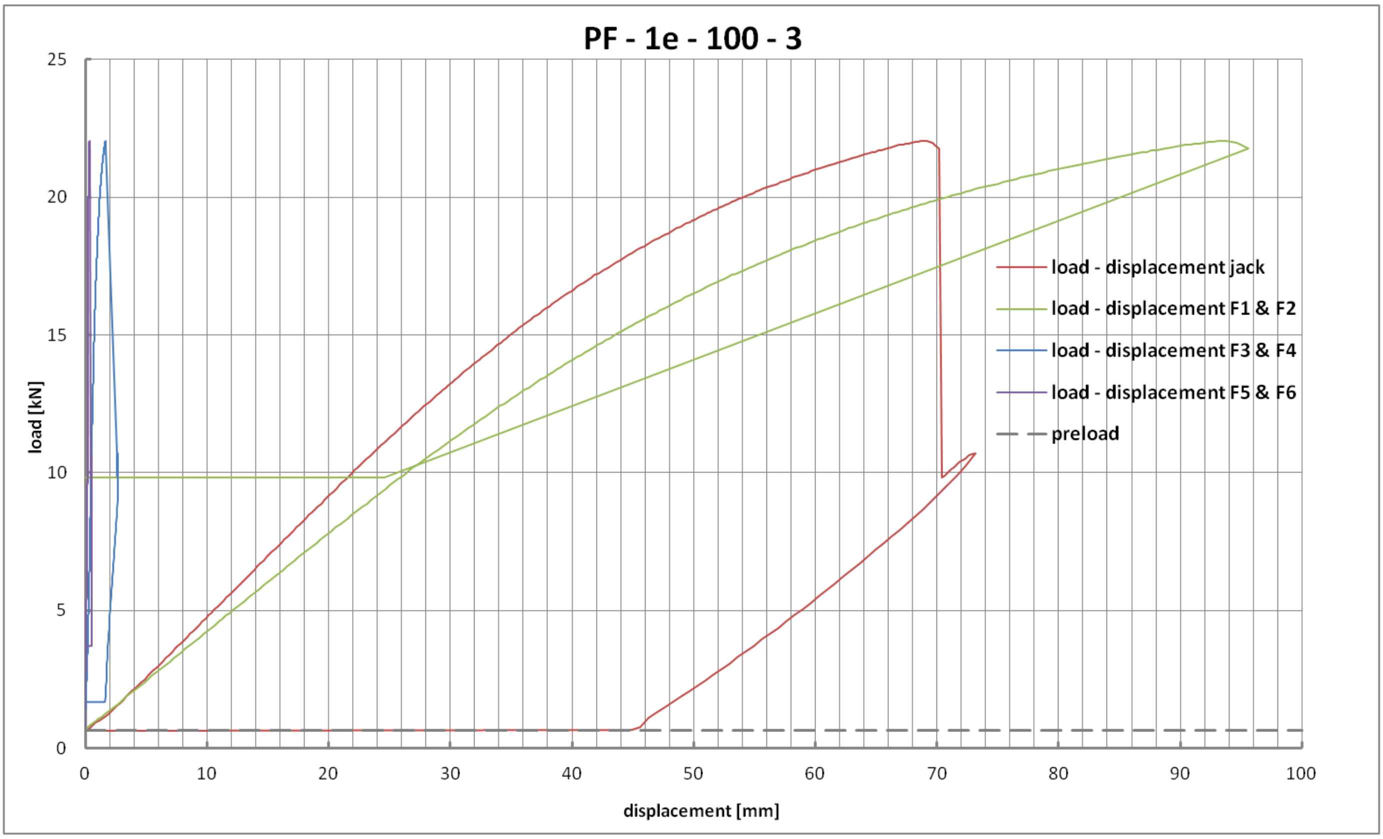

PF - 1e - 075 - 1
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
70
80
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload

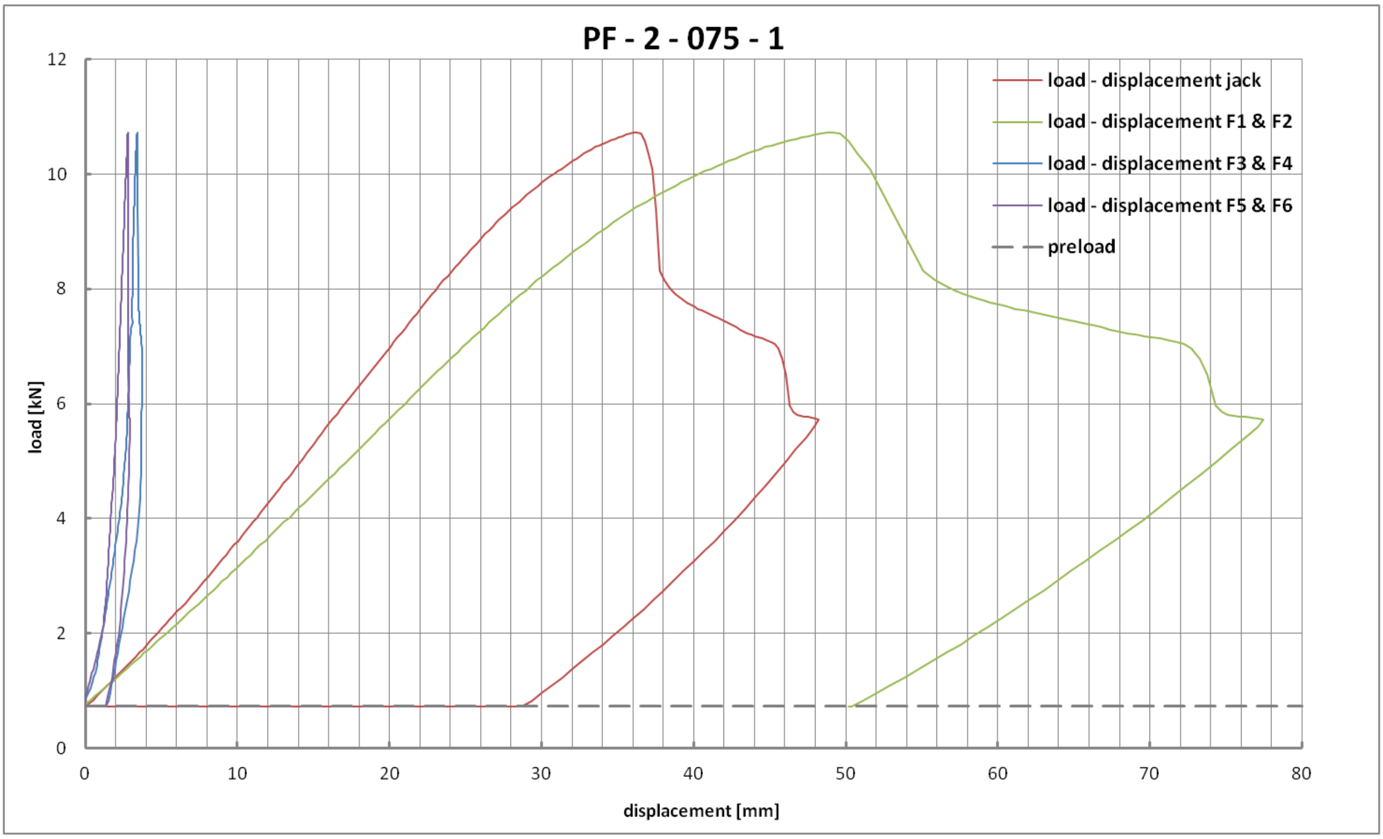

PF - 1e - 075 - 2
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
70
80
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload


PF - 1e- 075 - 3
load [kN]
16
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload


PF - 1e - 100 - 1
load [kN]
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload


PF - 1e - 100 - 2
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
20
40
60
80
100
120


PF - 1e - 100 - 3
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
100


PF - 2 - 075 - 1
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
0
10
20
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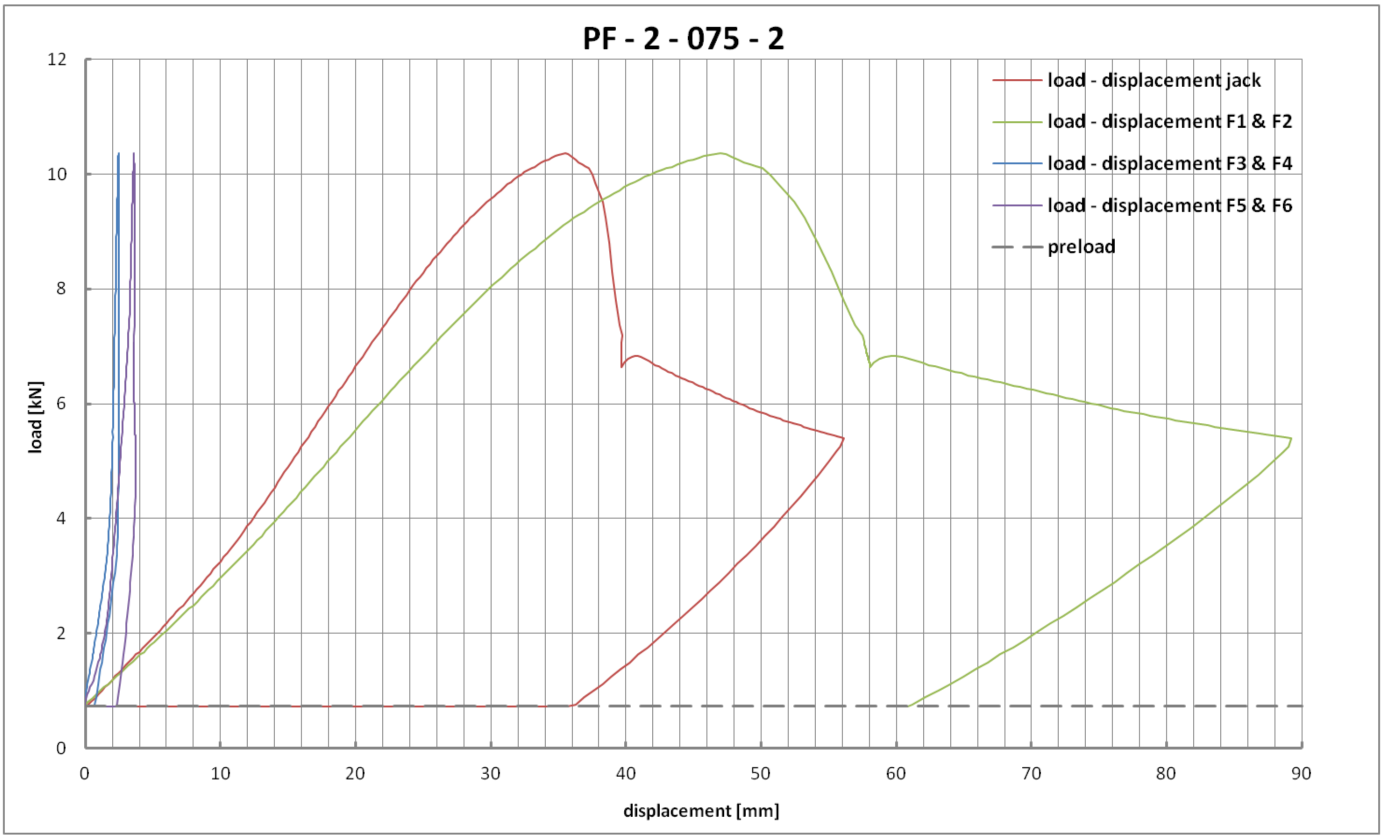
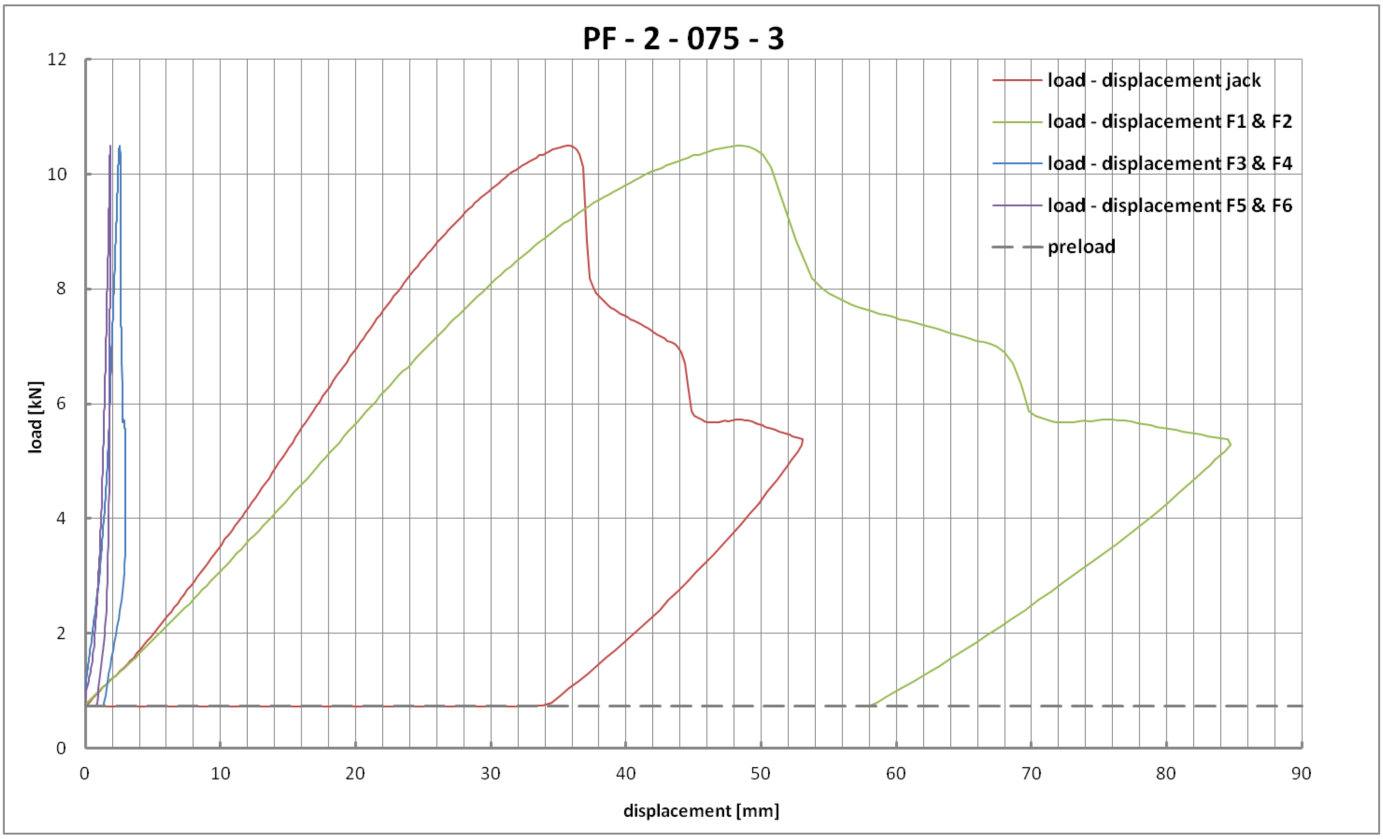
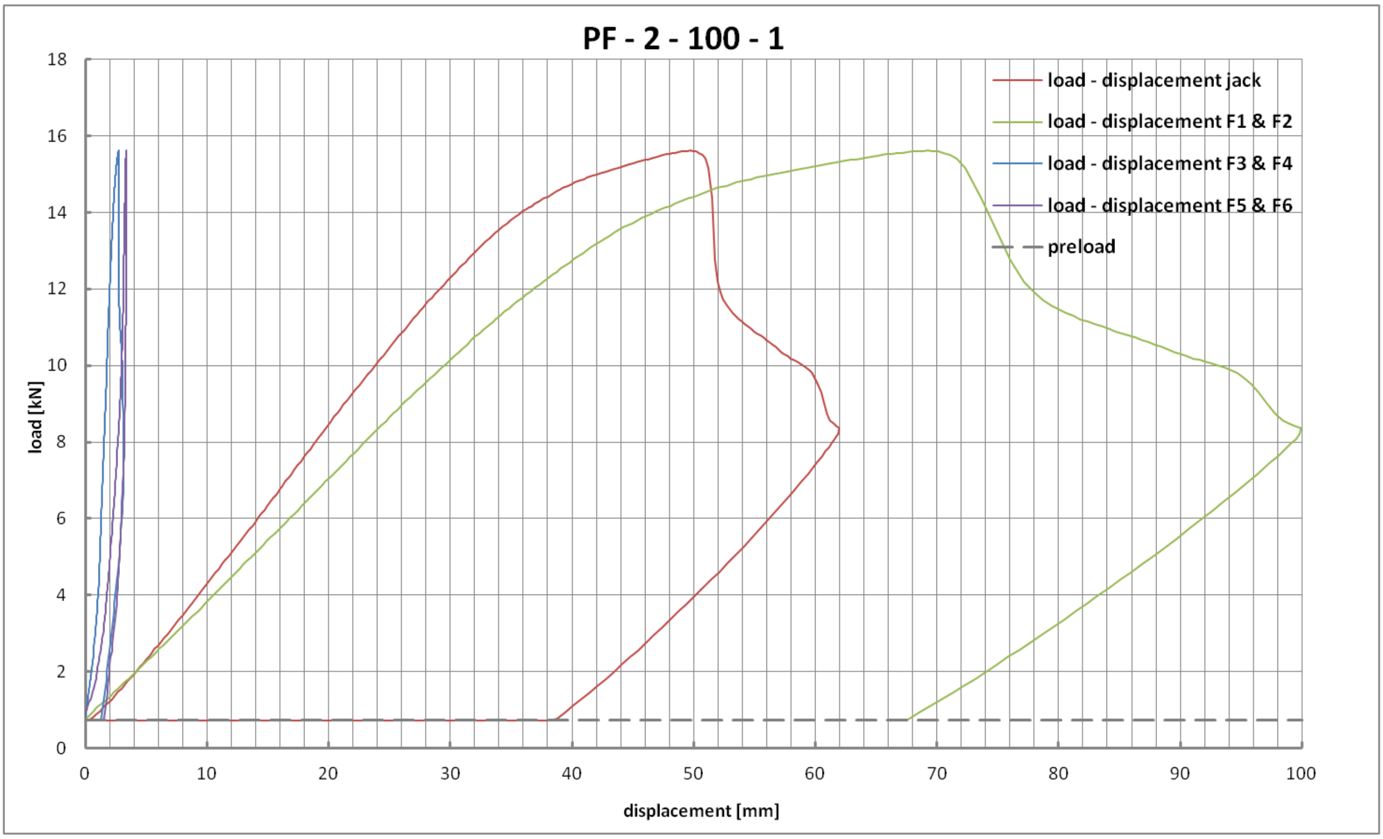
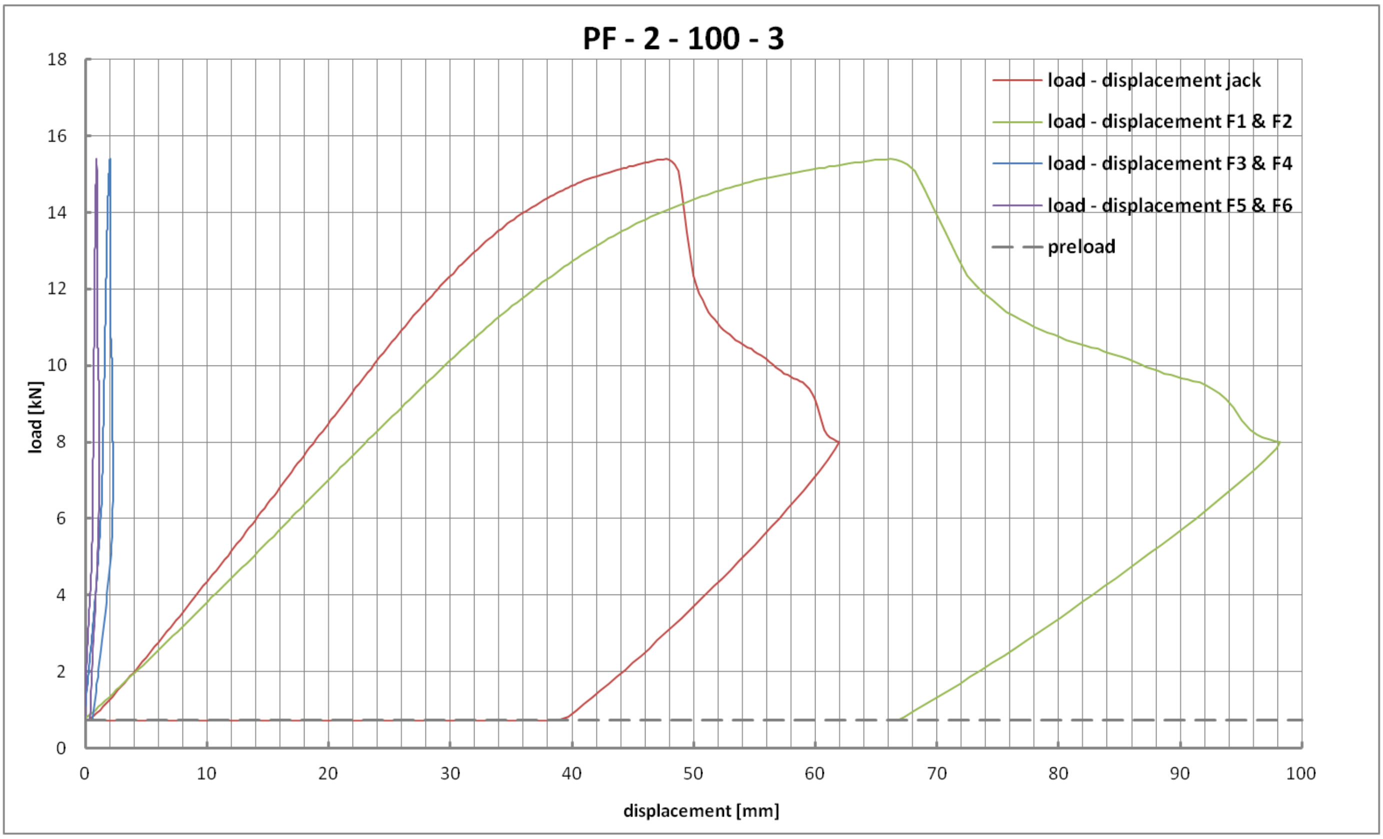
40
50
60
70
80

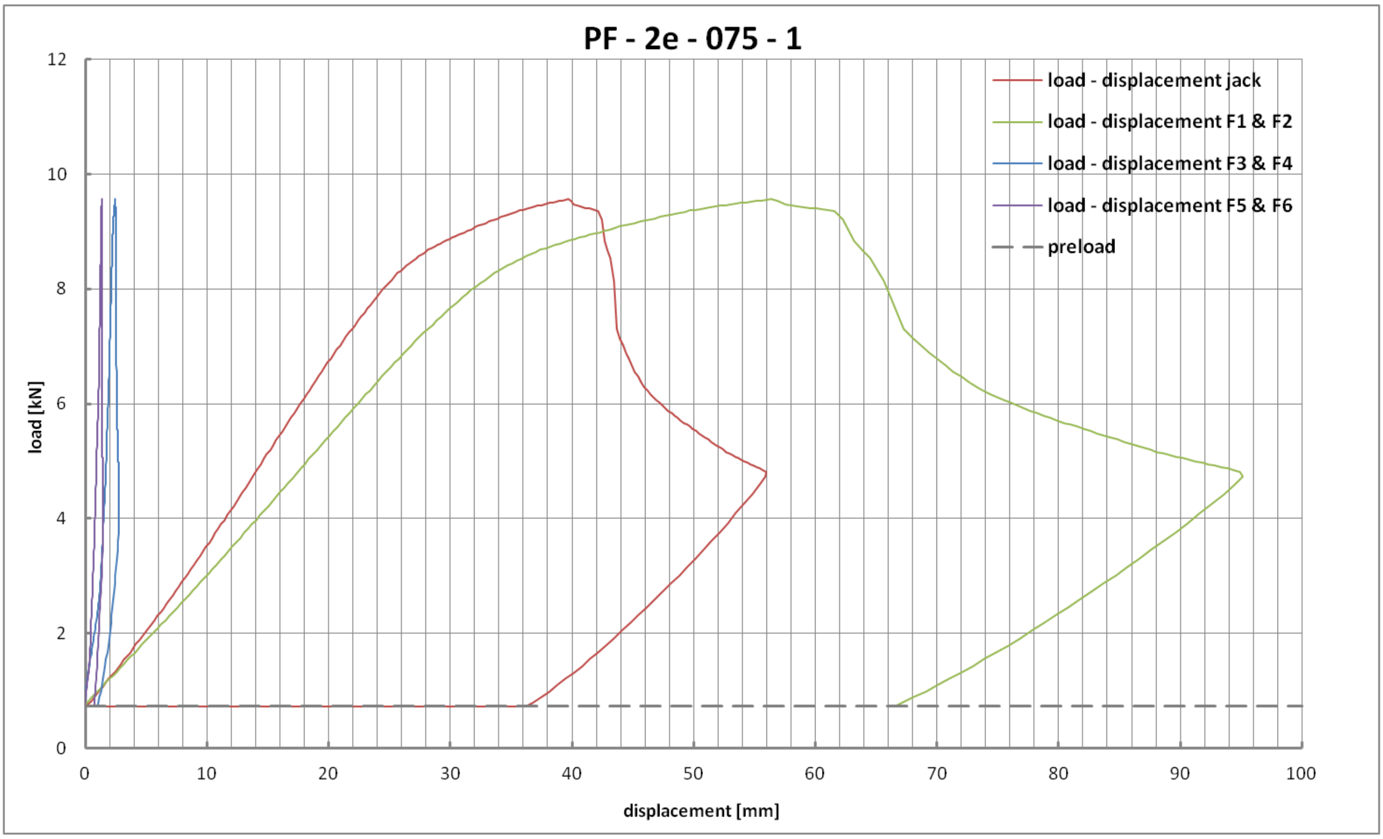

PF - 2 - 075 - 2
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
0
10
20
30
40
50
60
70
80
90





PF-2-100-2: error in data storage (see annex E for a copy of the load-deflection curve)


PF - 2 - 100 - 3
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
60
70
80
90
100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load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
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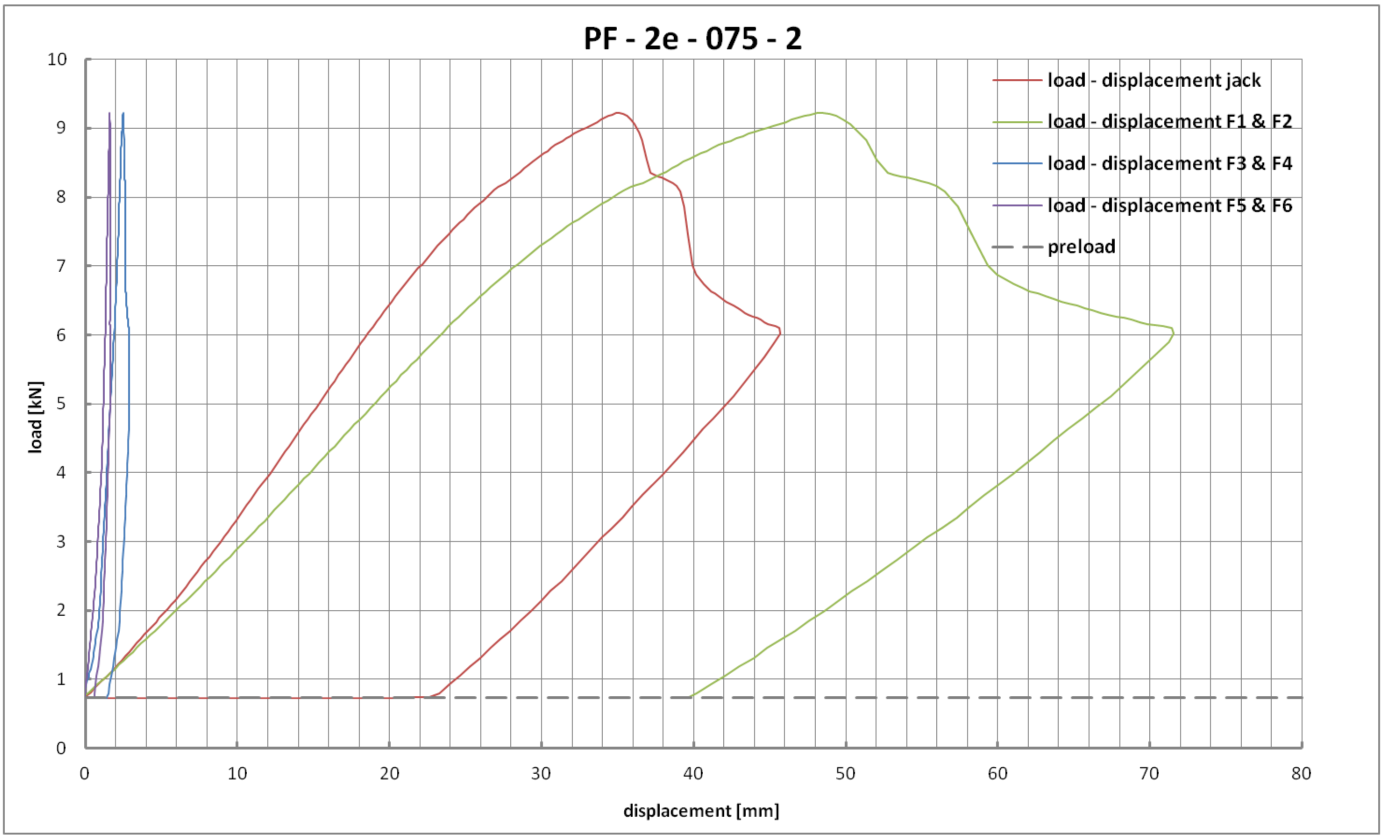
60
70
80
90
100


PF - 2e - 075 - 2
load [kN]
displacement [mm]
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load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
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70
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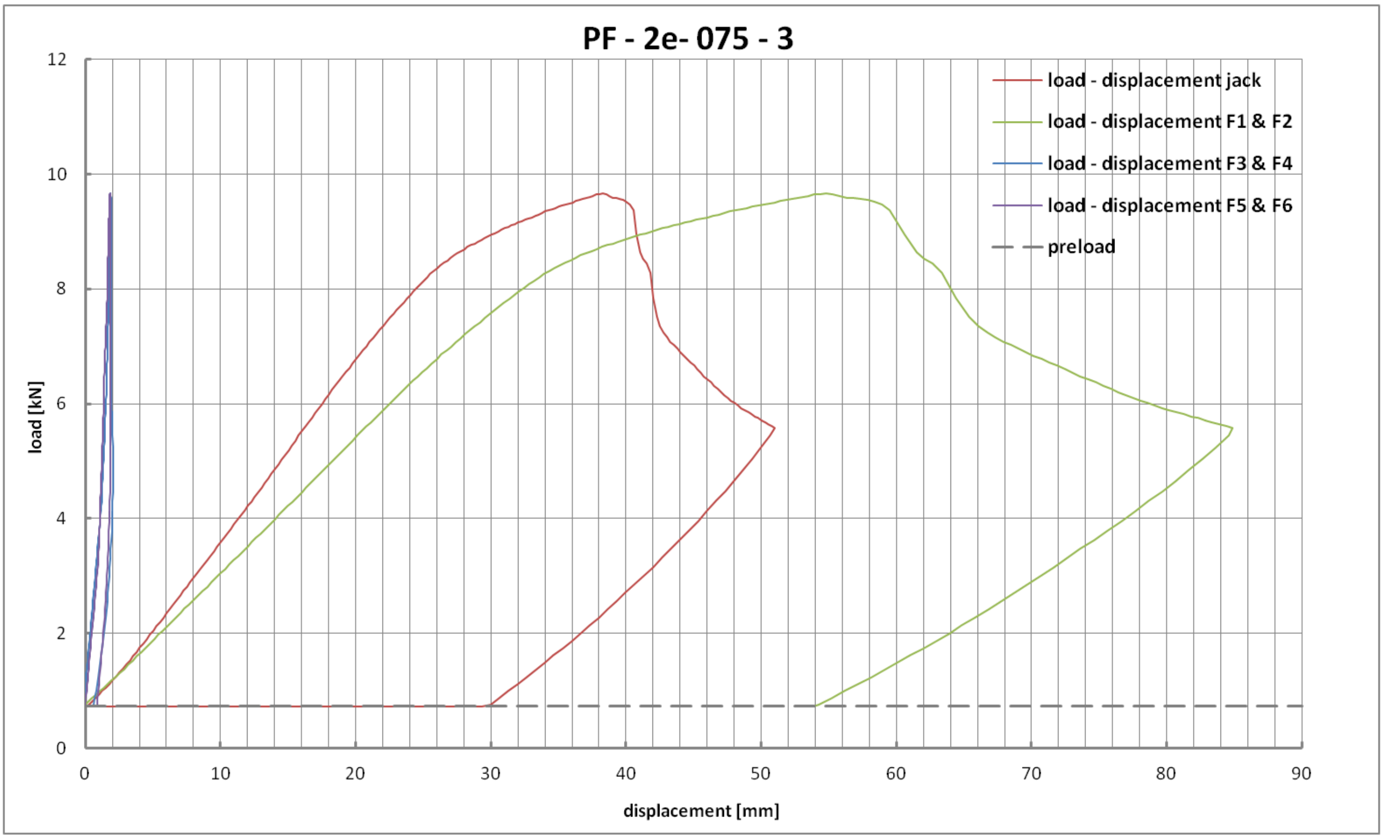
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displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
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2
4
6
8
10
12
0
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20
30
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60
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80
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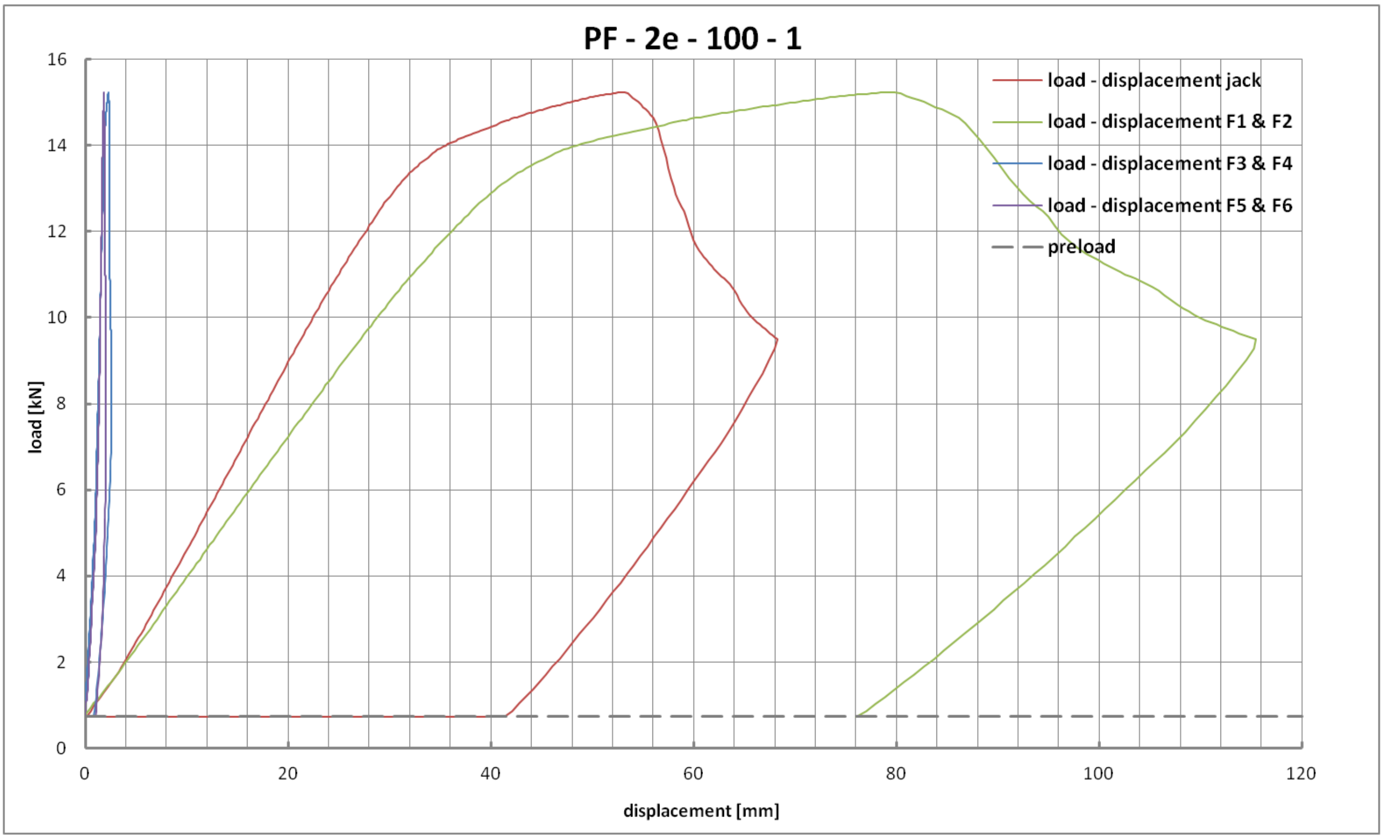
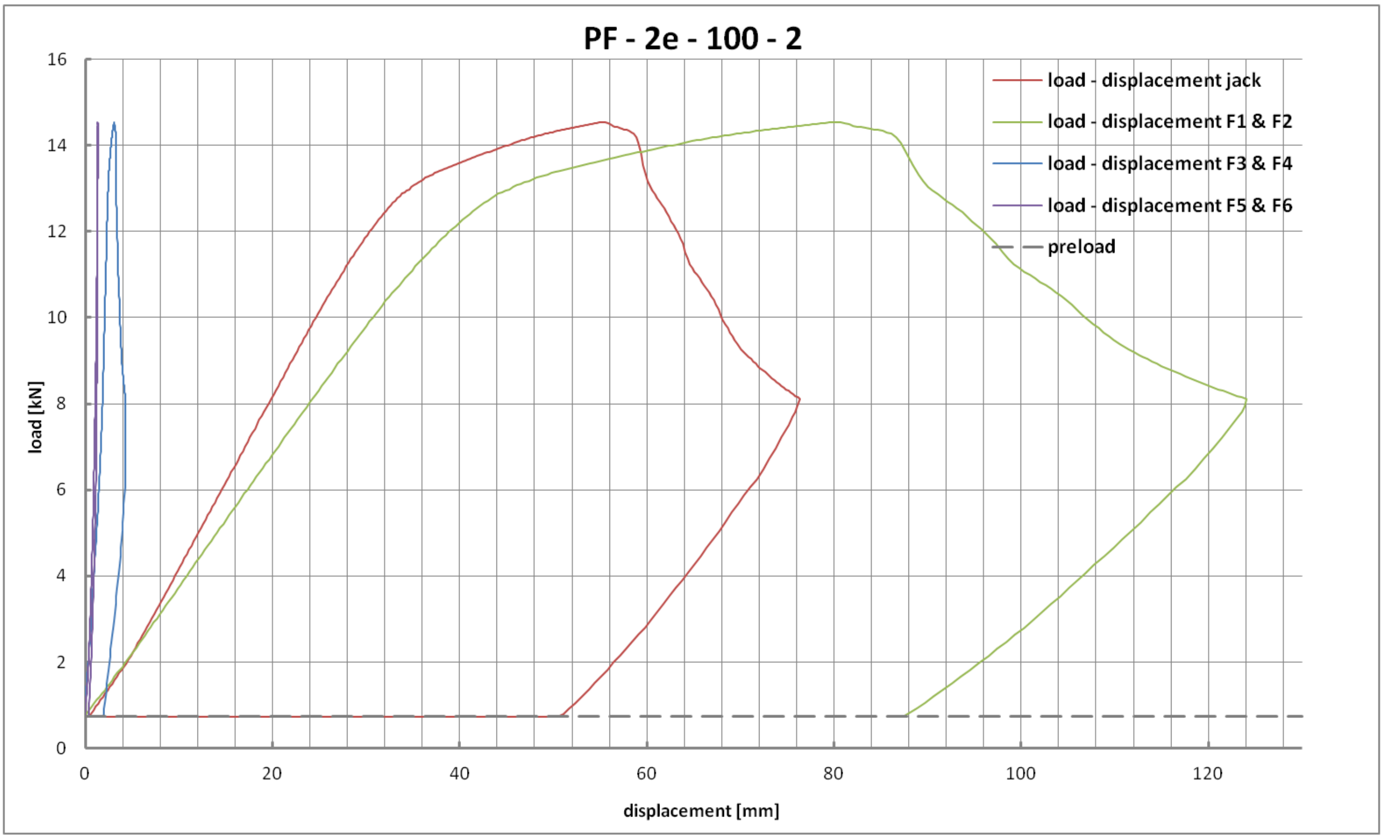

PF - 2e - 100 - 1
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
120


PF - 2e - 100 - 2
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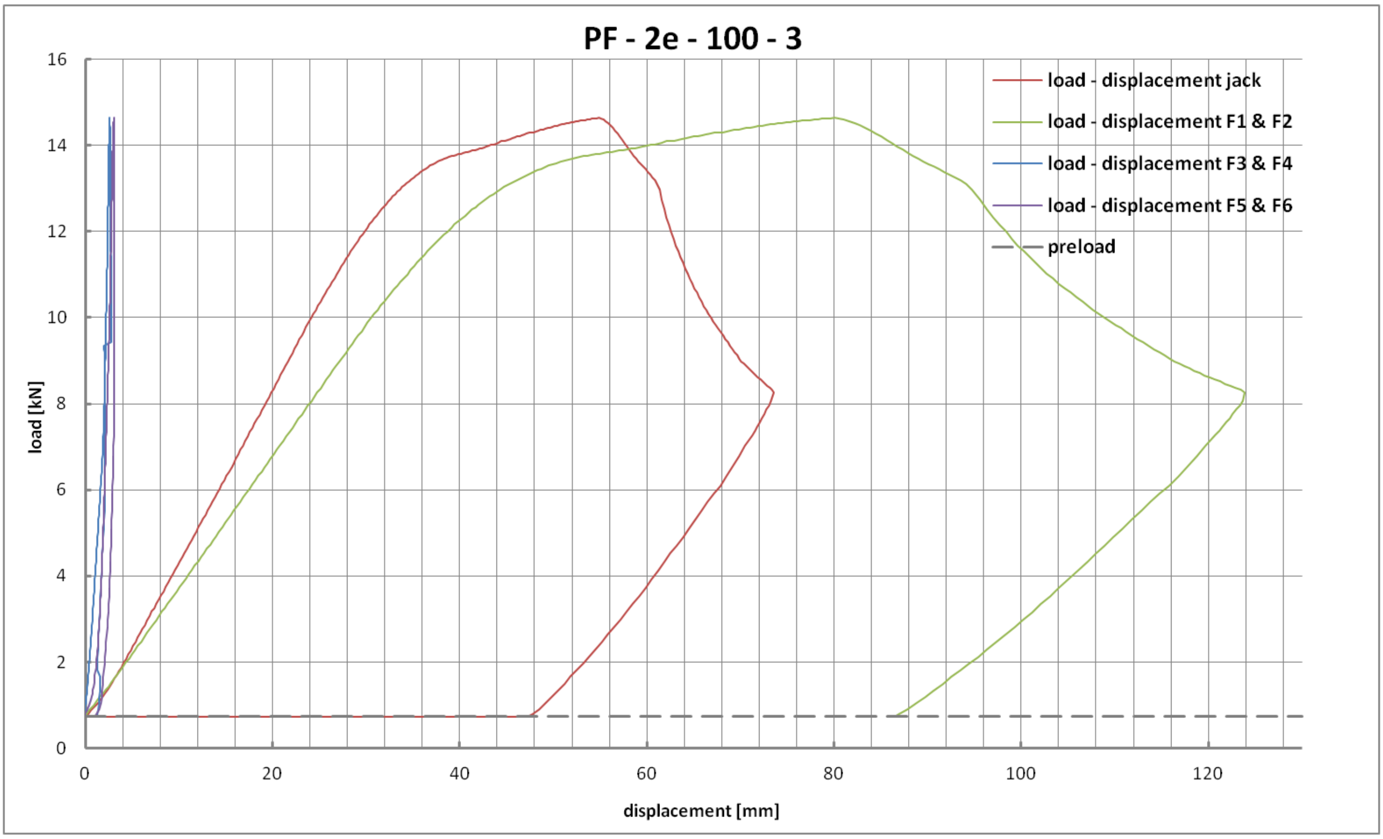
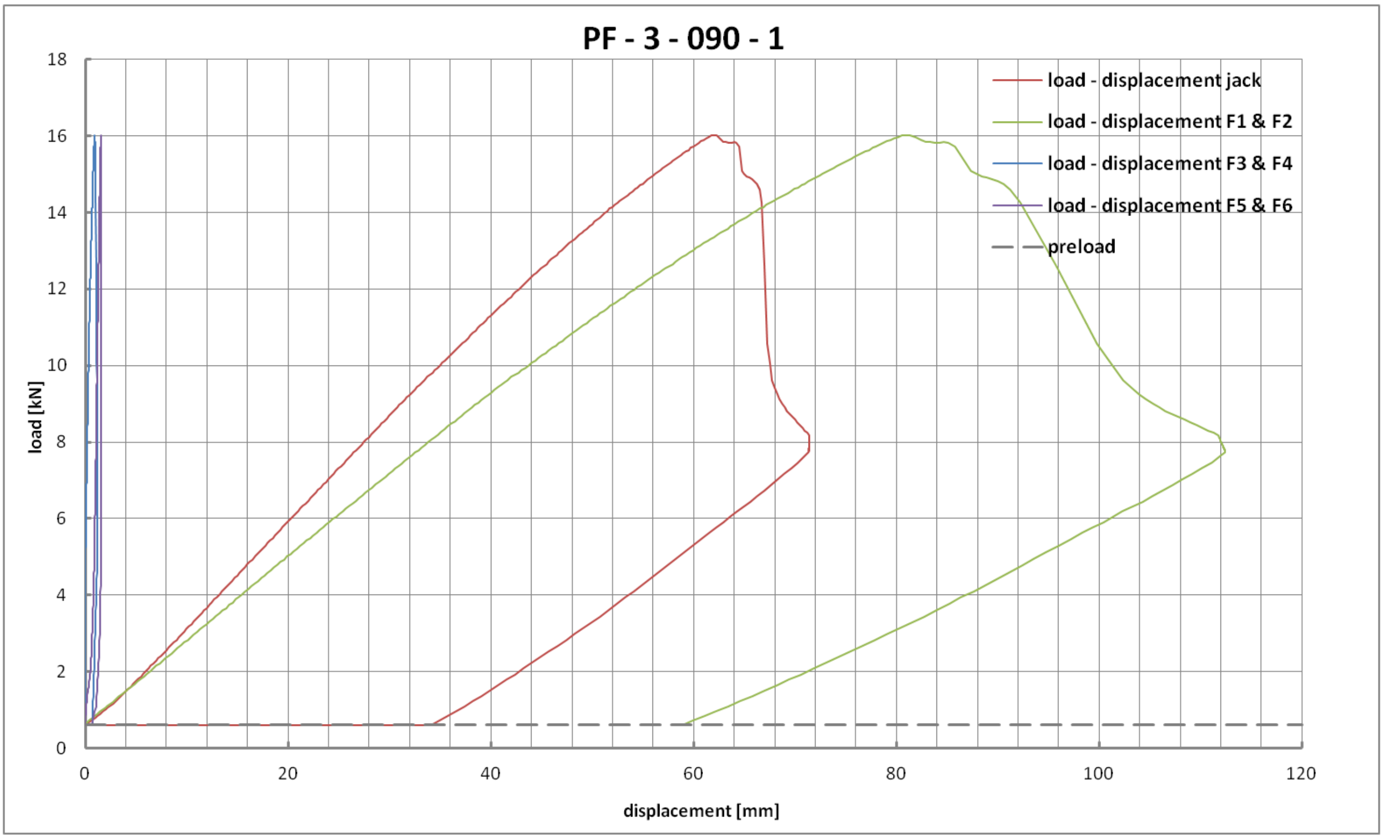
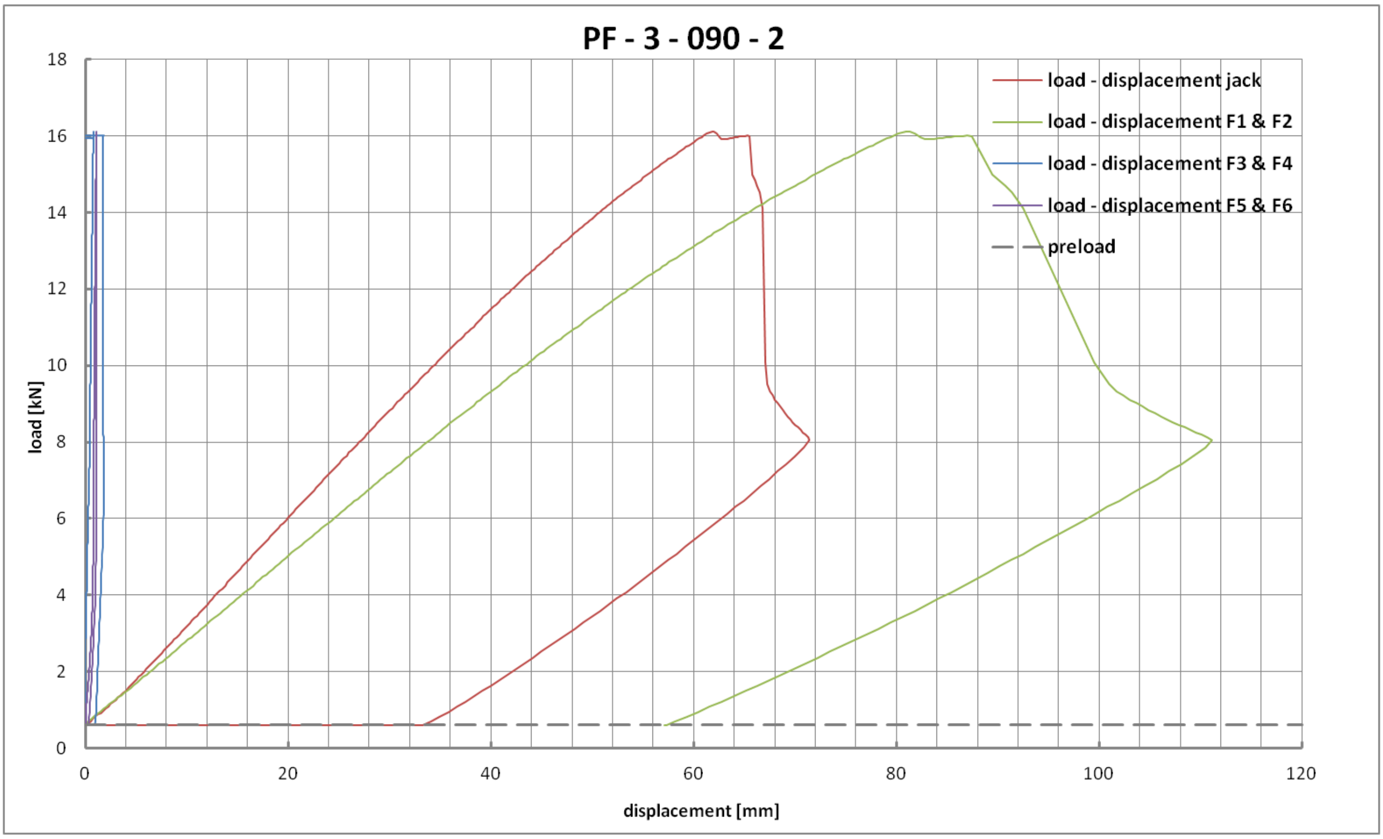
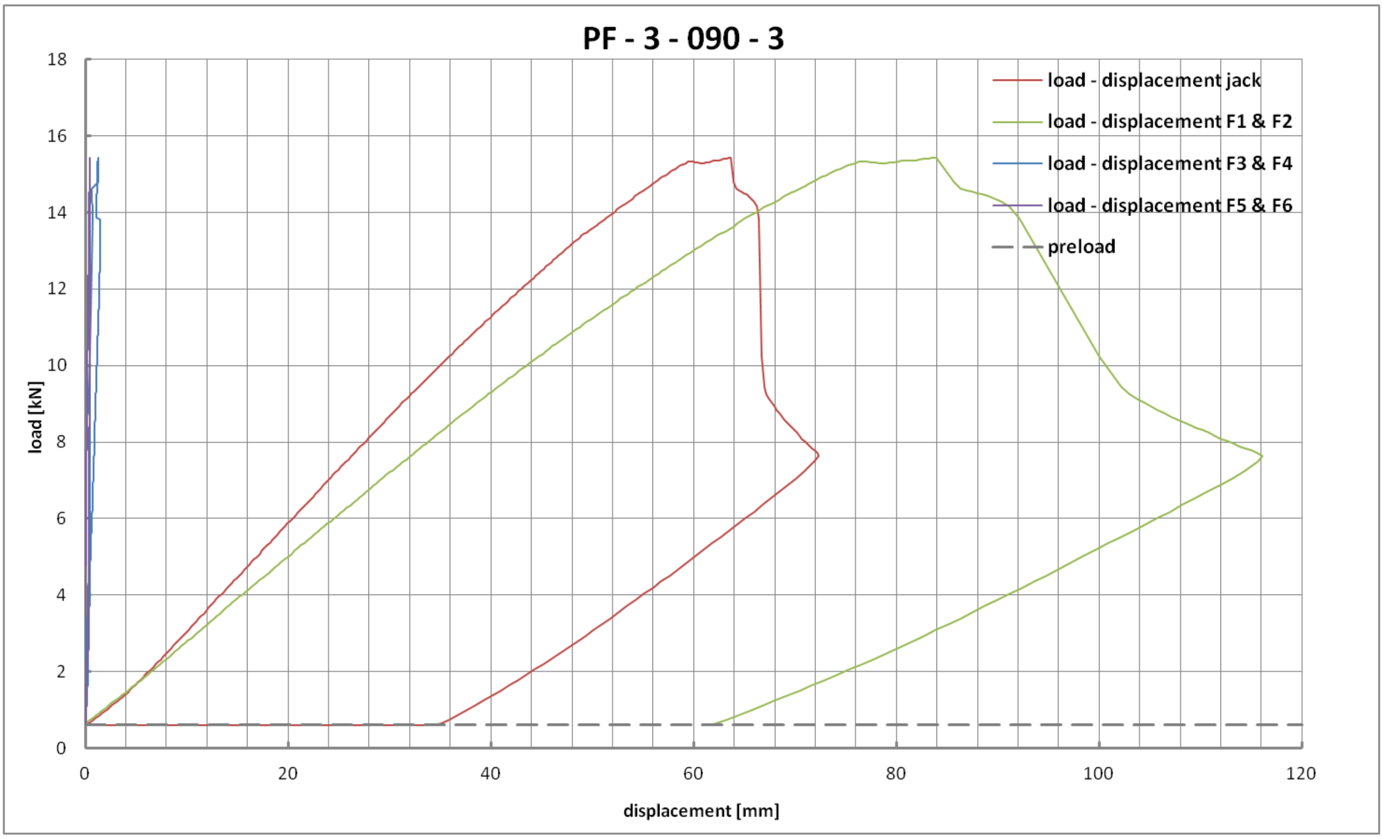
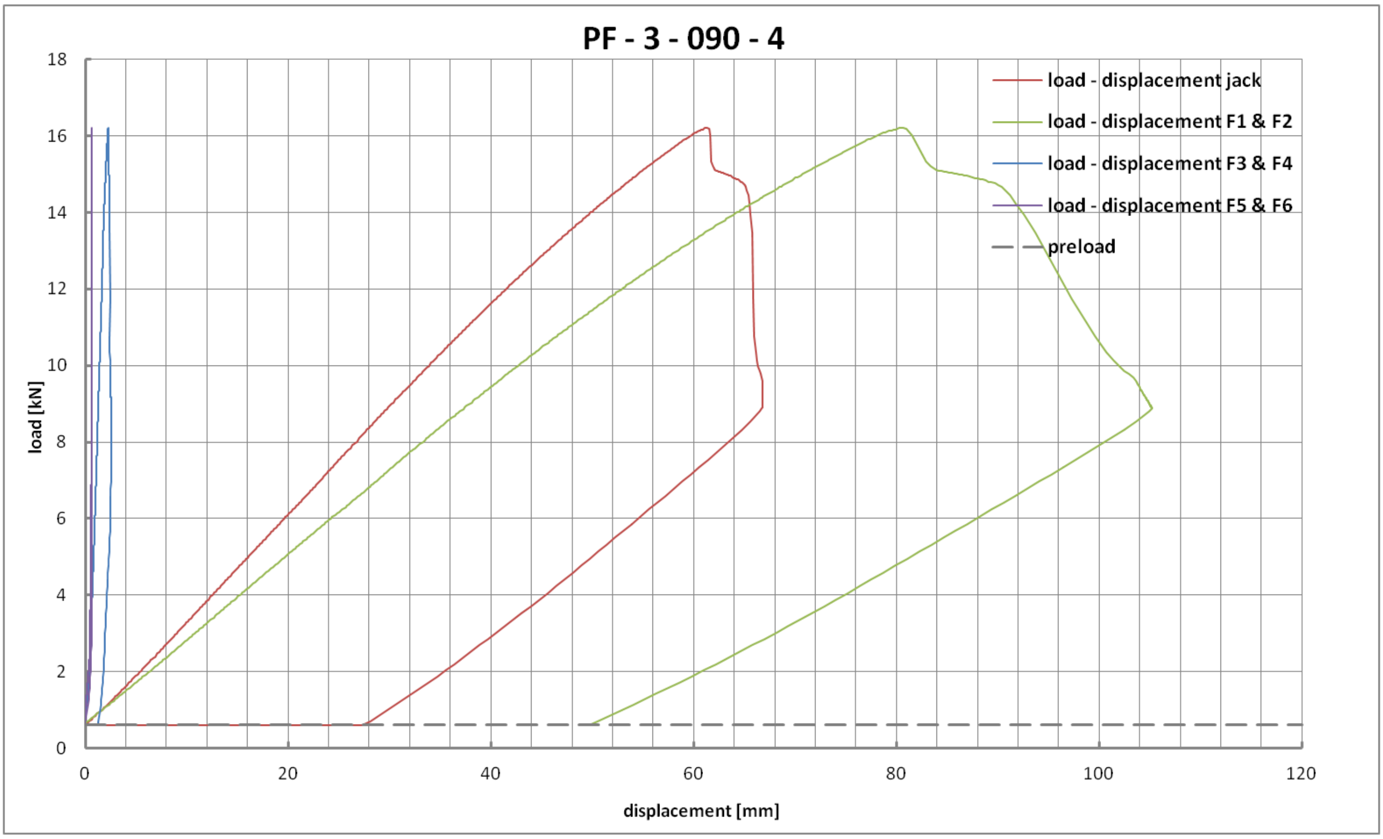
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
120


PF - 2e - 100 - 3
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
120

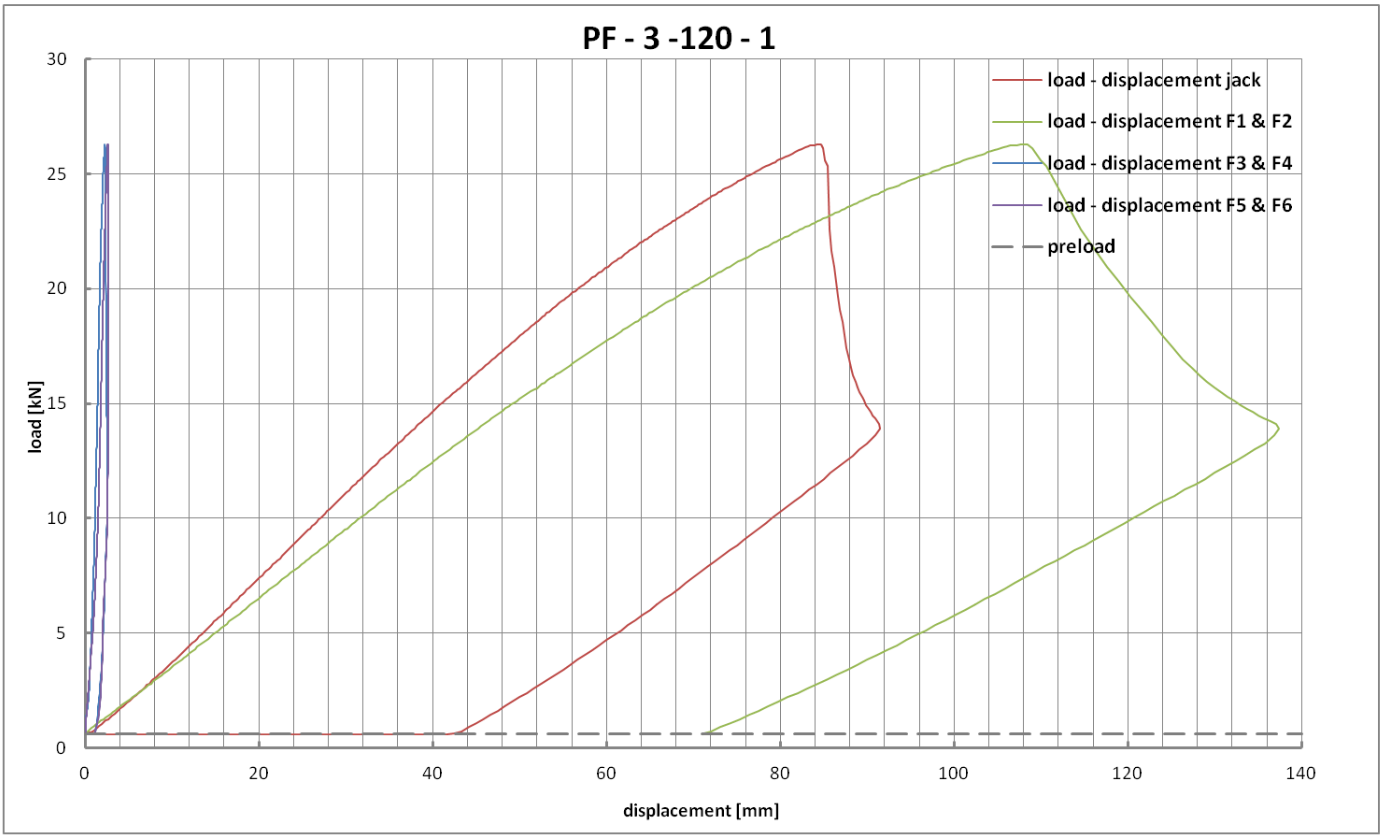

PF - 3 - 090 - 1
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
18
0
20
40
60
80
100
120


PF - 3 - 090 - 2
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
18
0
20
40
60
80
100
120

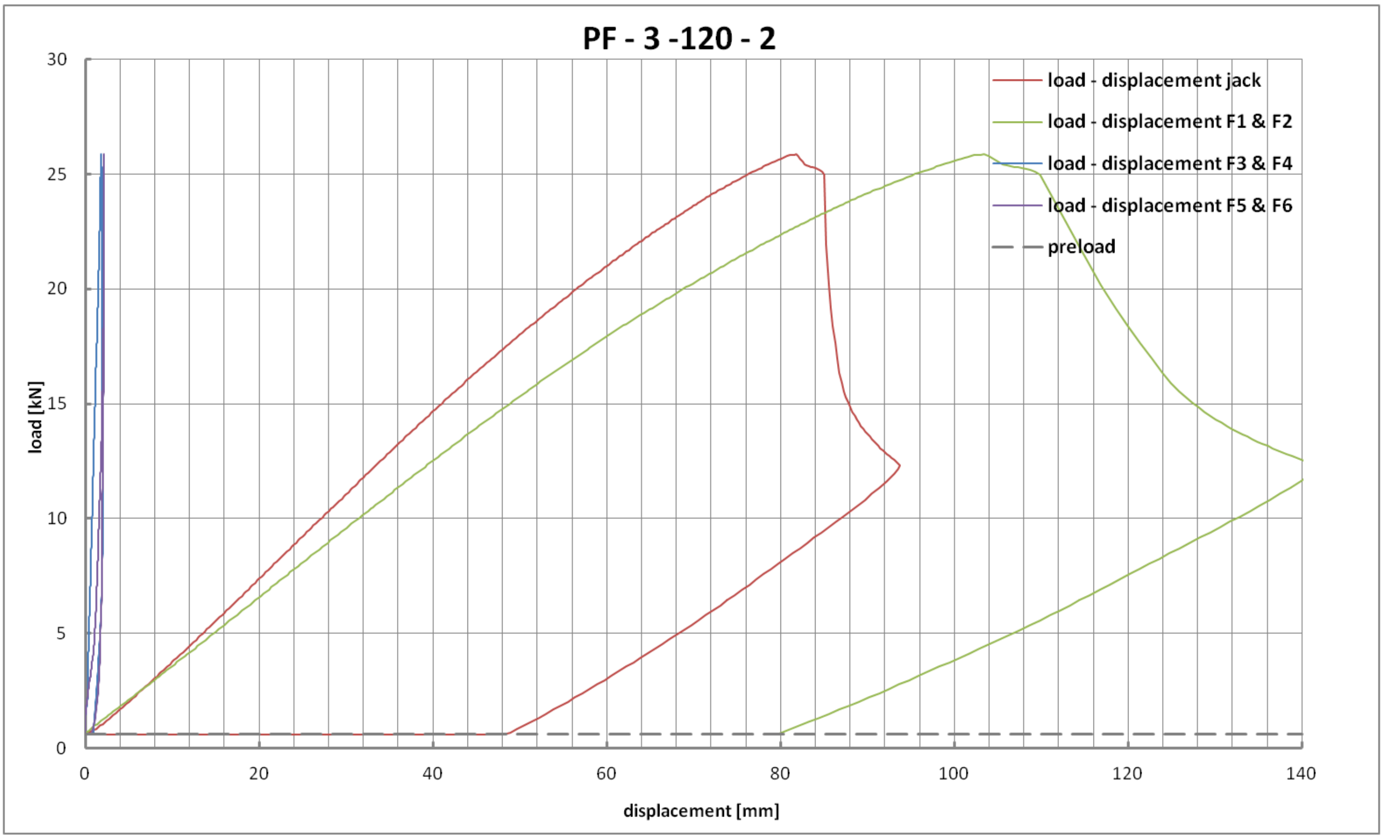

PF - 3 - 090 - 3
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
18
0
20
40
60
80
100
120

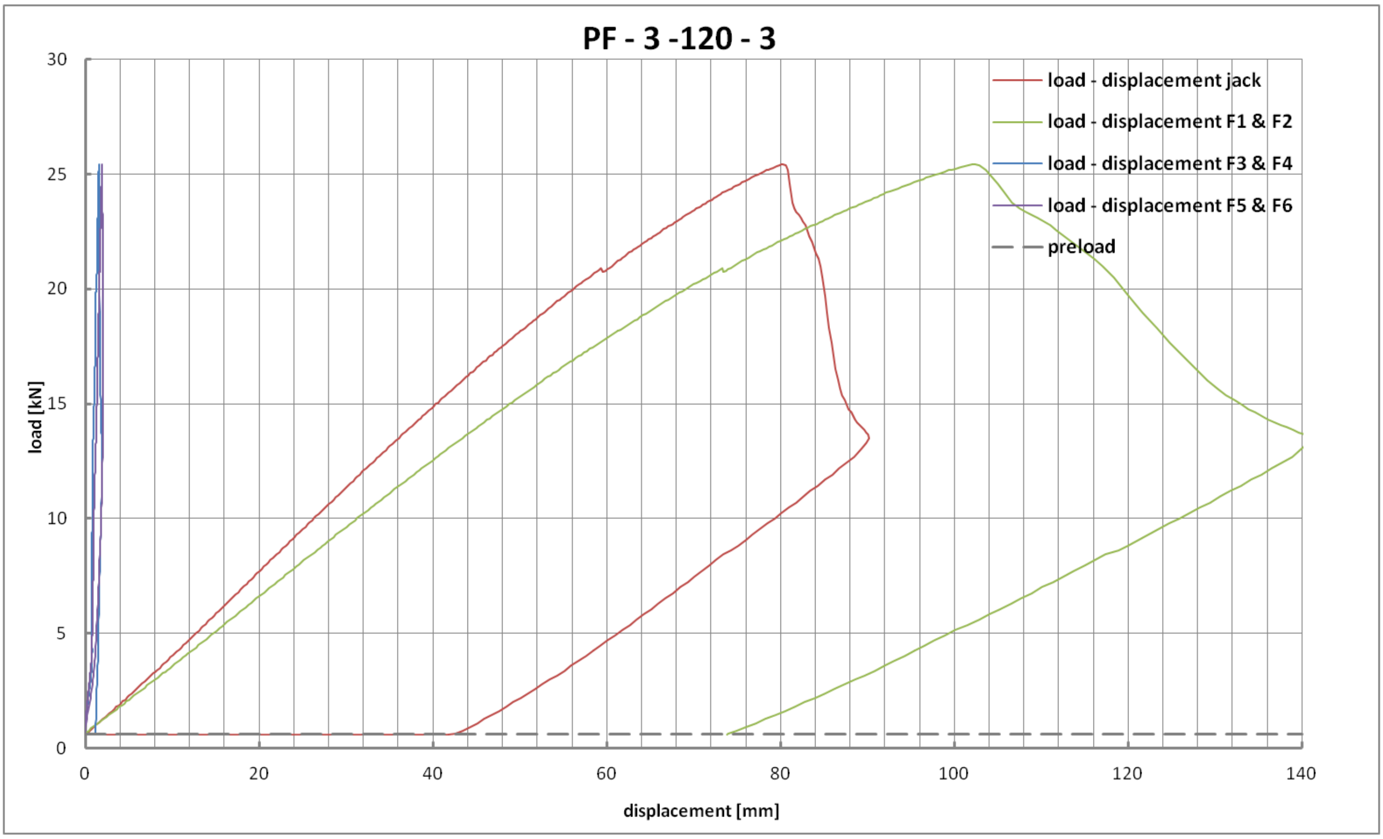


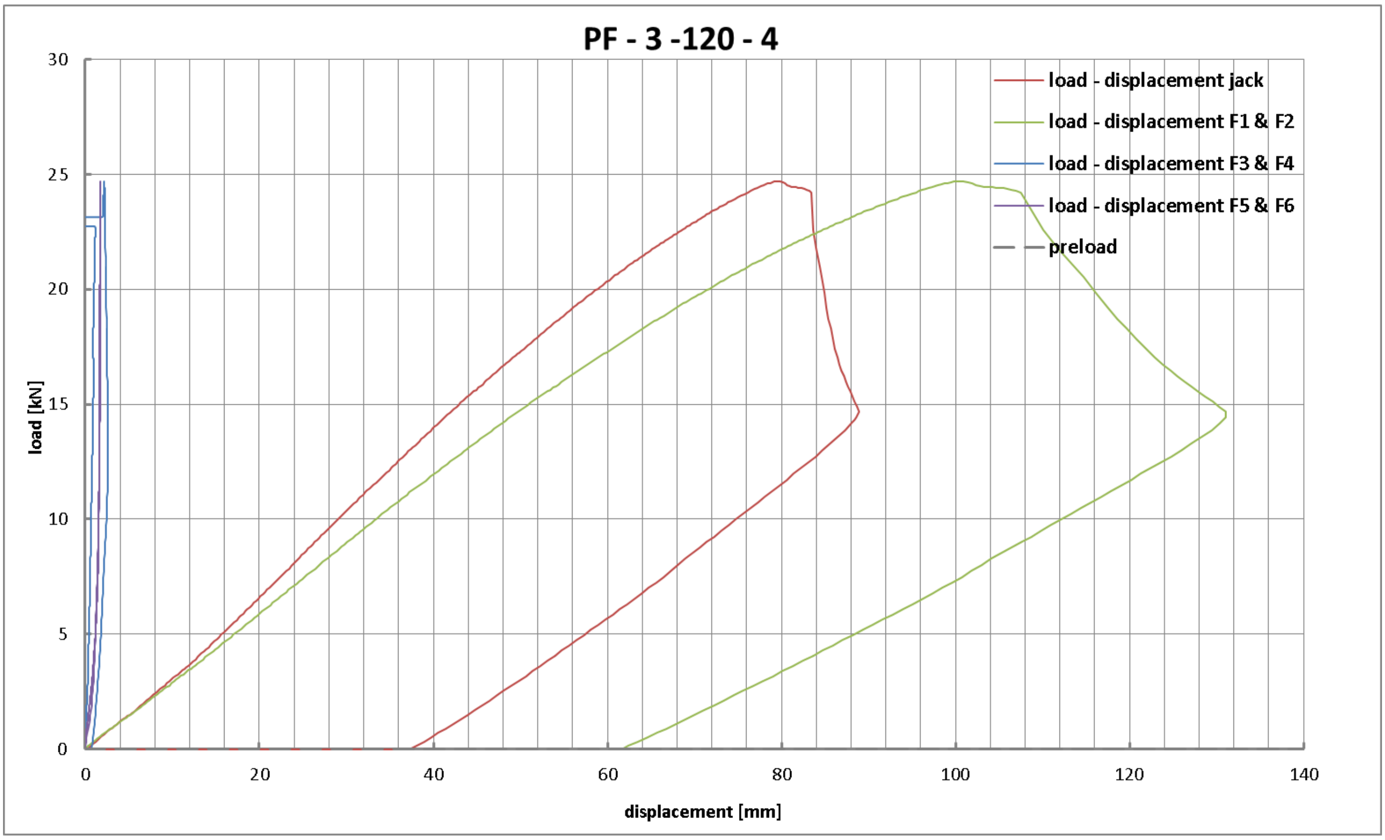
PF - 3 - 090 - 4
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
18
0
20
40
60
80
100
120



PF - 3 -120 - 1
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
0
20
40
60
80
100
120
140

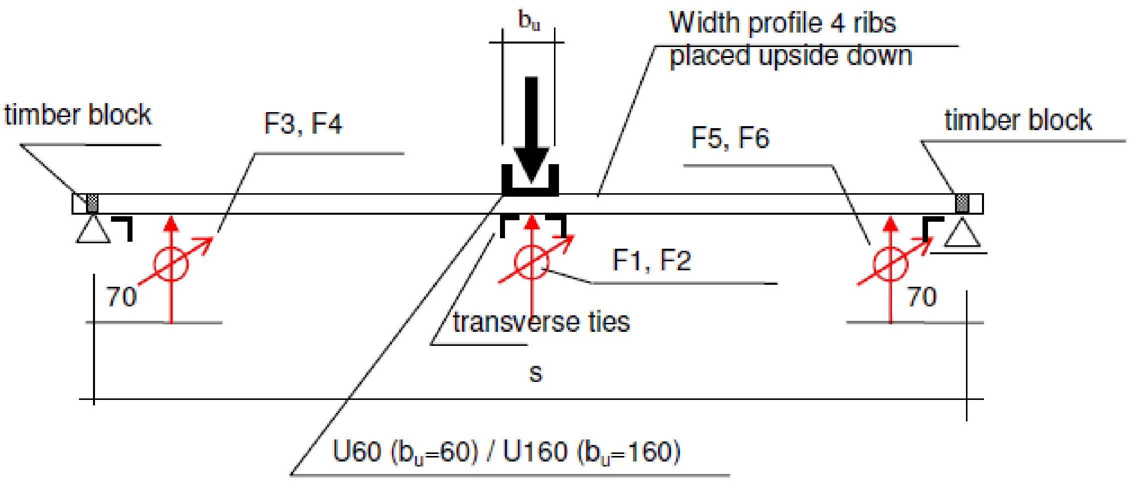

PF - 3 -120 - 2
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload


PF - 3 -120 - 3
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload



PF - 3 -120 - 4
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
0
20
40
60
80
100
120
140

Annex C: Intermediate support test with downward load



Cross section in the middle of the span
and near the end support

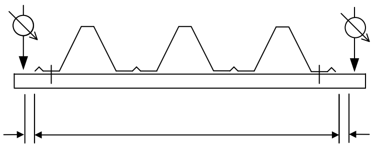


Figure C.1: Schematic test setup

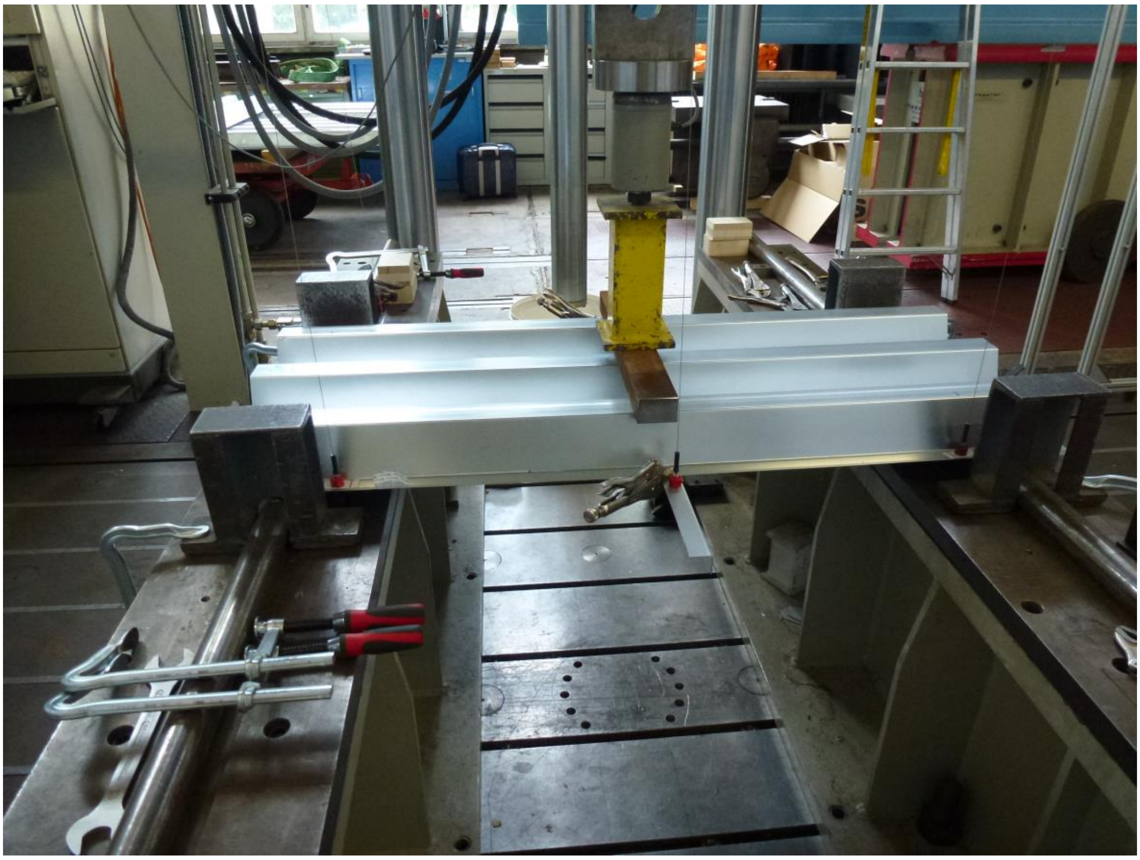


Figure C.2: Test setup (exemplary for PCB 80, b_u = 60 mm, t_N = 0.75 mm without embossments)

Figure C.3: Test setup (exemplary for PCB 60, b_u = 60 mm, t_N = 0.75 mm without emboss-ments)

Figure C.4: Failure mode (exemplary for PCB 80, b_u = 60 mm, t_N = 0.75 without emboss-ments)

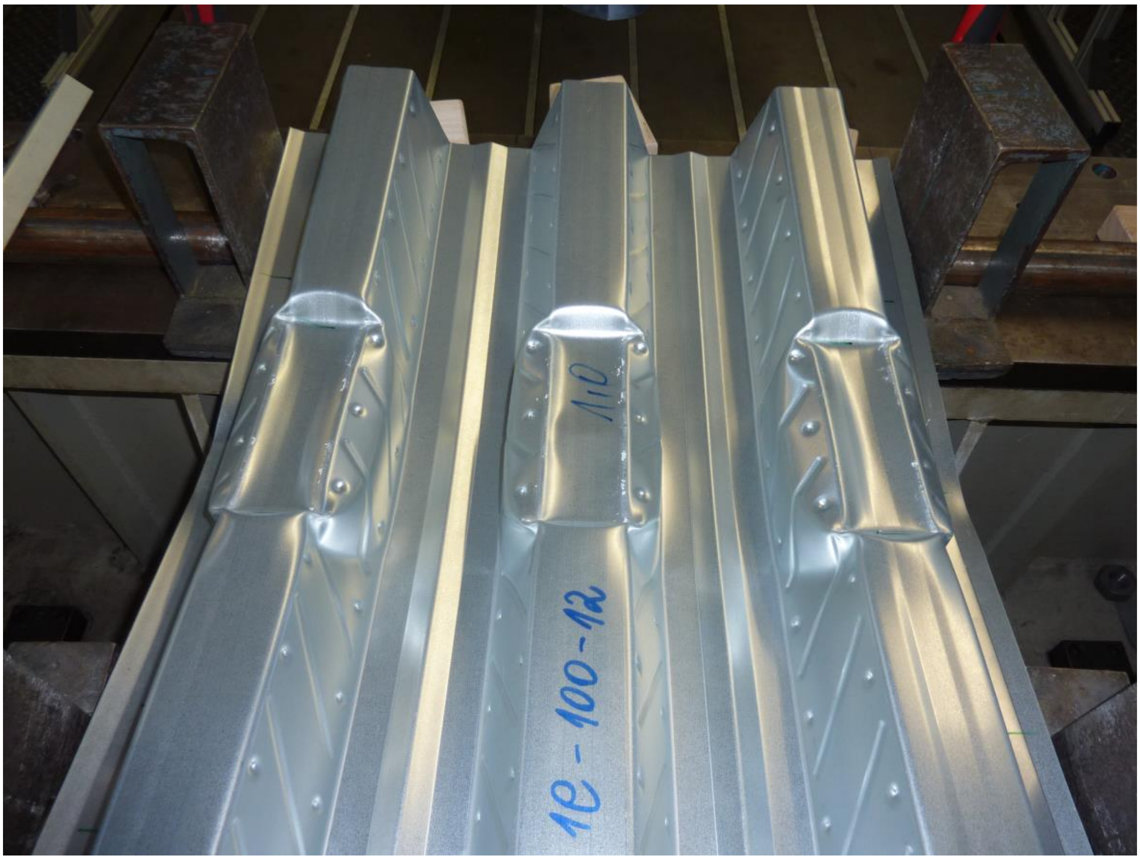


Figure C.5: Failure mode (exemplary for PCB 80, b_u = 160 mm, t_N = 1.00 with embossments)

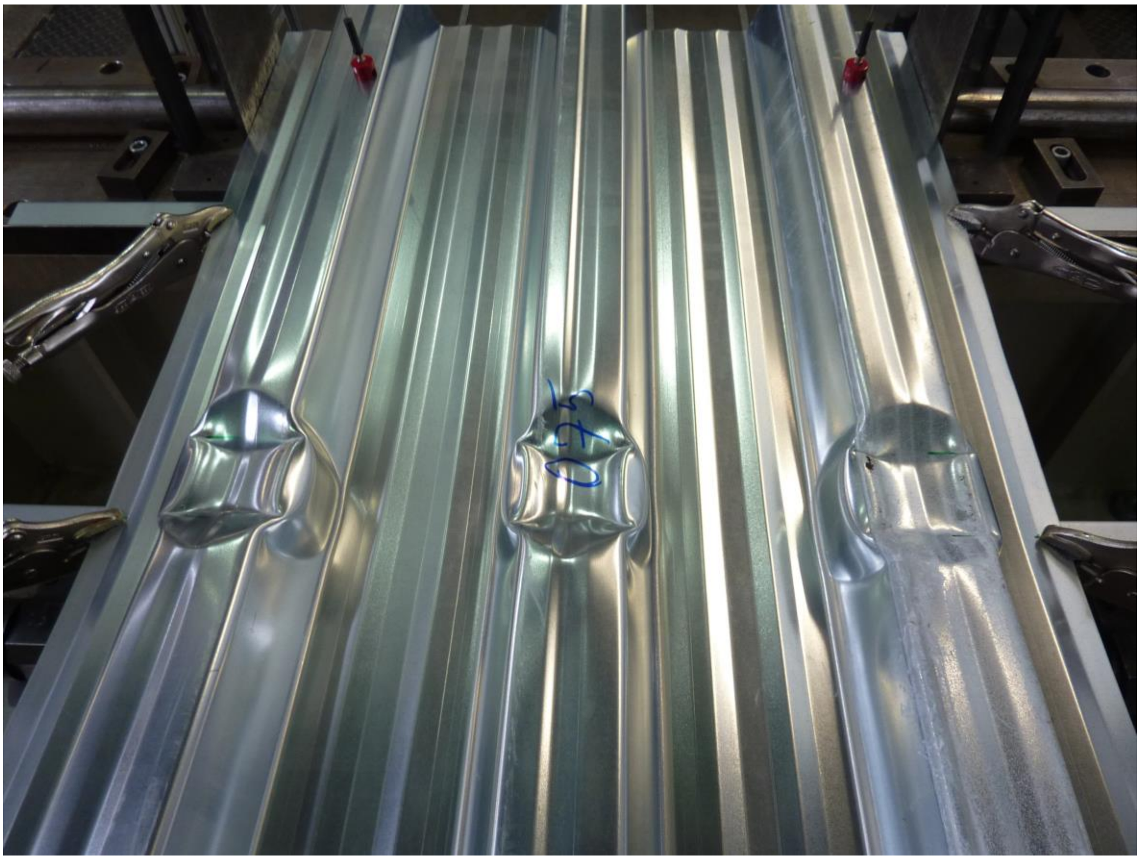


Figure C.6: Failure mode (exemplary for PCB 60, b_u = 60 mm, t_N = 0.75 without embossments)

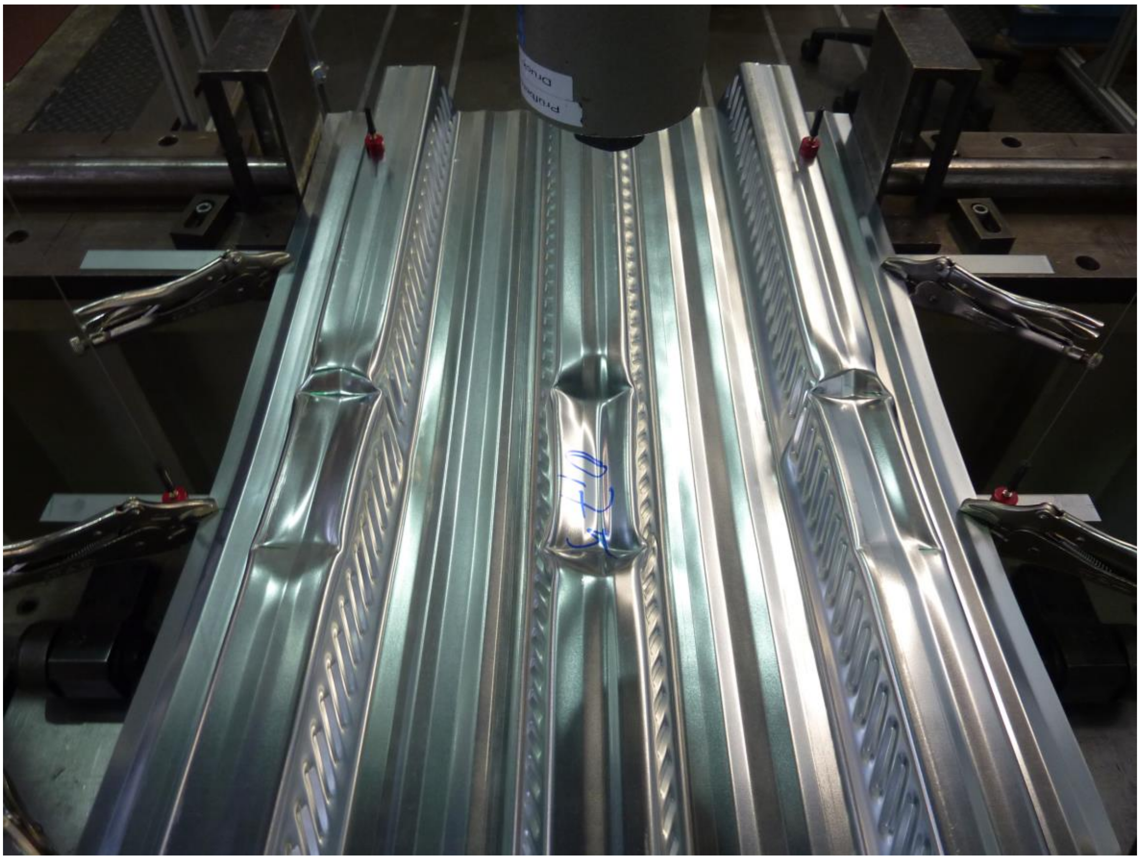
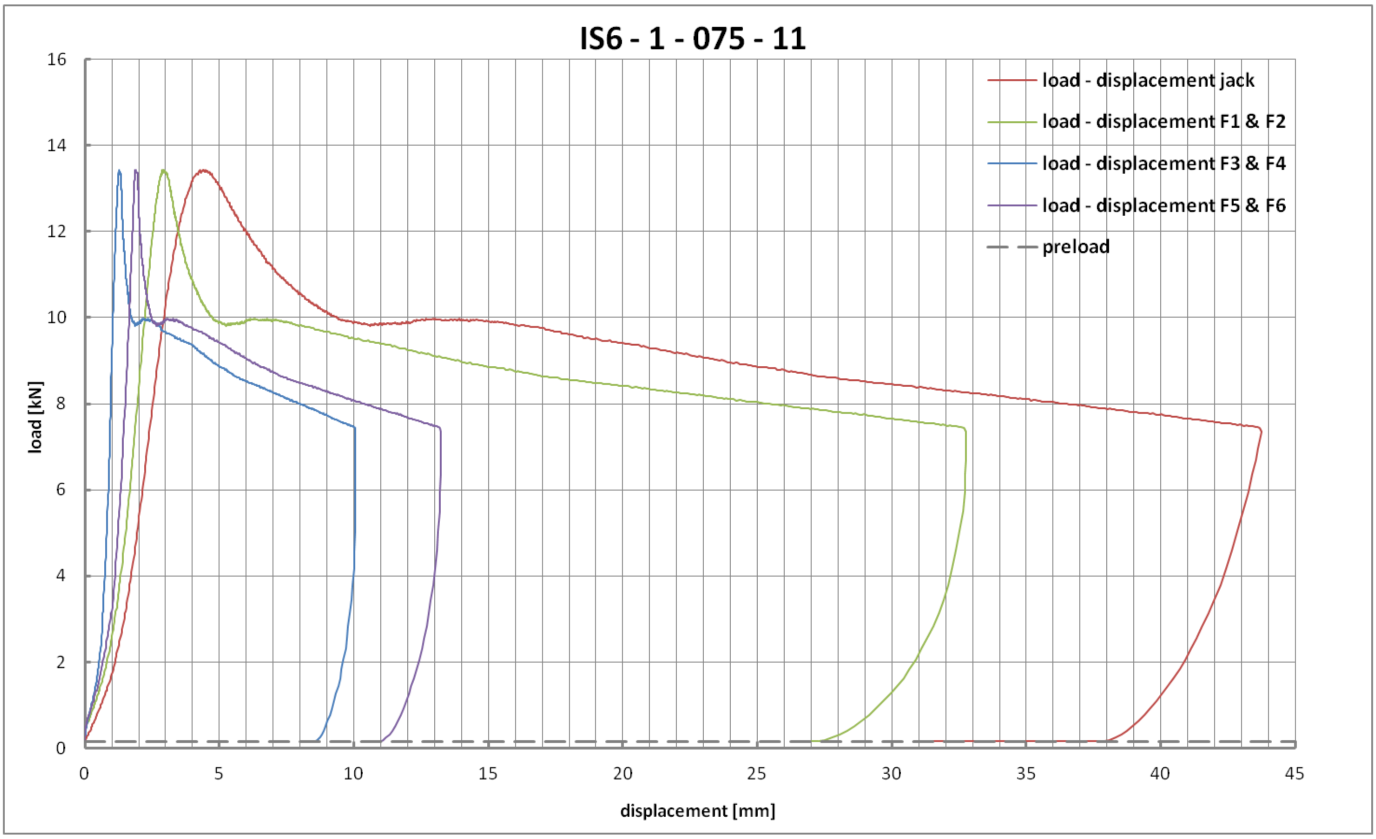
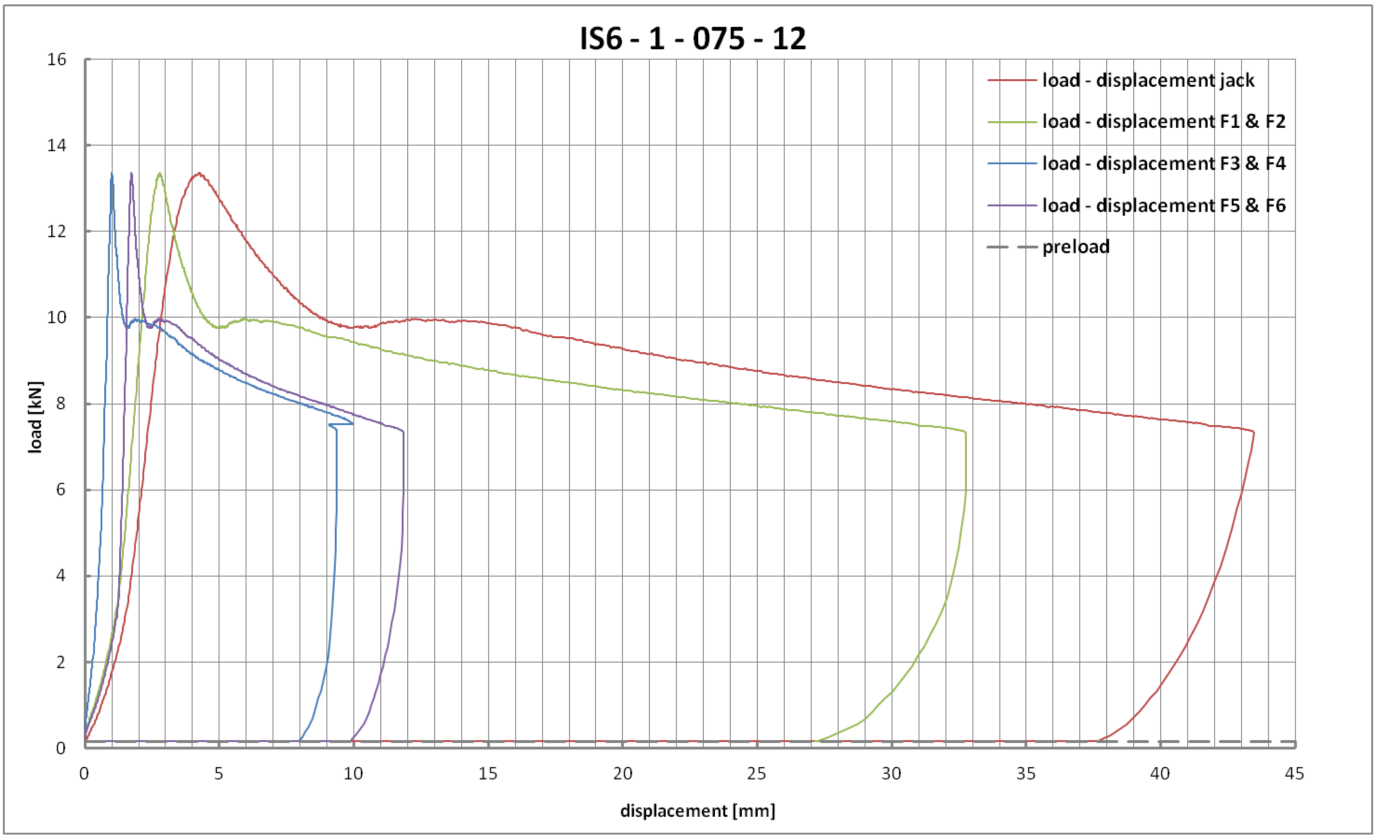
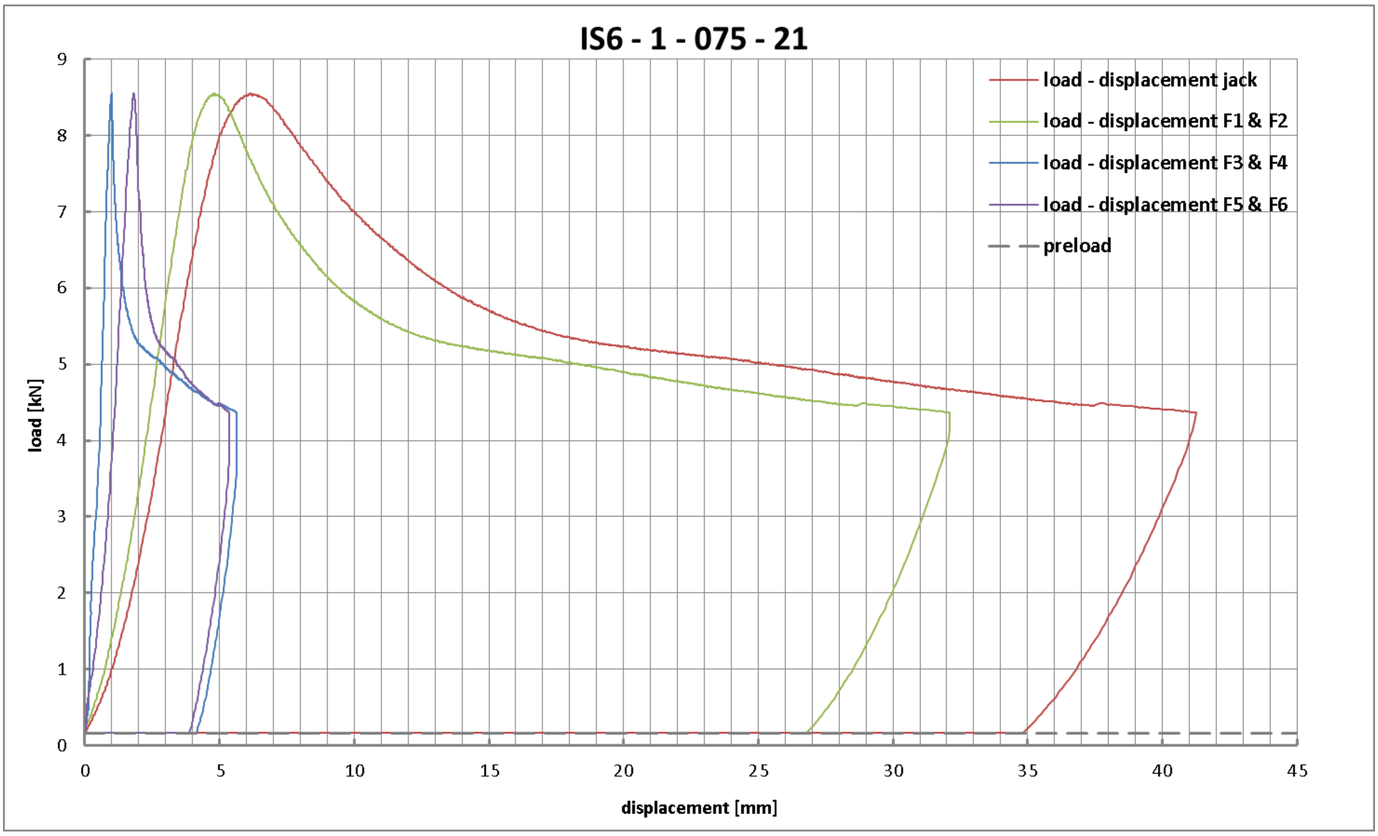


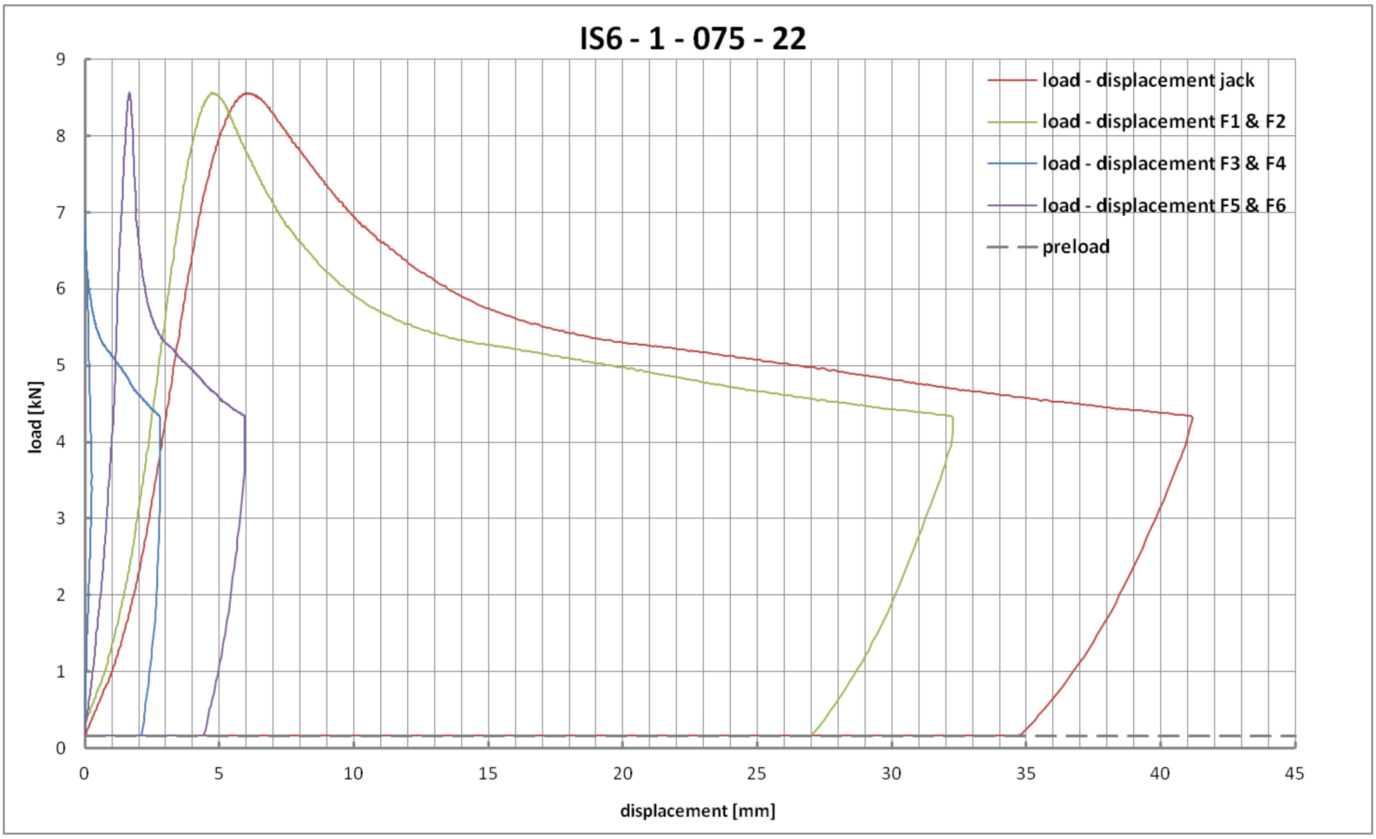
Figure C.7: Failure mode (exemplary for PCB 60, b_u = 160 mm, t_N = 0.75 with embossments)

Load-deflection curves:

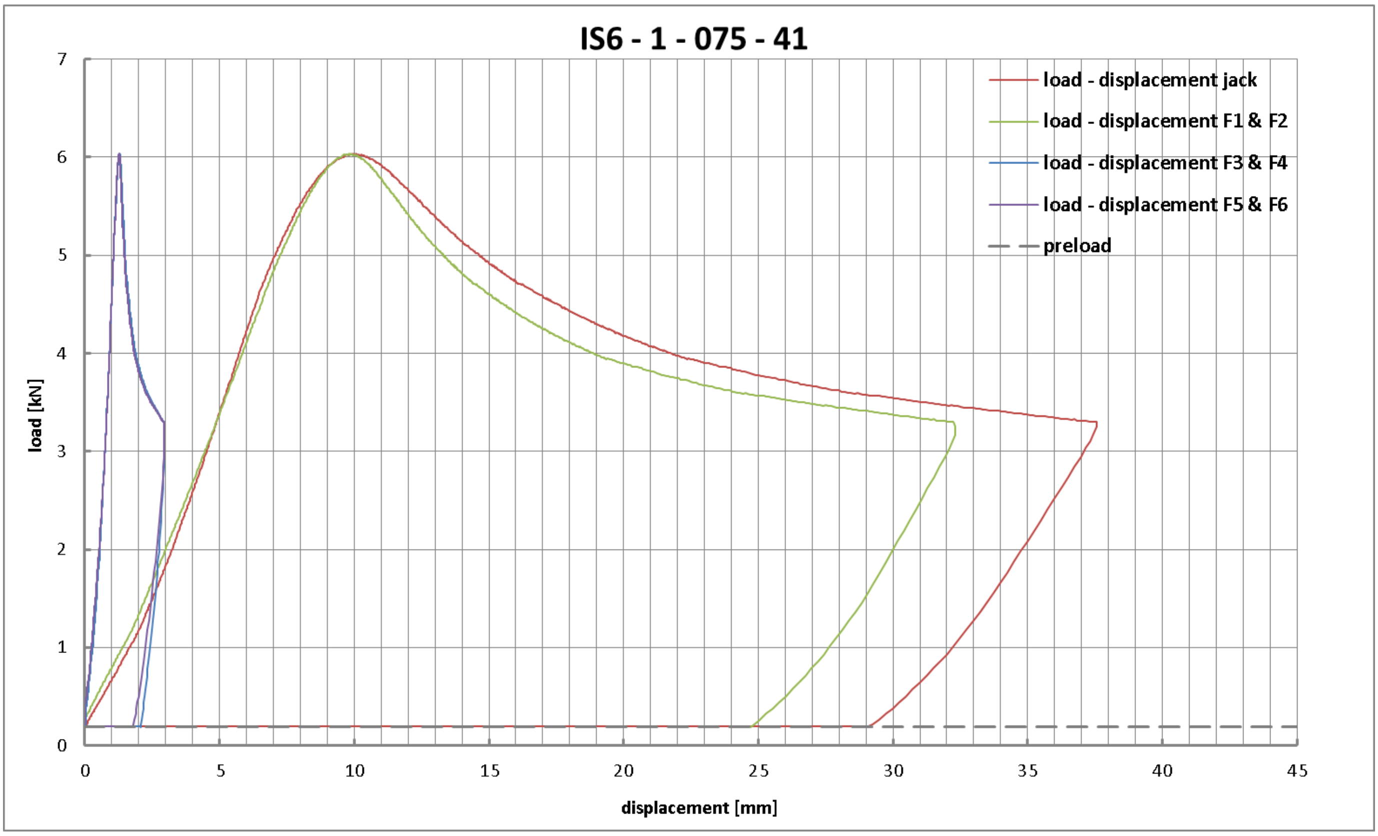



IS6 - 1 - 075 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
40
45

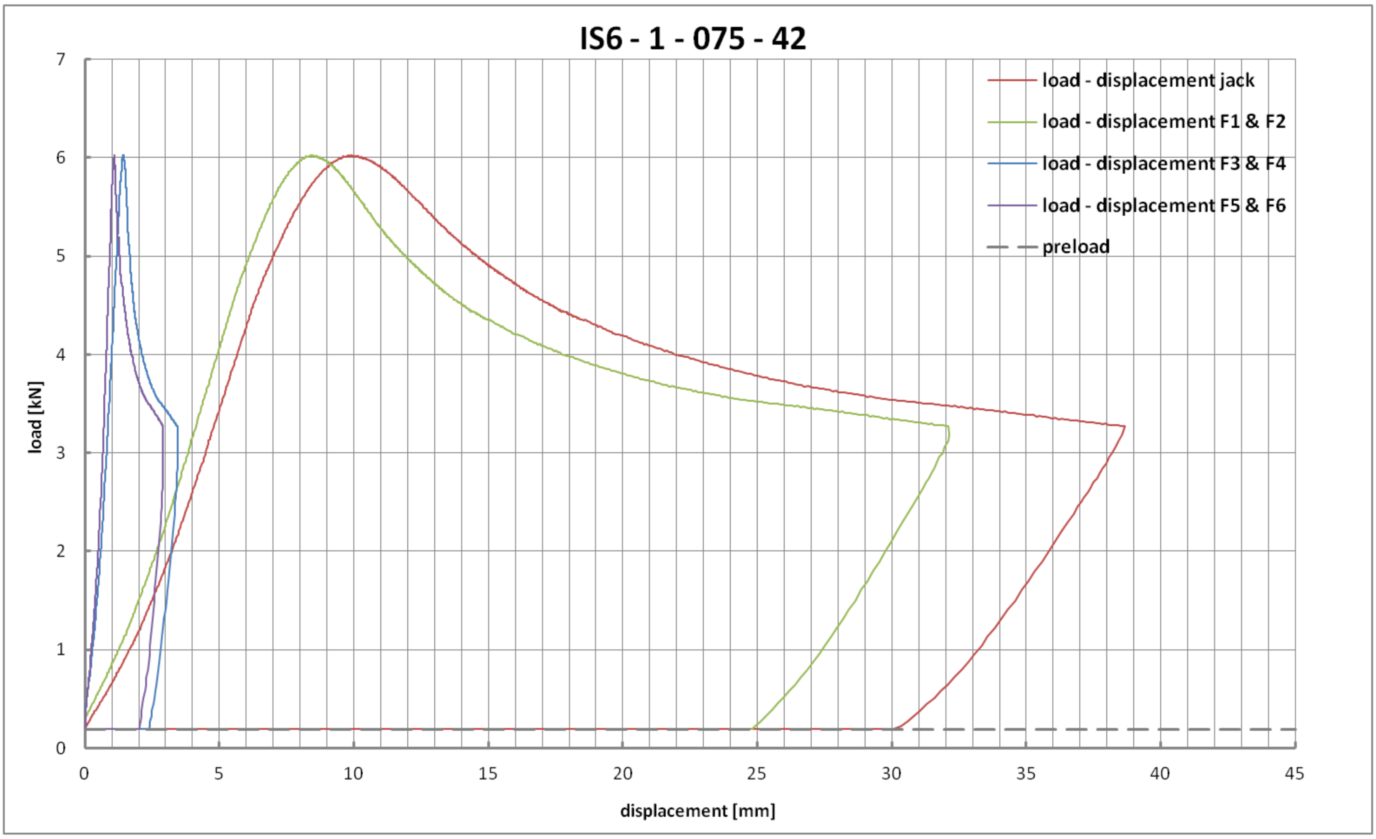

IS6 - 1 - 075 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45

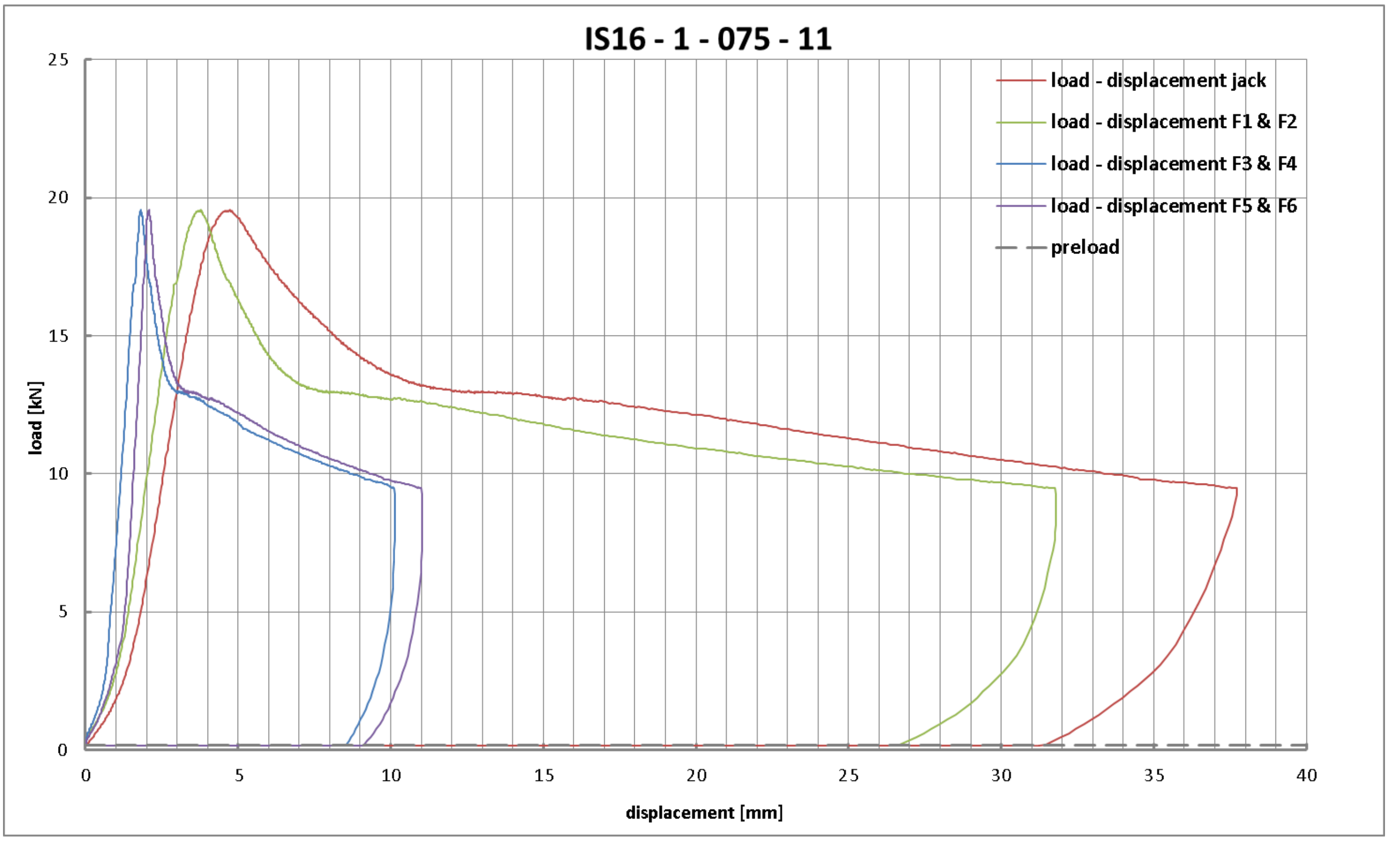


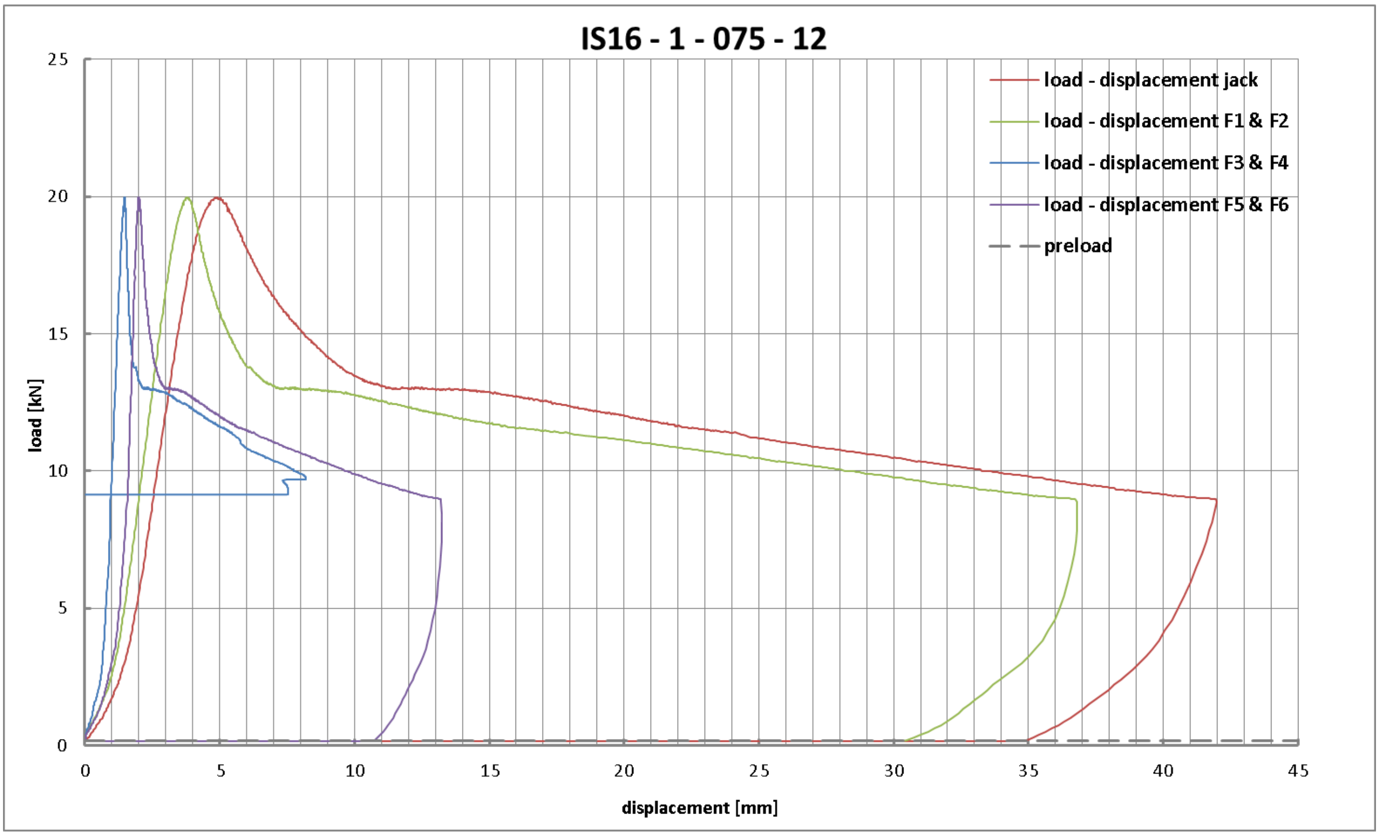
IS6 - 1 - 075 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45



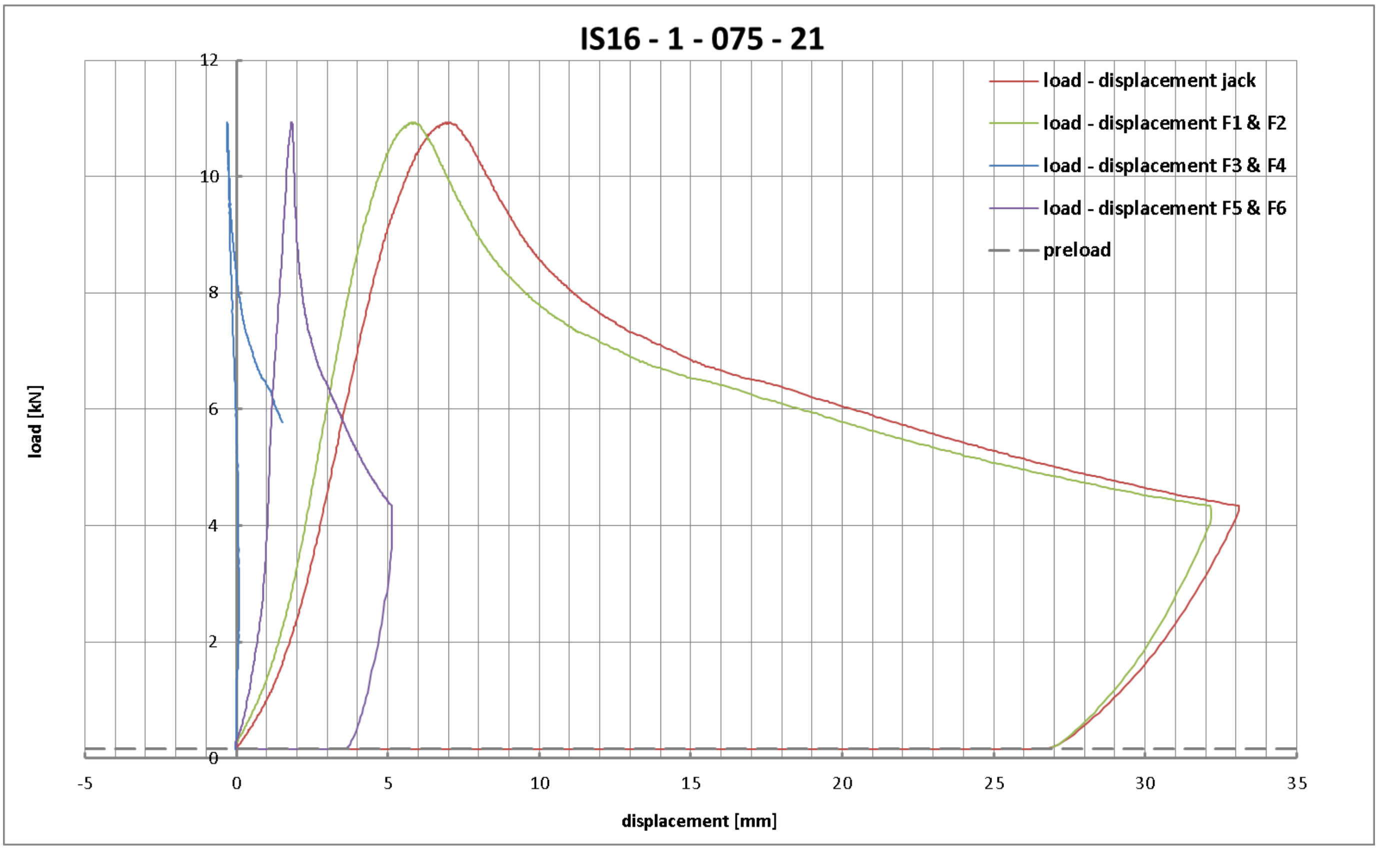
IS6 - 1 - 075 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40
45


IS6 - 1 - 075 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40
45

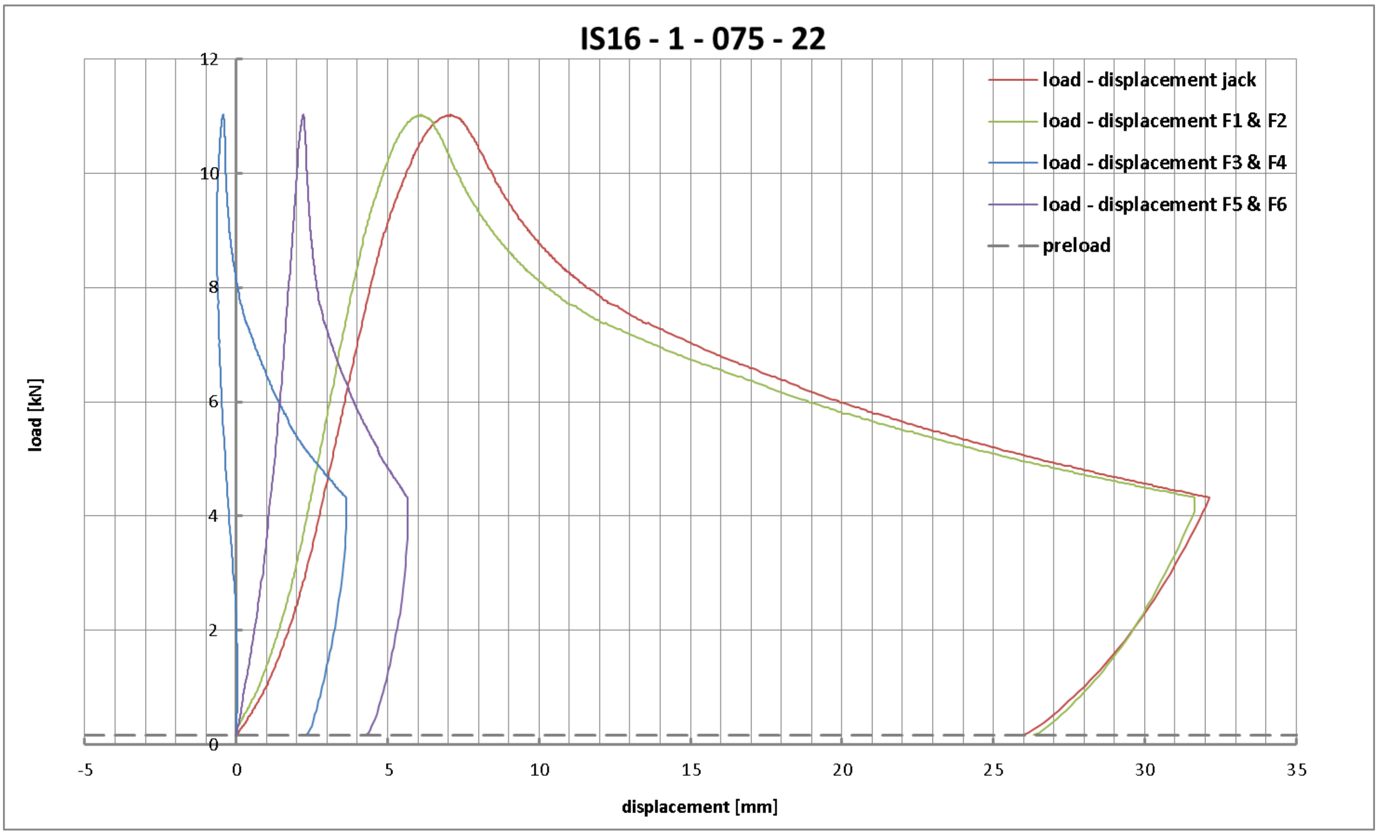

IS16 - 1 - 075 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
5
10
15
20
25
30
35
40

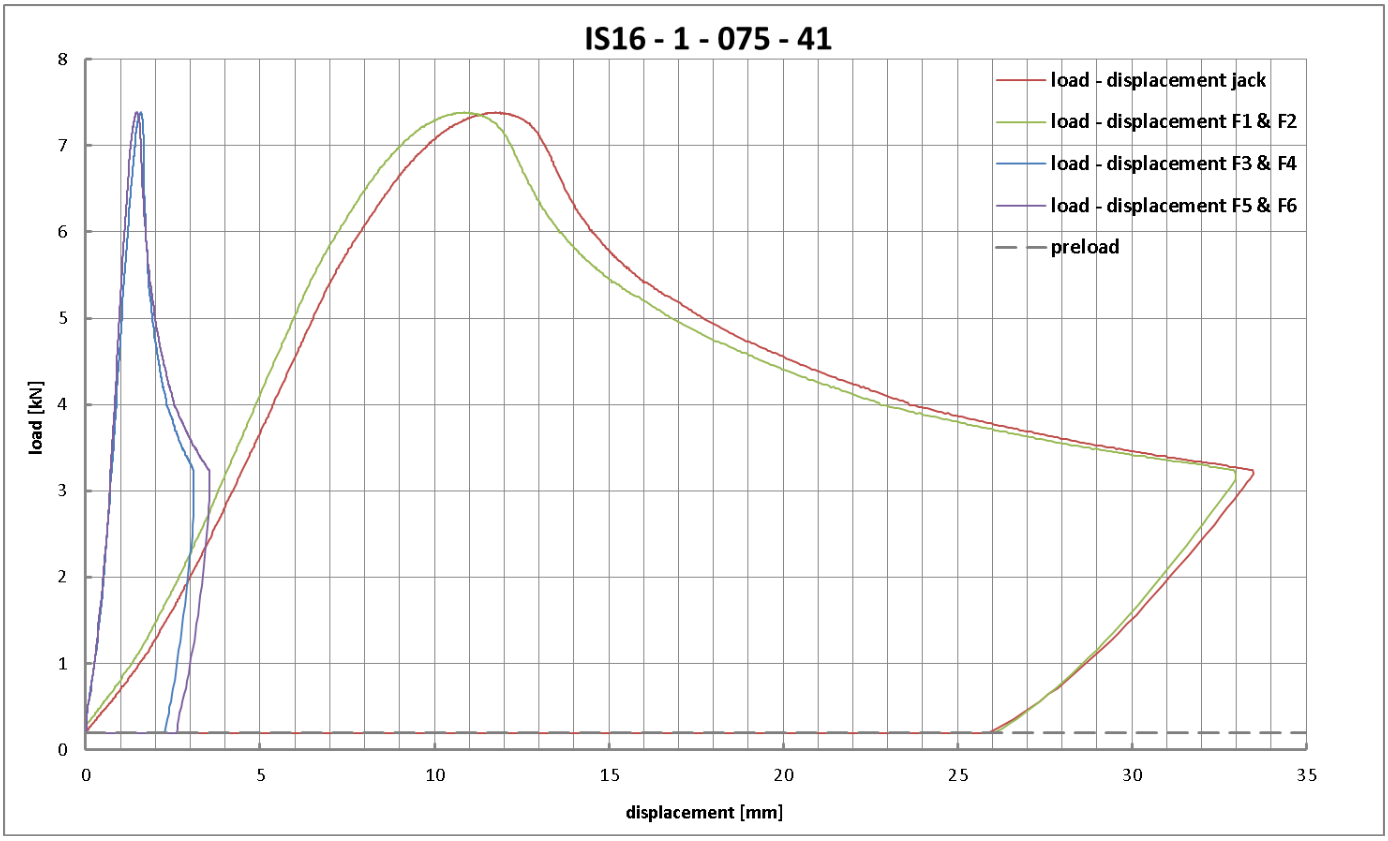


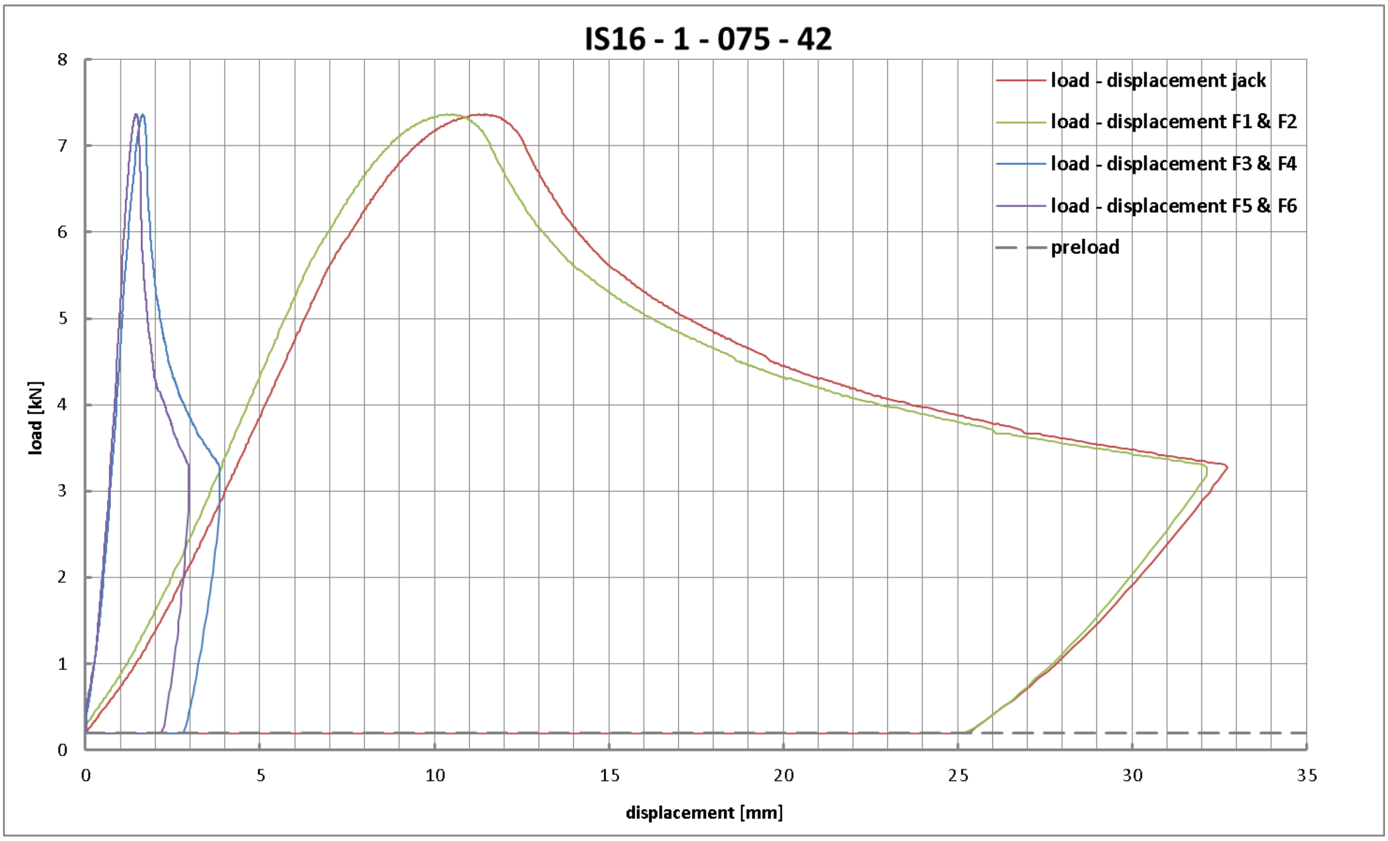
IS16 - 1 - 075 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
5
10
15
20
25
30
35
40
45

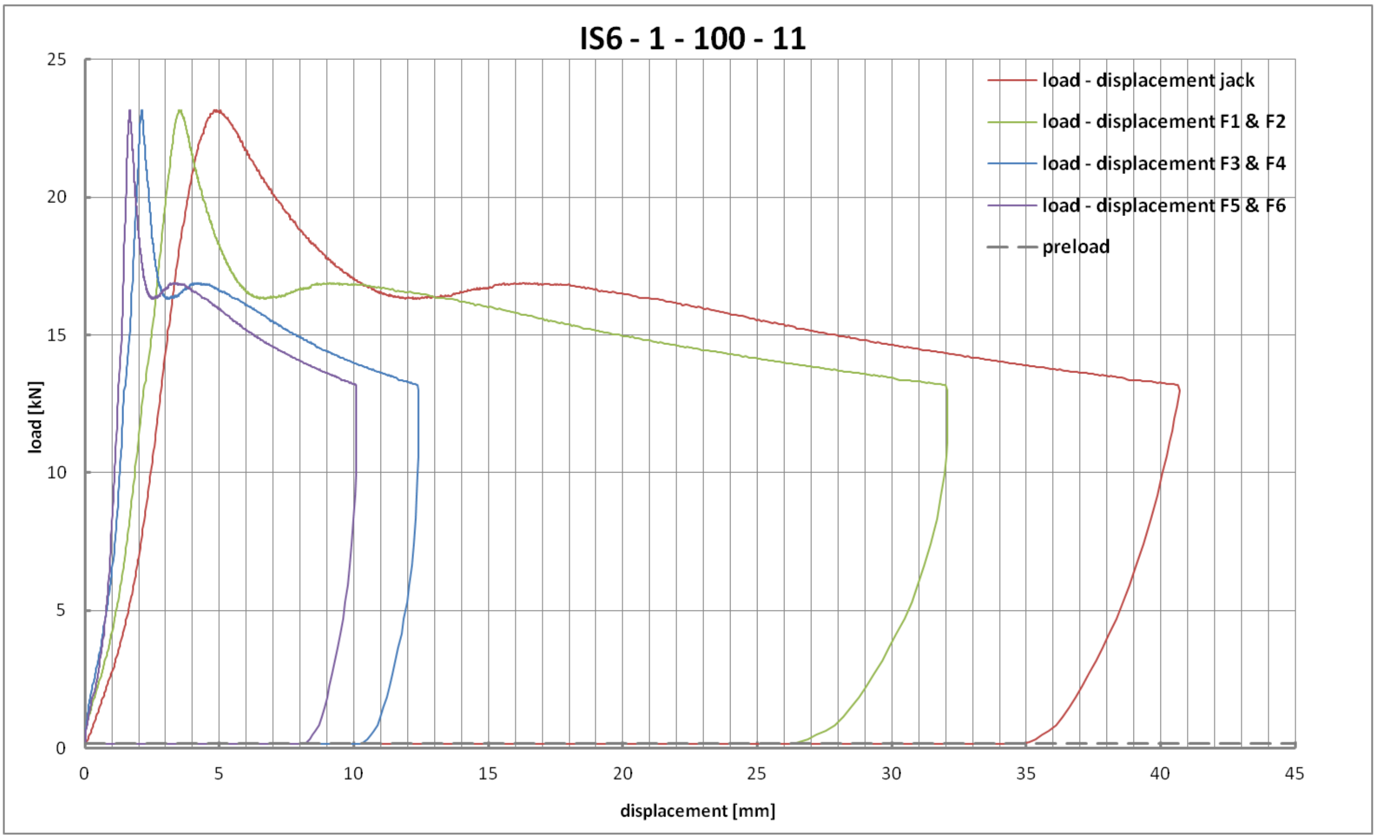


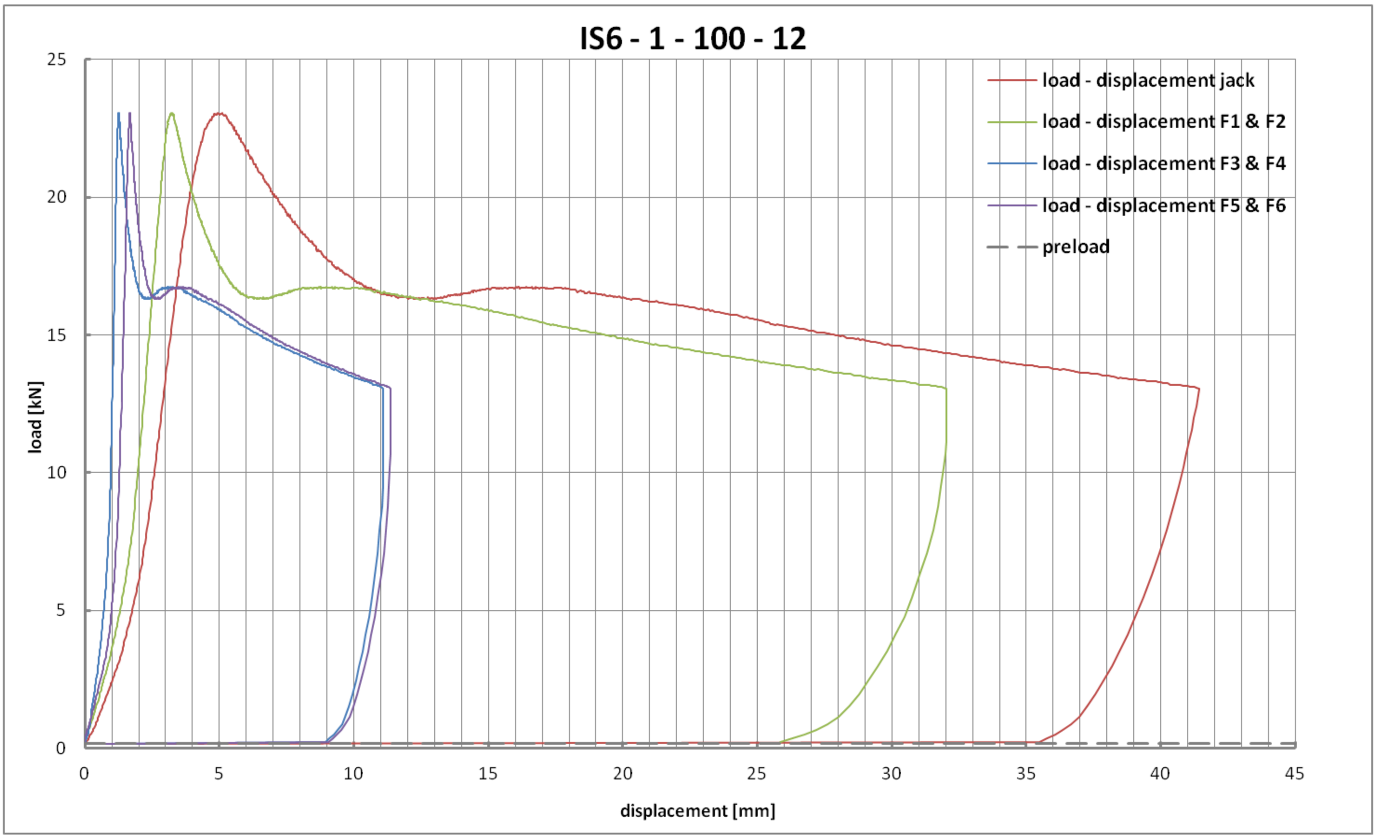
IS16 - 1 - 075 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
-5
0
5
10
15
20
25
30
35

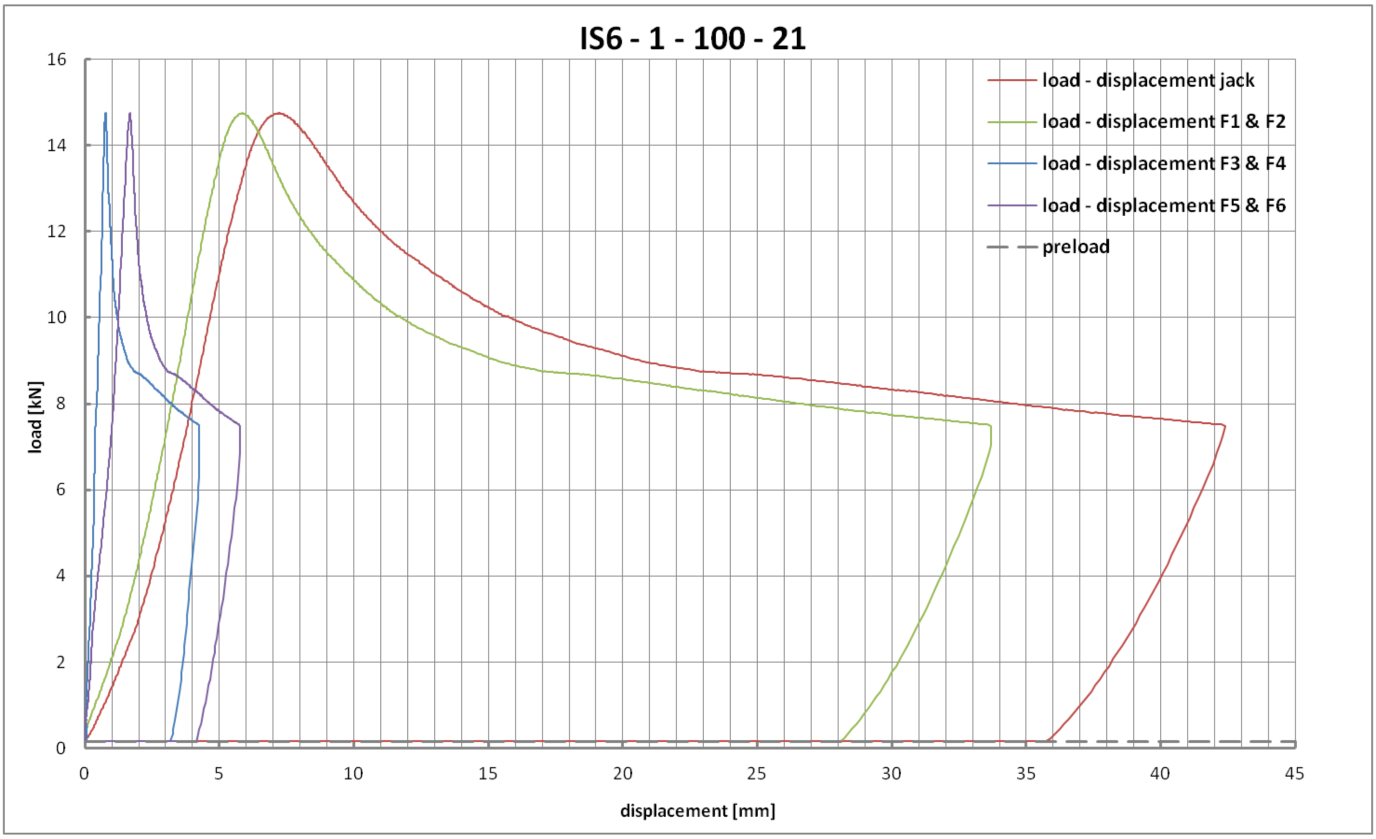

IS16 - 1 - 075 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
12
10
8
6
4
2
0
-5
0
5
10
15
20
25
30
35

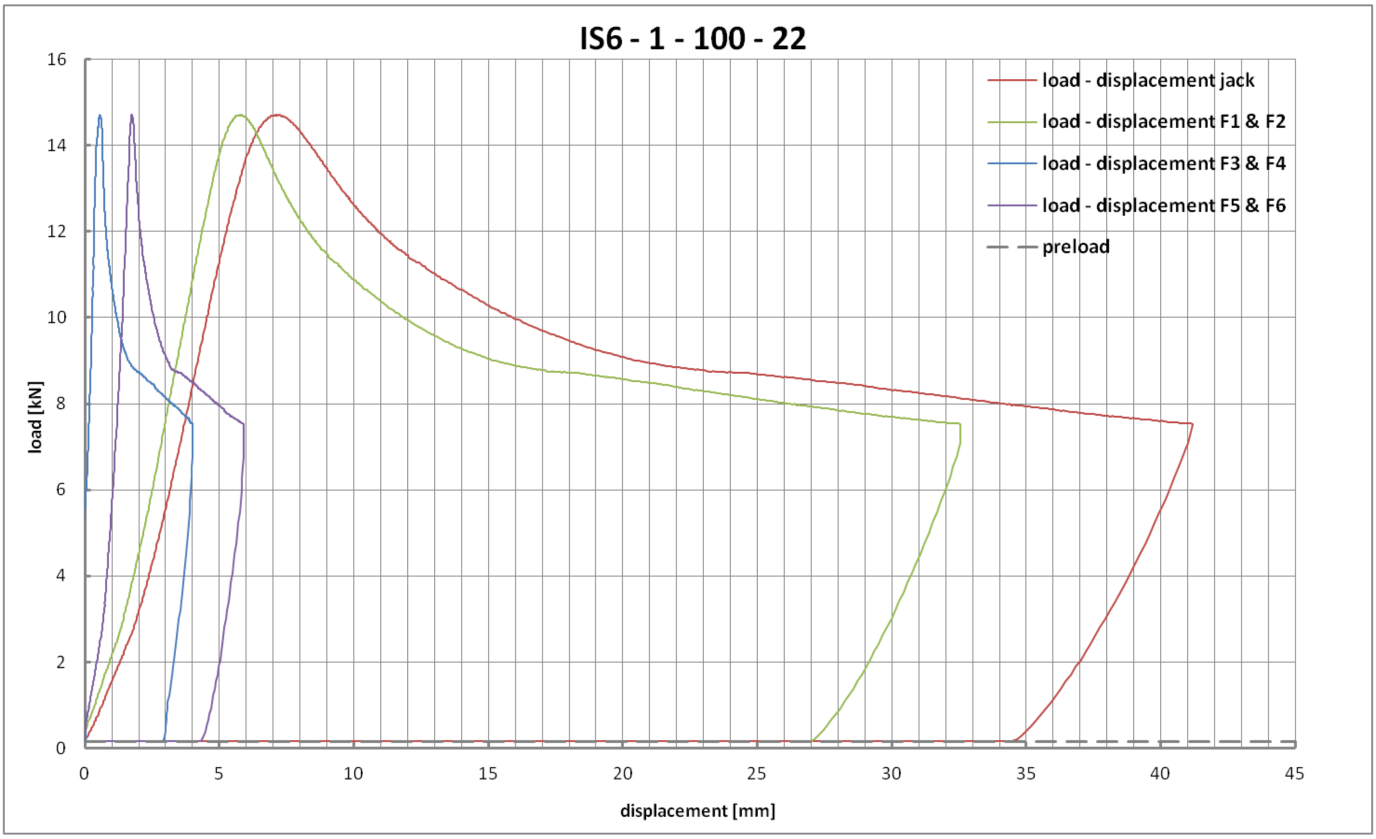

IS16 - 1 - 075 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25
30
35

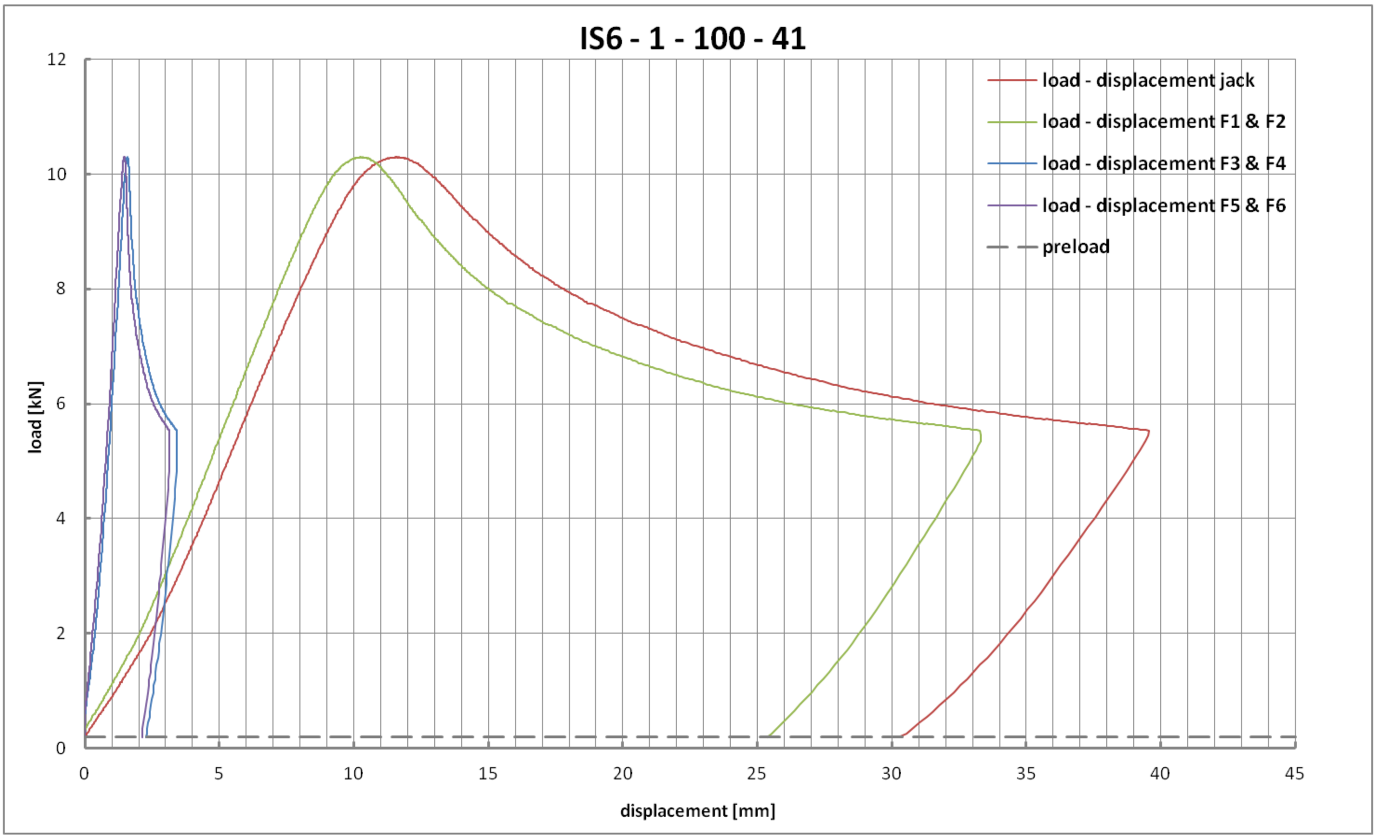

IS16 - 1 - 075 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35

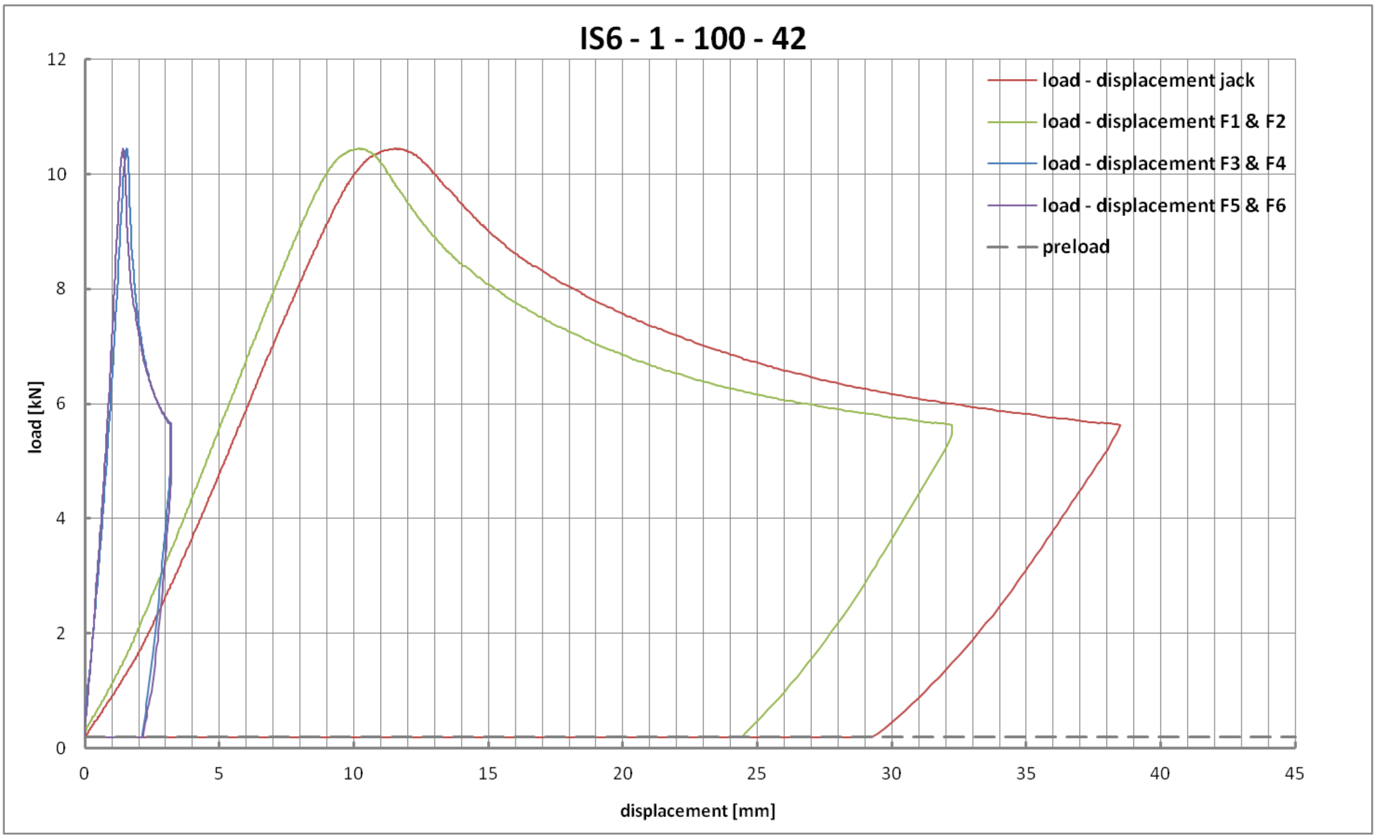

IS6 - 1 - 100 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
5
10
15
20
25
30
35
40
45

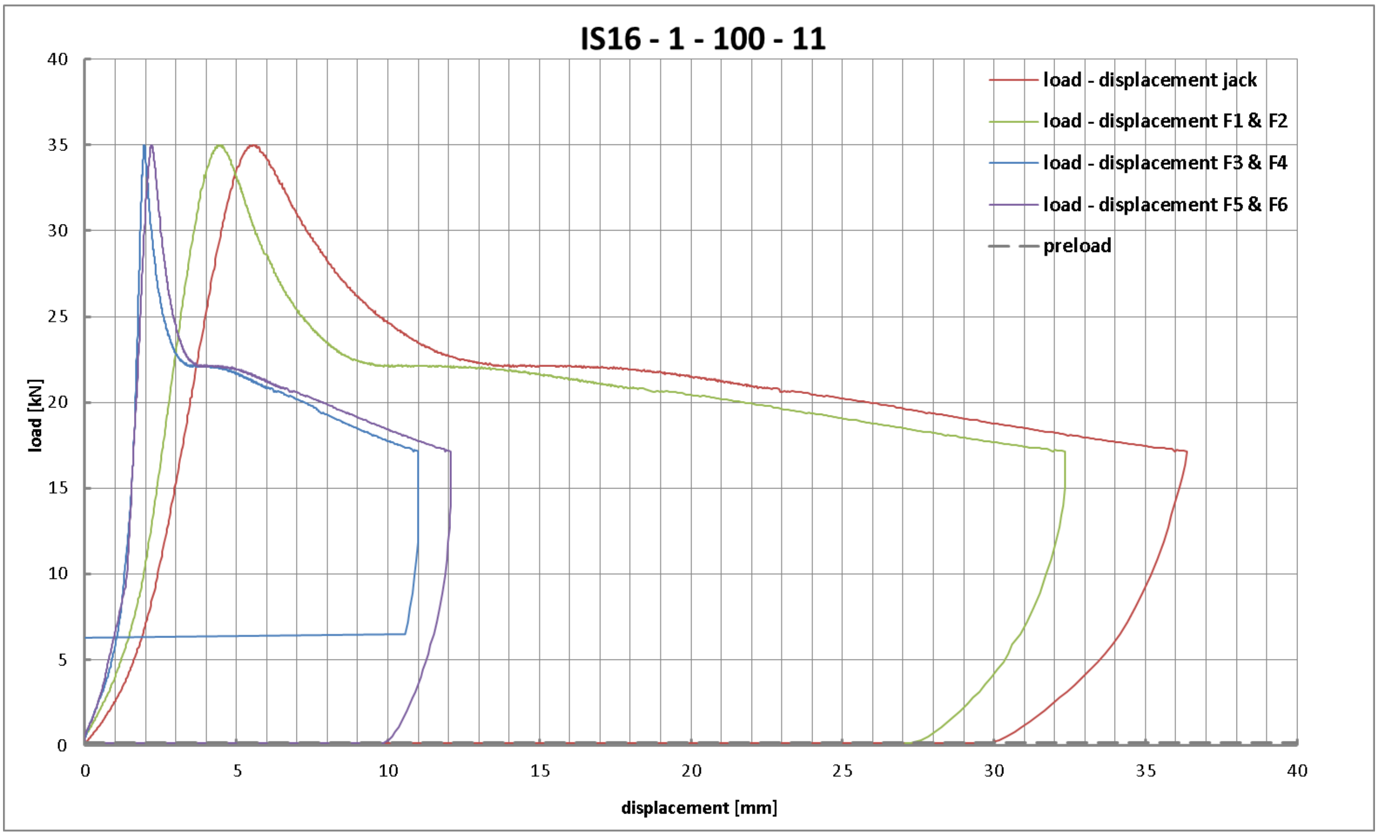

IS6 - 1 - 100 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
5
10
15
20
25
30
35
40
45

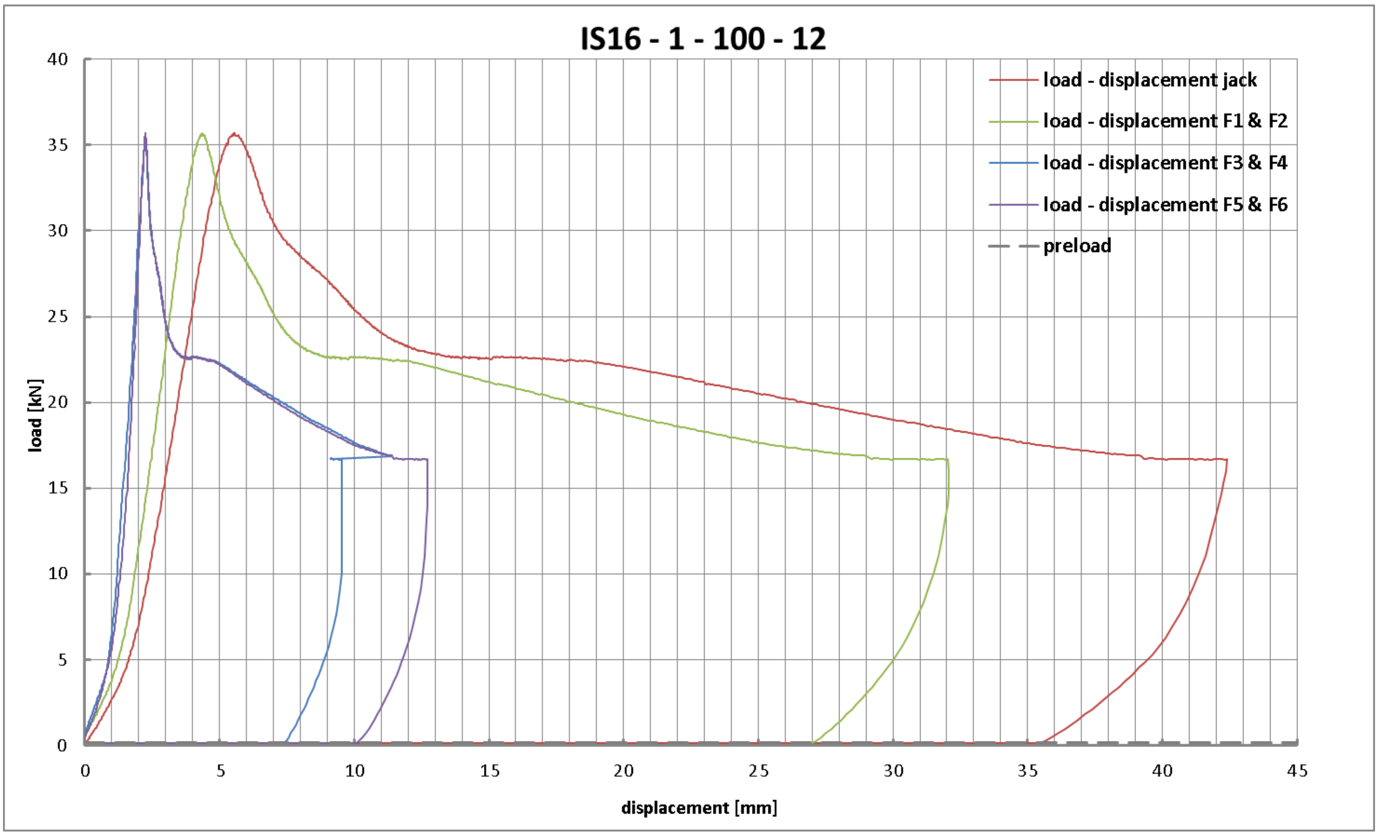

IS6 - 1 - 100 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
40
45

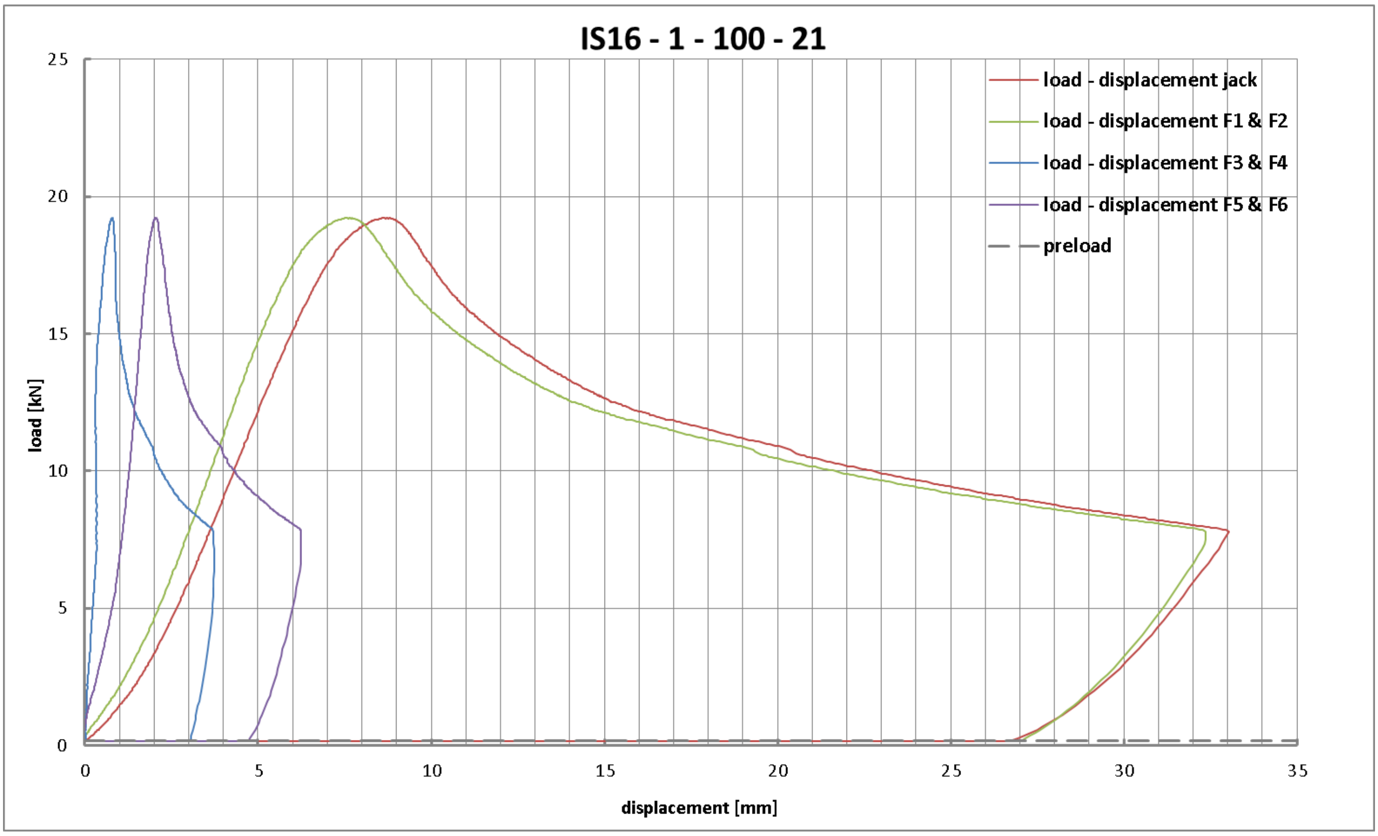

IS6 - 1 - 100 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
40
45

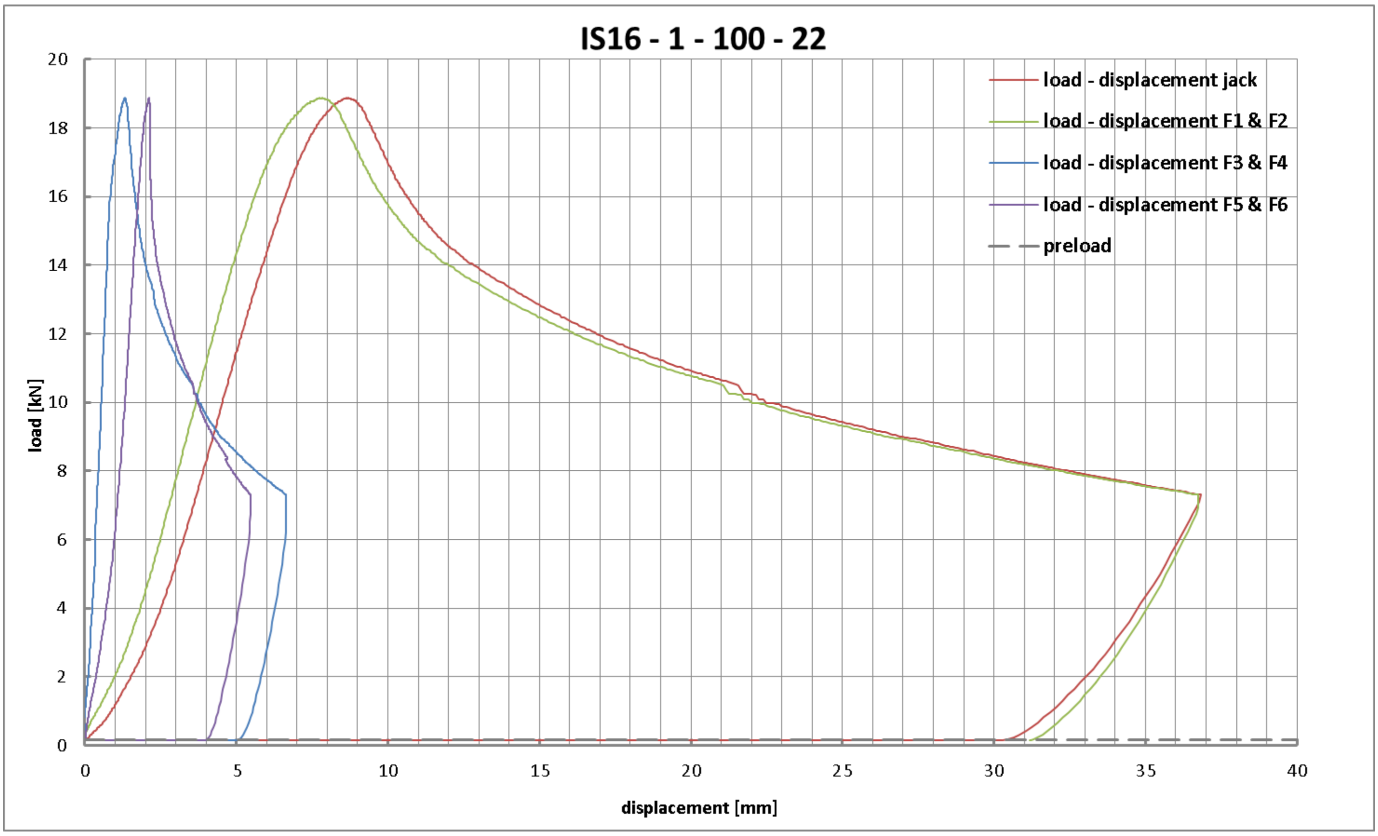

IS6 - 1 - 100 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45

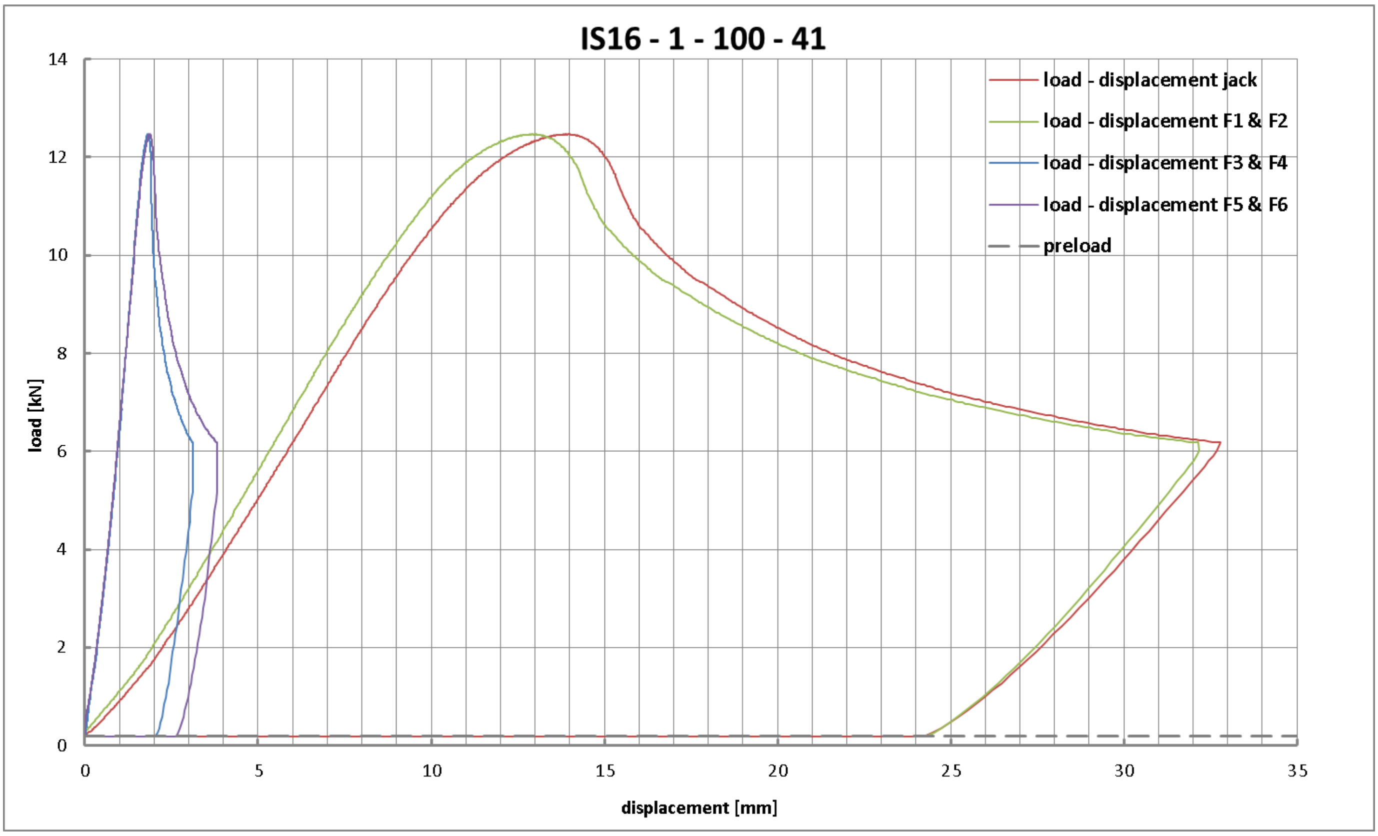

IS6 - 1 - 100 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45

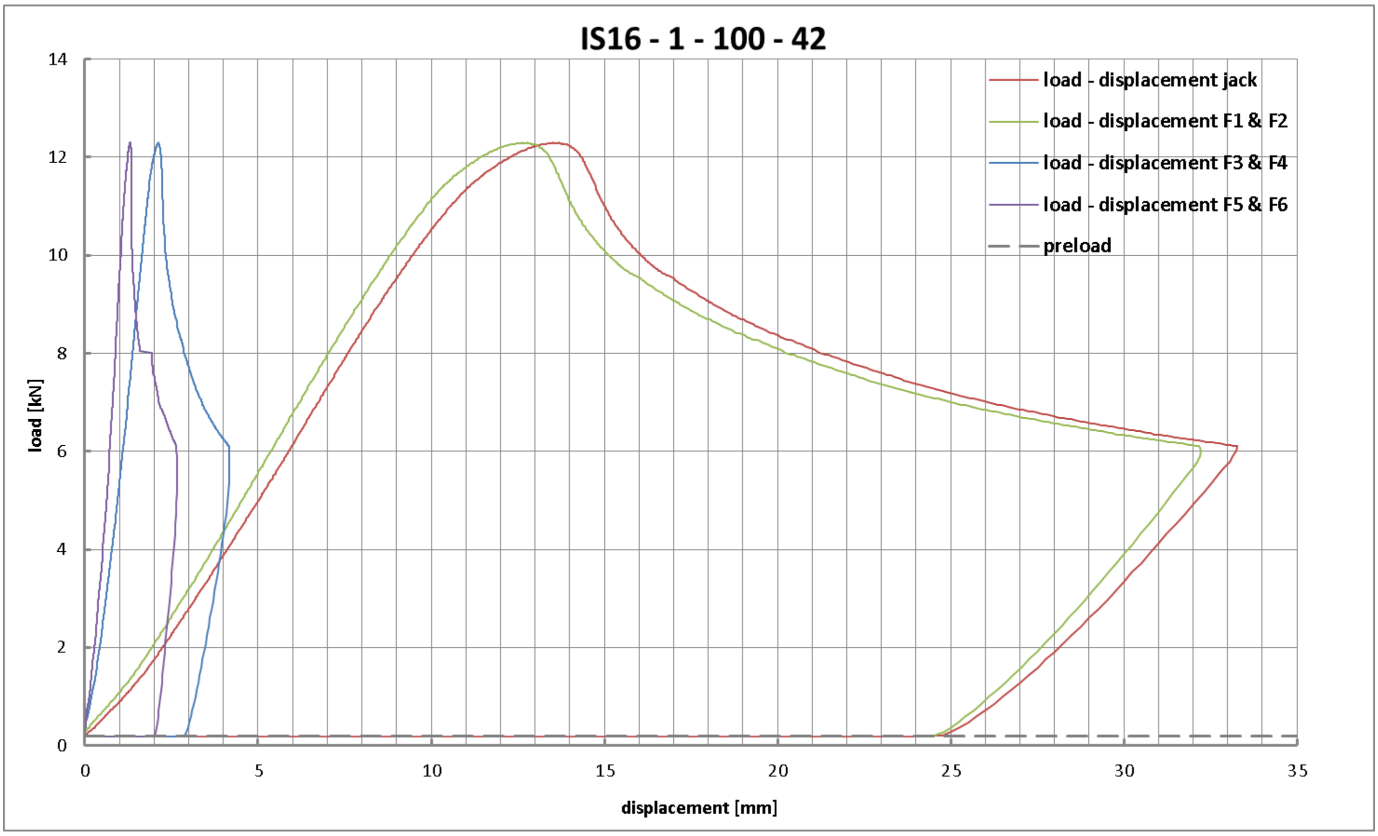

IS16 - 1 - 100 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
0
5
10
15
20
25
30
35
40

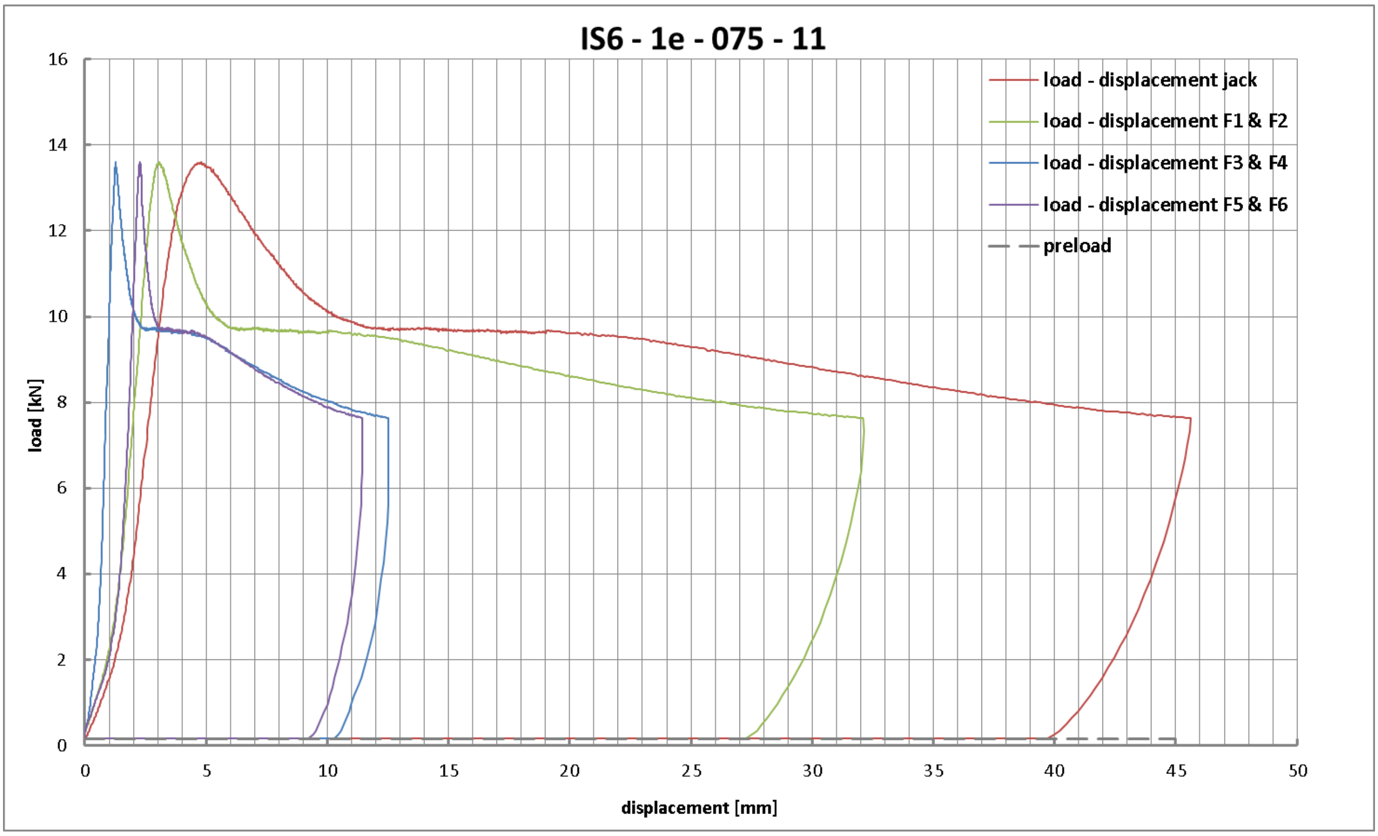

IS16 - 1 - 100 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45

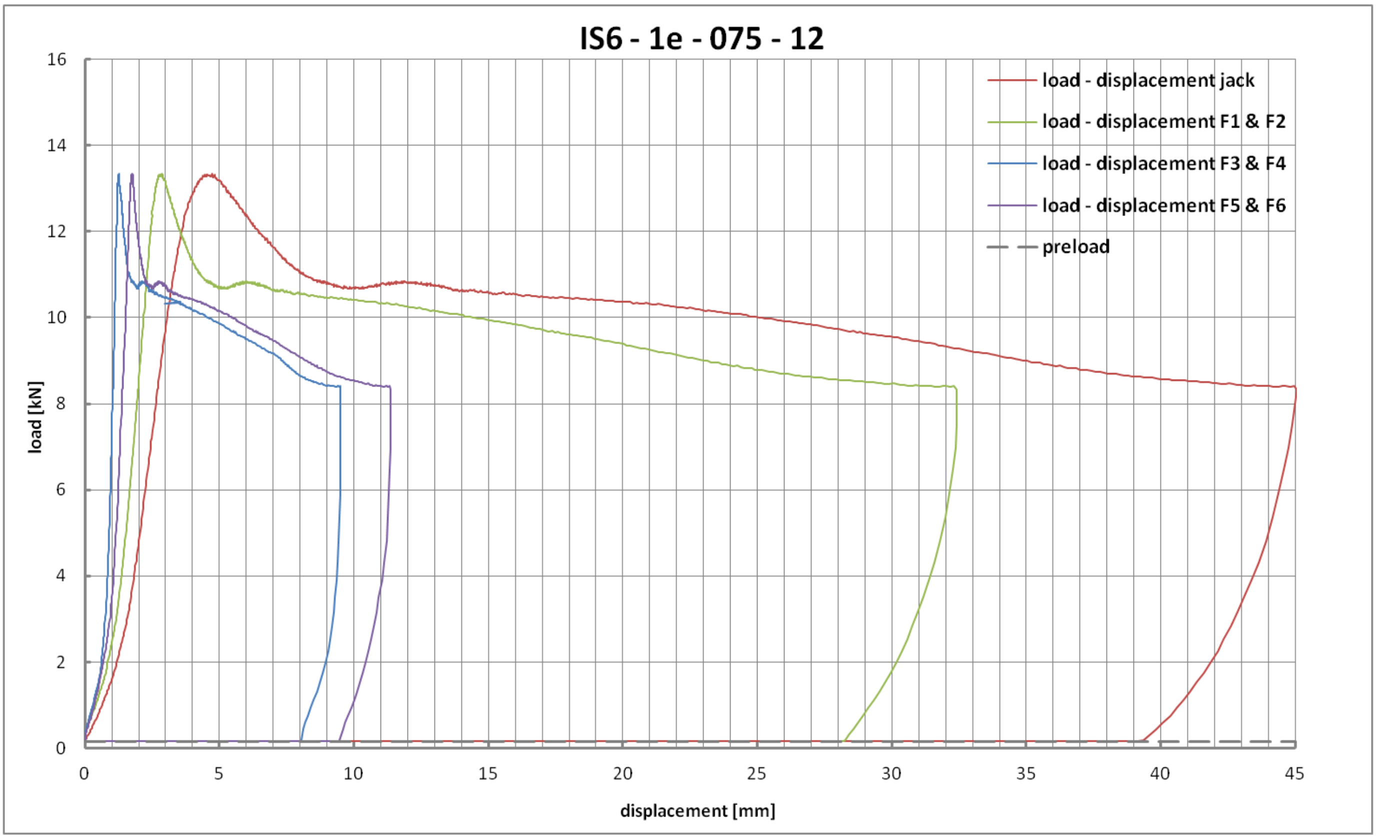

IS16 - 1 - 100 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35


IS16 - 1 - 100 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
35
40

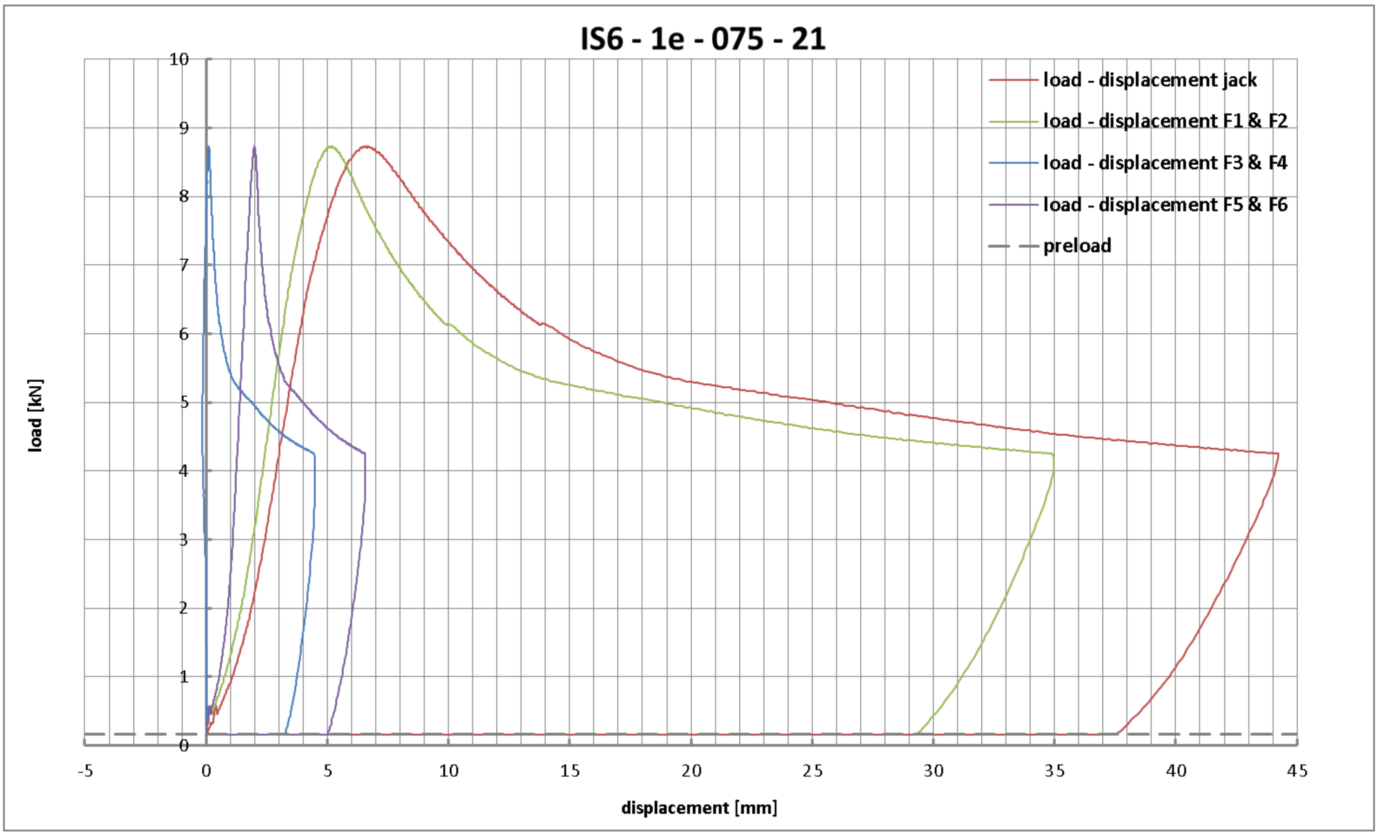

IS16 - 1 - 100 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35


IS16 - 1 - 100 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35


IS6 - 1e - 075 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
40
45
50



IS6 - 1e - 075 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
40
45



IS6 - 1e - 075 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
10
-5
0
5
10
15
20
25
30
35
40
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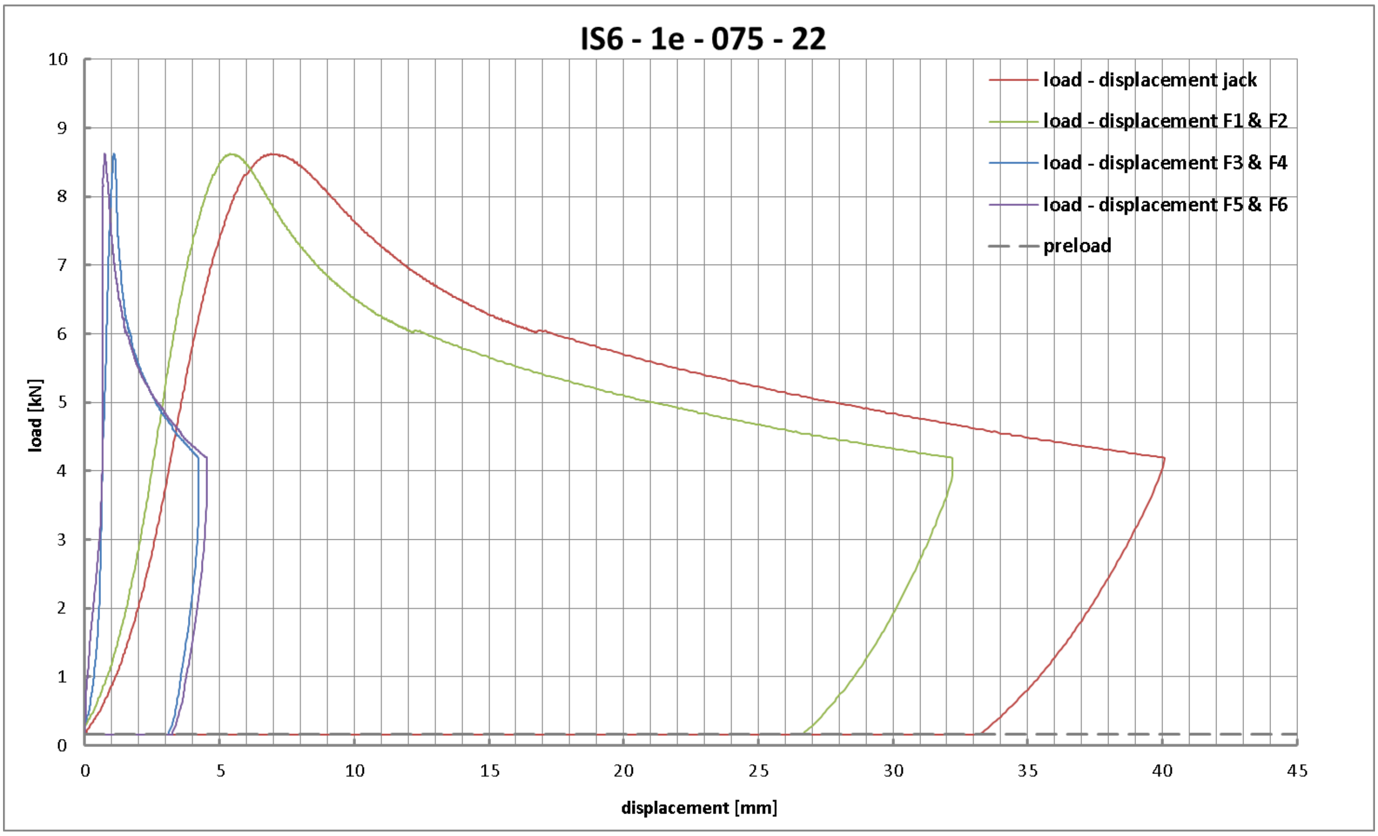
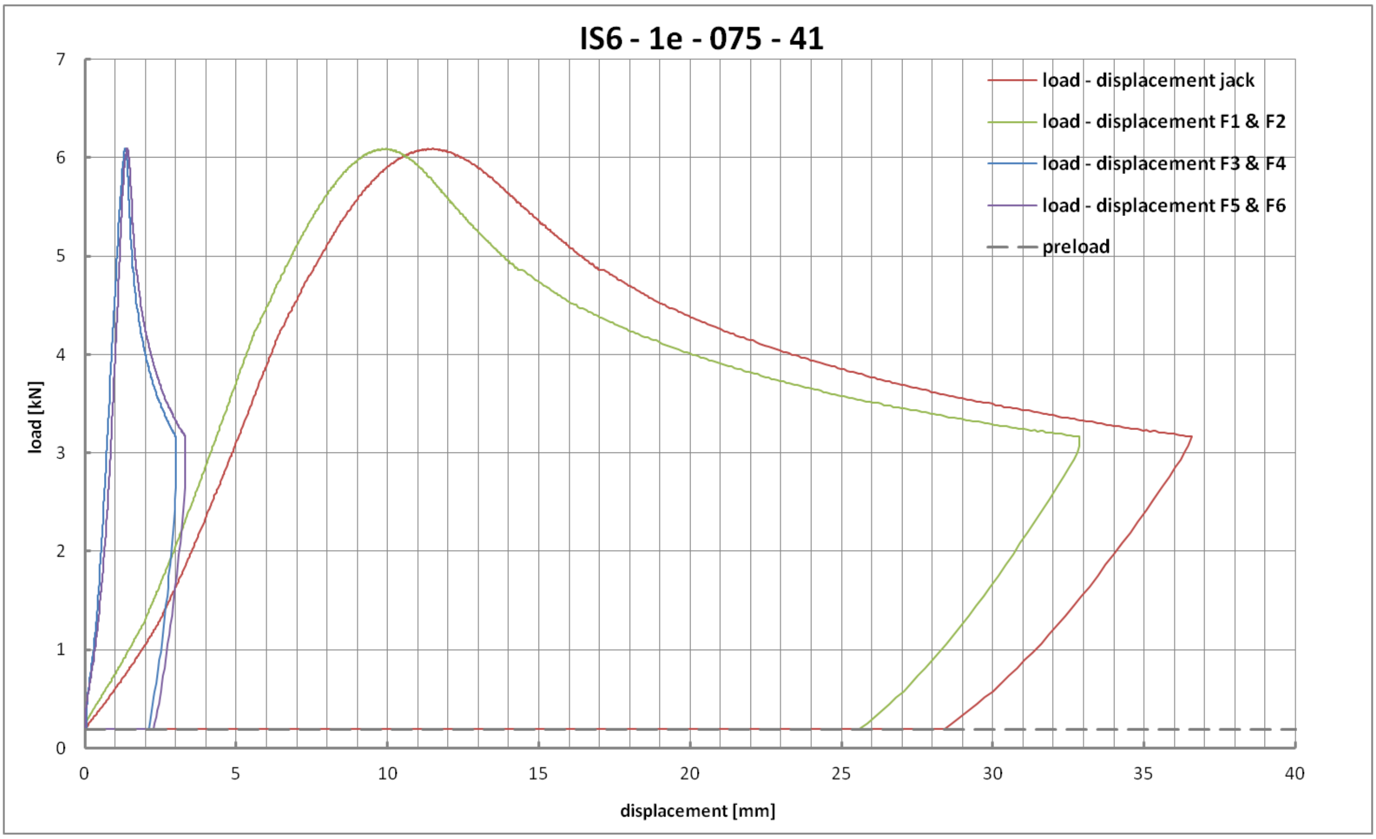
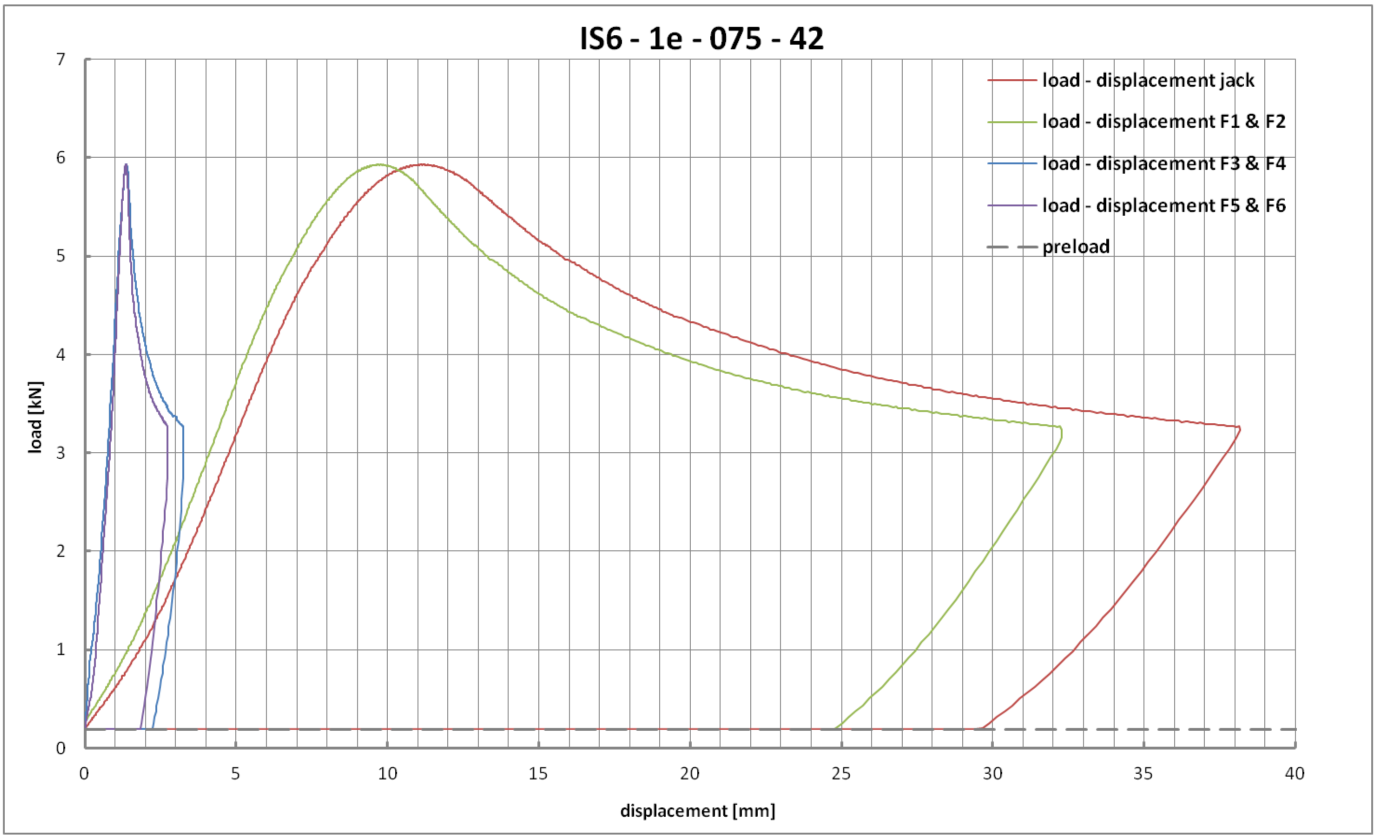
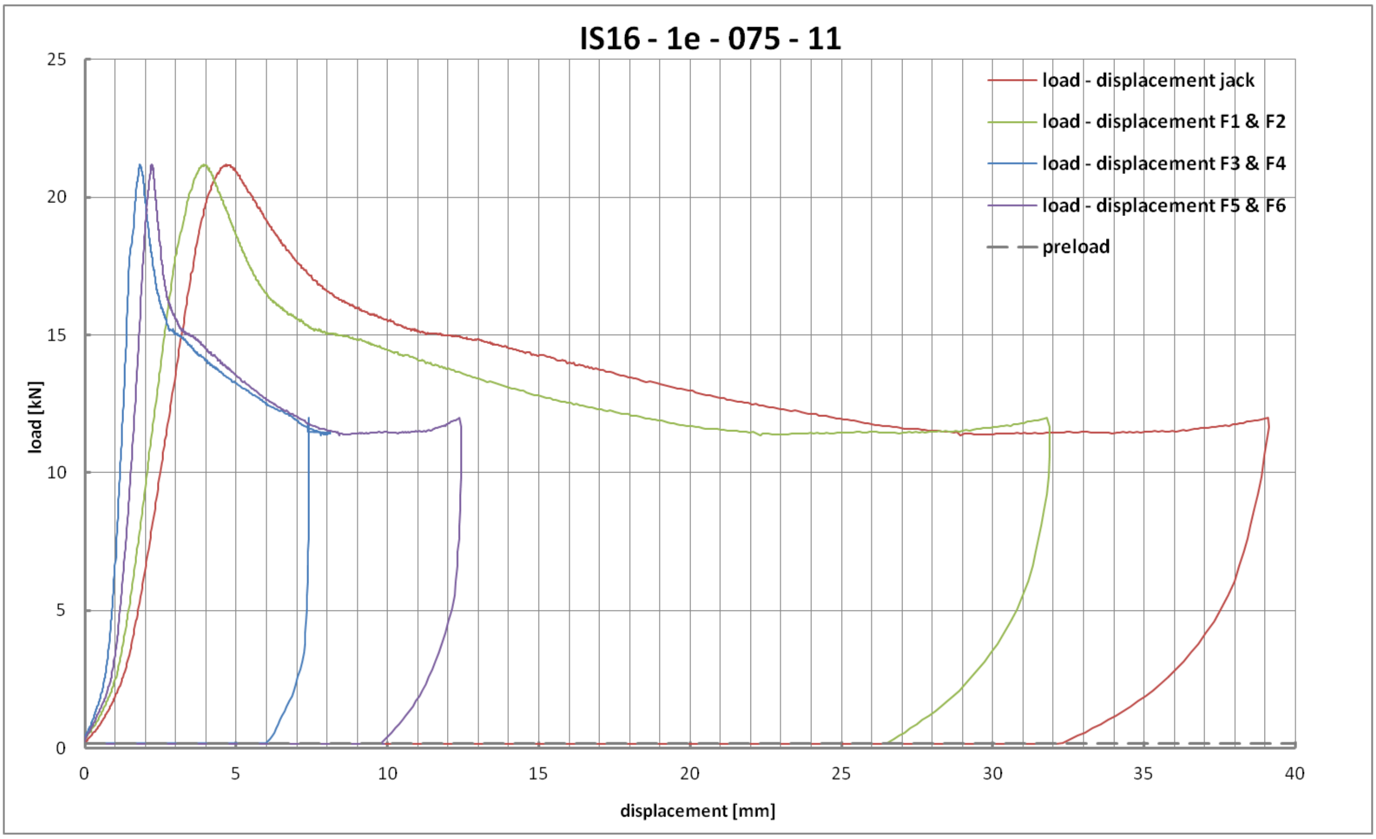
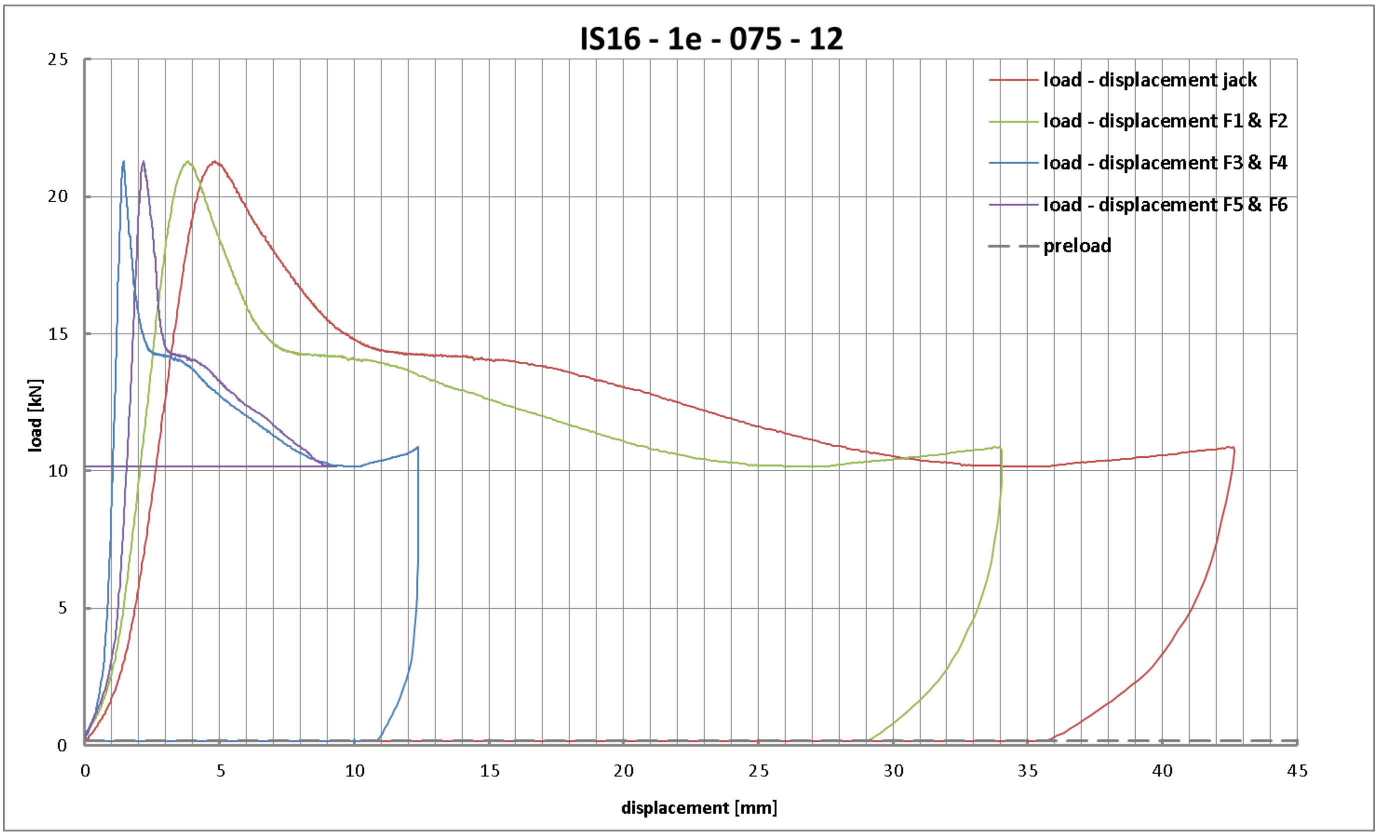
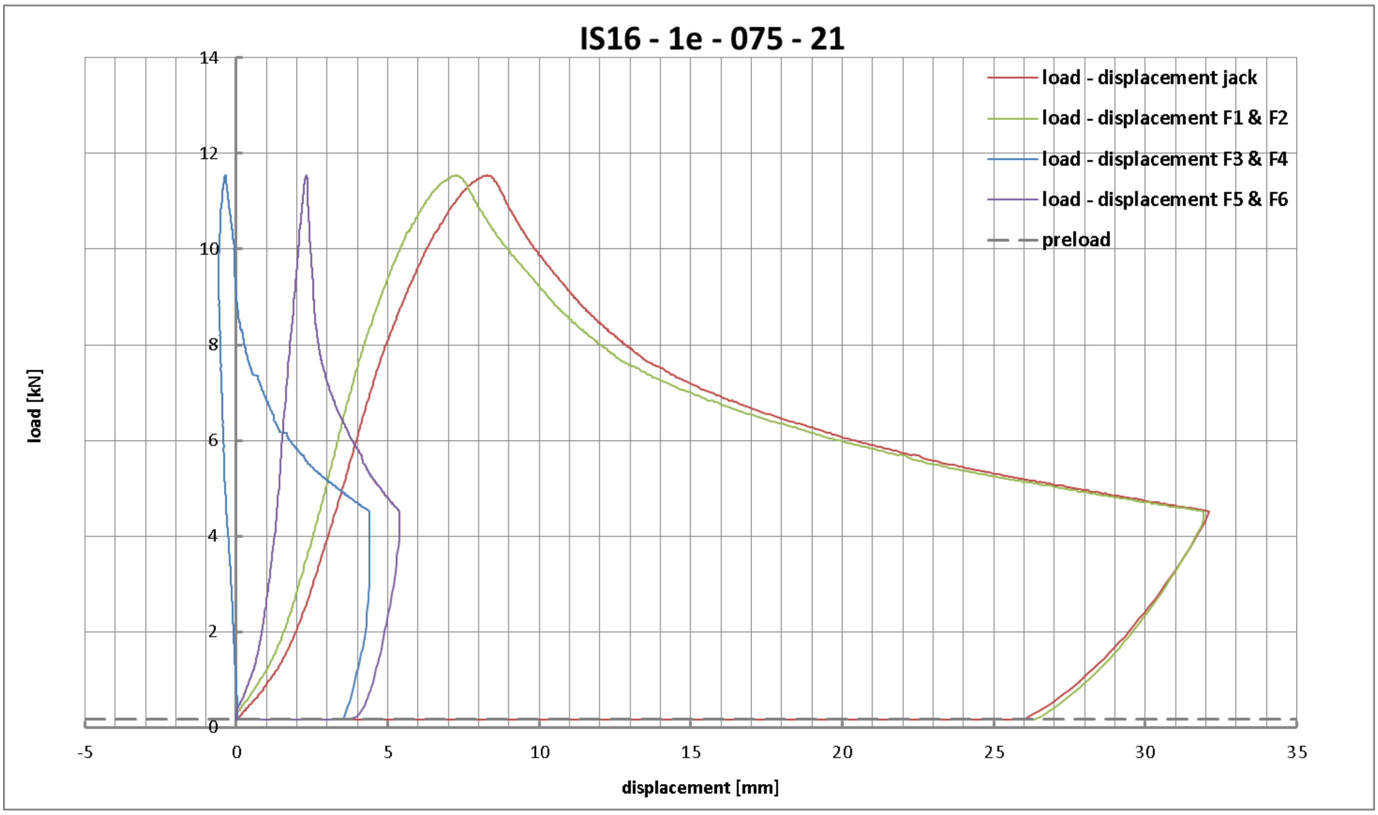

IS6 - 1e - 075 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35
40
45

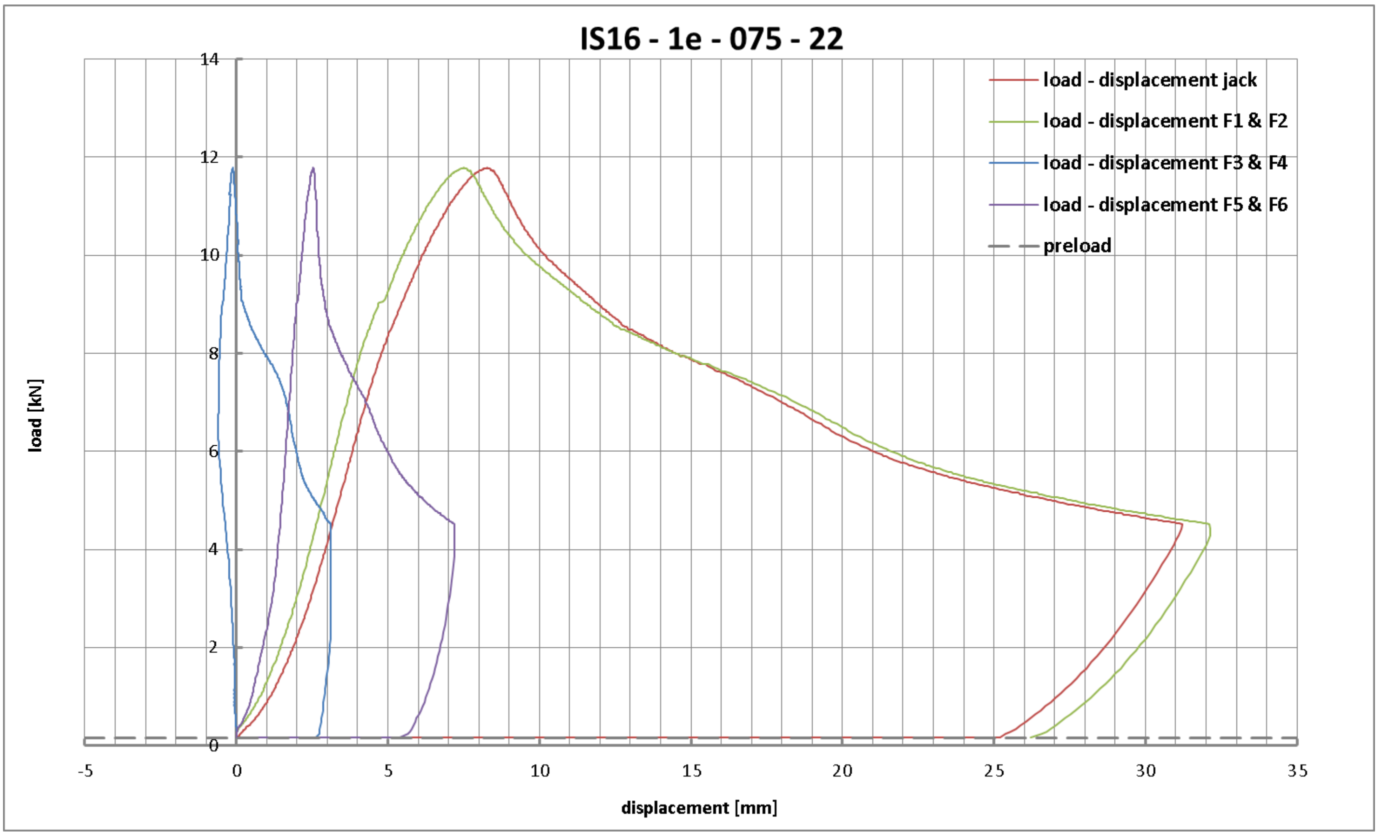

IS6 - 1e - 075 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40

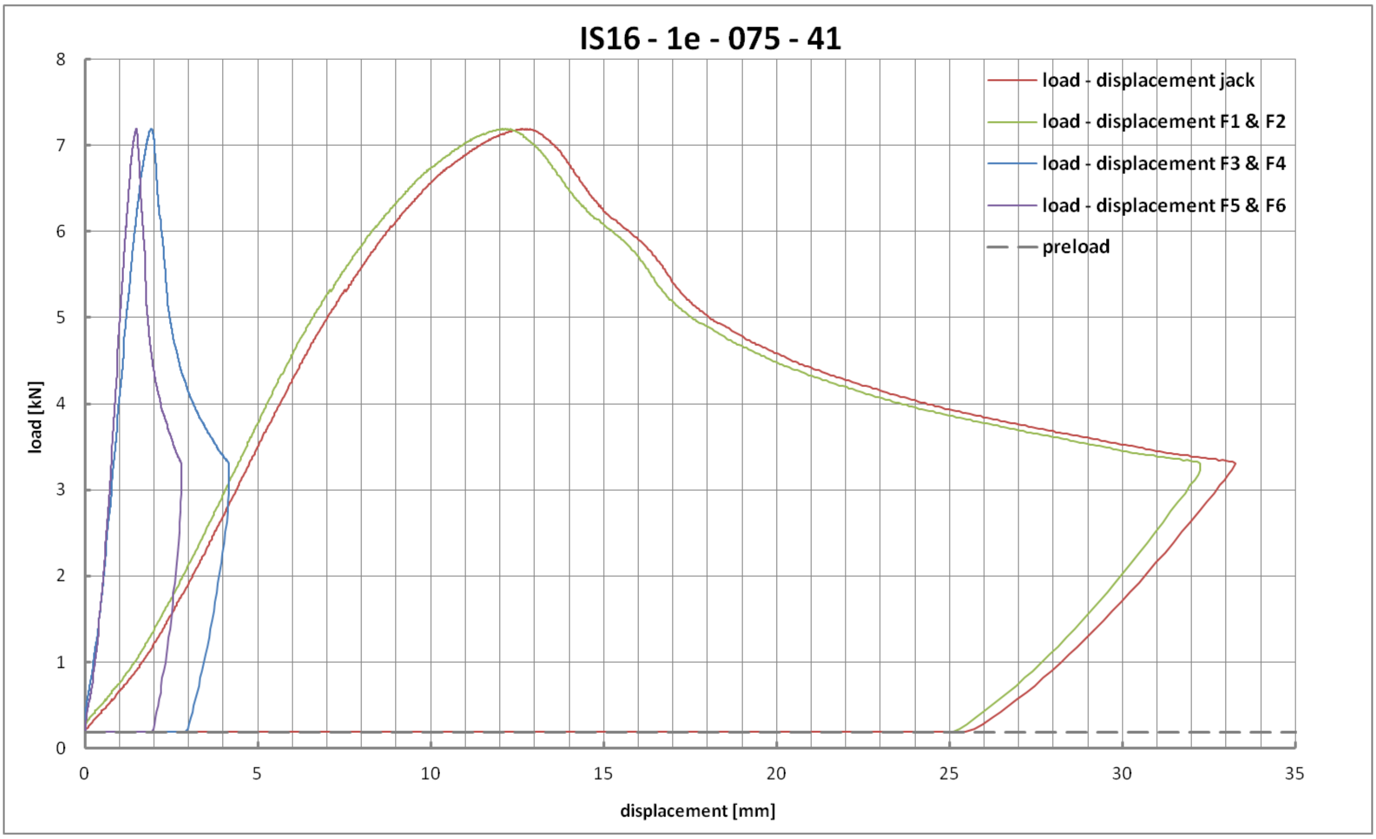

IS6 - 1e - 075 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40

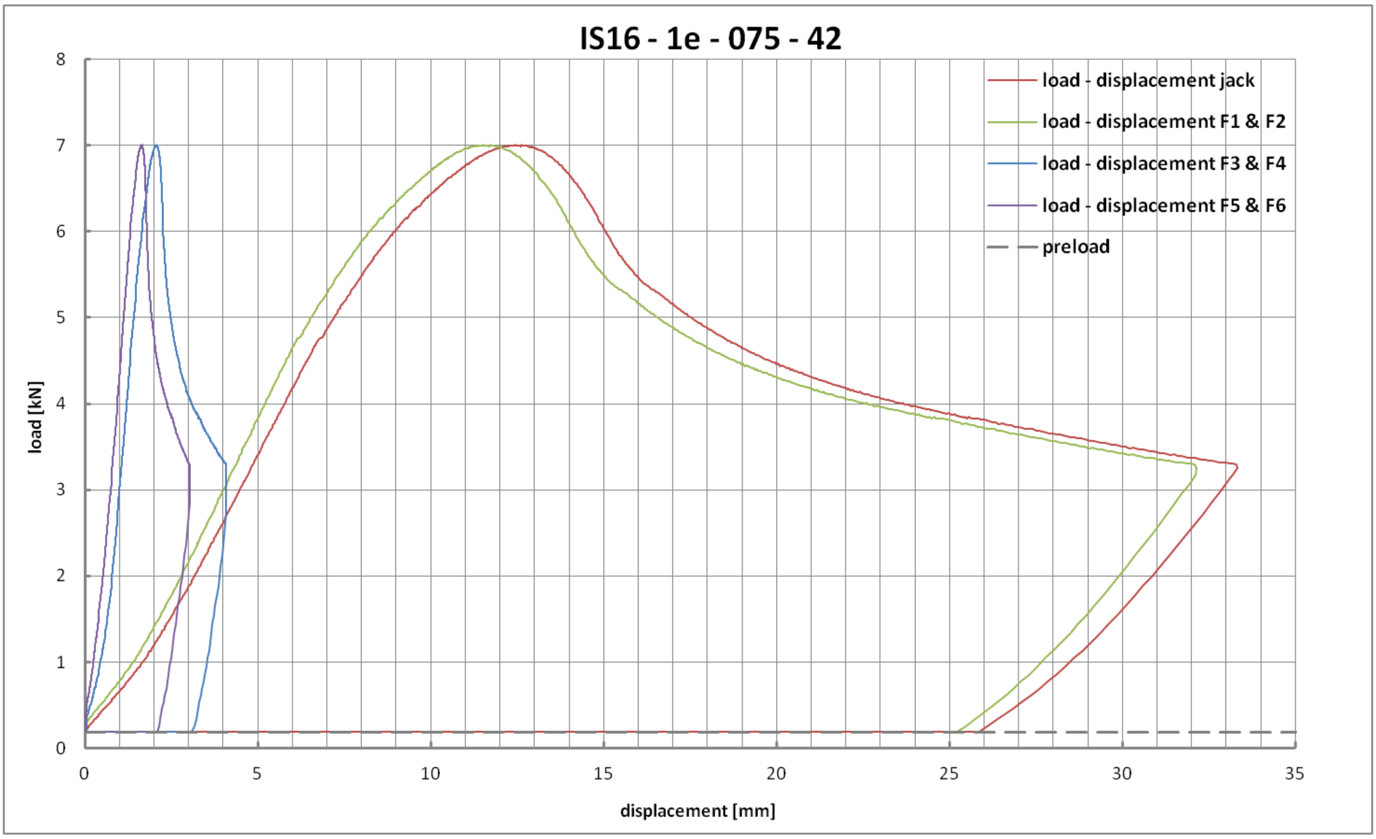

IS16 - 1e - 075 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
5
10
15
20
25
30
35
40


IS16 - 1e - 075 - 12
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
5
10
15
20
25
0
5
10
15
20
25
30
35
40
45


IS16 - 1e - 075 - 21
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
-5
0
5
10
15
20
25
30
35


IS16 - 1e - 075 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
14
12
10
8
6
4
2
0
-5
0
5
10
15
20
25
30
35


IS16 - 1e - 075 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25
30
35


IS16 - 1e - 075 - 42
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
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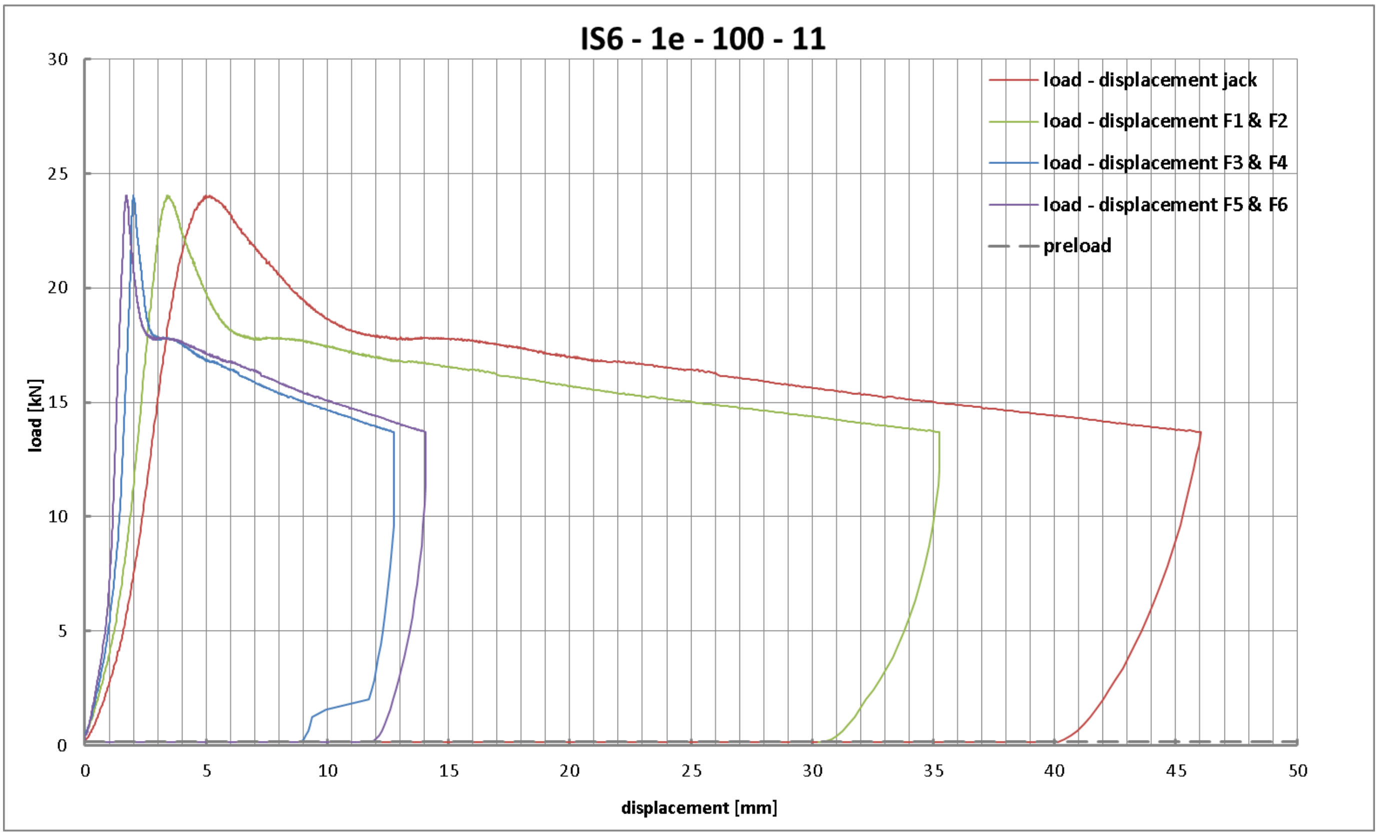
IS6 - 1e - 100 - 11
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
5
10
15
20
25
30
0
5
10
15
20
25
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35
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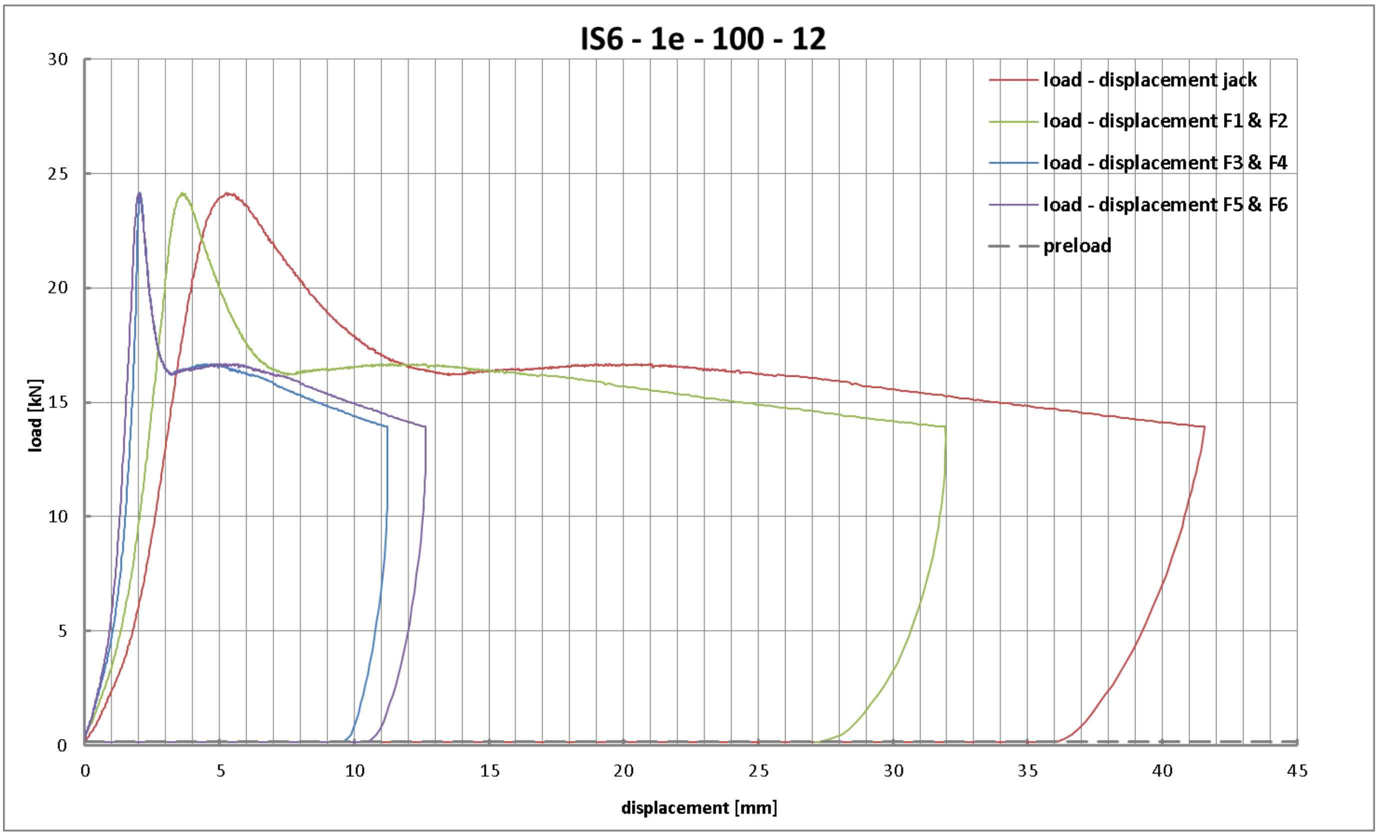
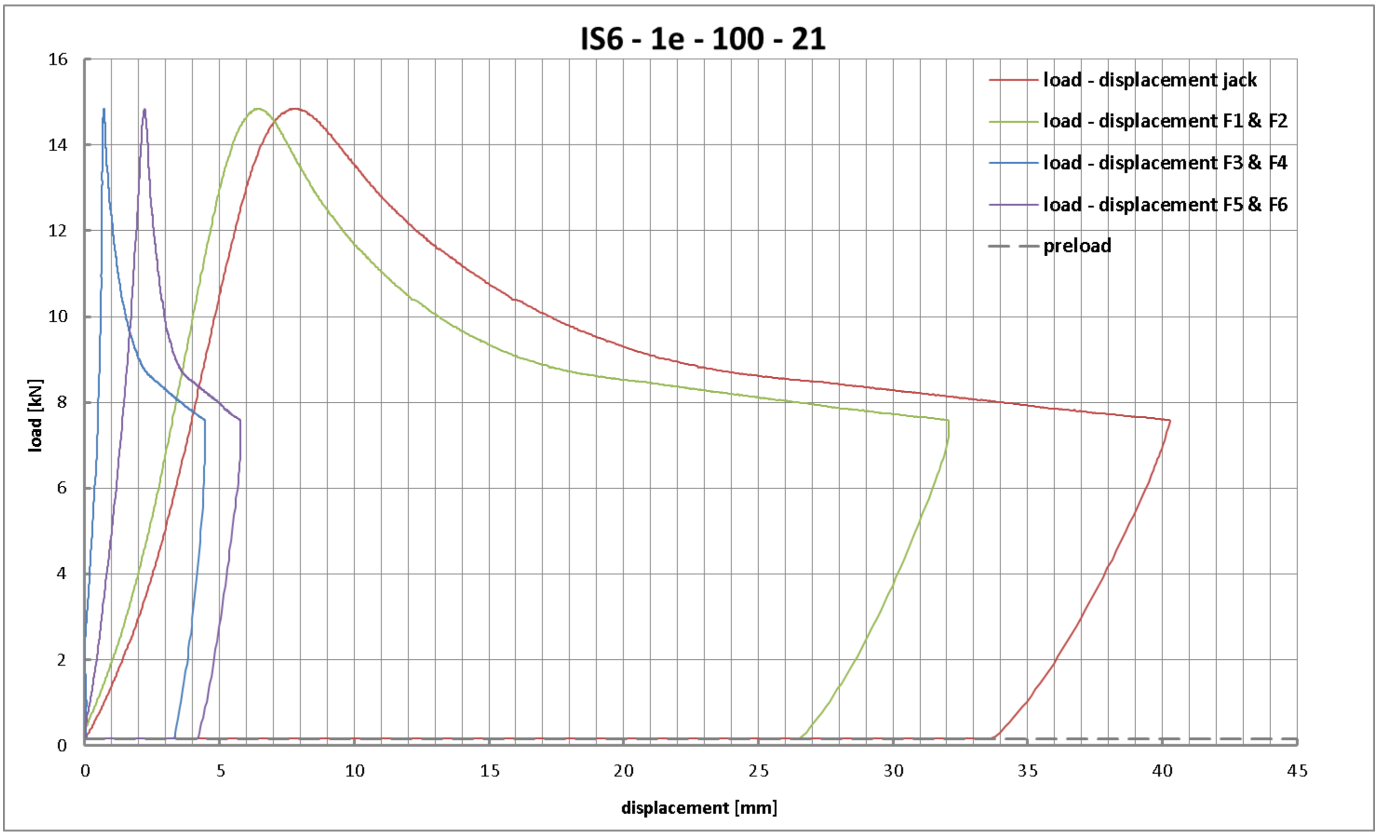
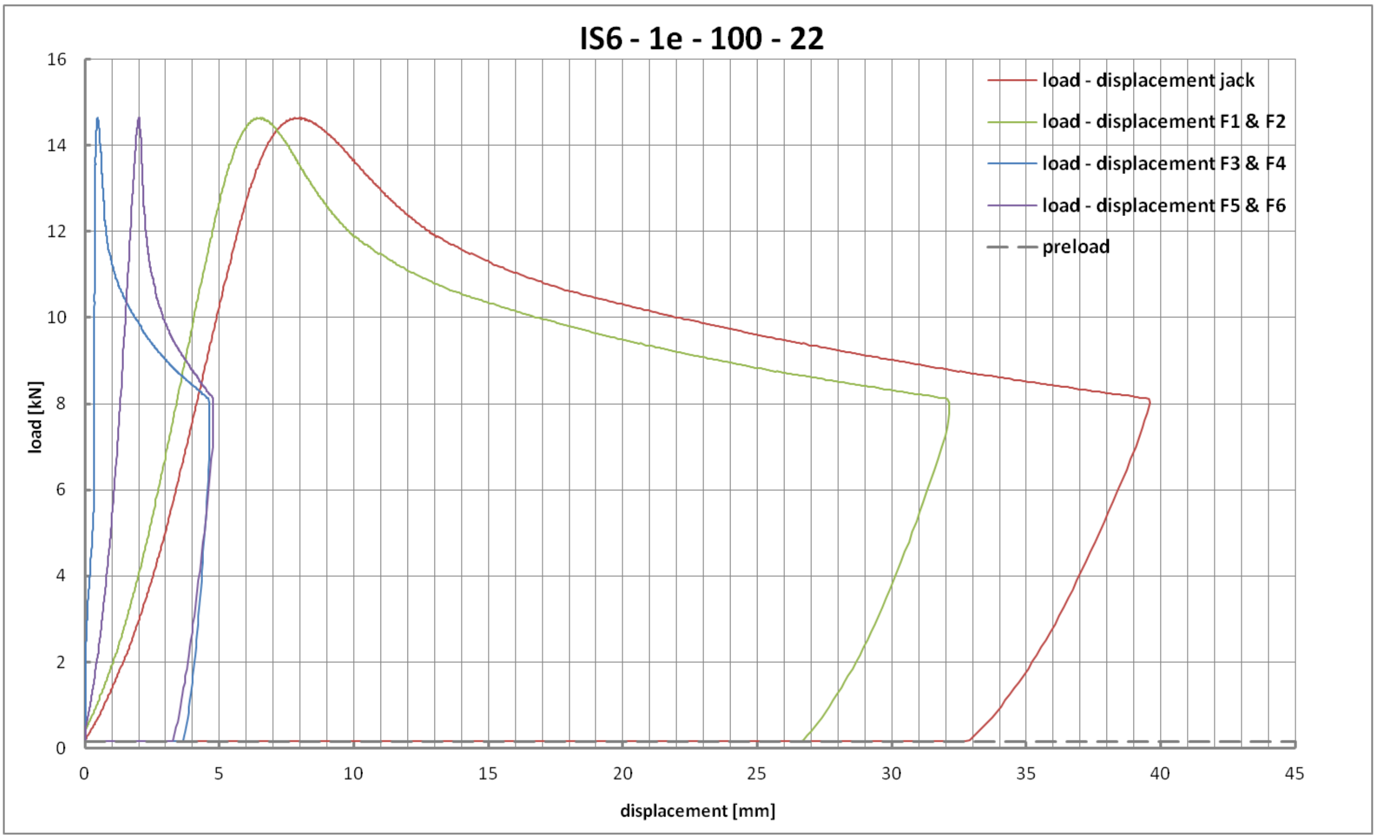

IS6 - 1e - 100 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]


IS6 - 1e - 100 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]



IS6 - 1e - 100 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
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8
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12
14
16
0
5
10
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20
25
30
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40
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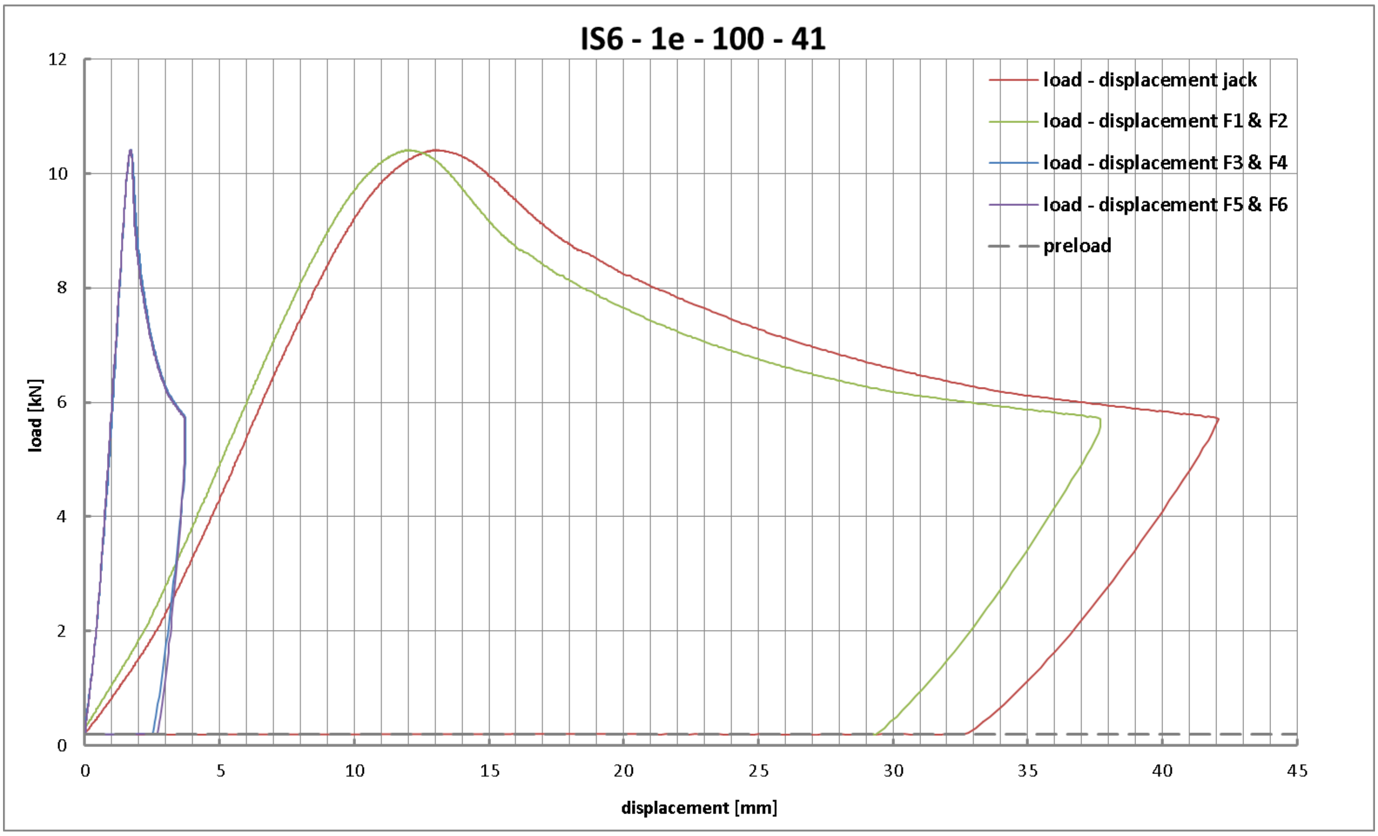

IS6 - 1e - 100 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
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12
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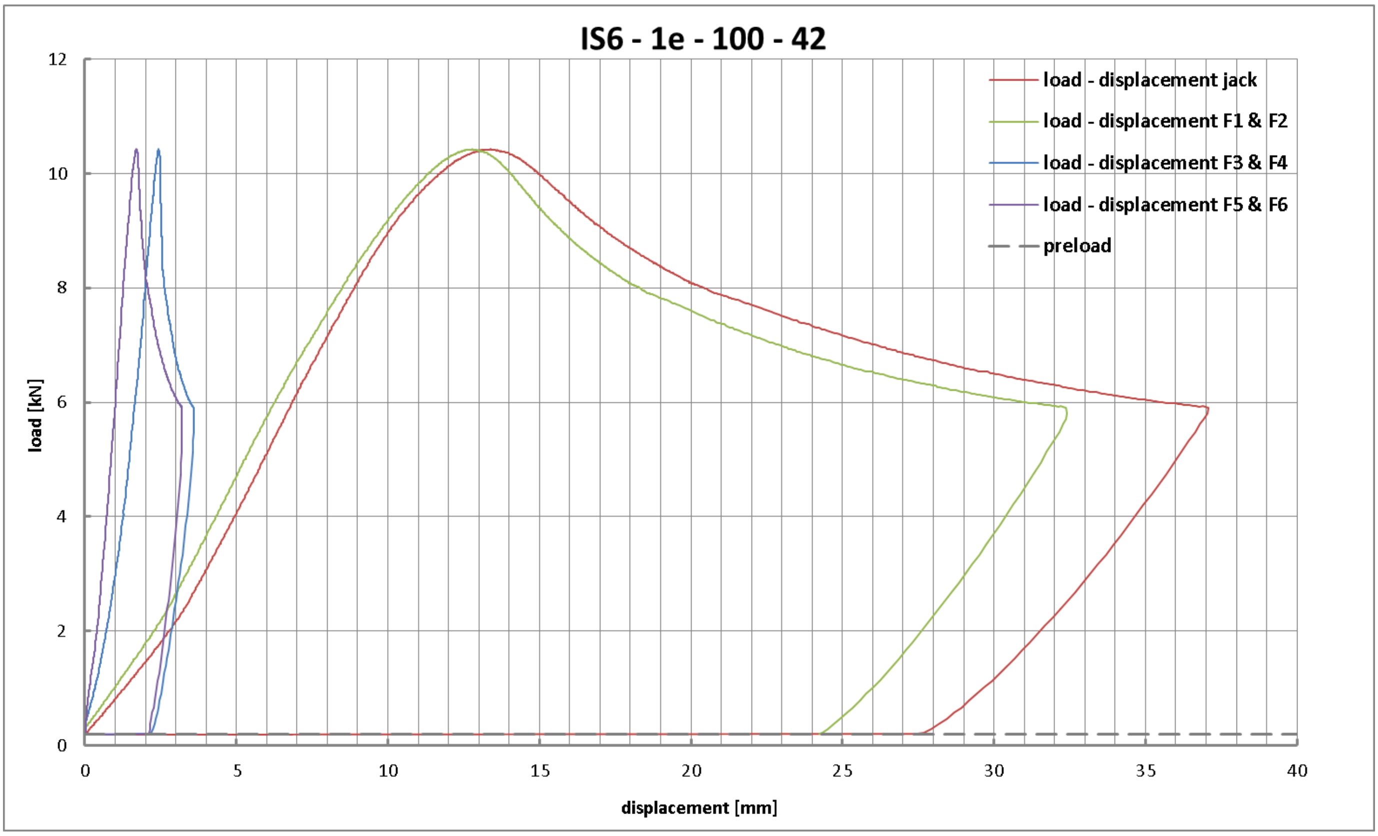
IS6 - 1e - 100 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
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12
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5
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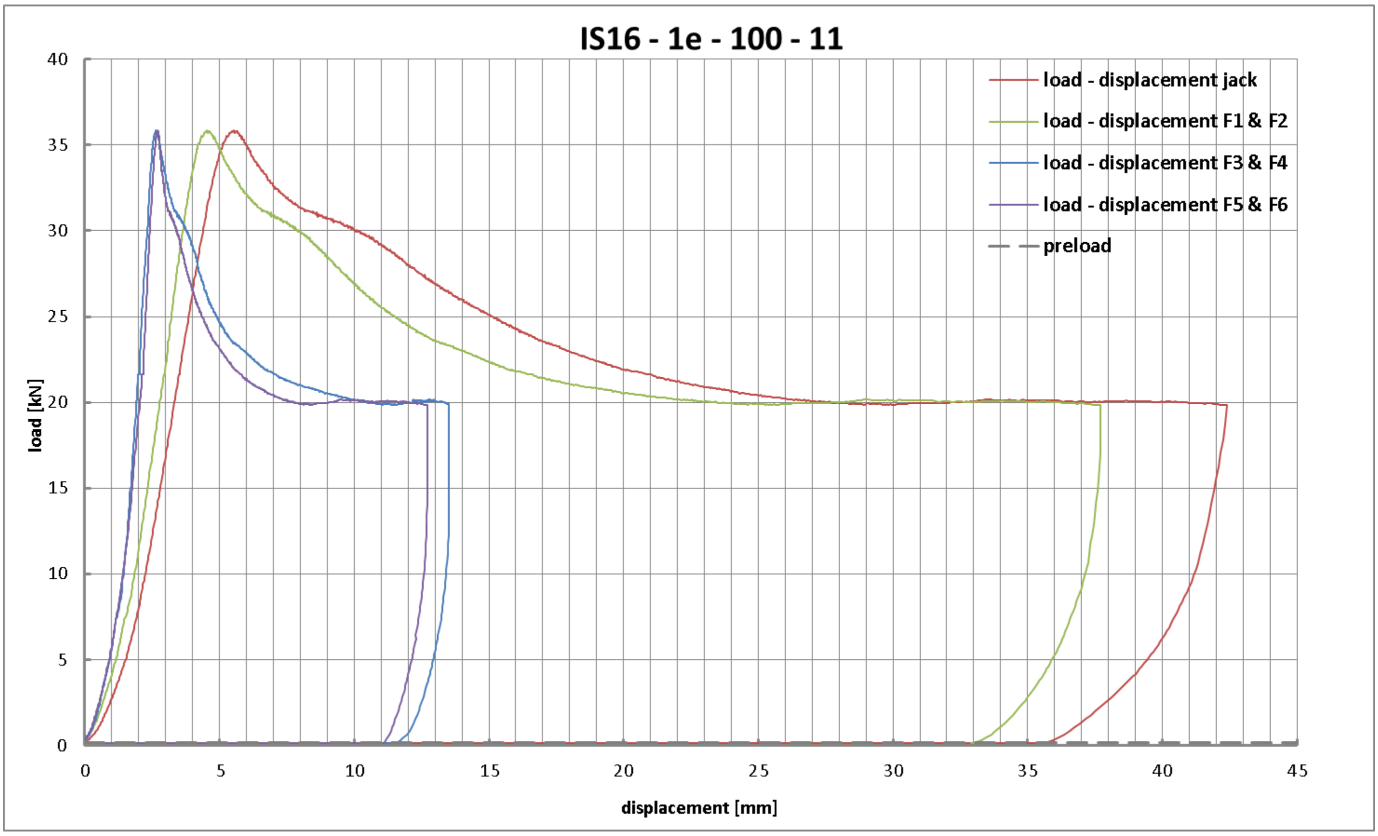
IS16 - 1e - 100 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
0
5
10
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20
25
30
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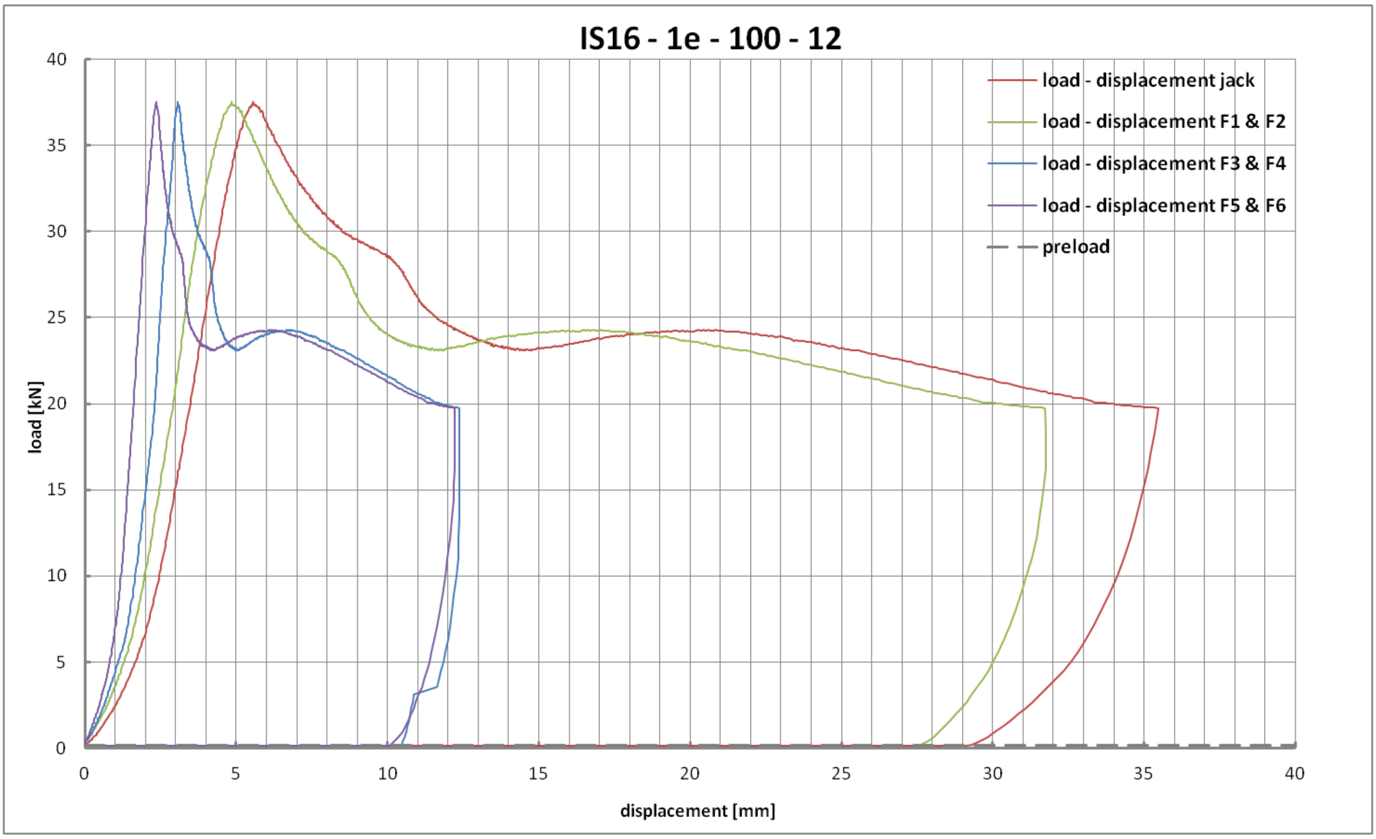
IS16 - 1e - 100 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
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25
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35
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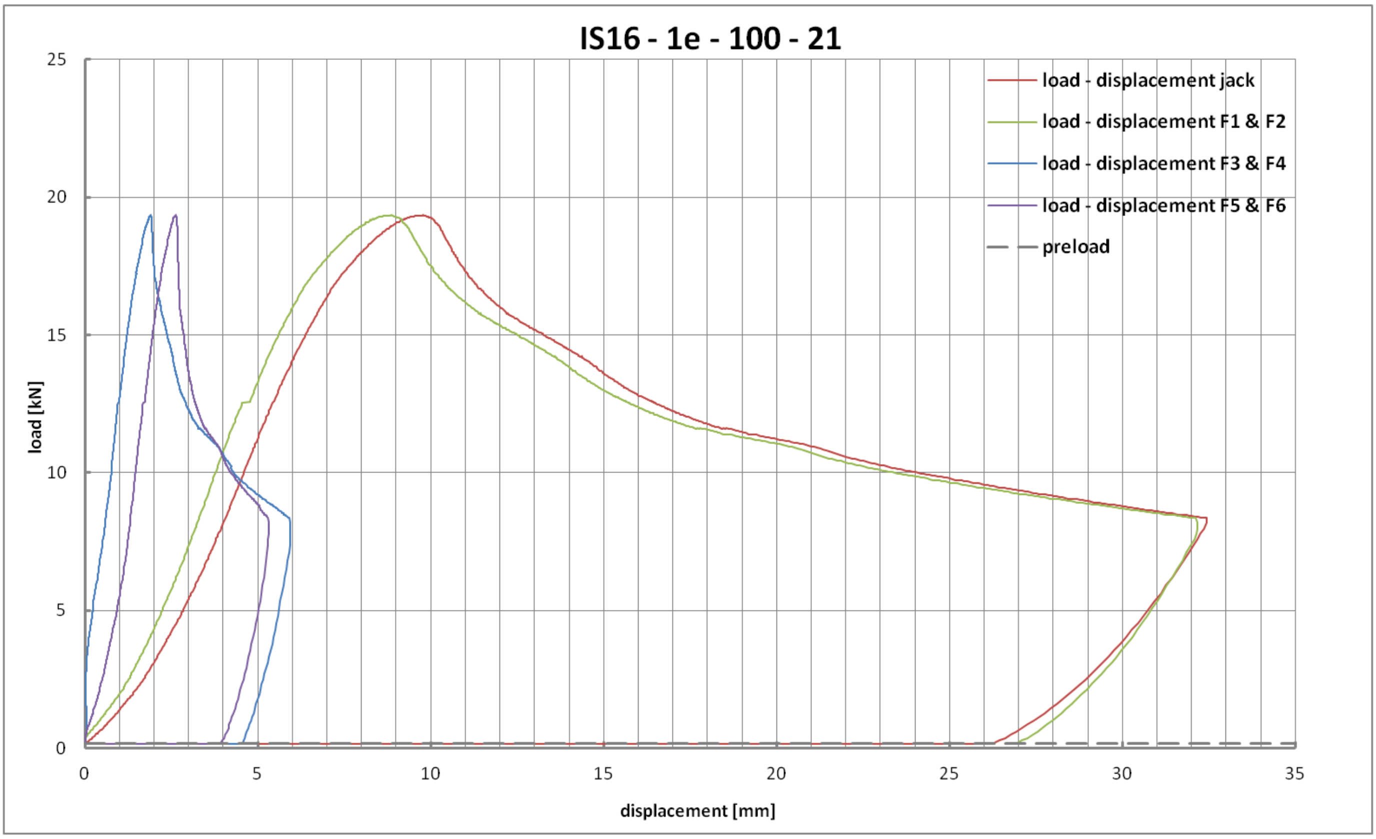
IS16 - 1e - 100 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
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15
20
25
30
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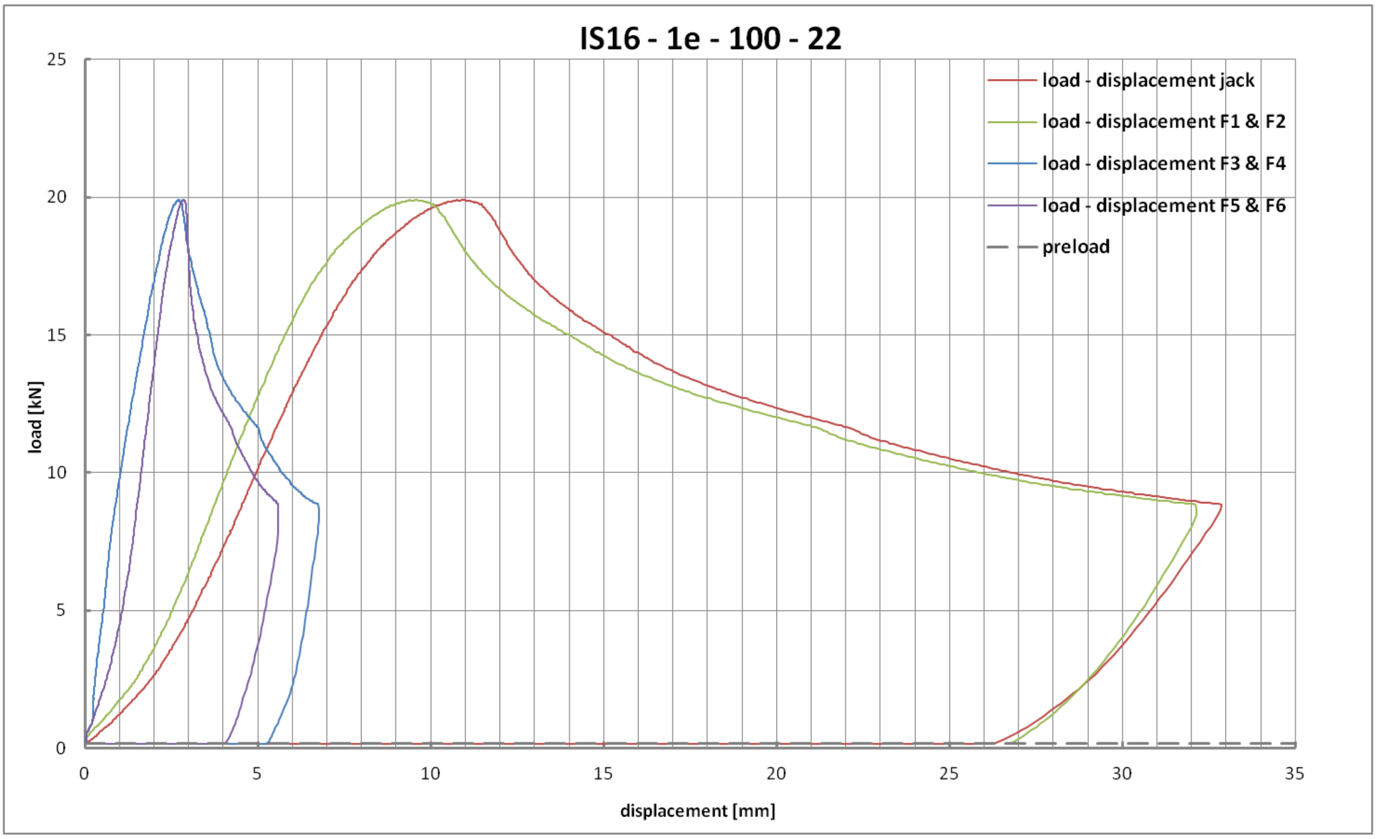
IS16 - 1e - 100 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
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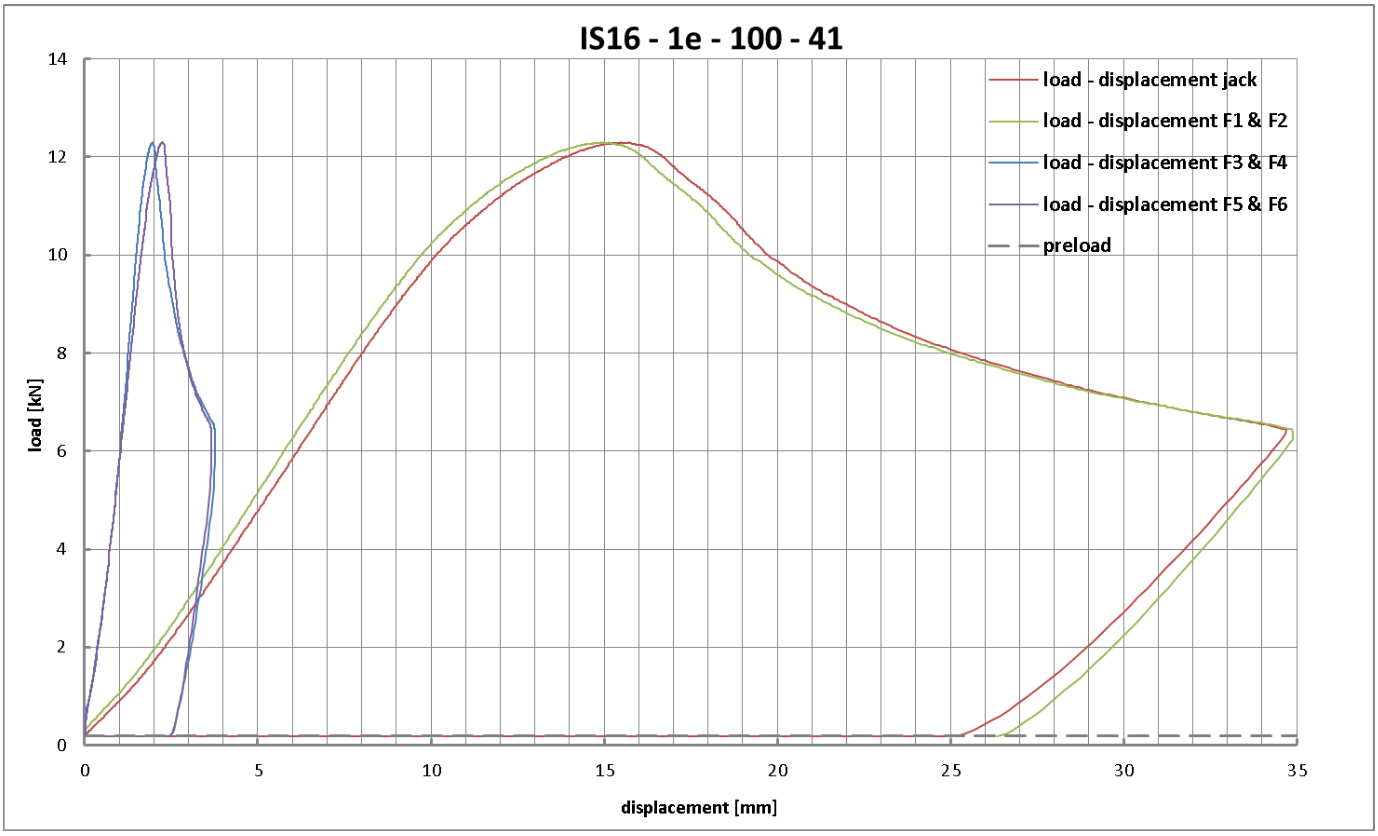
IS16 - 1e - 100 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
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5
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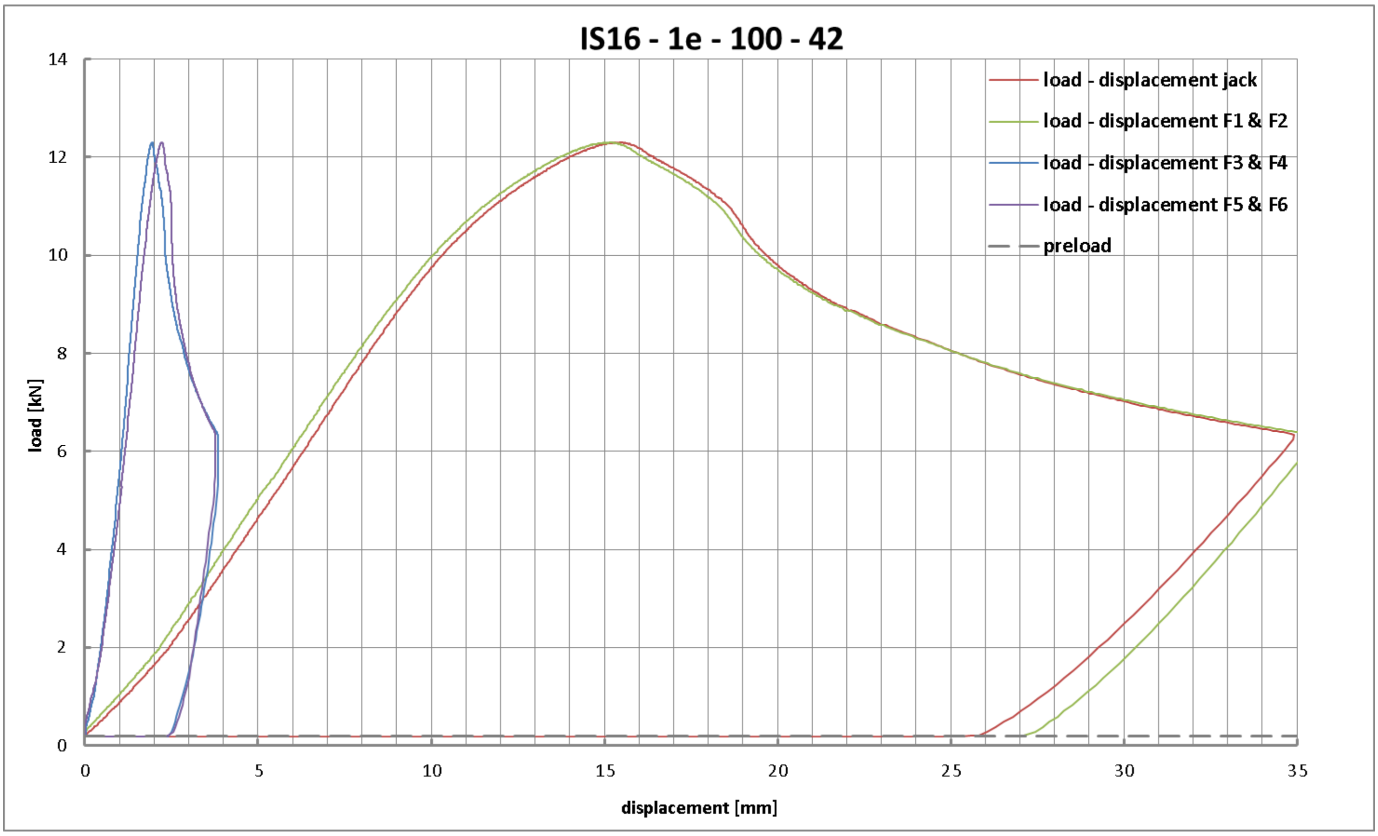
IS16 - 1e - 100 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
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0
5
10
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20
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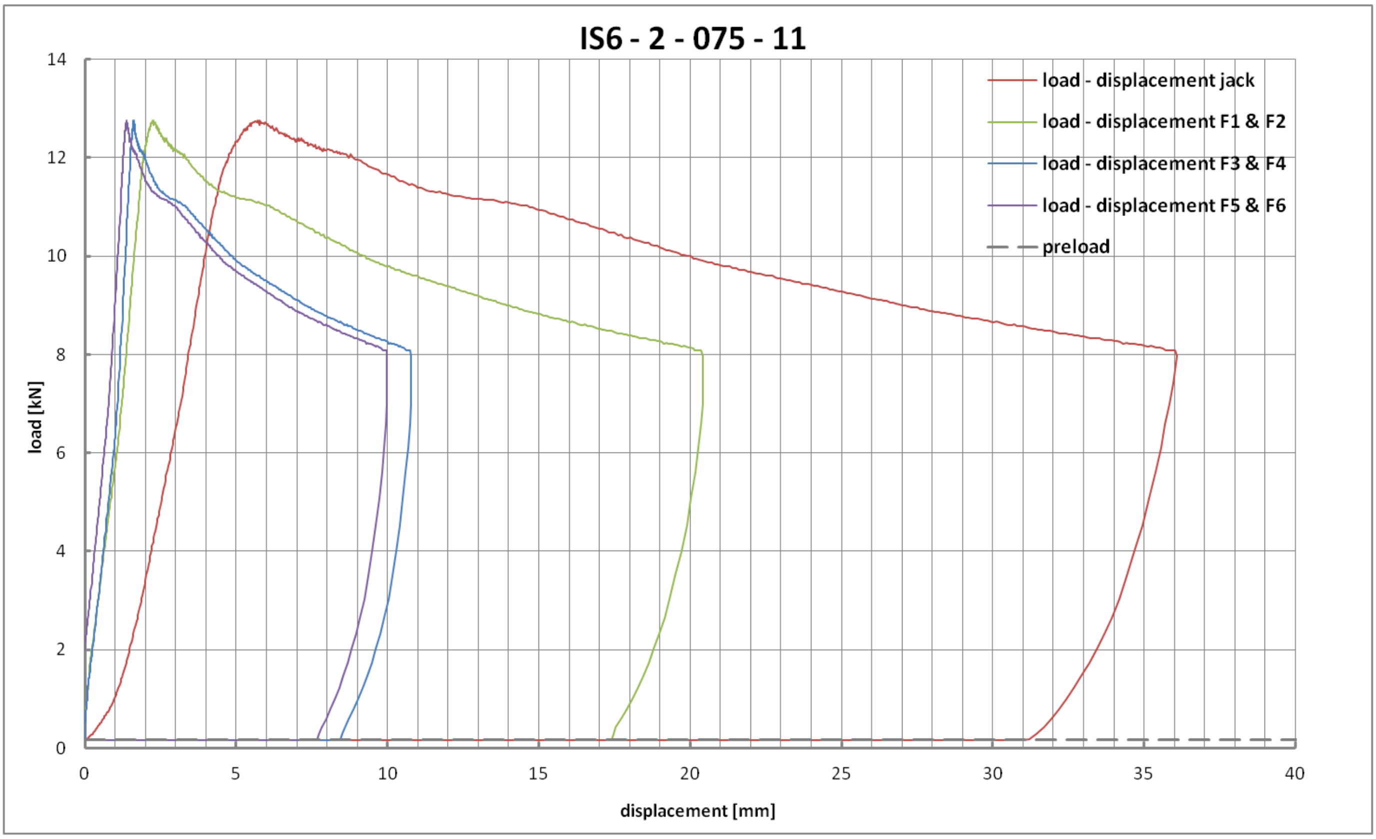
IS6 - 2 - 075 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
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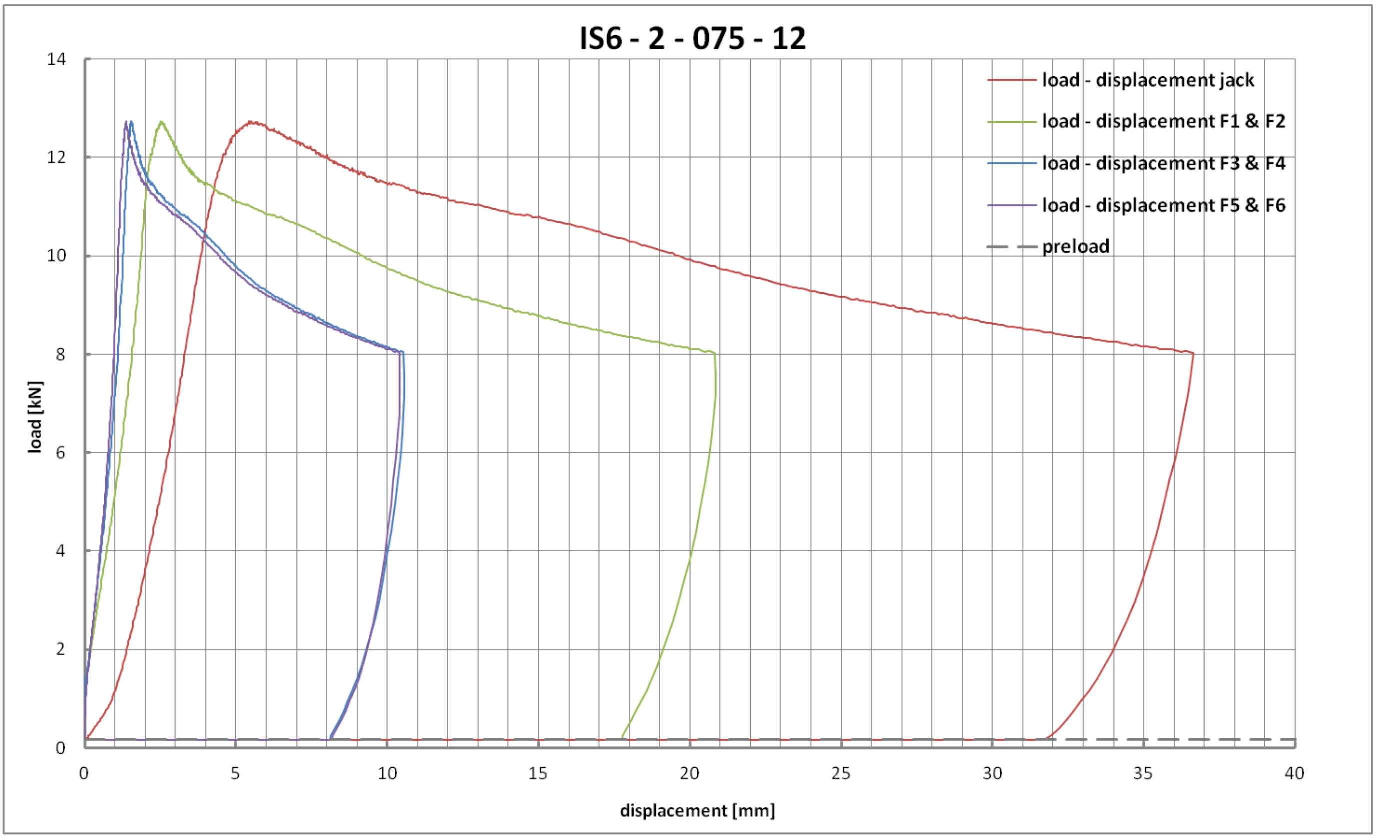

IS6 - 2 - 075 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
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35
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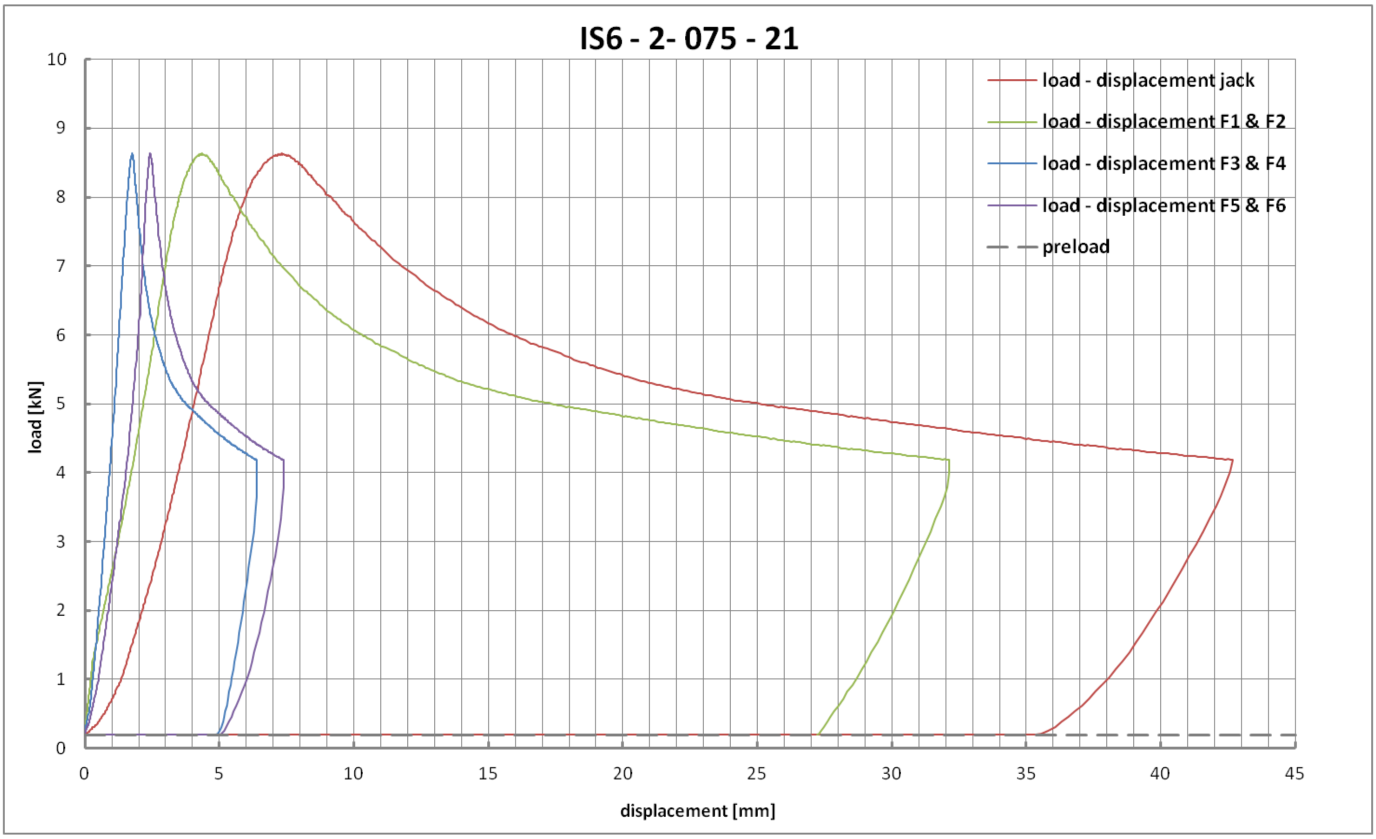
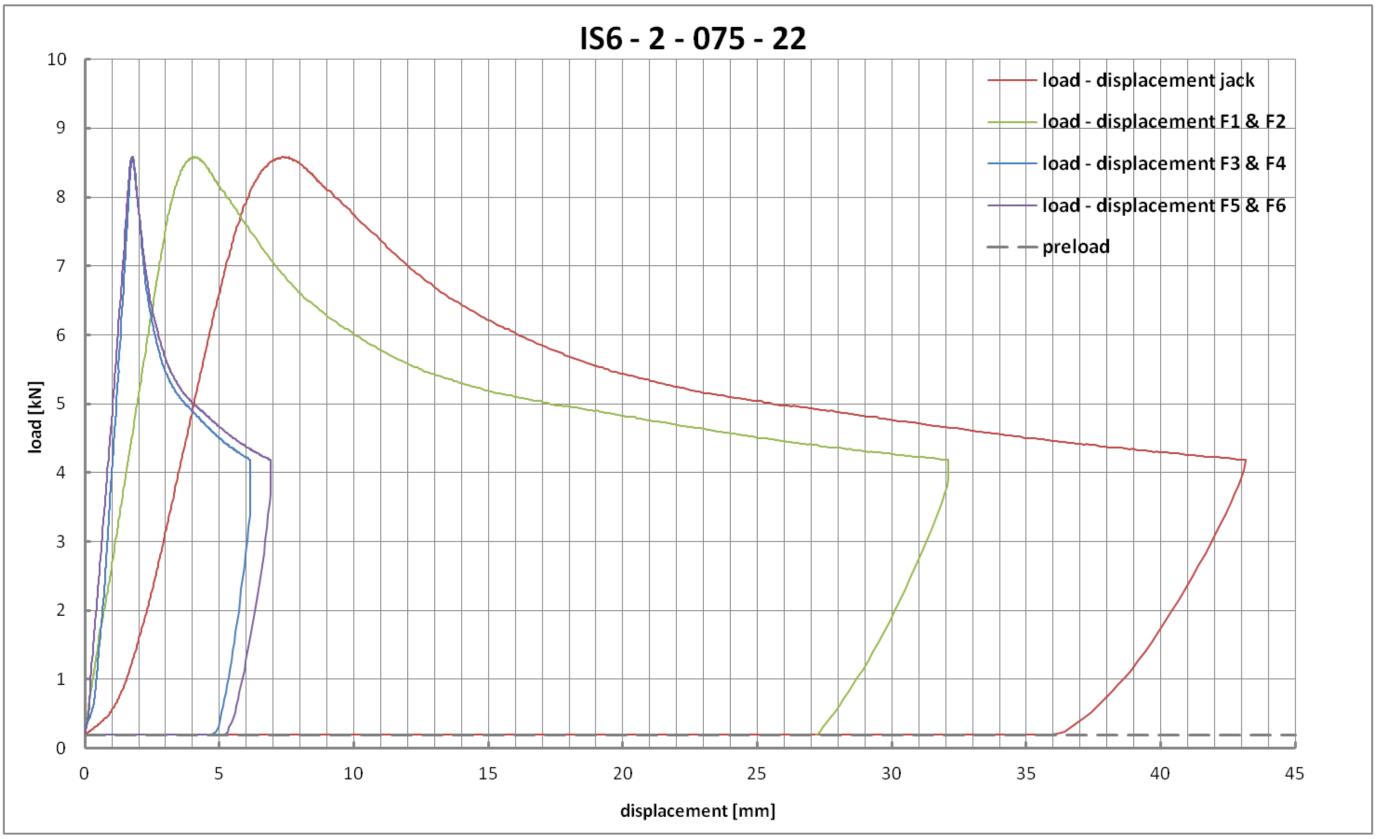


IS6 - 2- 075 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35
40
45


IS6 - 2 - 075 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
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preload
load [kN]
displacement [mm]
0
1
2
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4
5
6
7
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0
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10
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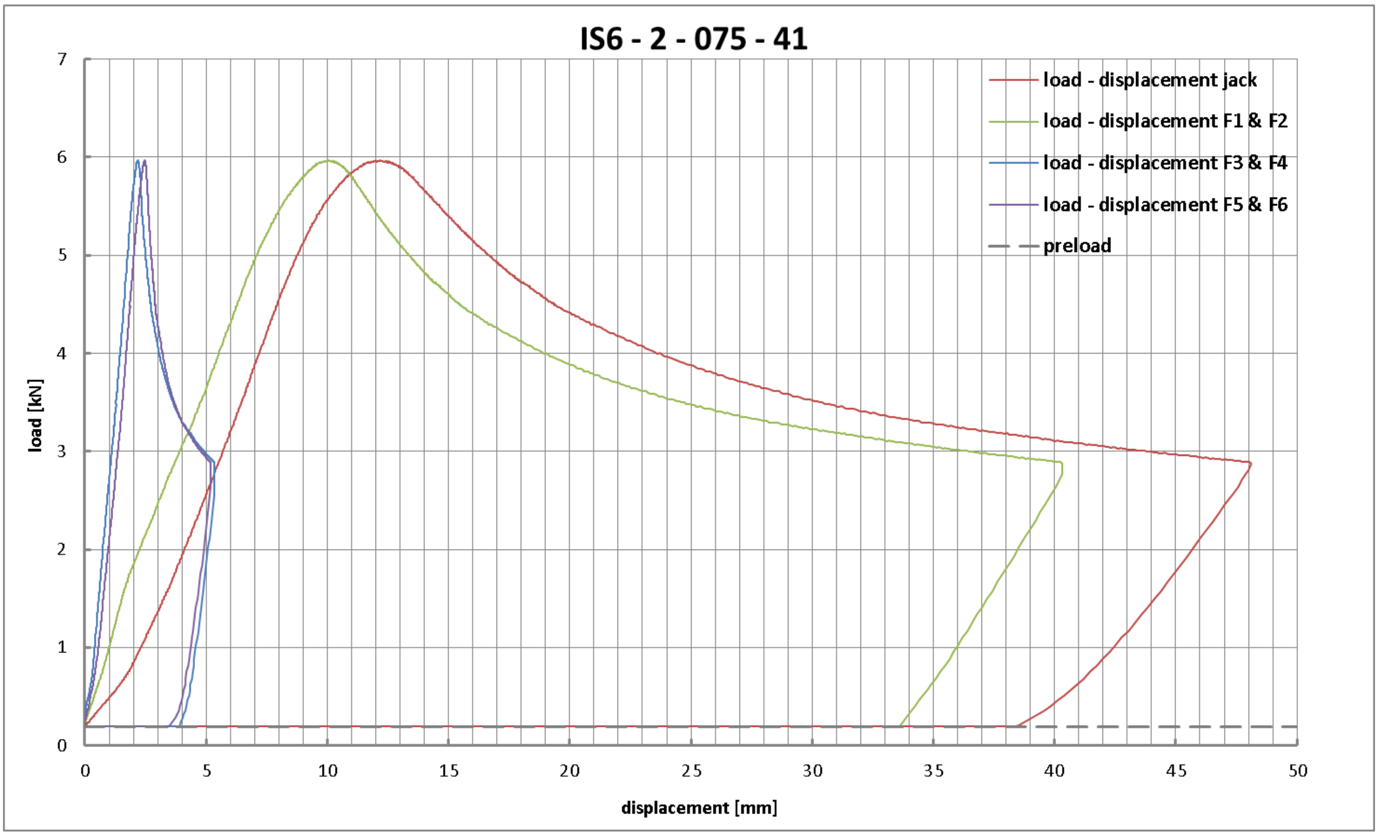
IS6 - 2 - 075 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
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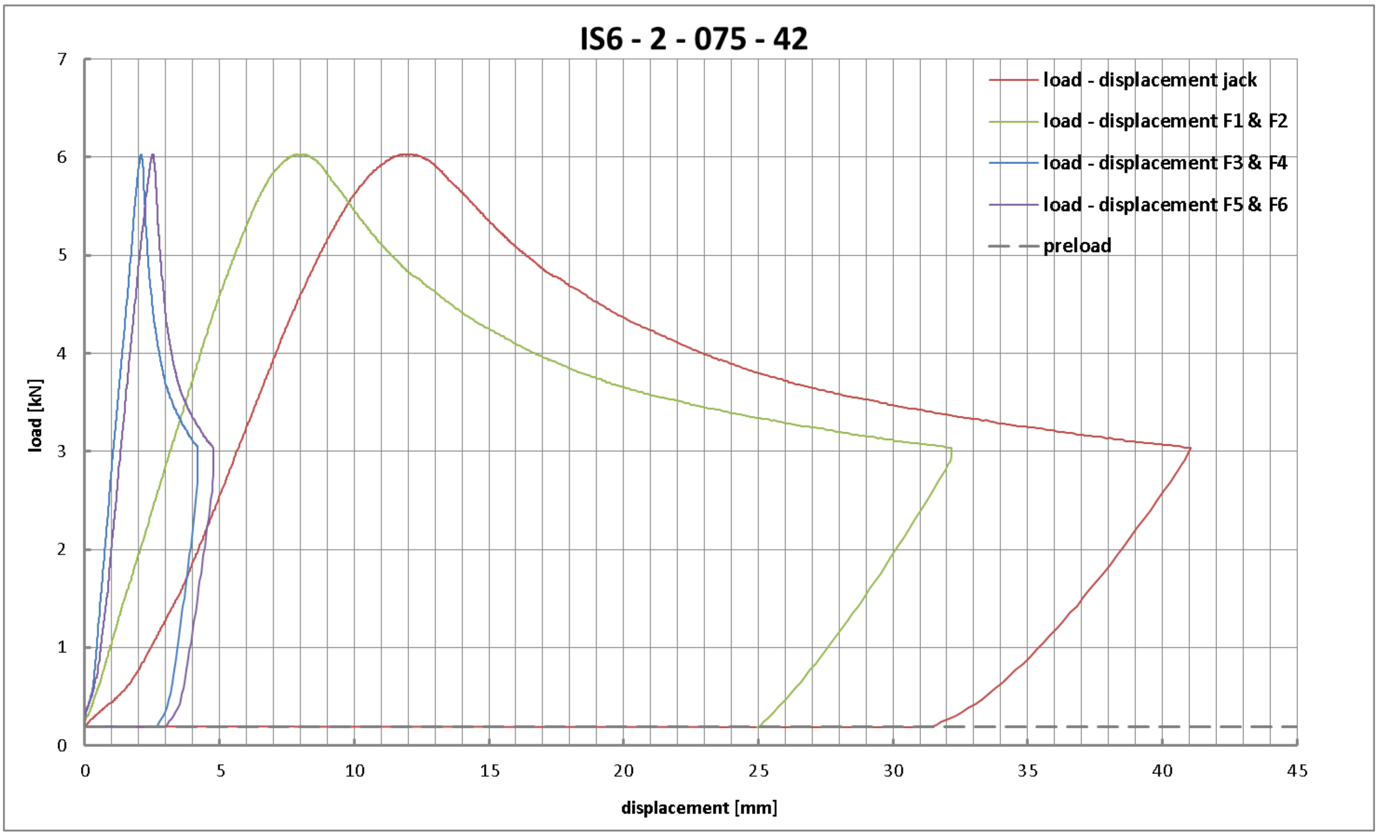
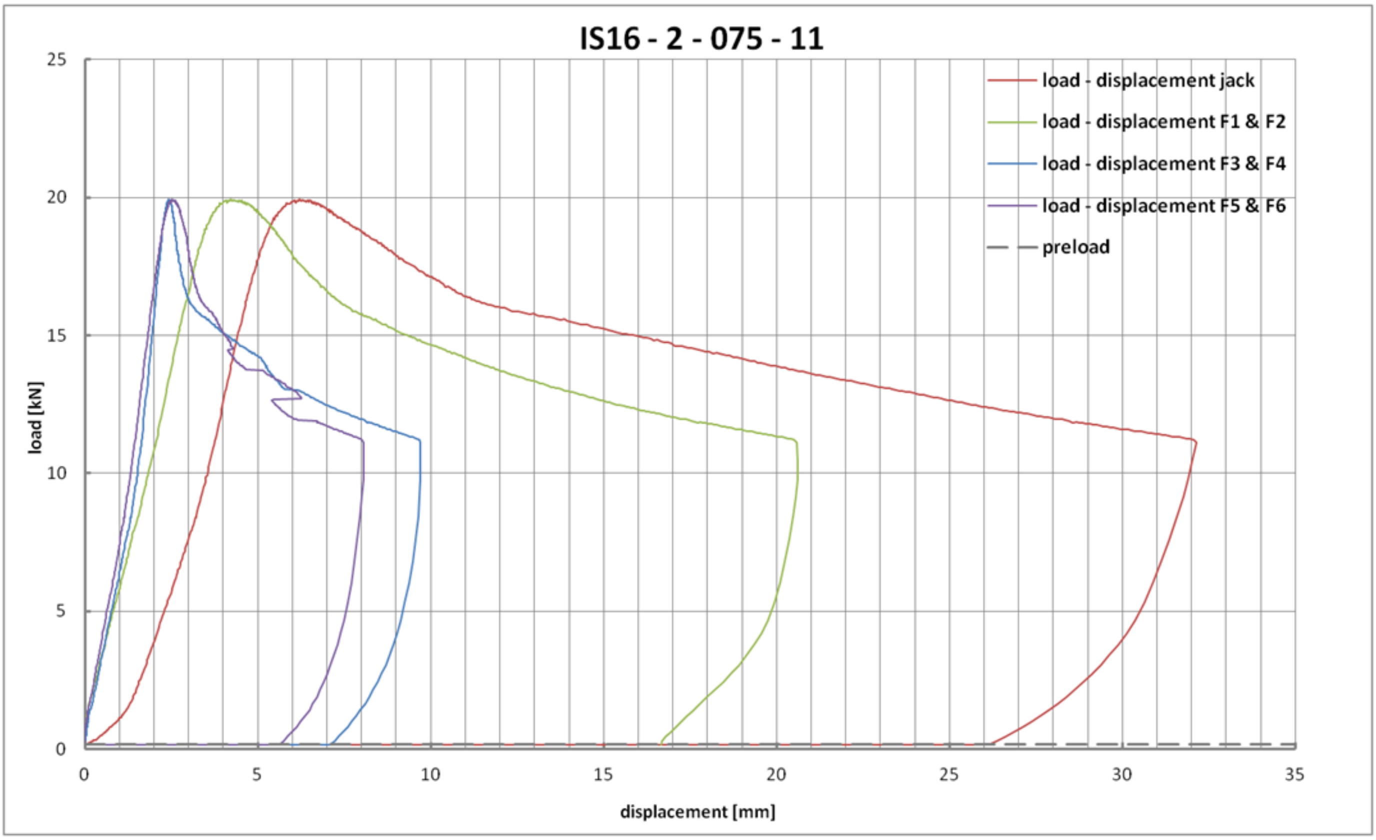
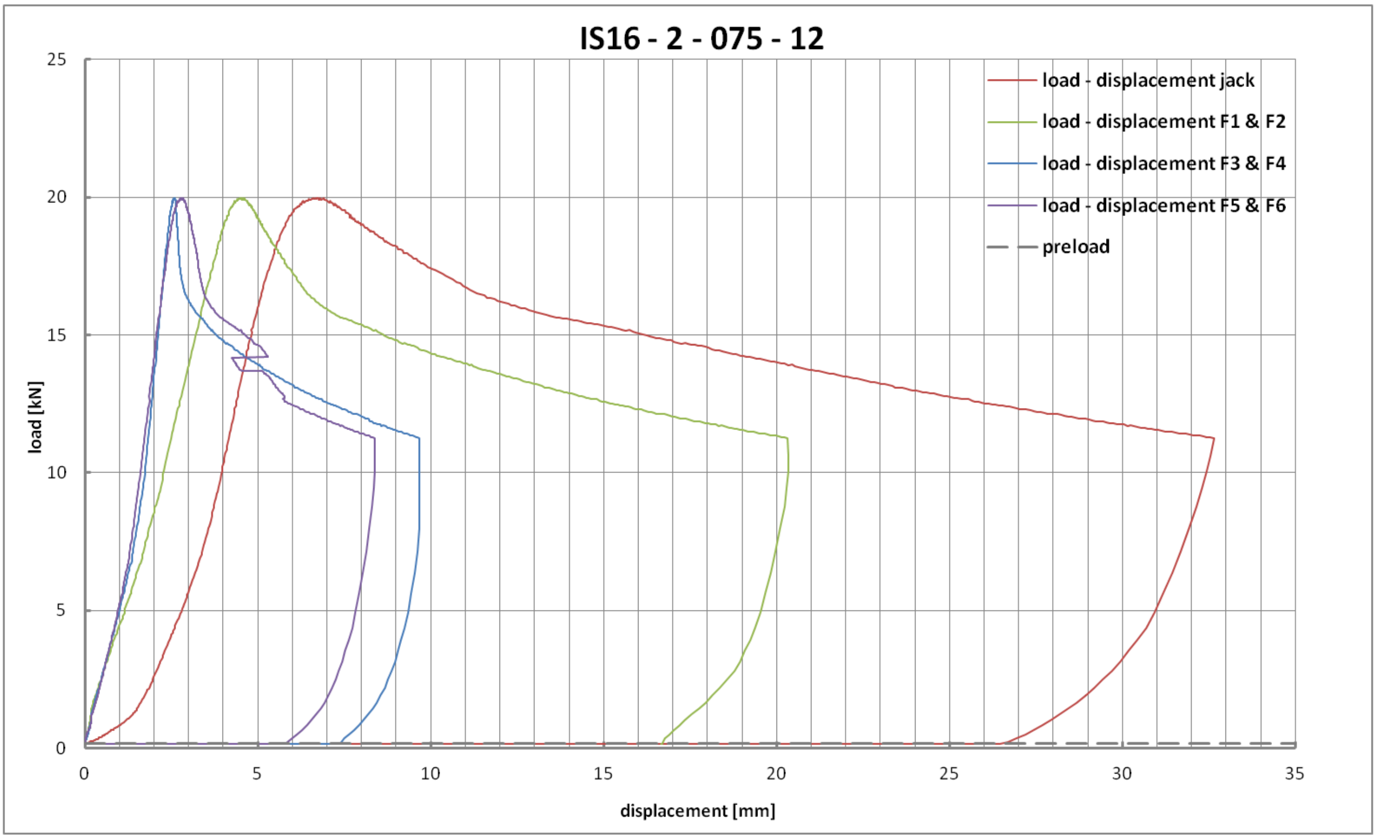
30
35
40
45
50



IS6 - 2 - 075 - 42
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload



IS16 - 2 - 075 - 11
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload


IS16 - 2 - 075 - 12
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
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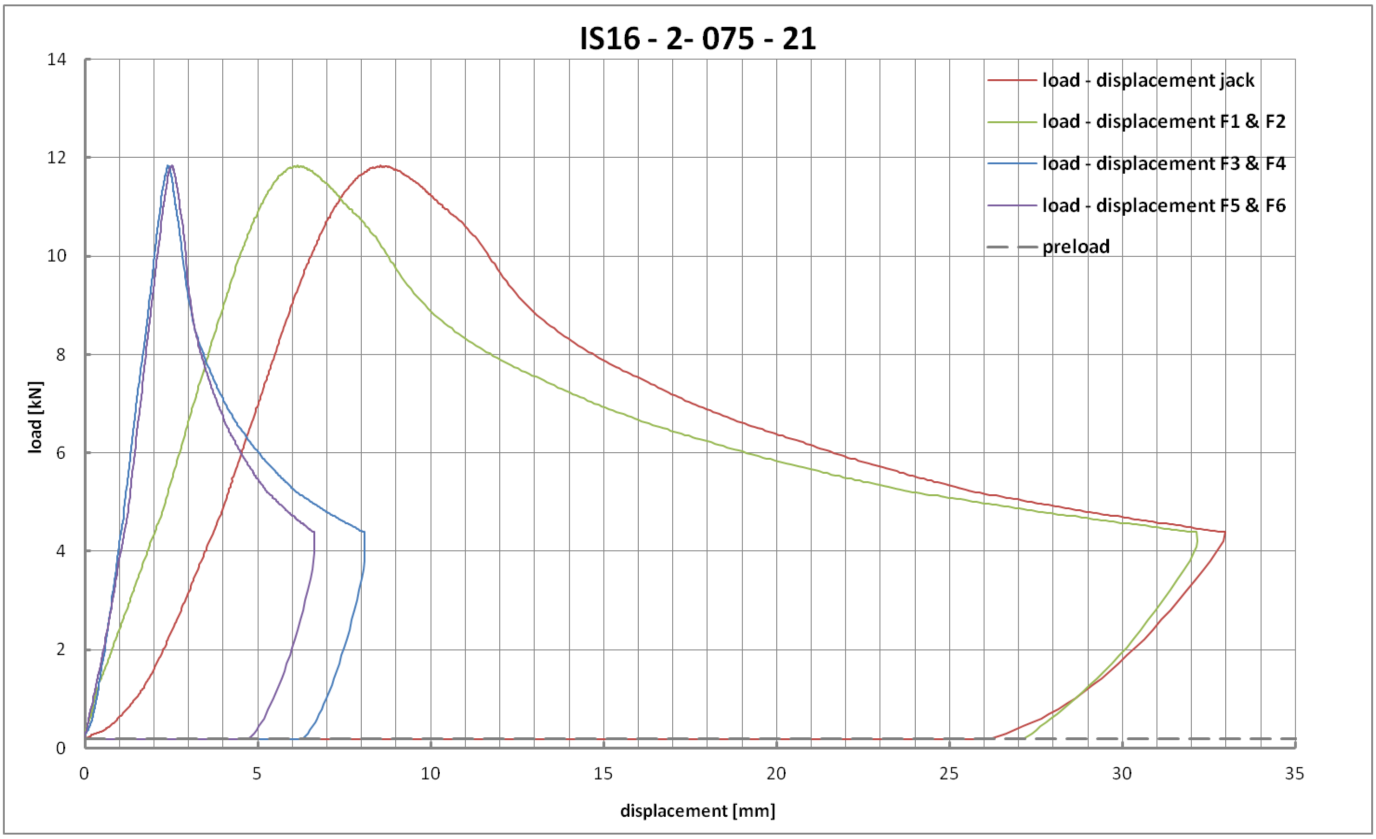
IS16 - 2- 075 - 21
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
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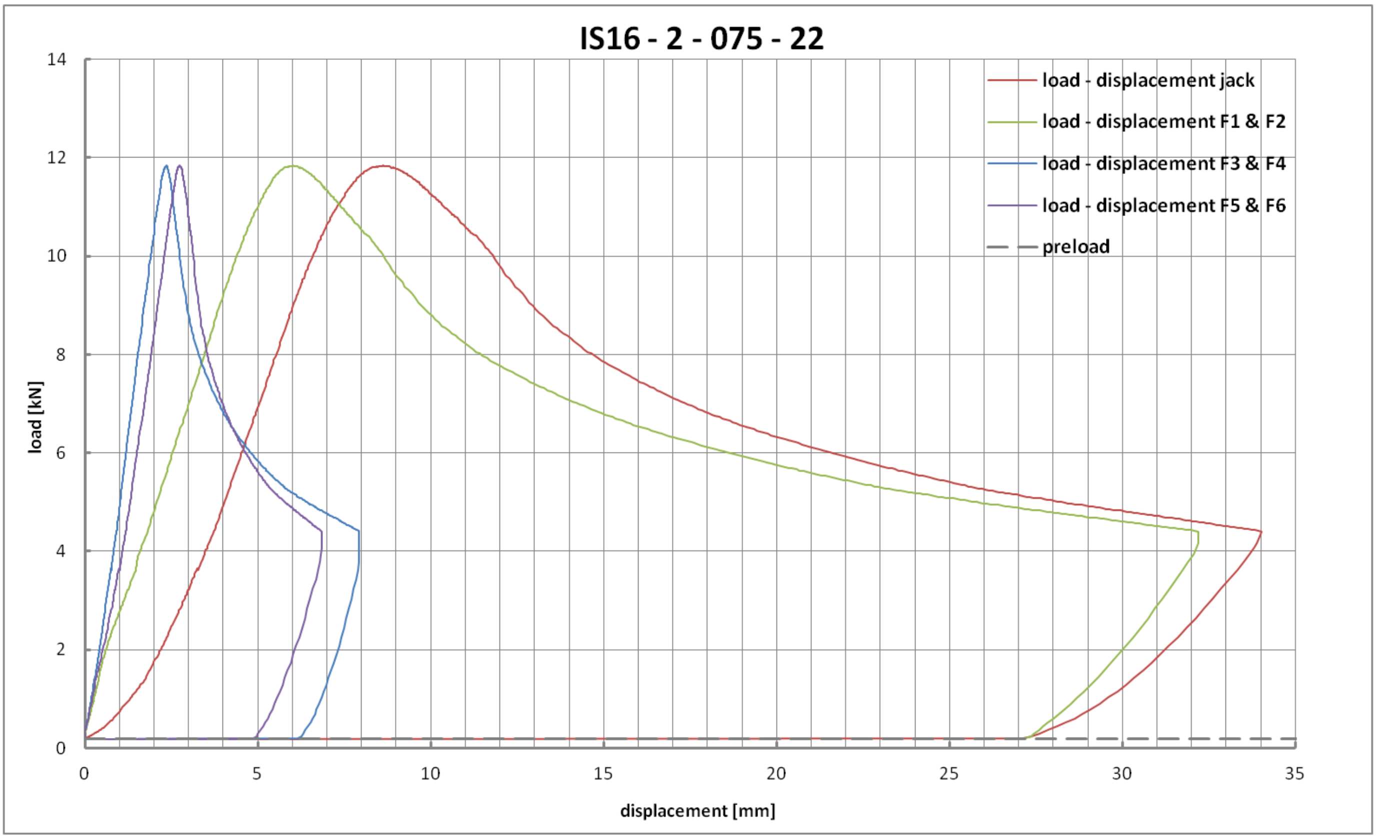

IS16 - 2 - 075 - 22
load - displacement jack
load - displacement F1 & F2
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load - displacement F5 & F6
preload
load [kN]
displacement [mm]
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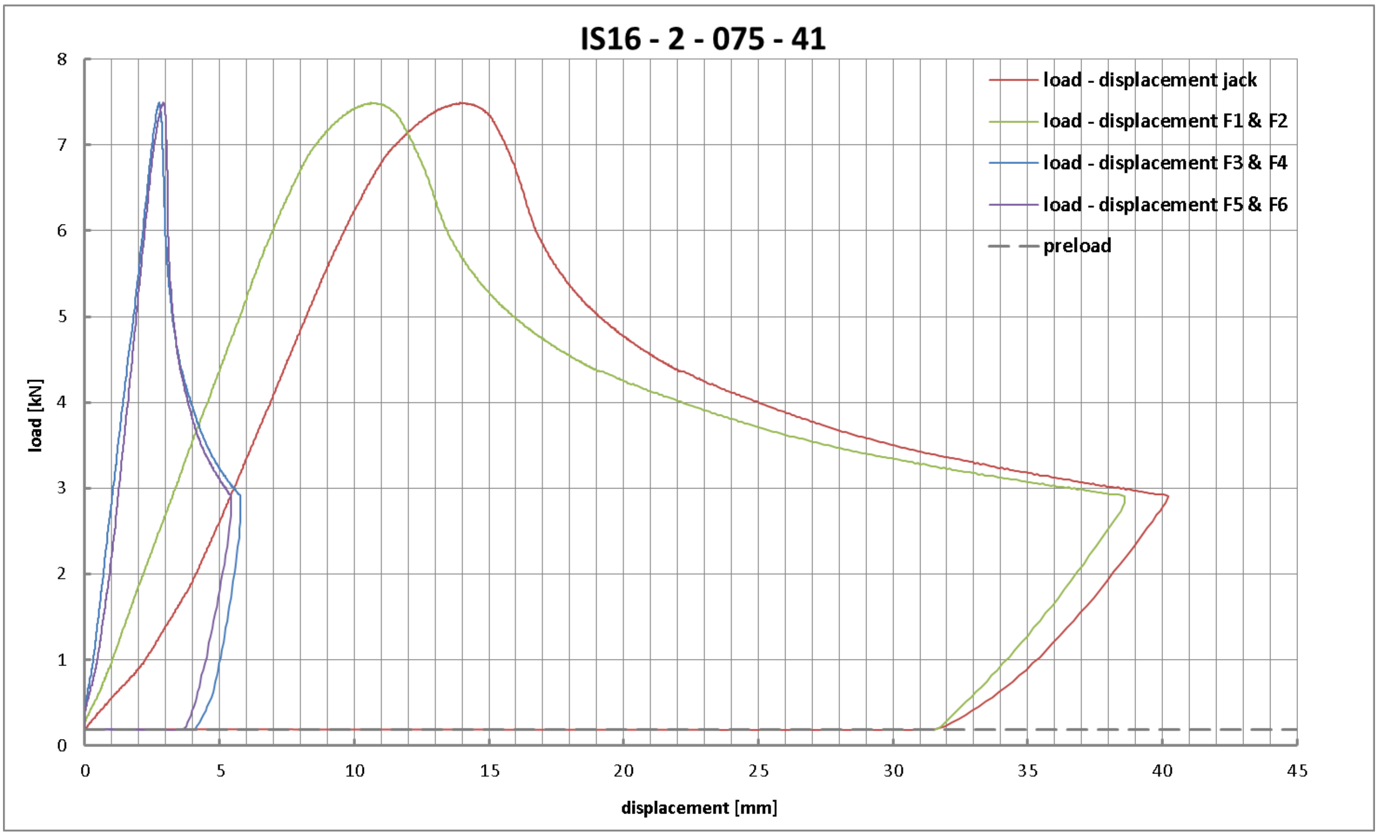

IS16 - 2 - 075 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
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2
3
4
5
6
7
8
0
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10
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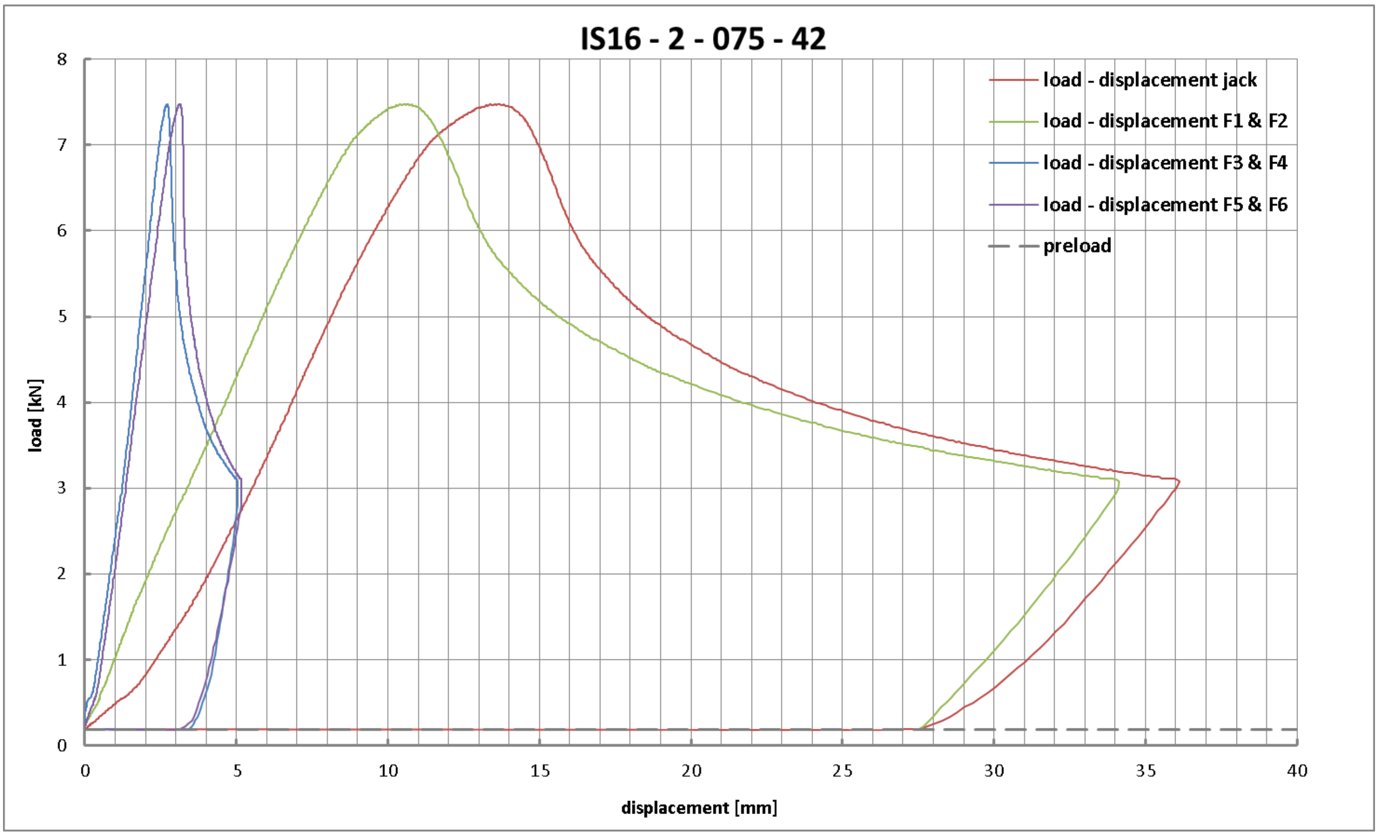

IS16 - 2 - 075 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
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4
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6
7
8
0
5
10
15
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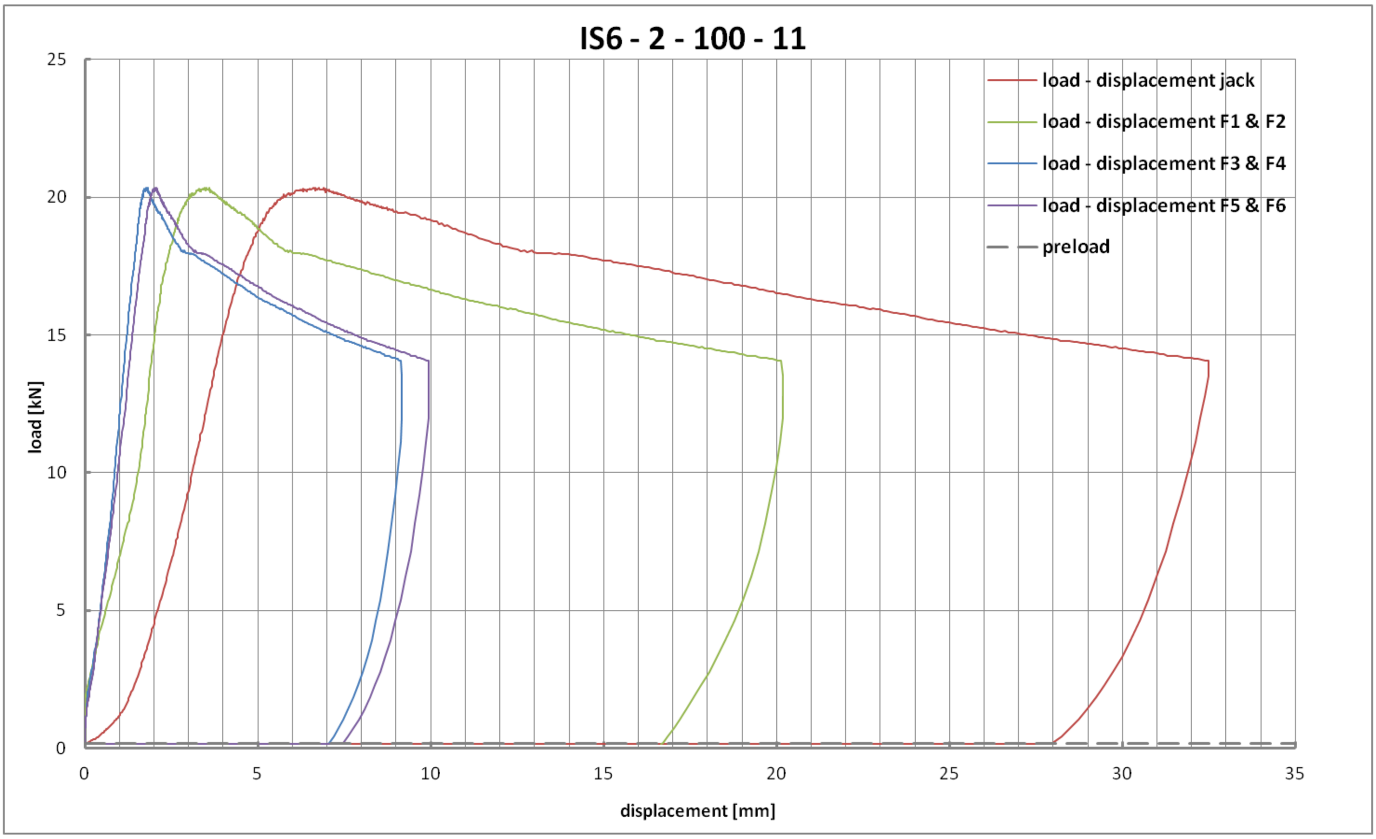
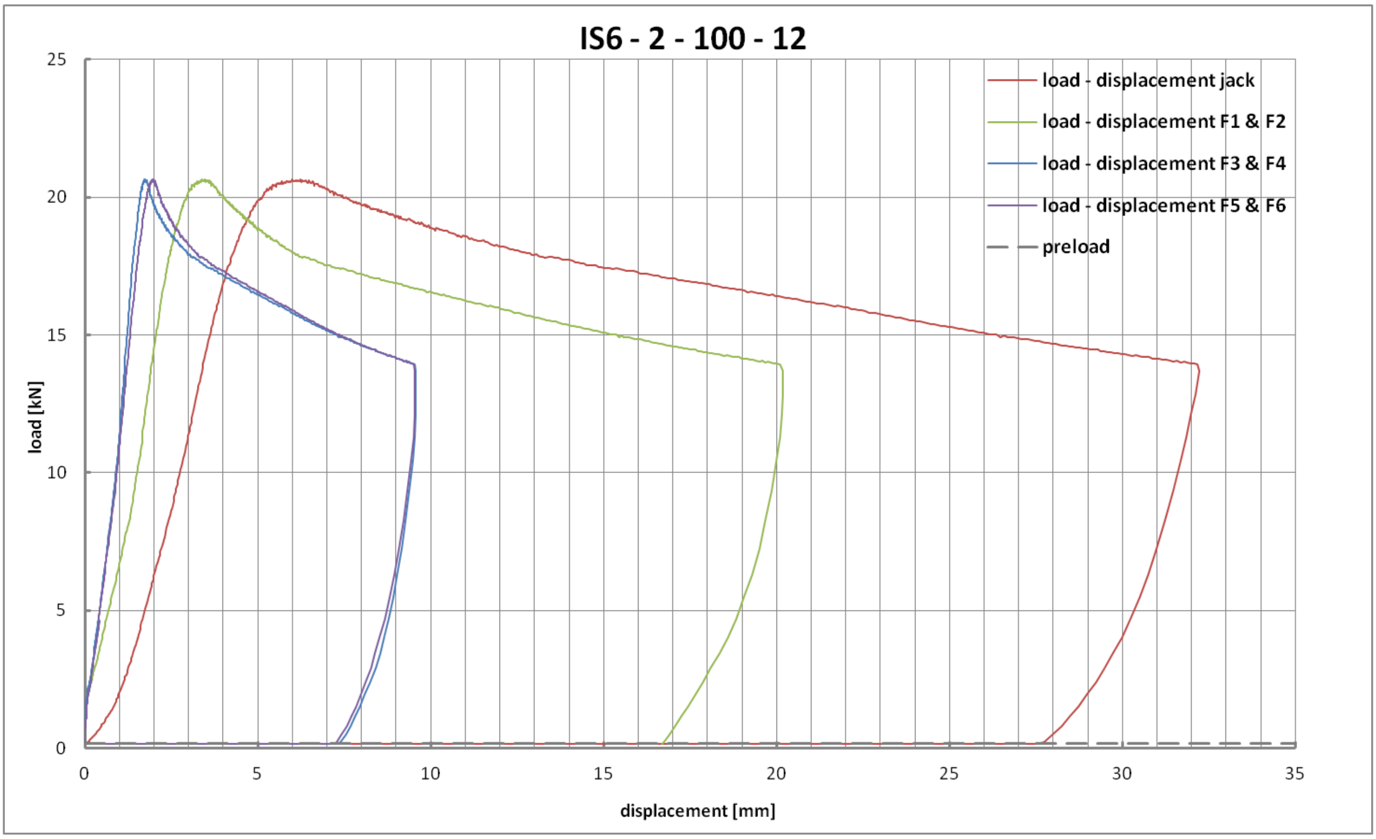


IS6 - 2 - 100 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
0
5
10
15
20
25
30
35


IS6 - 2 - 100 - 12
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
5
10
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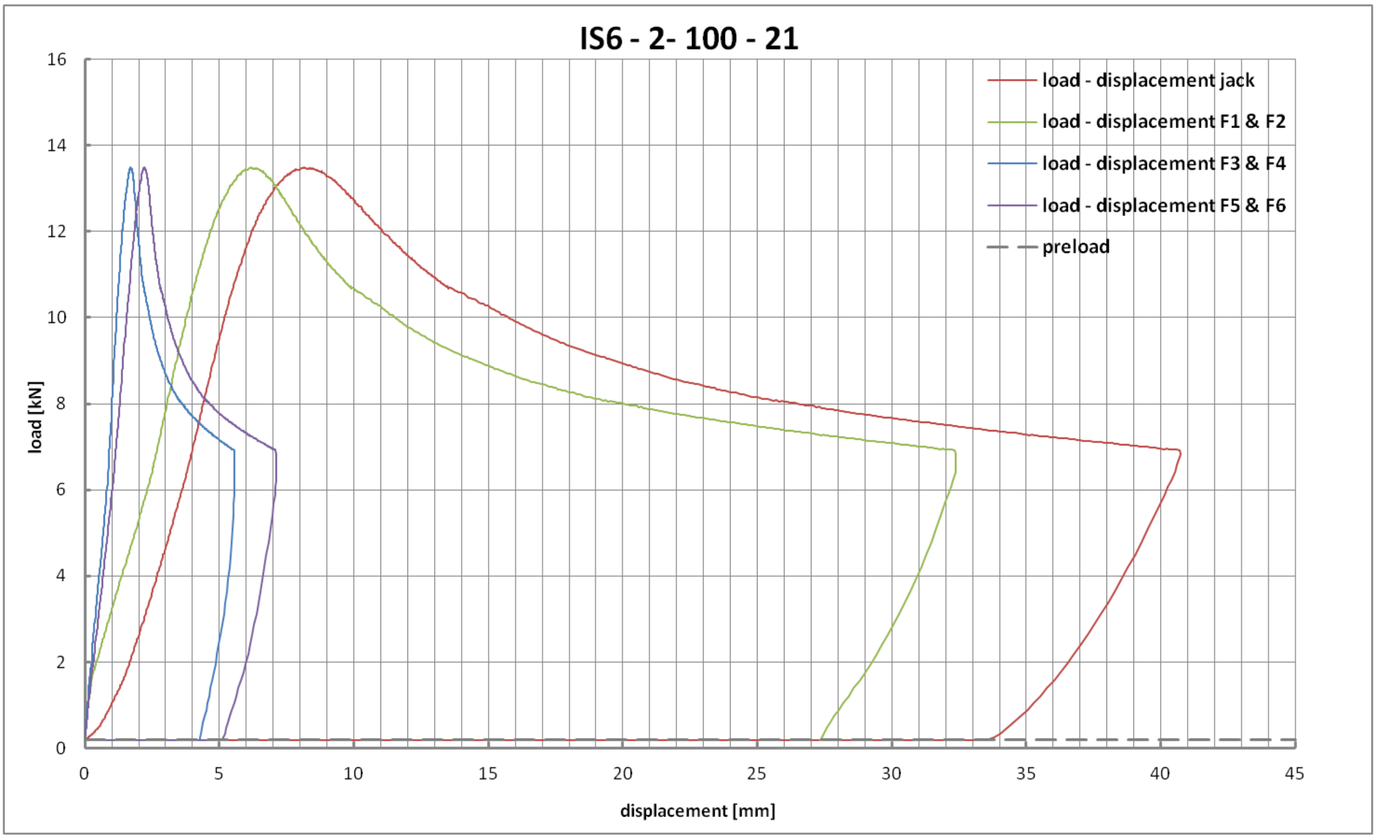
IS6 - 2- 100 - 21
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
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12
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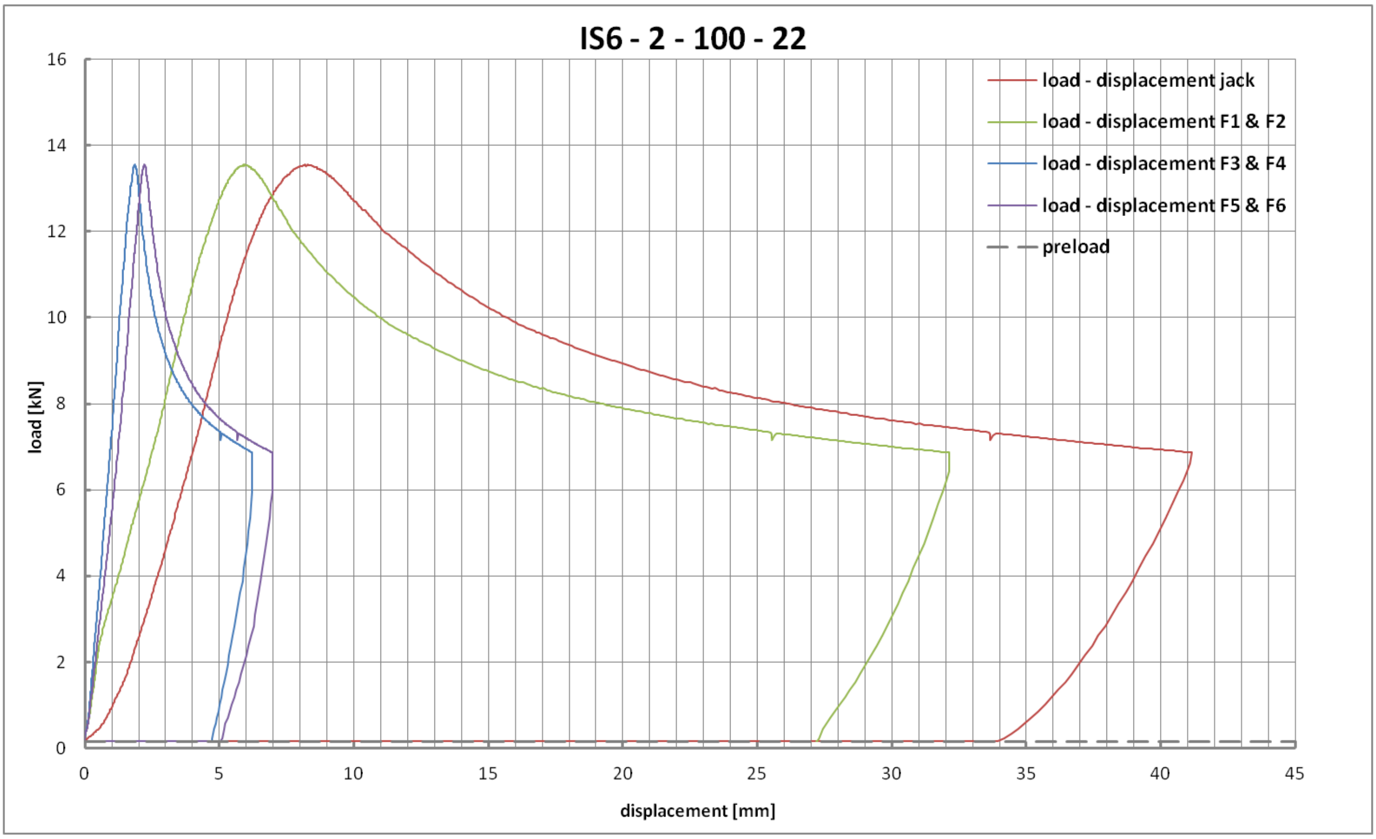
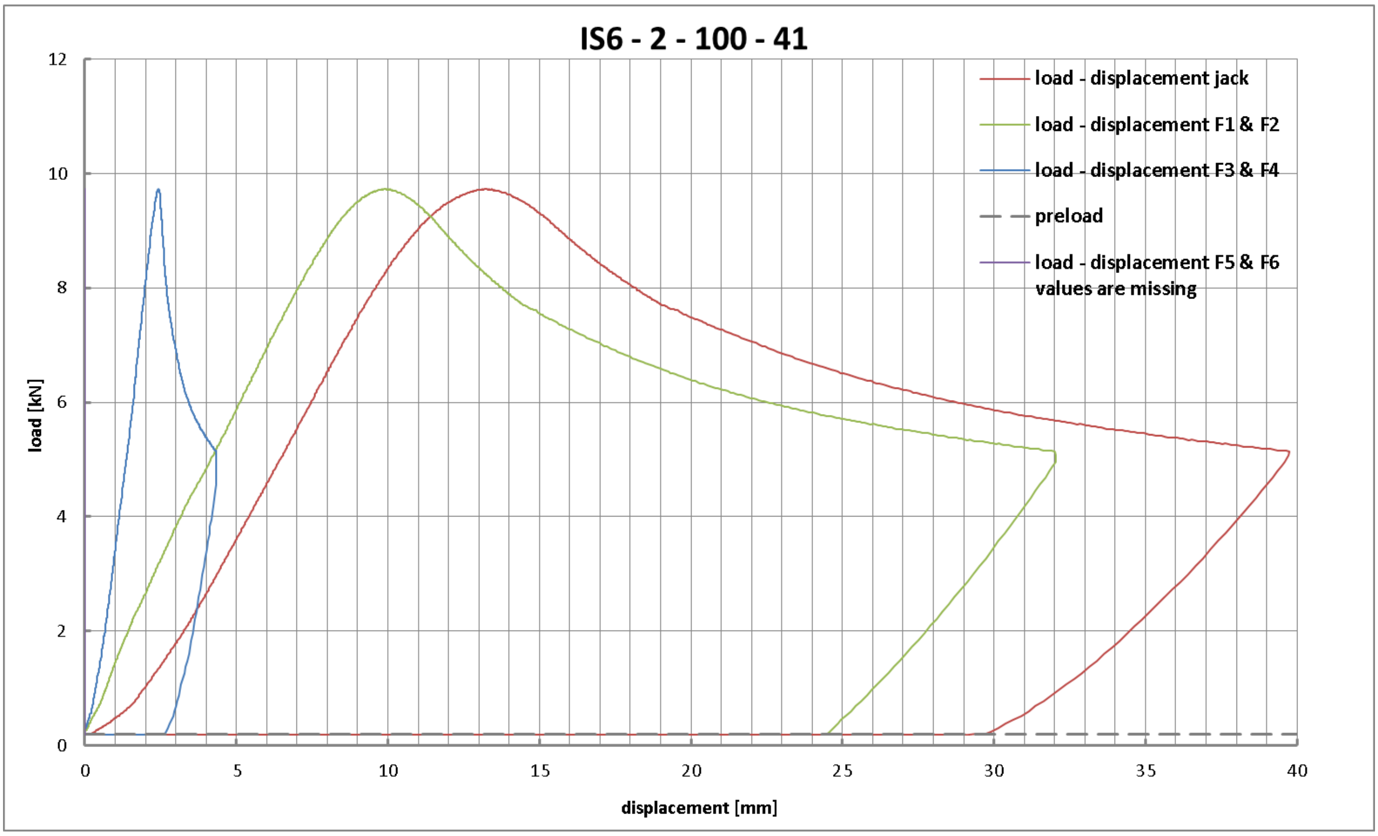
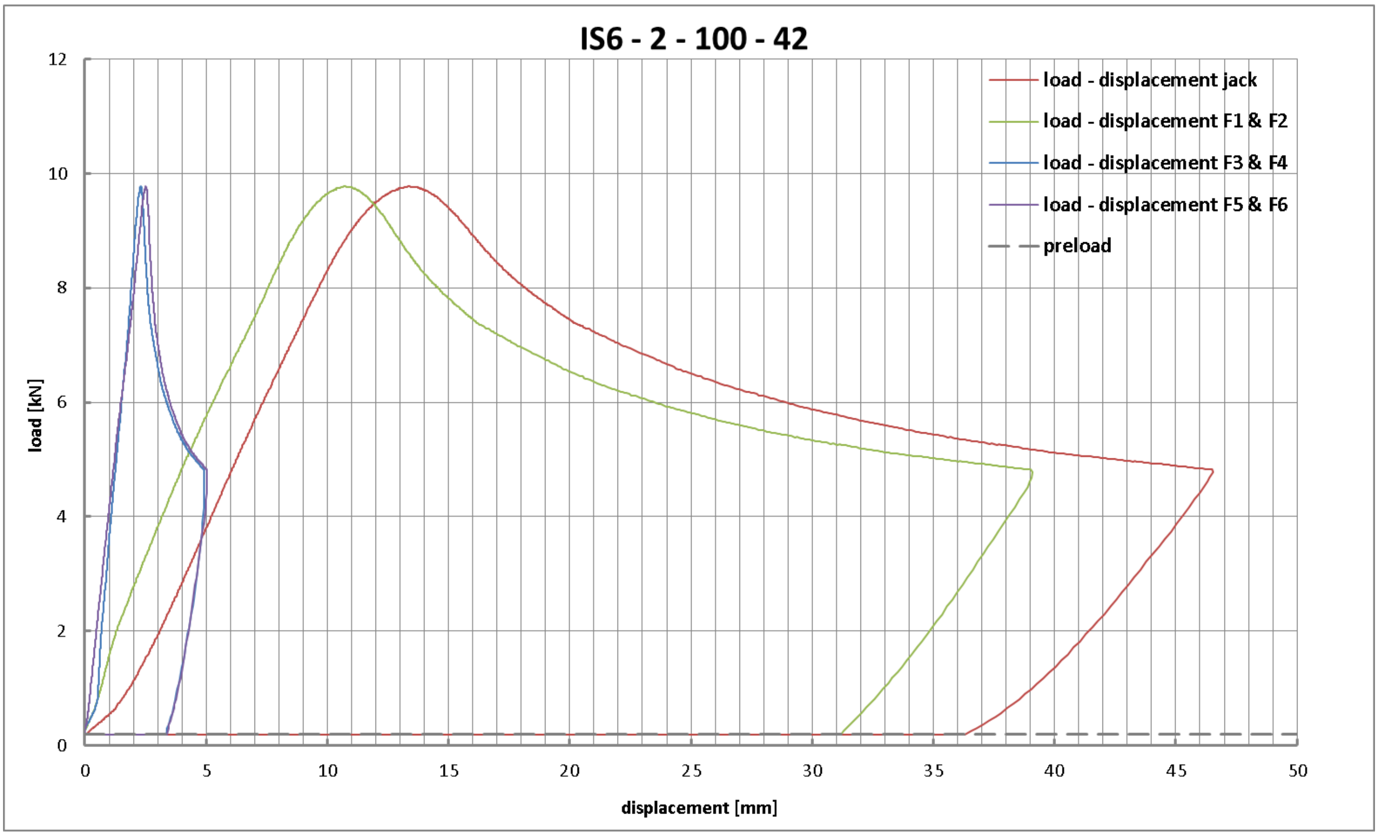
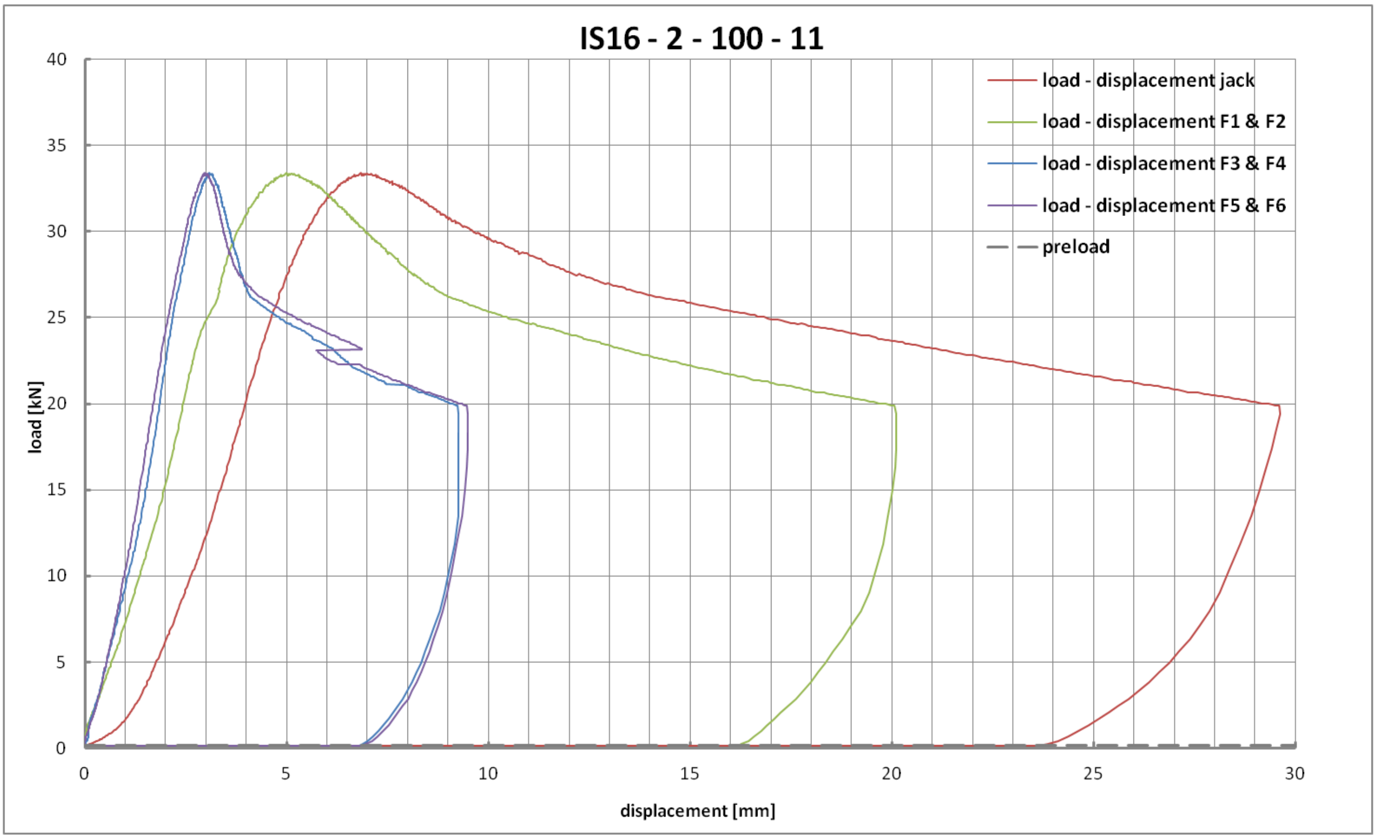
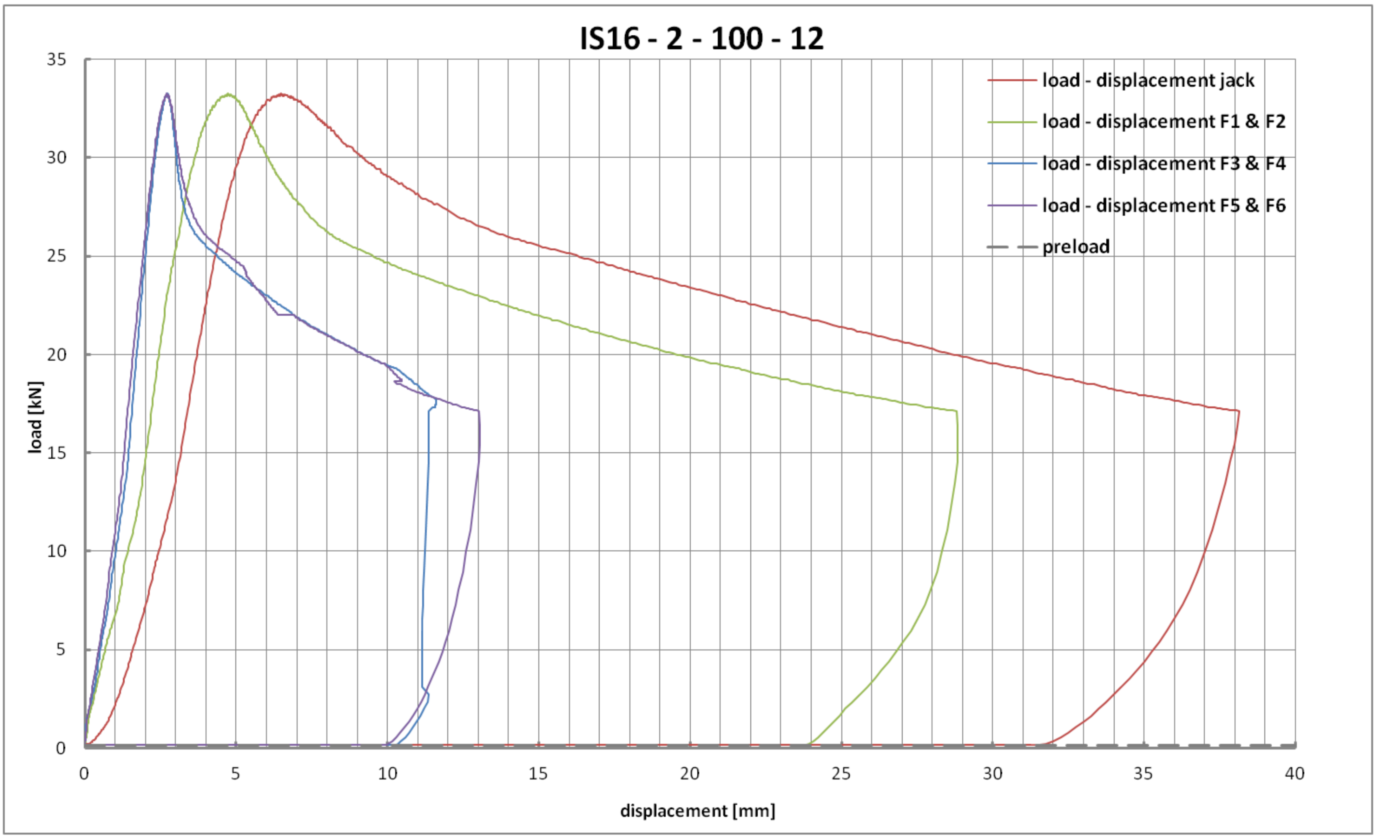

IS6 - 2 - 100 - 22
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
40
45

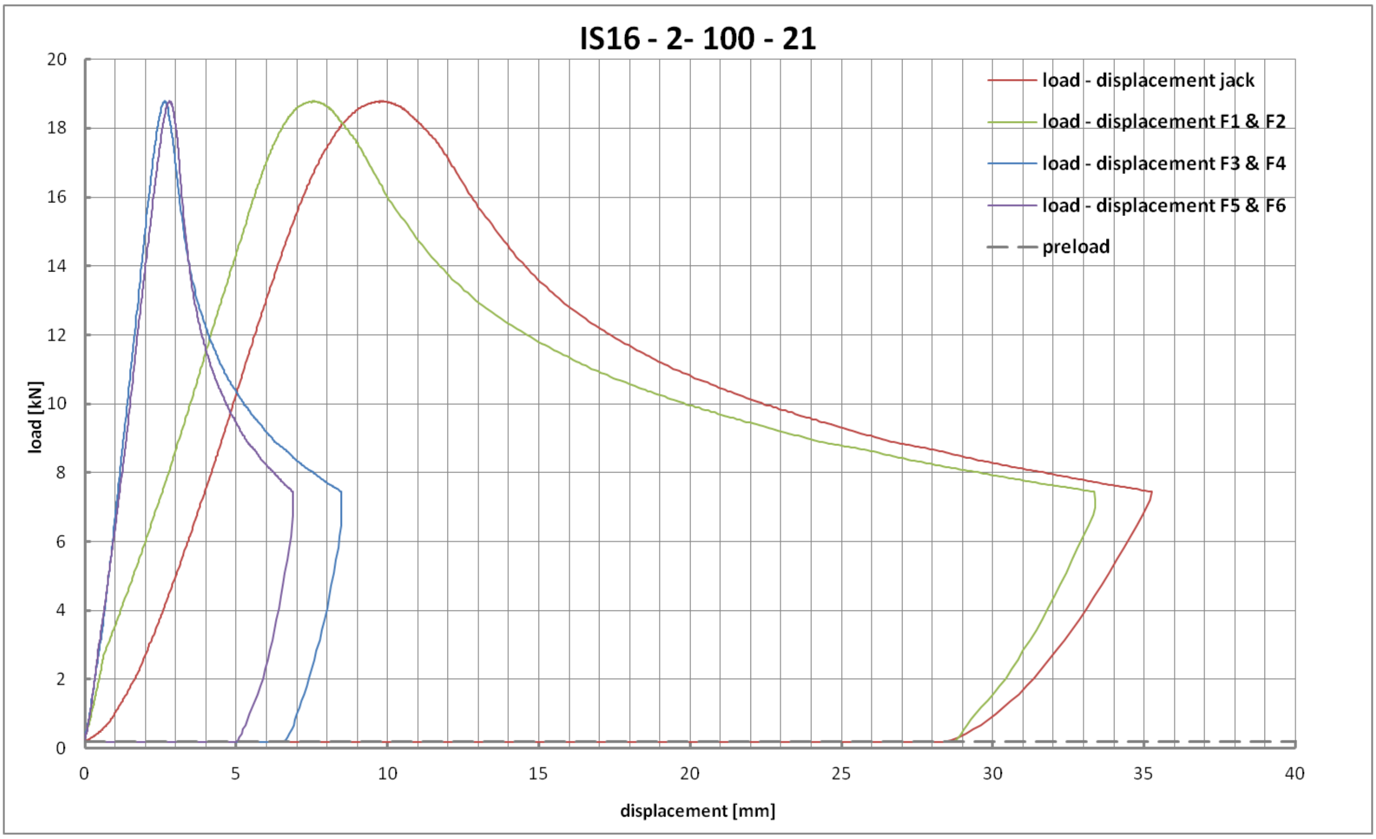

IS6 - 2 - 100 - 41
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
preload
load - displacement F5 & F6
values are missing
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40


IS6 - 2 - 100 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45
50

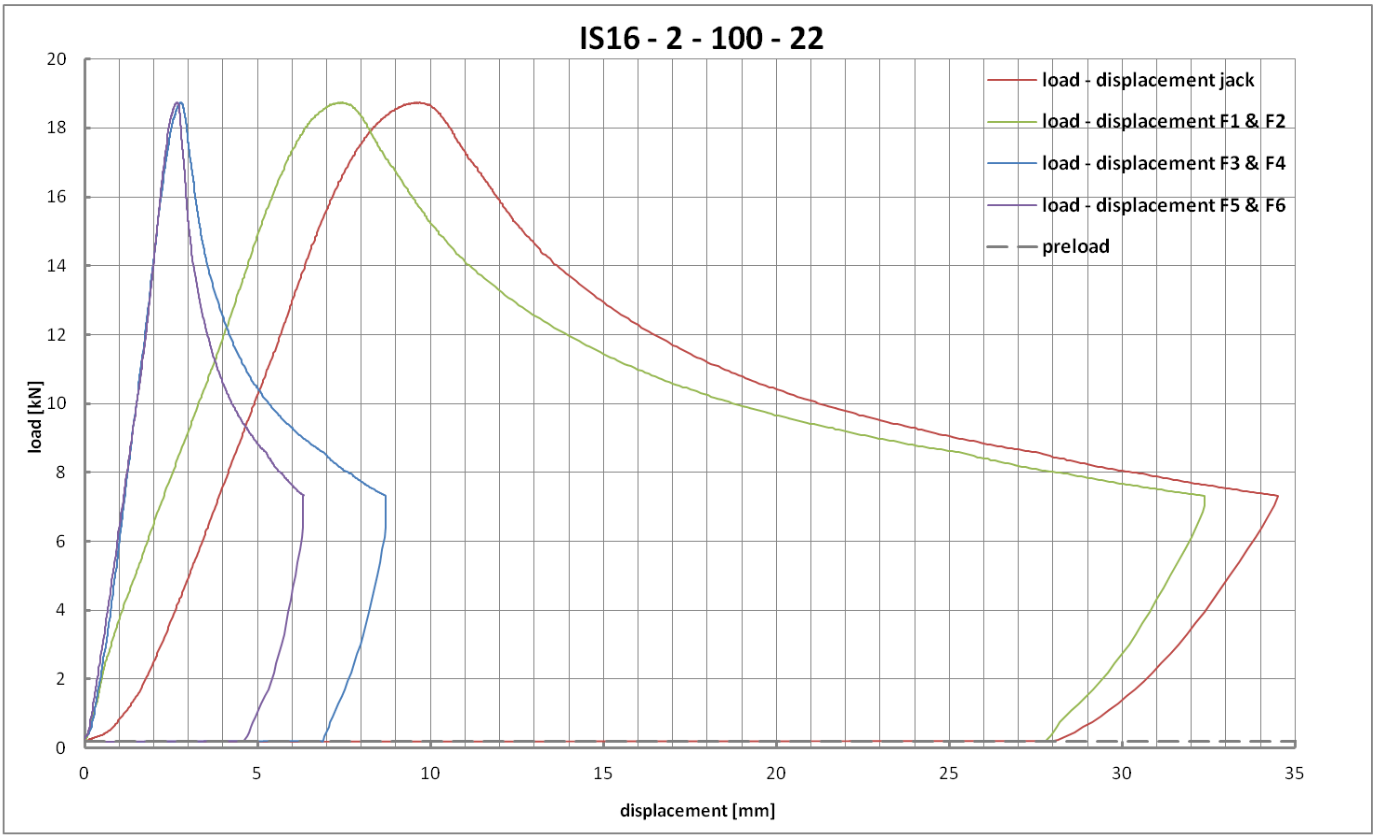

IS16 - 2 - 100 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
0
5
10
15
20
25
30

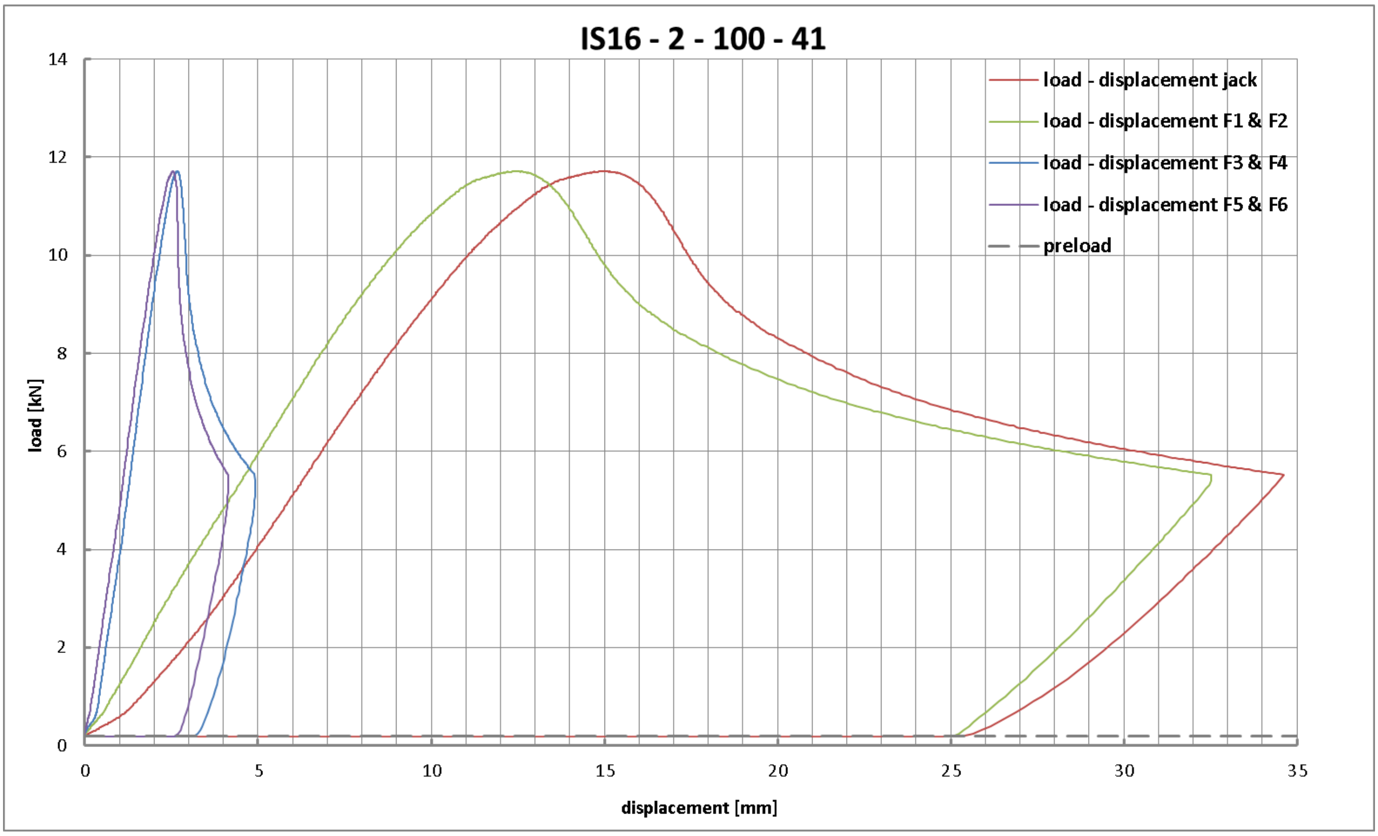


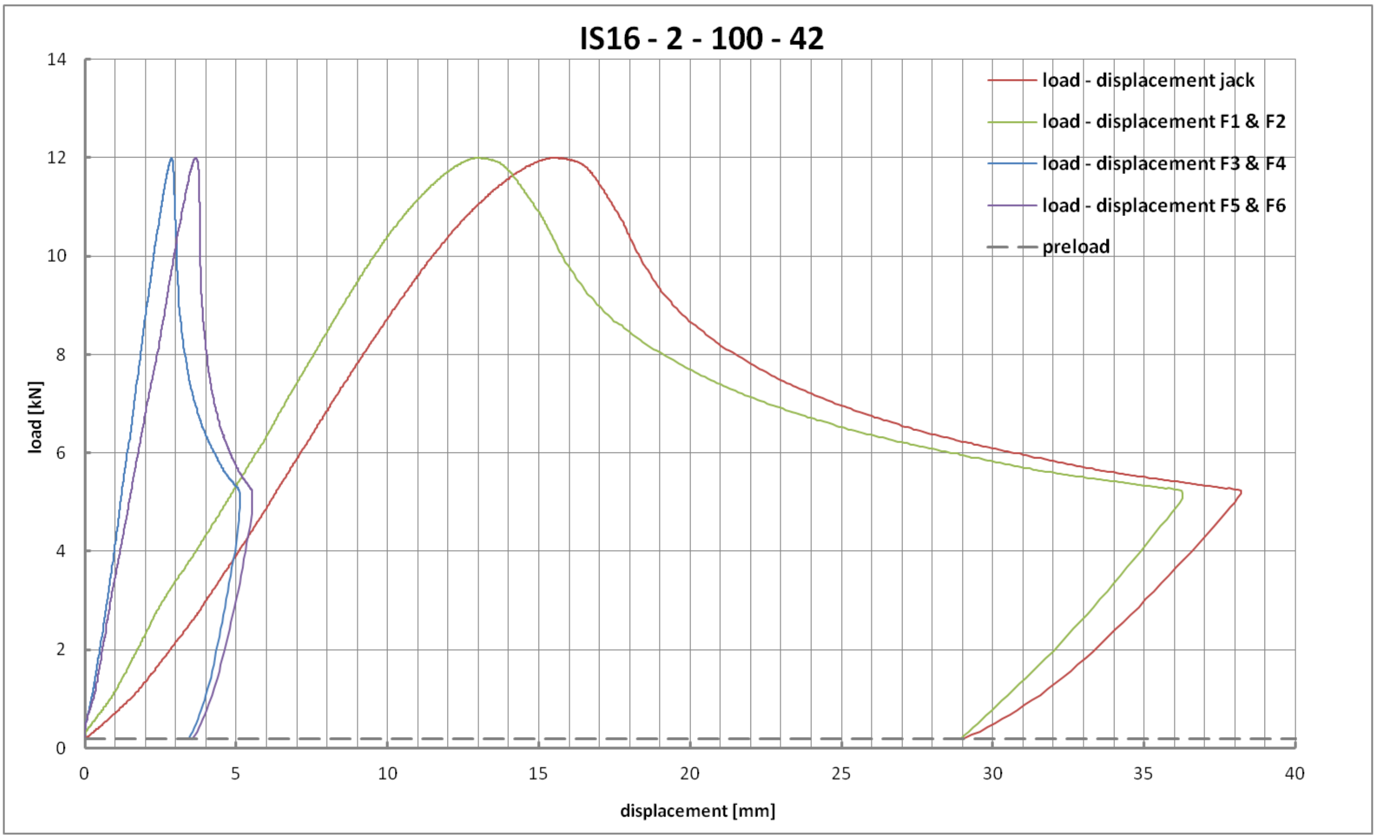
IS16 - 2 - 100 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40

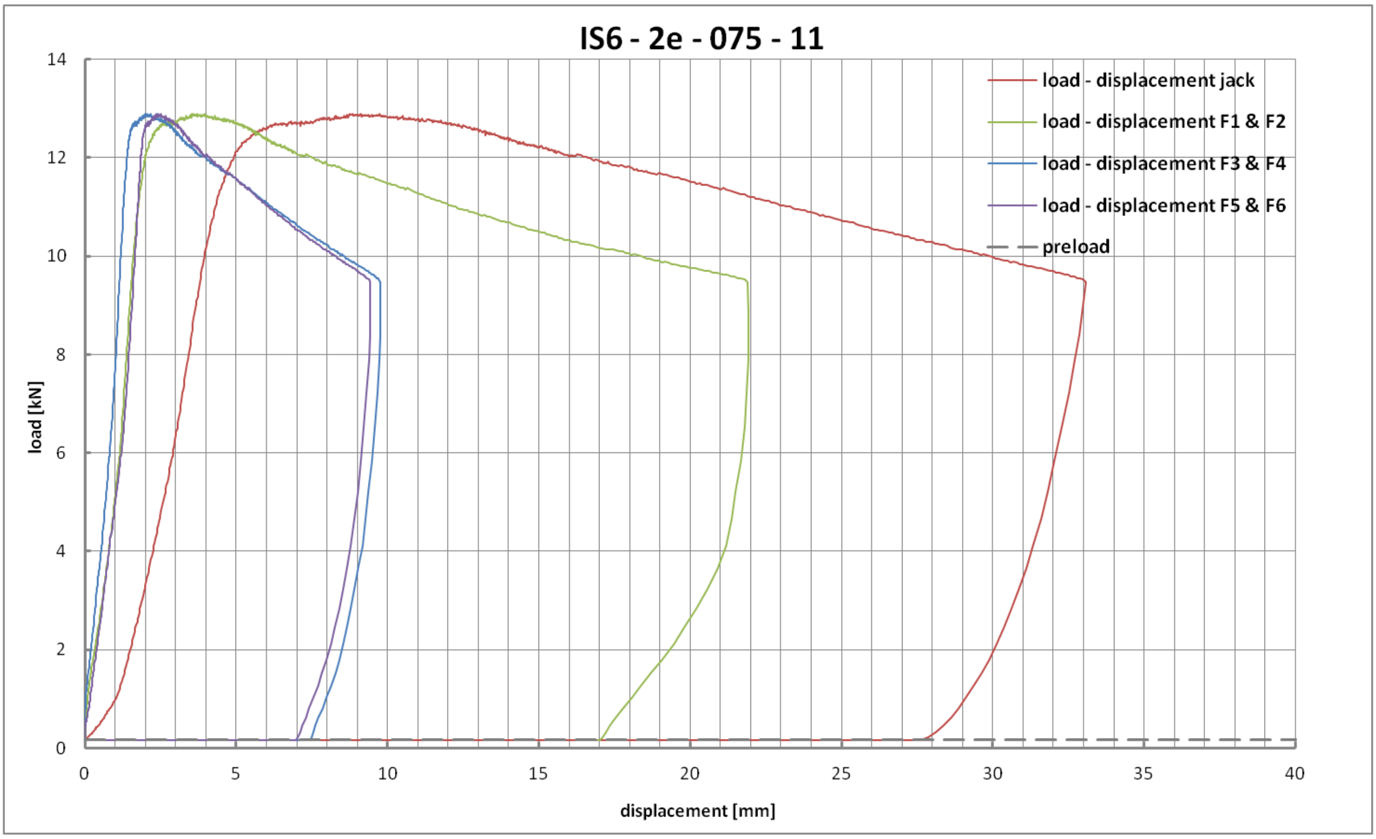


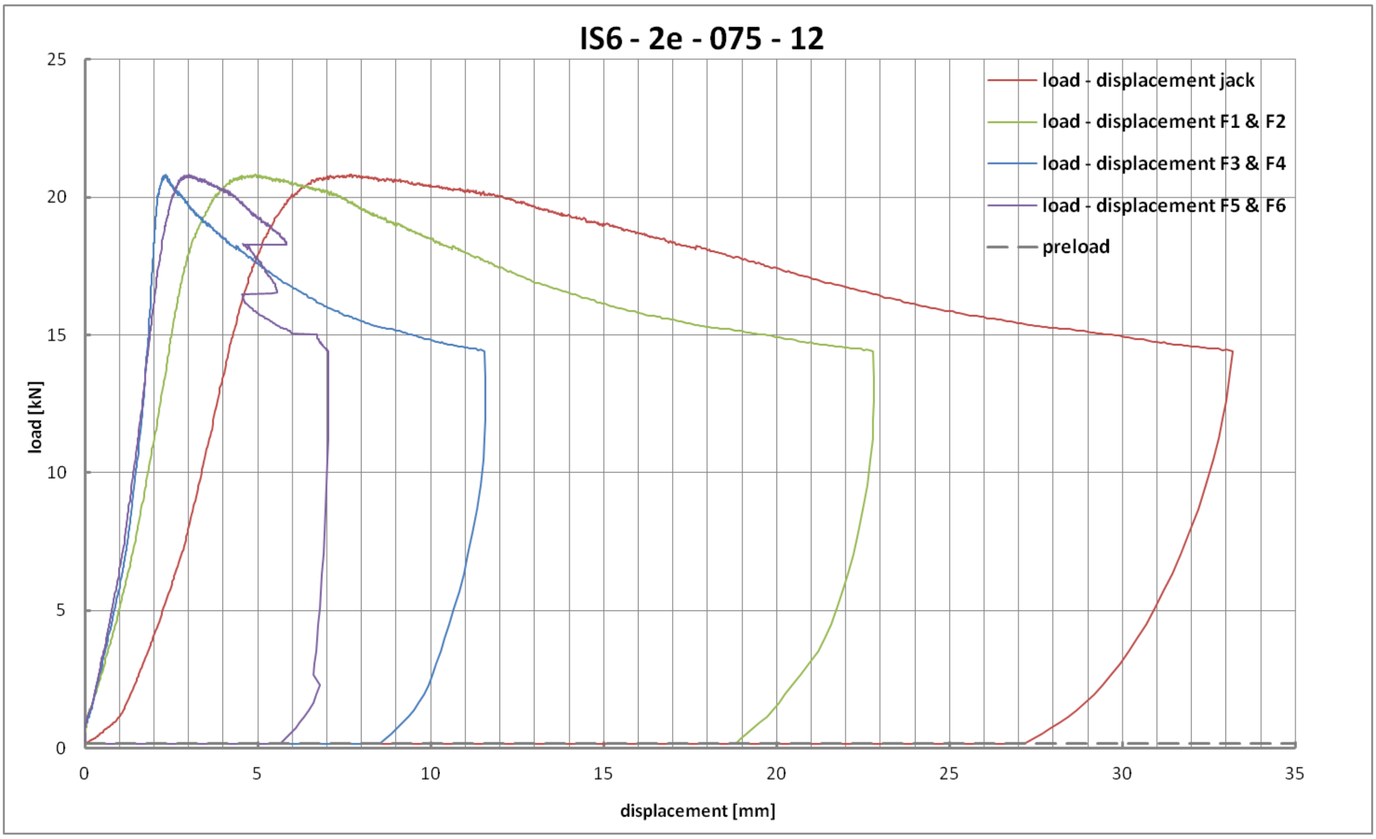
IS16 - 2- 100 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
18
20
25
30
35
40

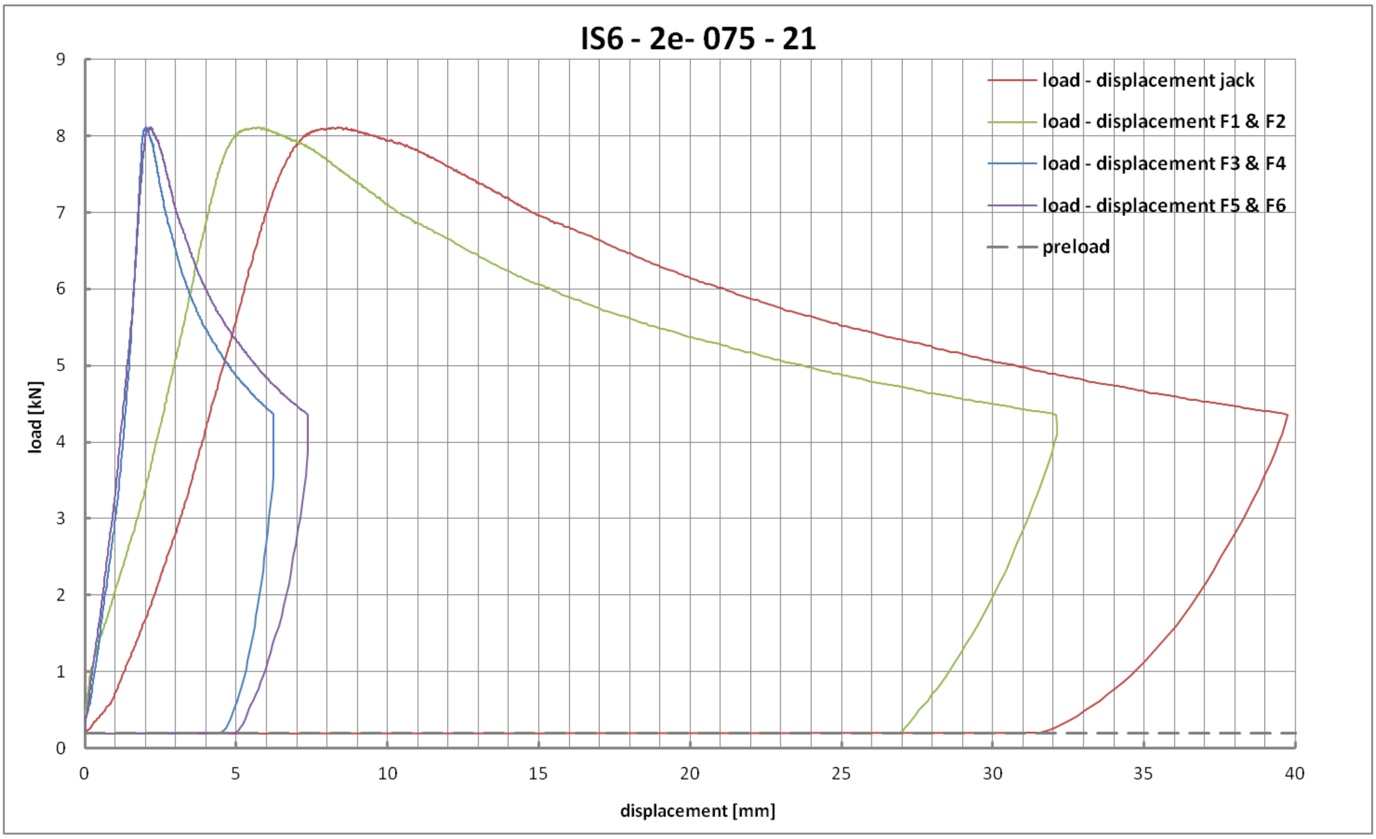

IS16 - 2 - 100 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]

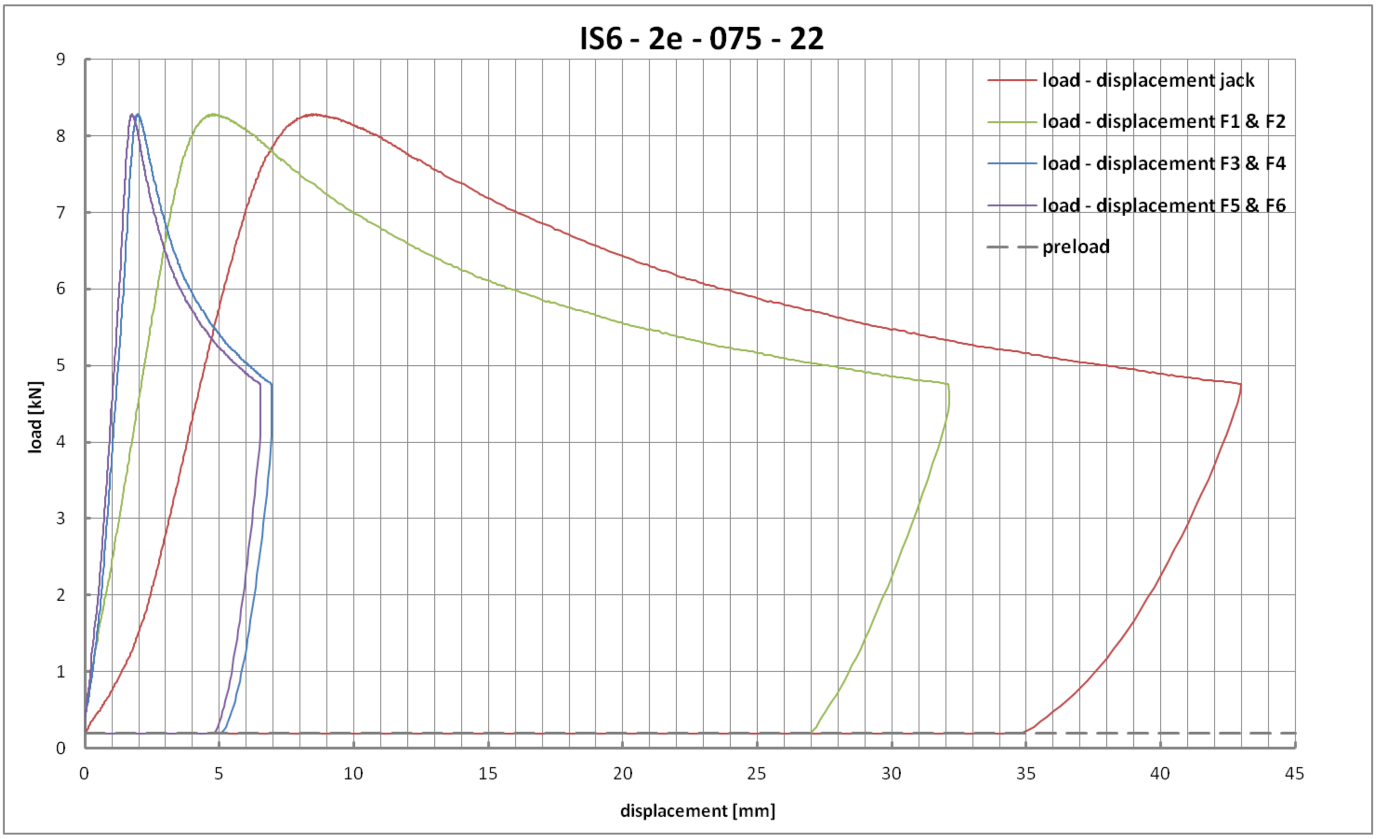

IS16 - 2 - 100 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]

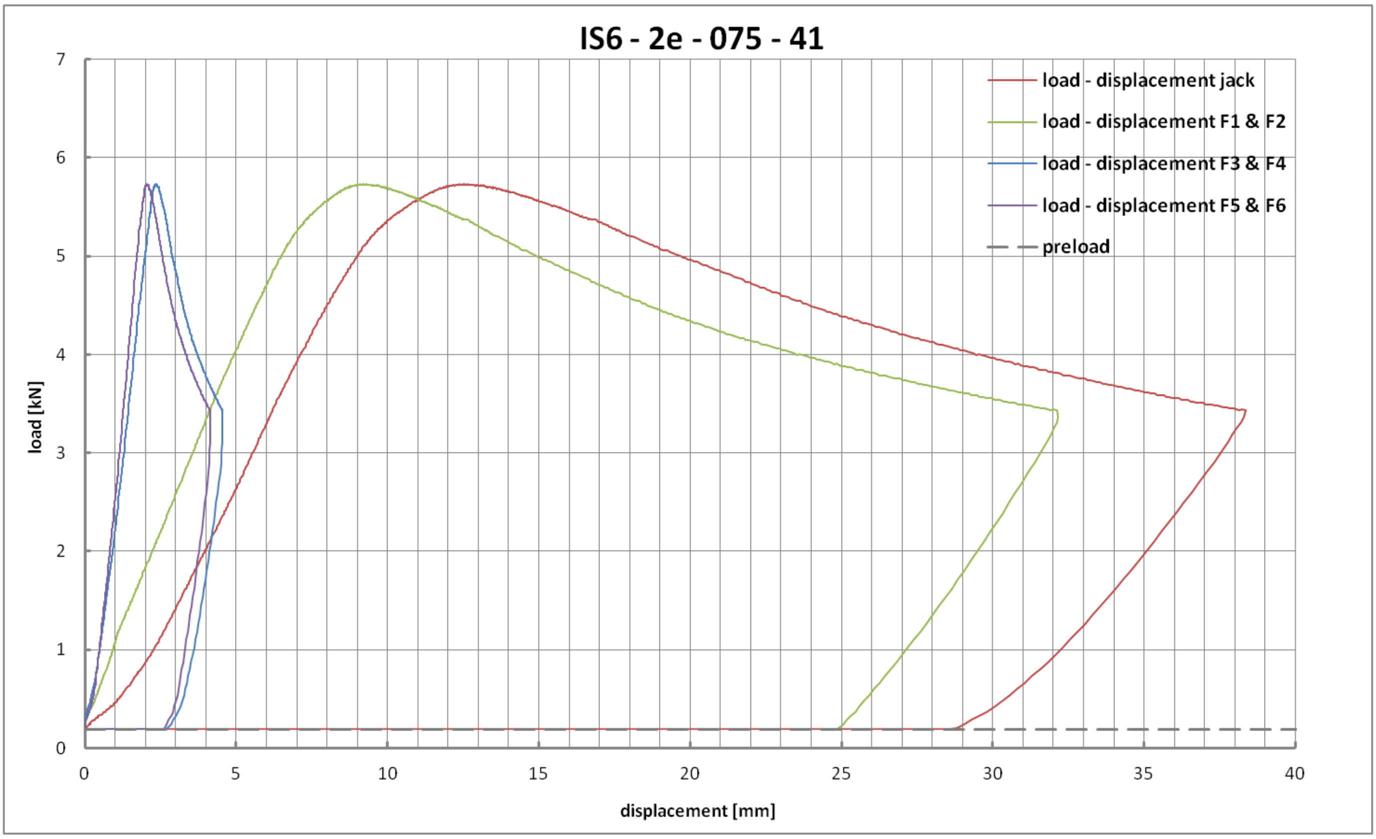

IS16 - 2 - 100 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40

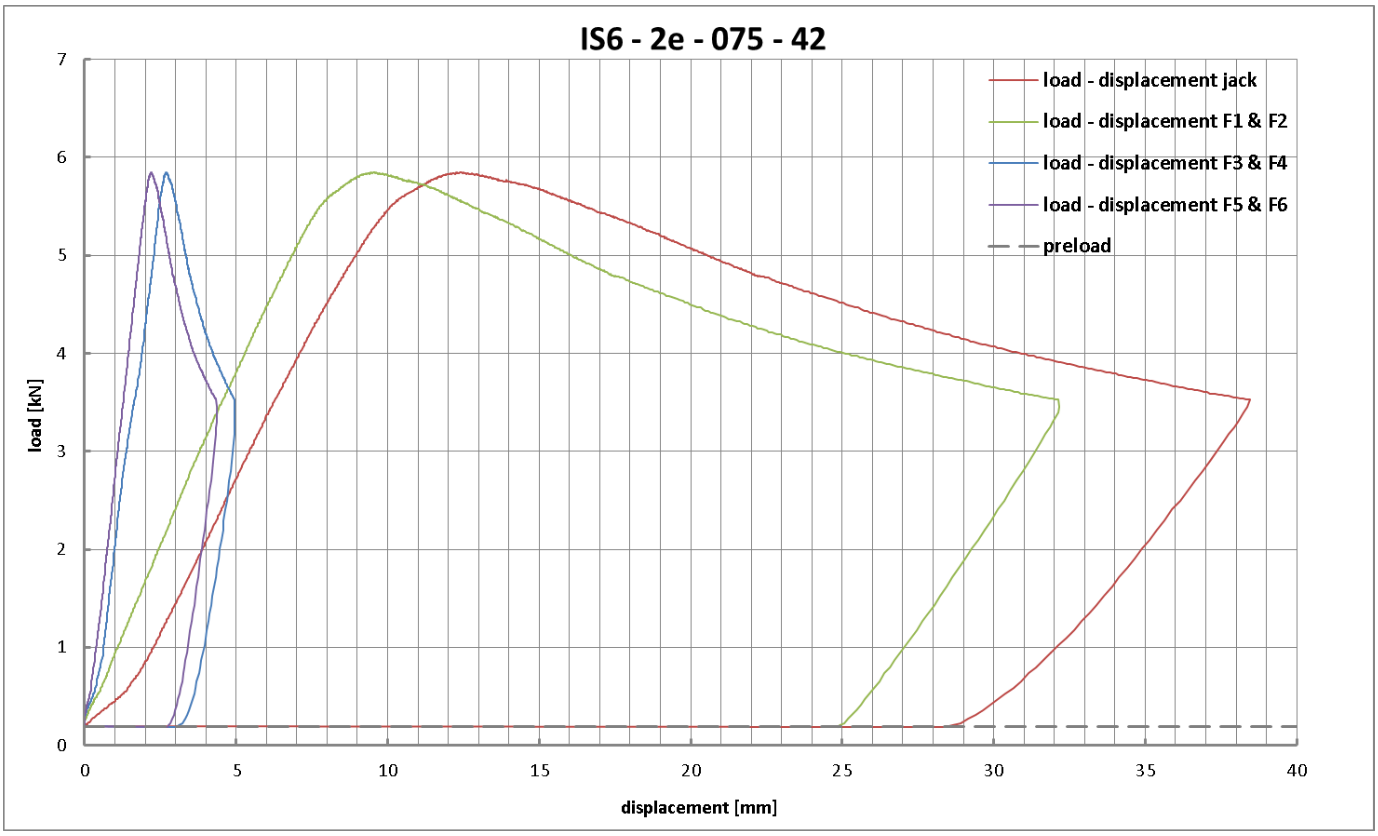

IS6 - 2e - 075 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40

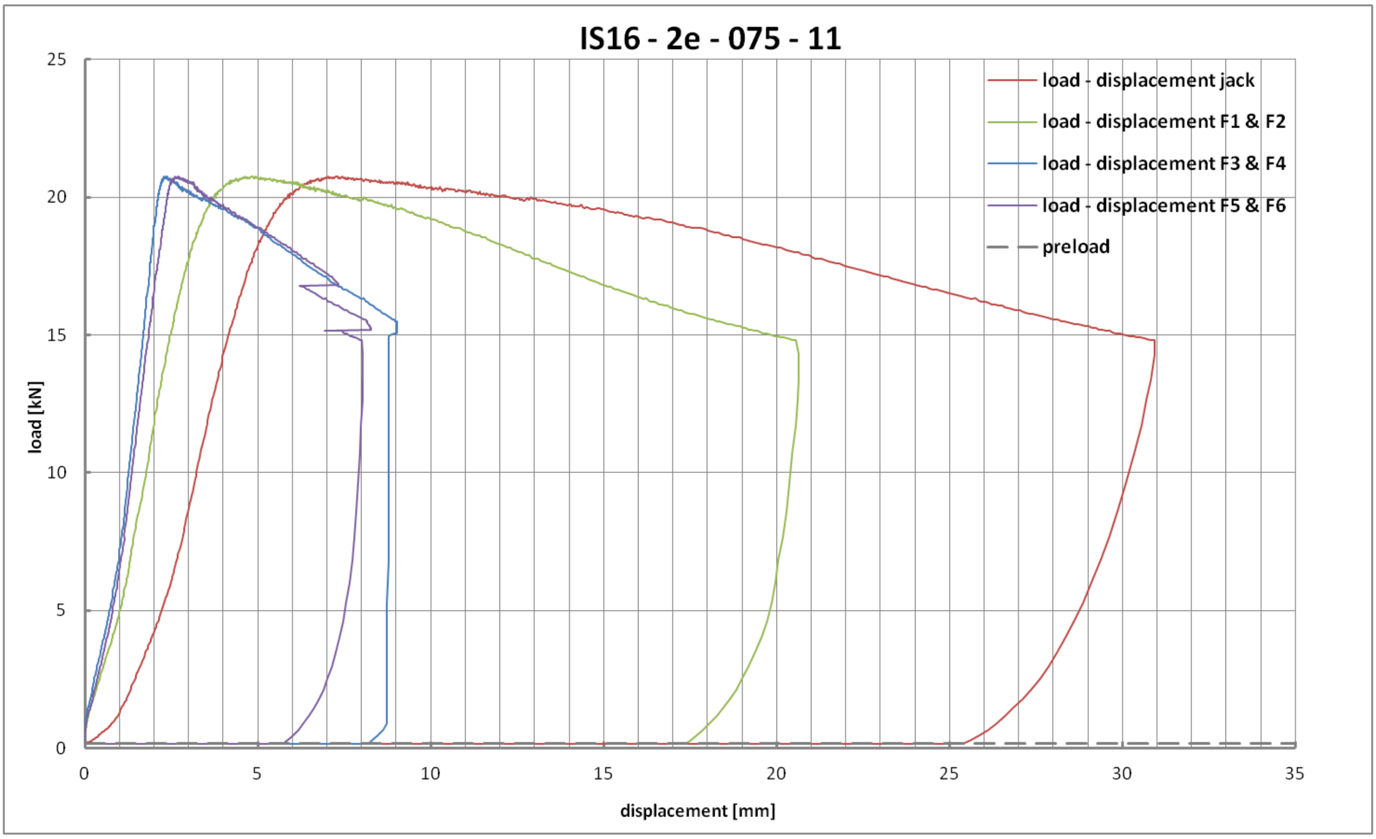

IS6 - 2e - 075 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35


IS6 - 2e- 075 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
10
15
20
25
30
35
40


IS6 - 2e - 075 - 22
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45

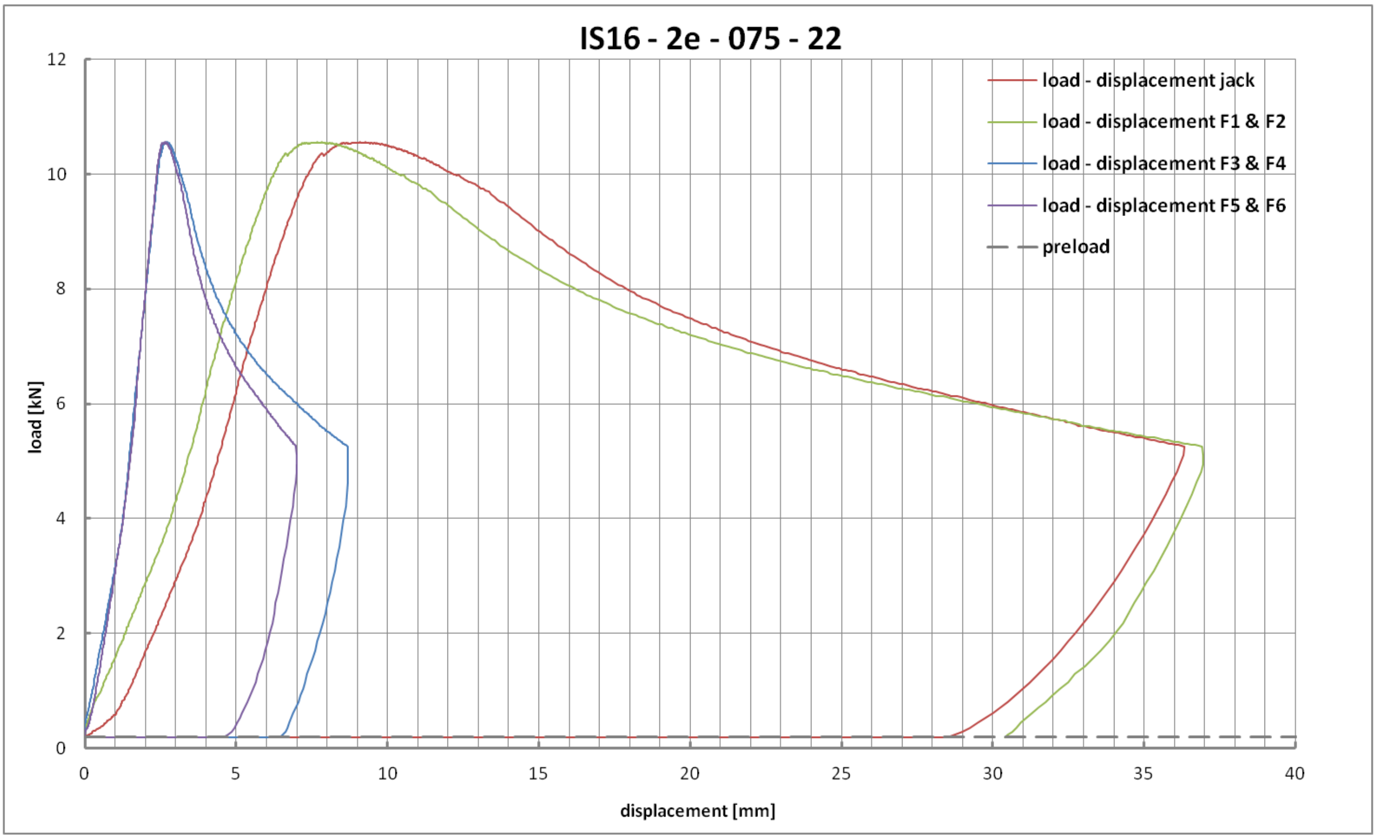

IS6 - 2e - 075 - 41
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40

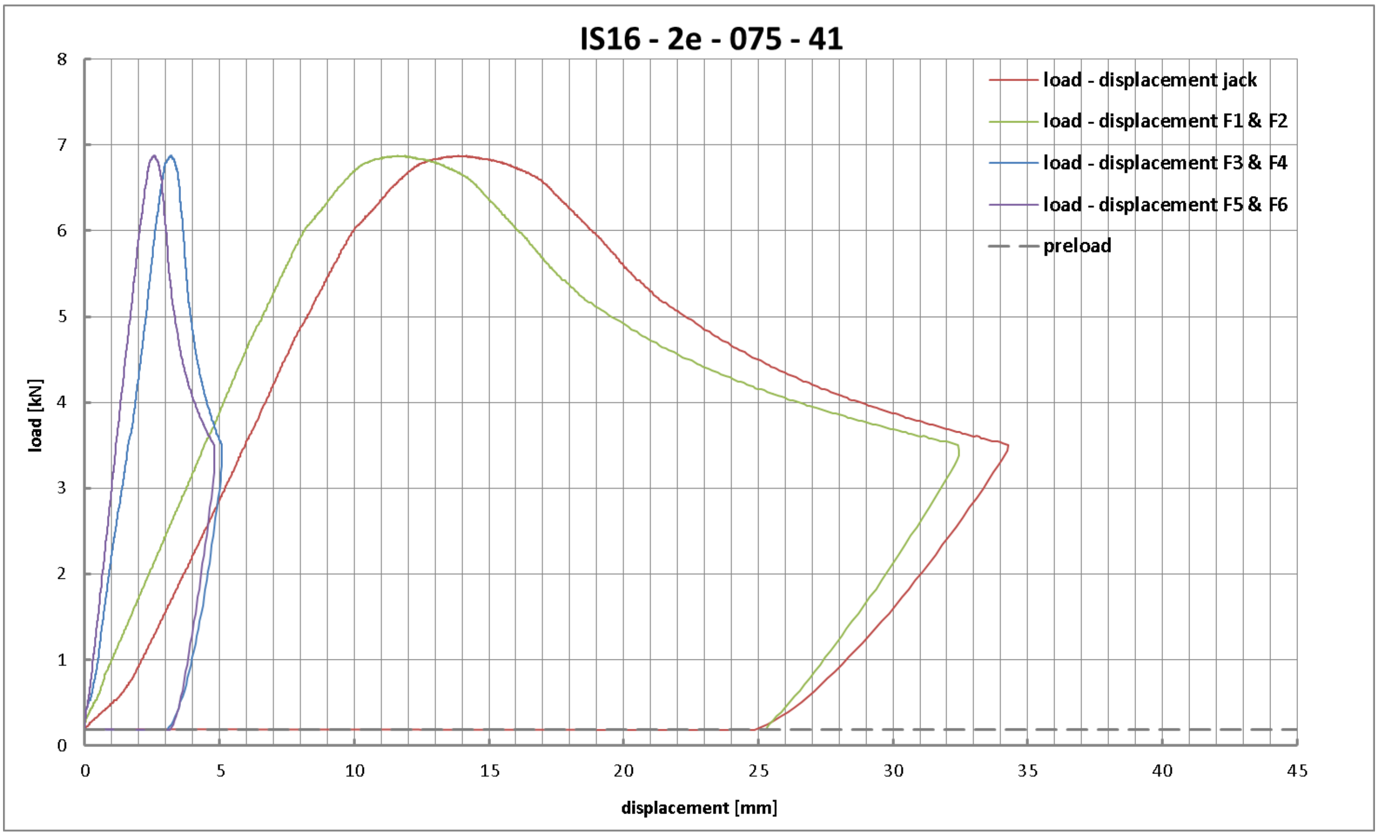




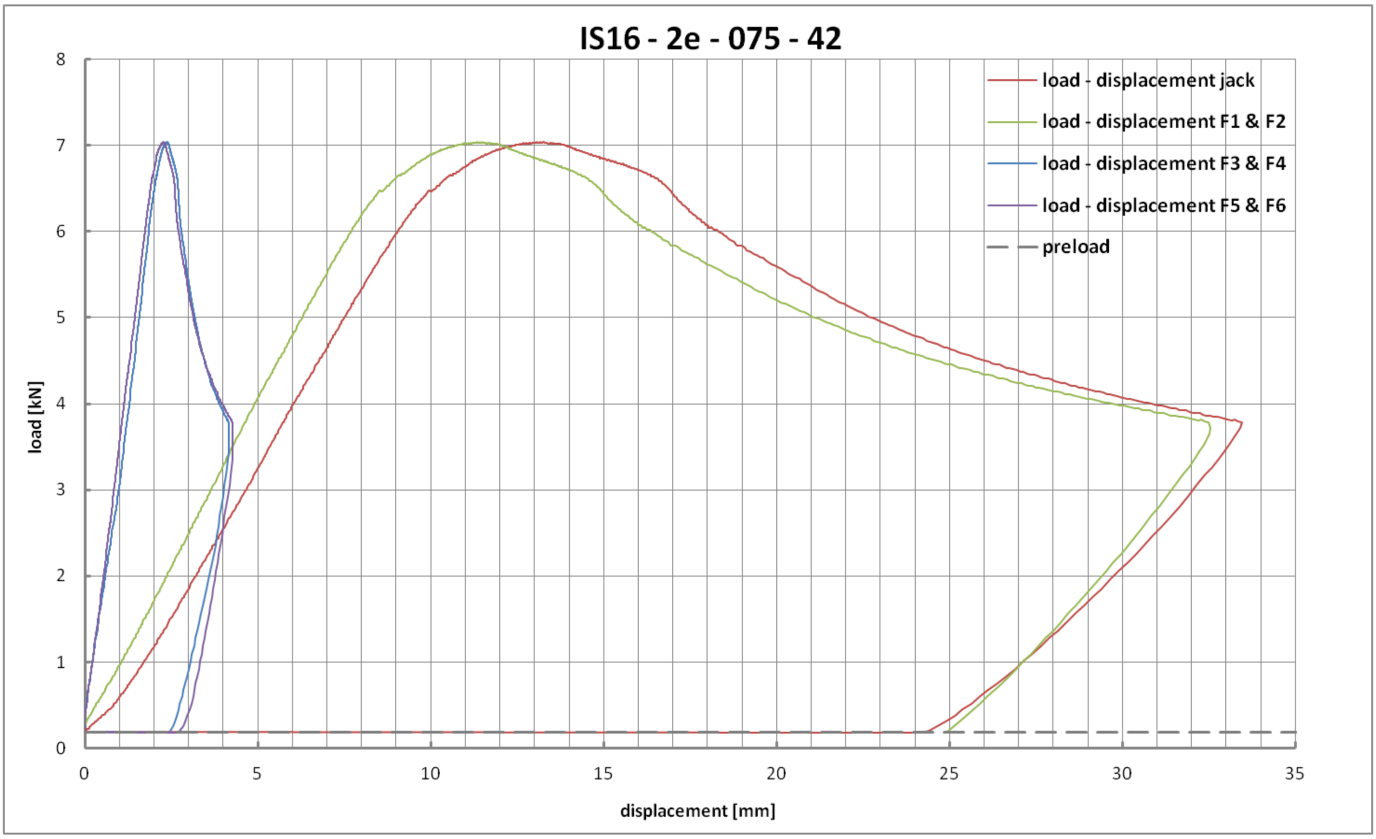
IS16-2e-075-12: error in data storage (see annex E for a copy of the load-deflection curve)


IS16 - 2e- 075 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45

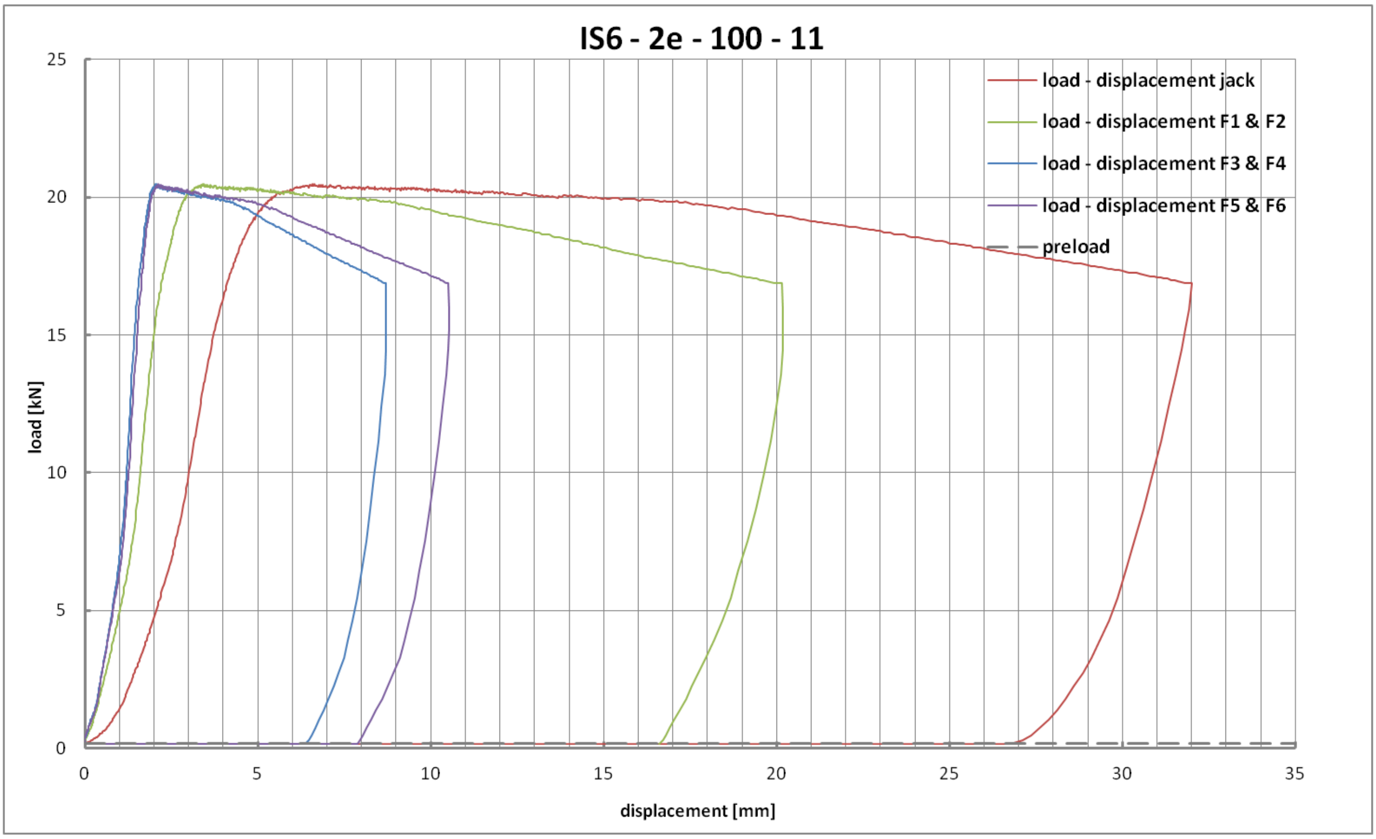

IS16 - 2e - 075 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40

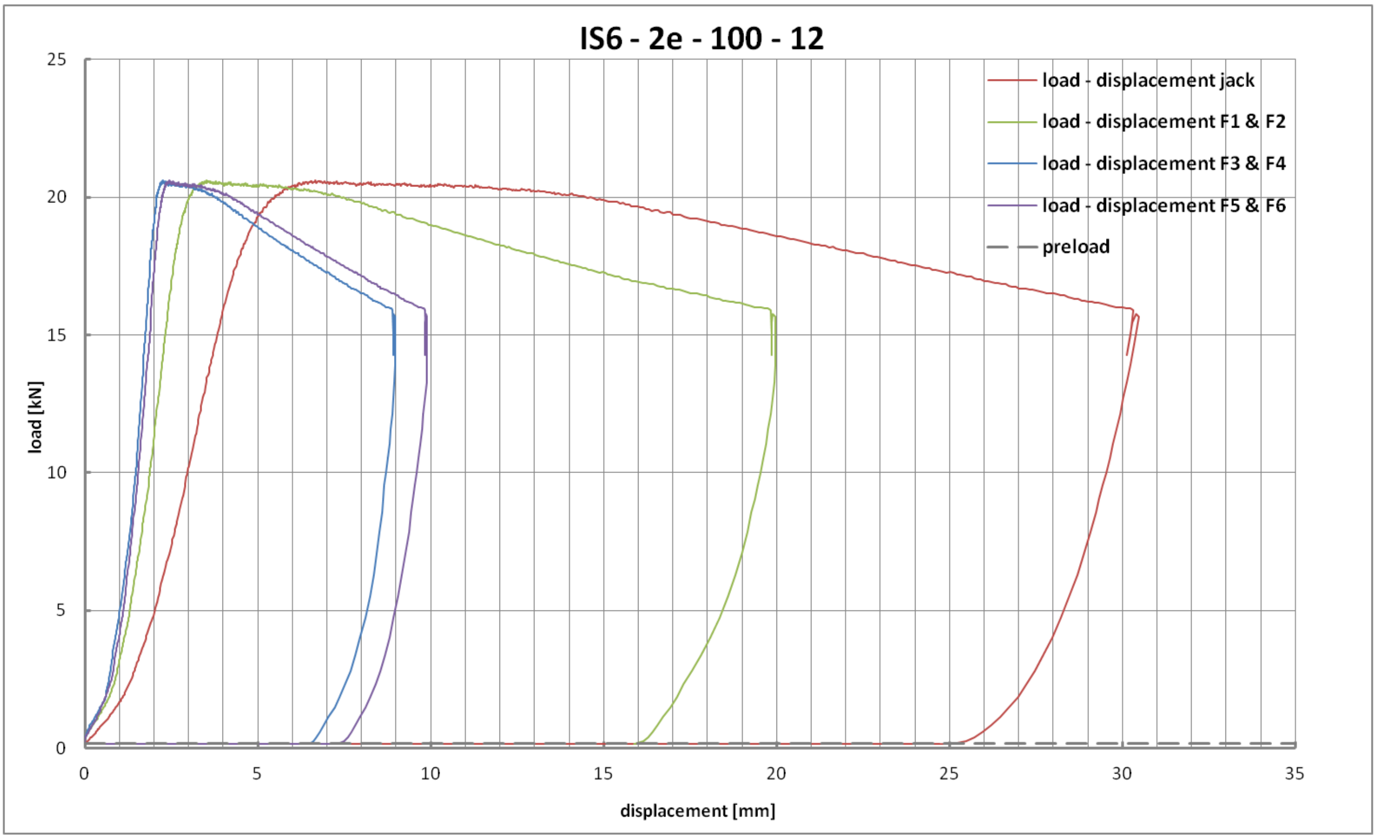


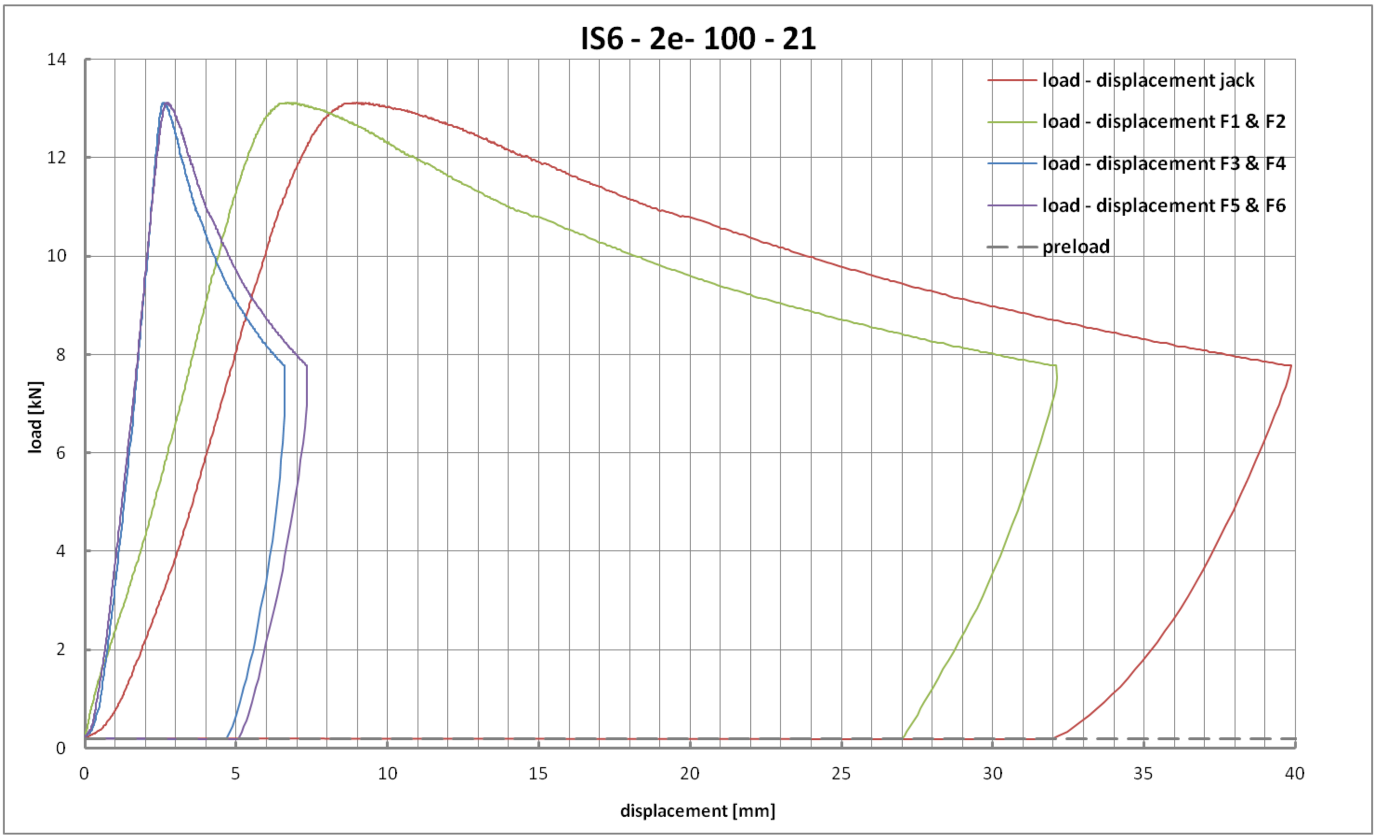
IS16 - 2e - 075 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
40
45

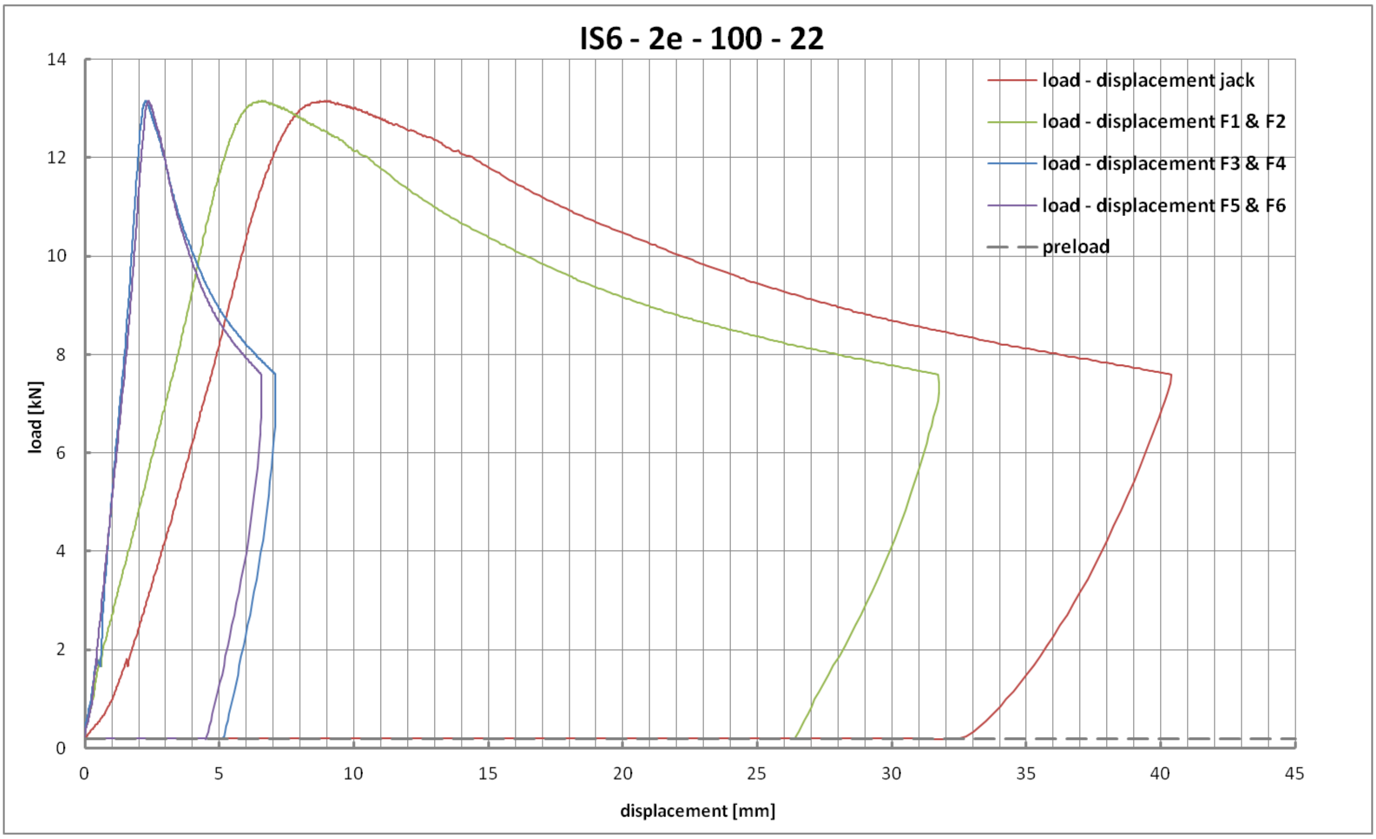


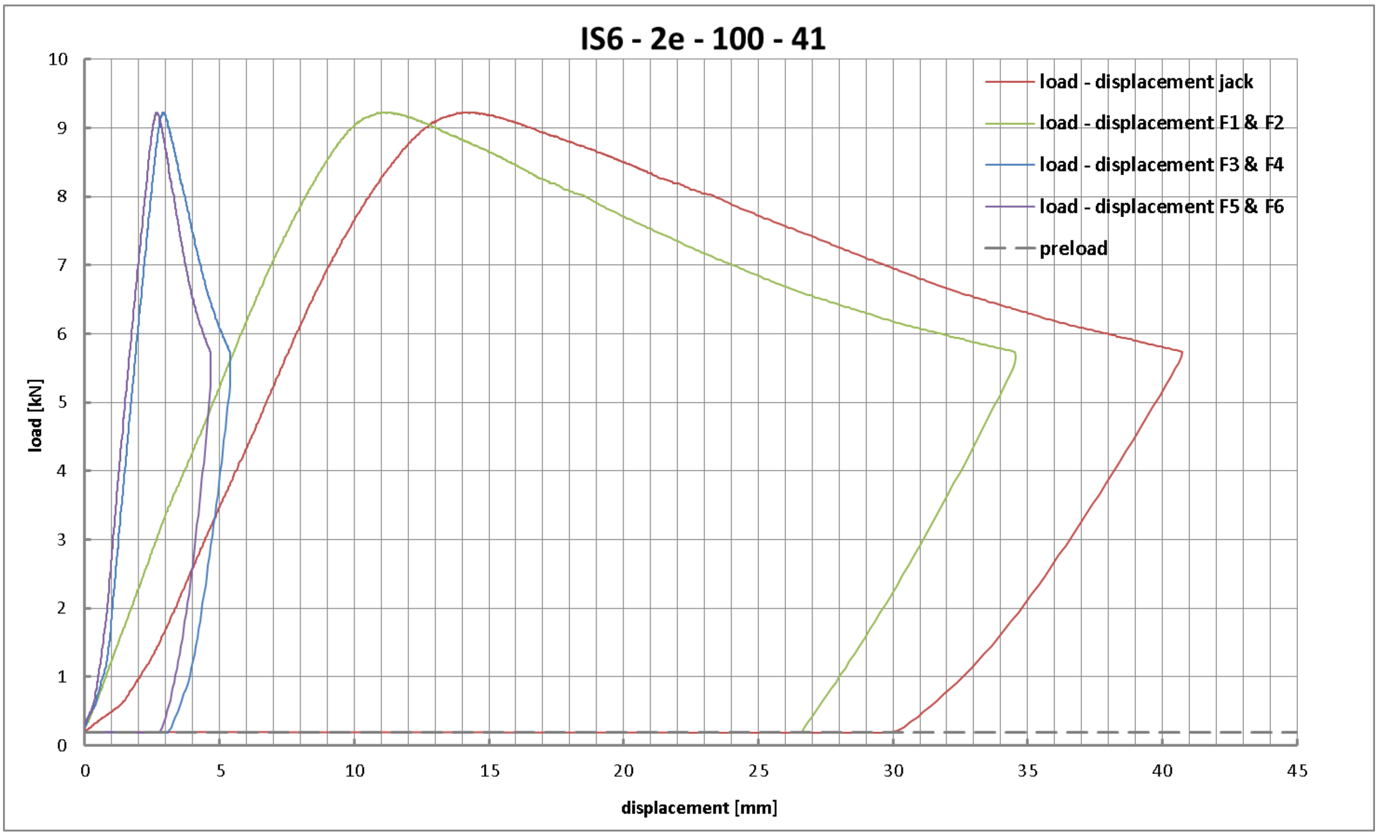
IS16 - 2e - 075 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35

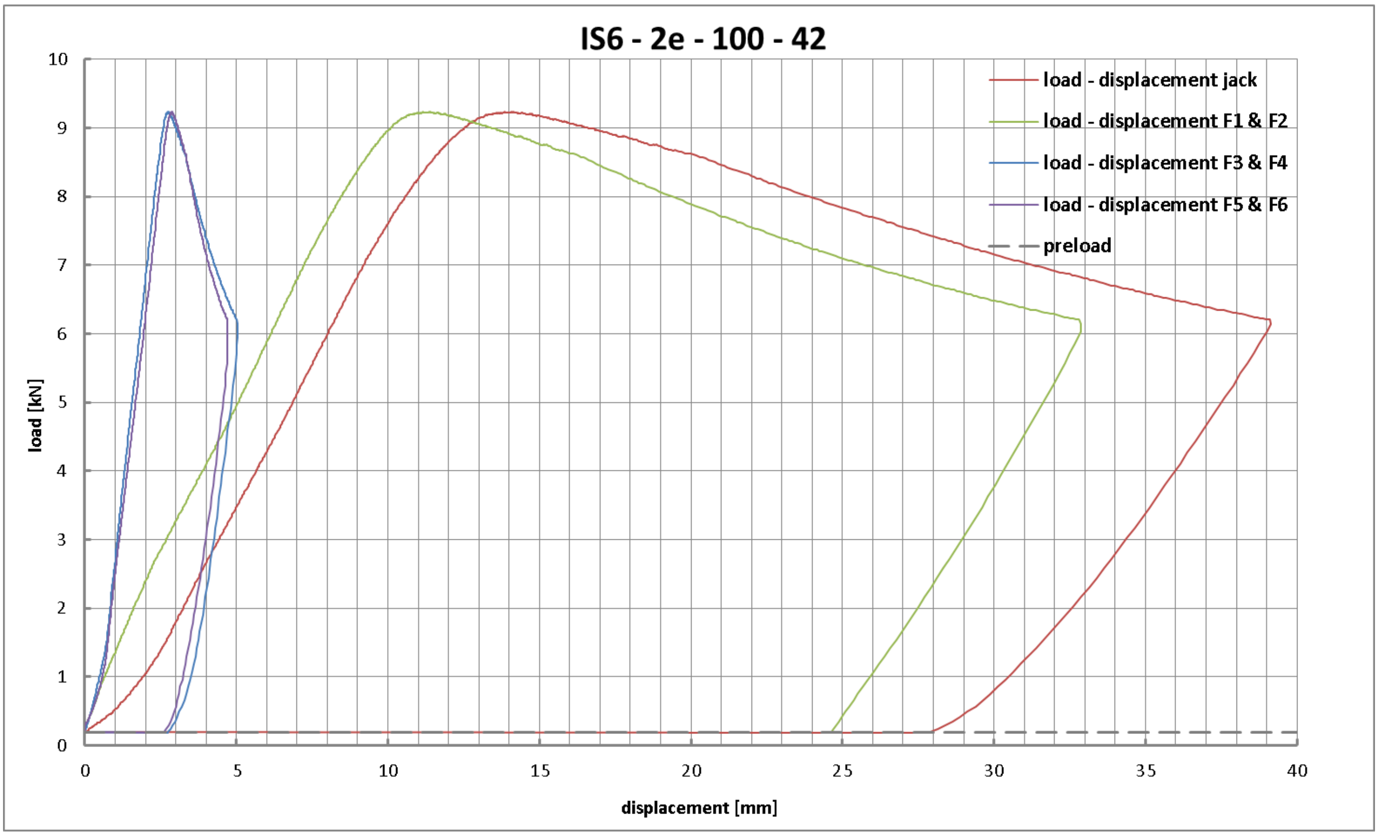

IS6 - 2e - 100 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35

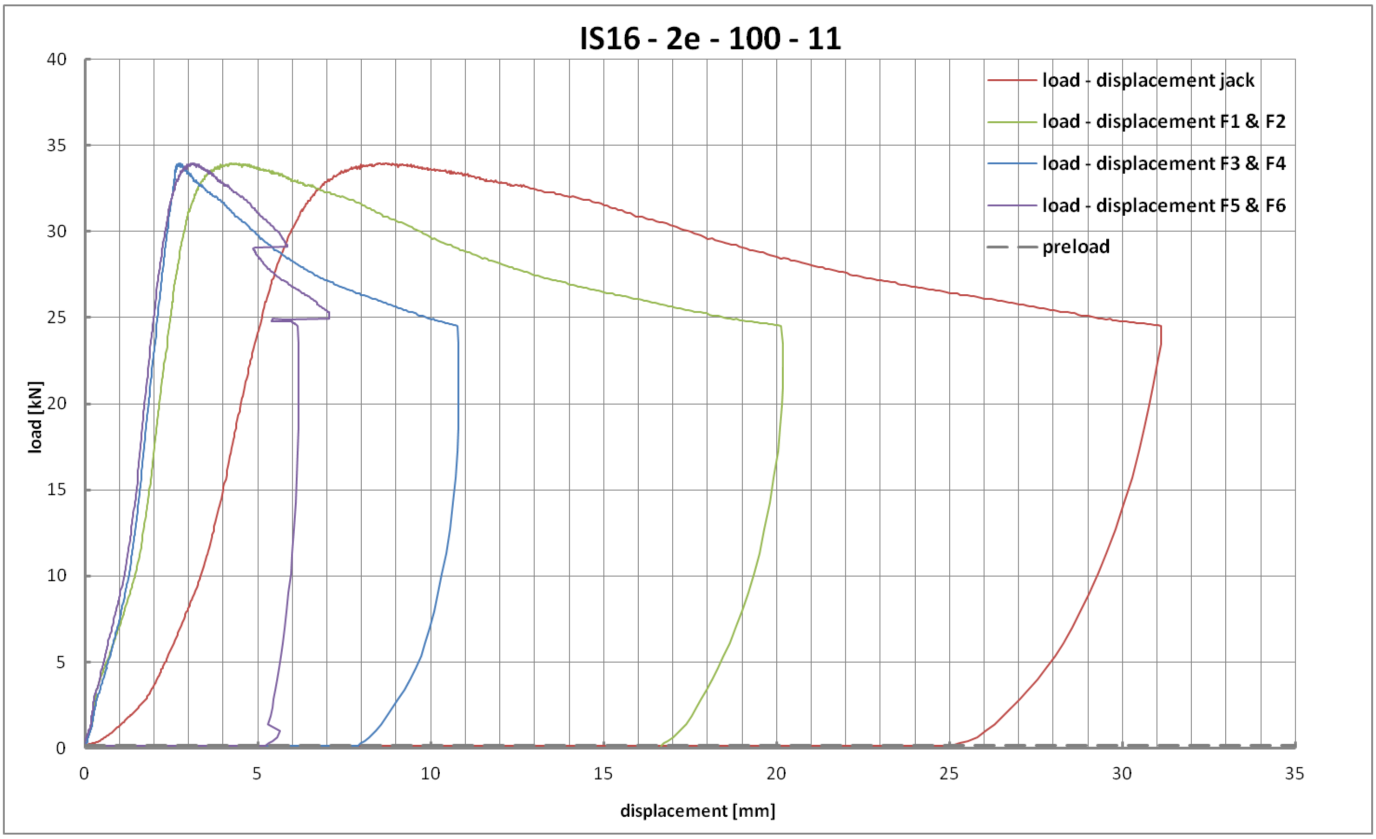

IS6 - 2e - 100 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35


IS6 - 2e- 100 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40

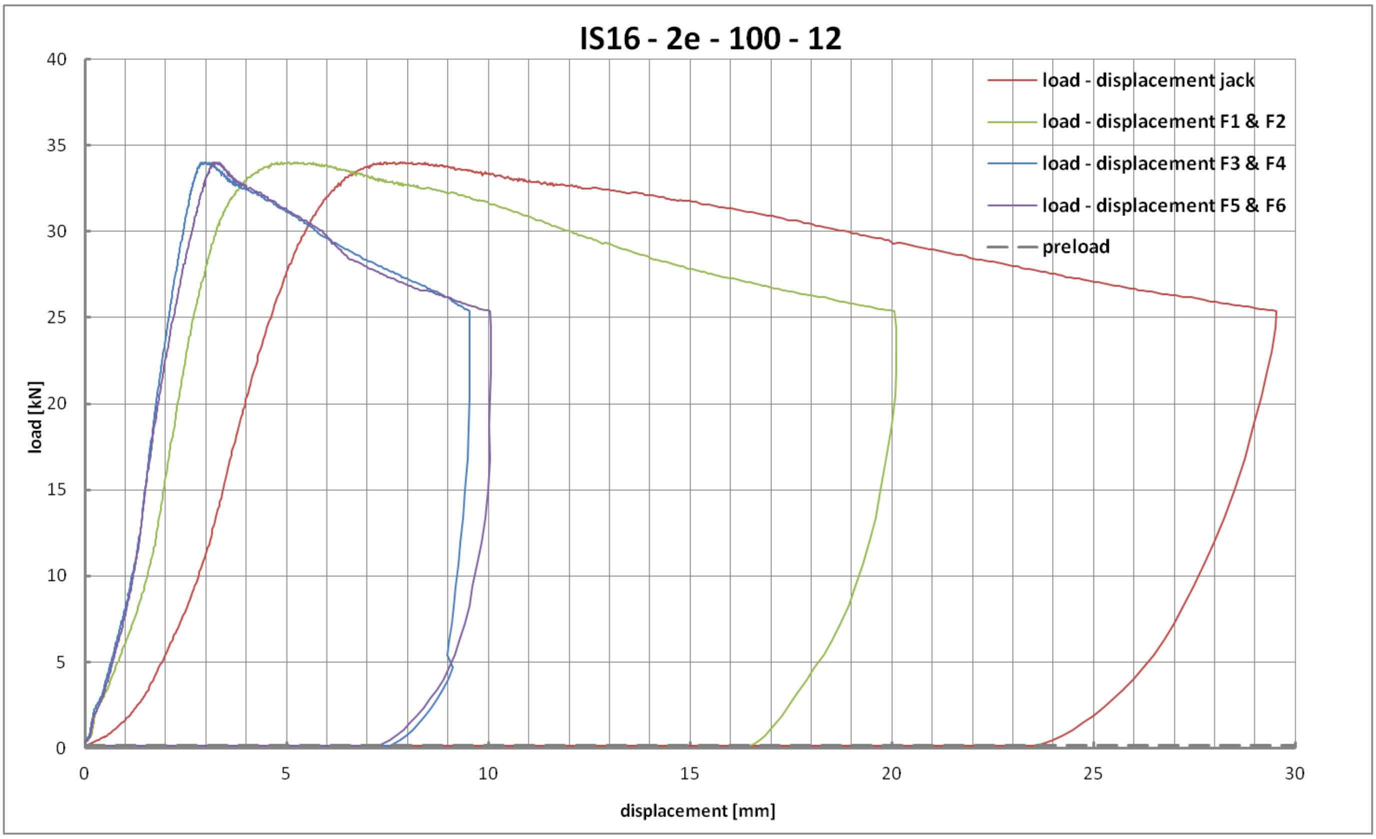

IS6 - 2e - 100 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45


IS6 - 2e - 100 - 41
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35
40
45

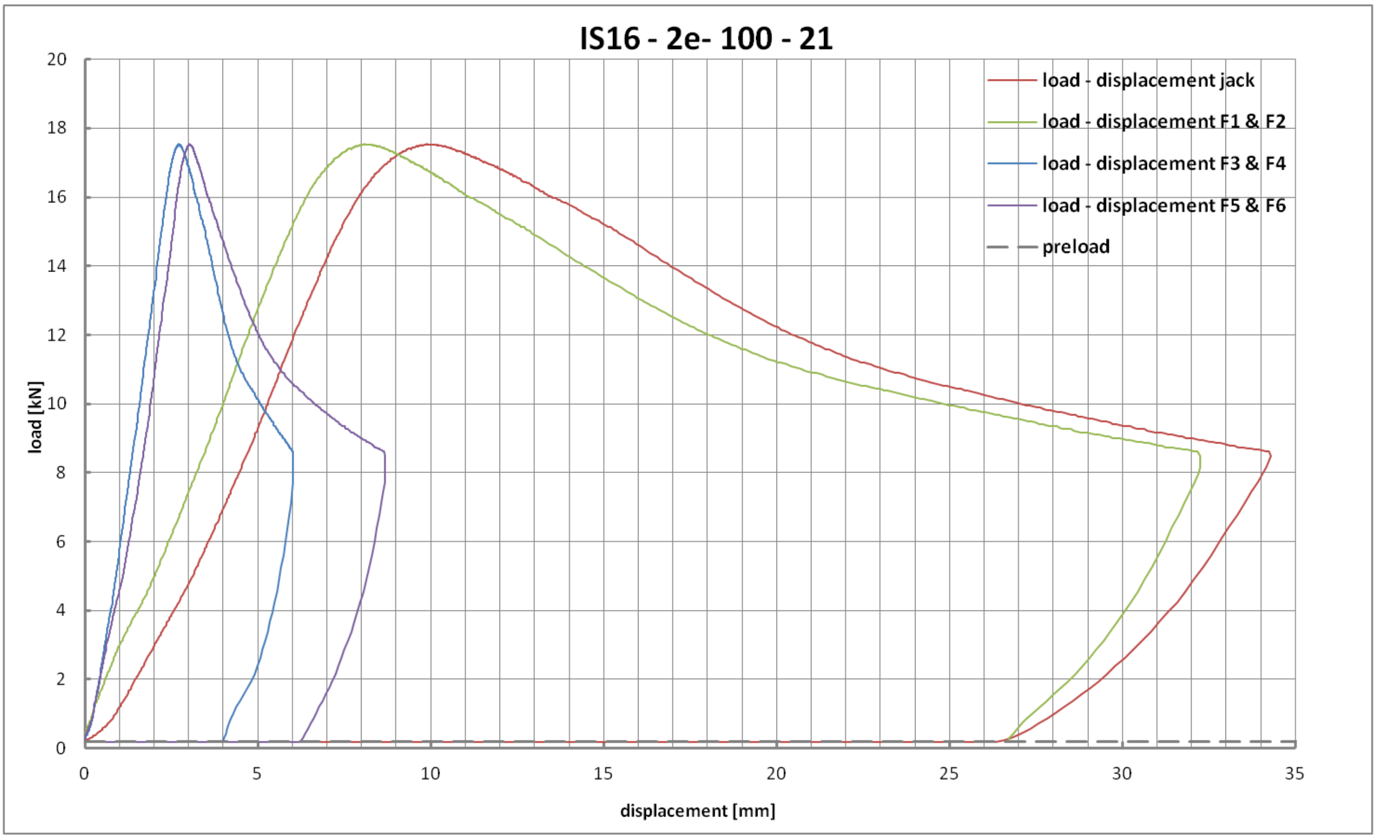

IS6 - 2e - 100 - 42
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35
40

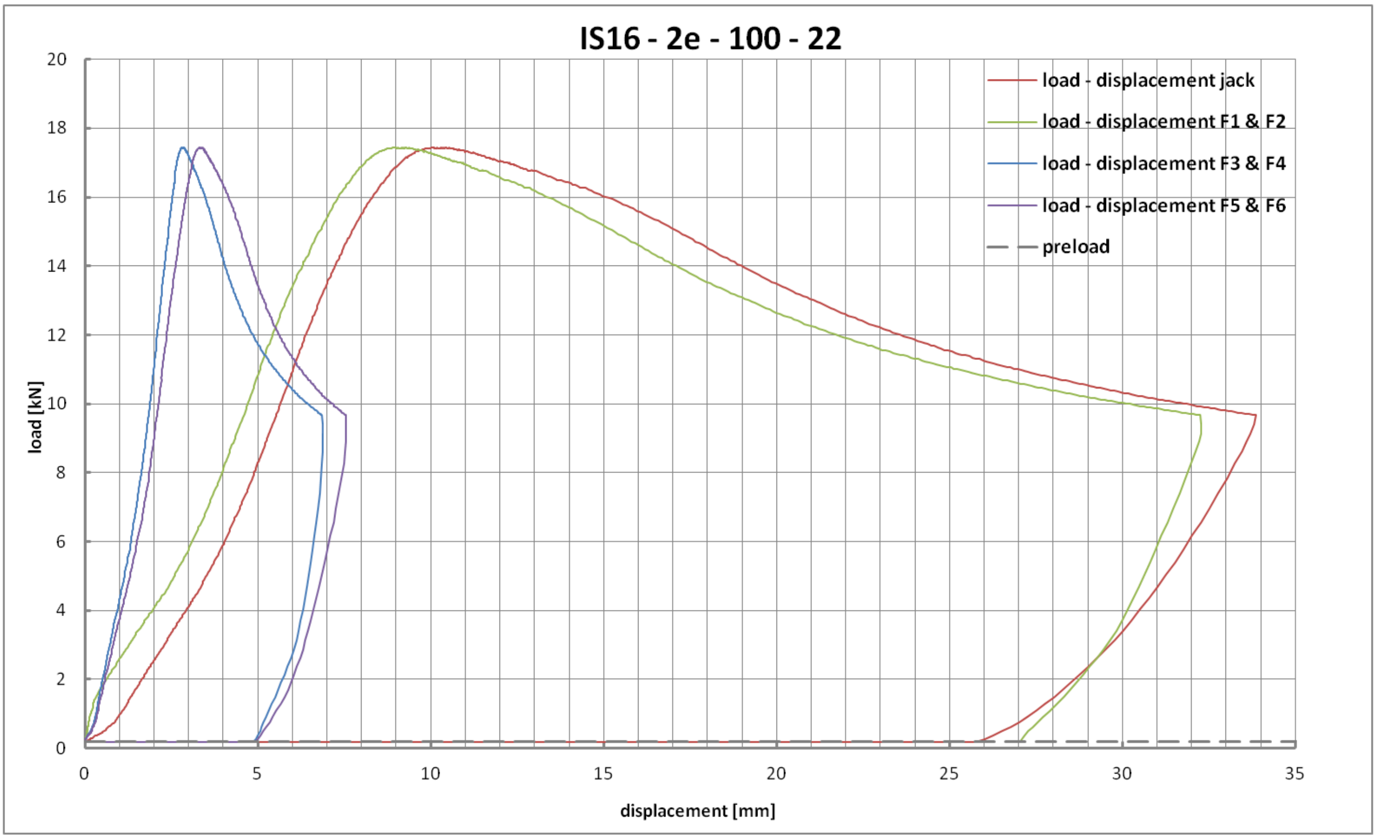


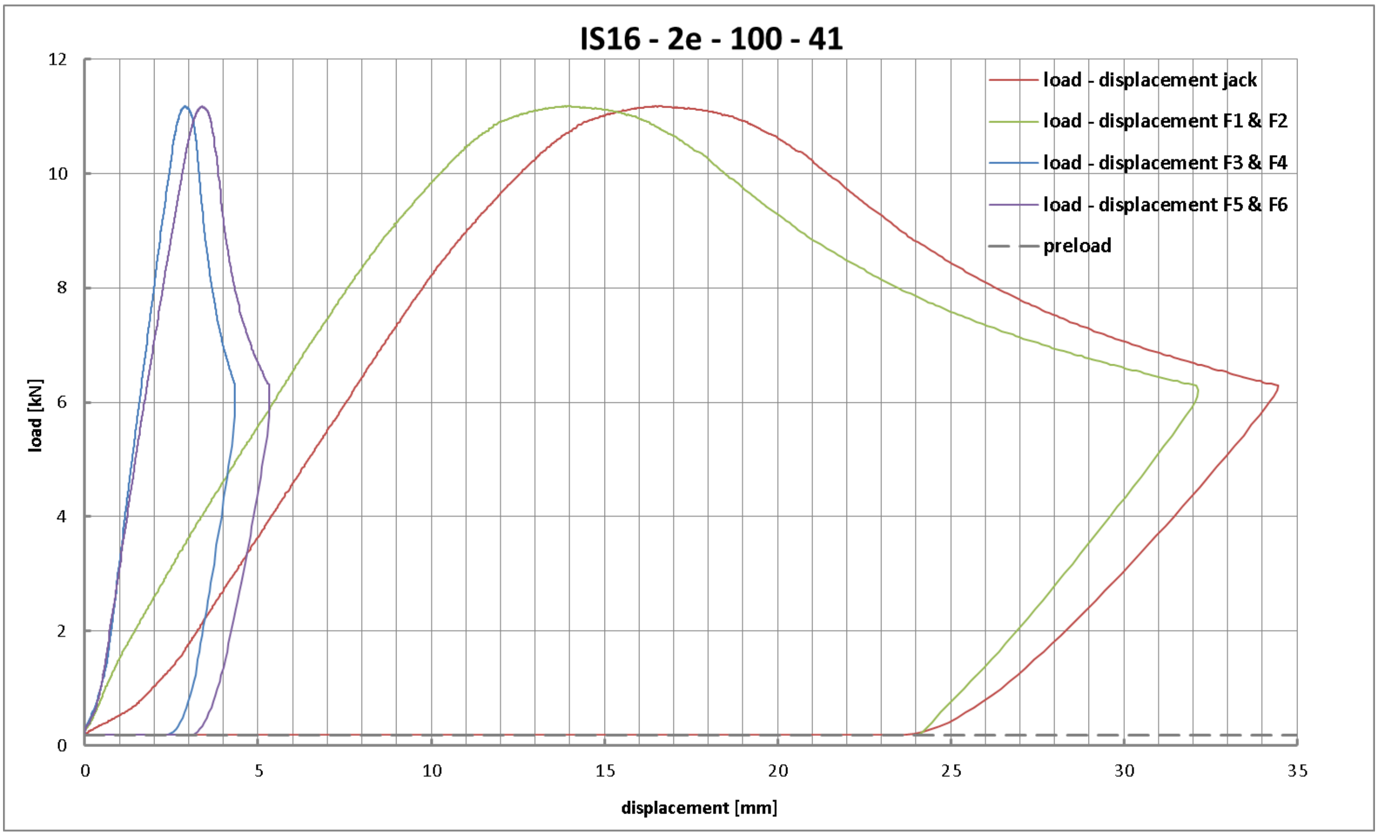
IS16 - 2e - 100 - 11
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40

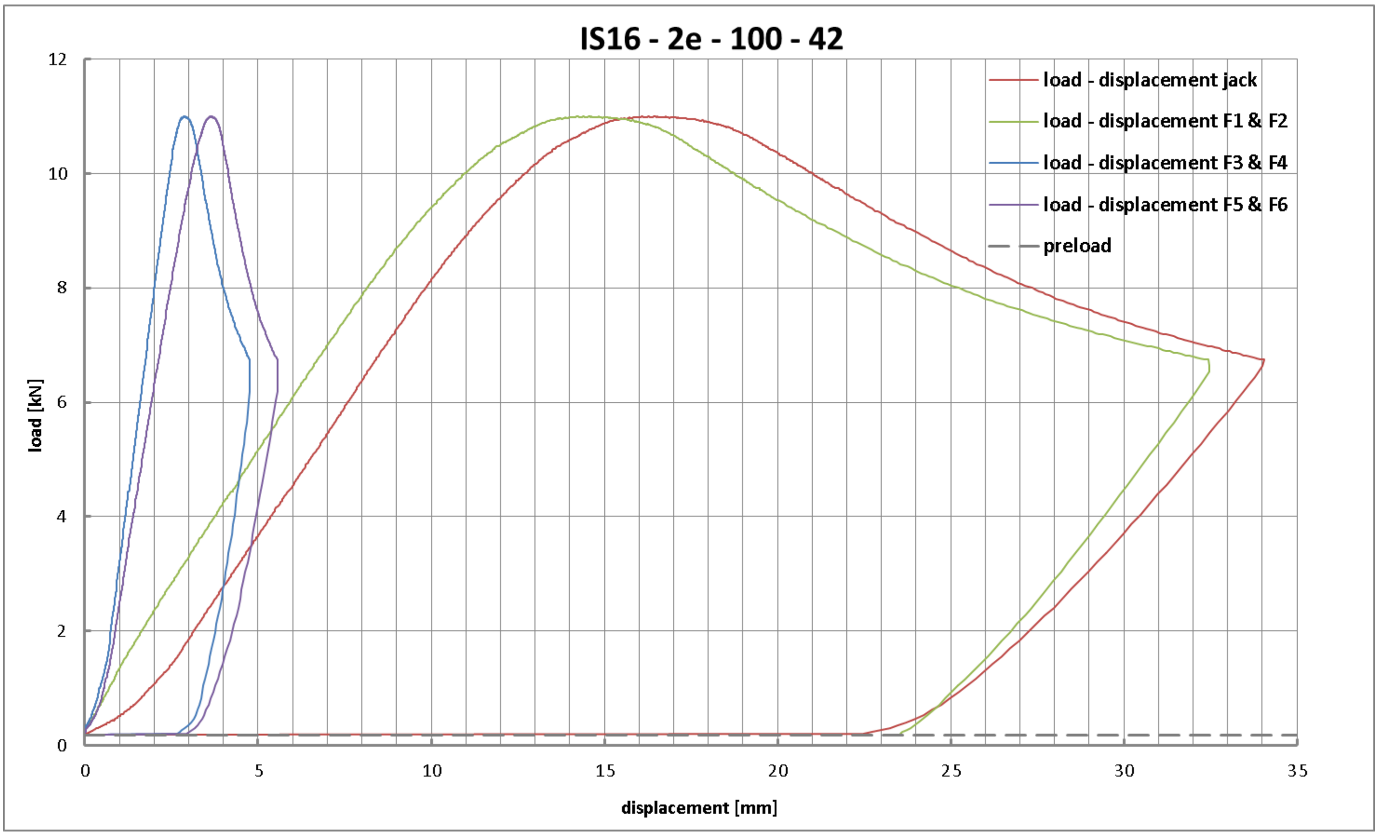


IS16 - 2e - 100 - 12
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40


IS16 - 2e- 100 - 21
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
35


IS16 - 2e - 100 - 22
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
load [kN]
displacement [mm]
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
35


IS16 - 2e - 100 - 41
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35


IS16 - 2e - 100 - 42
load [kN]
displacement [mm]
load - displacement jack
load - displacement F1 & F2
load - displacement F3 & F4
load - displacement F5 & F6
preload
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35

Annex D: End support test with downward load

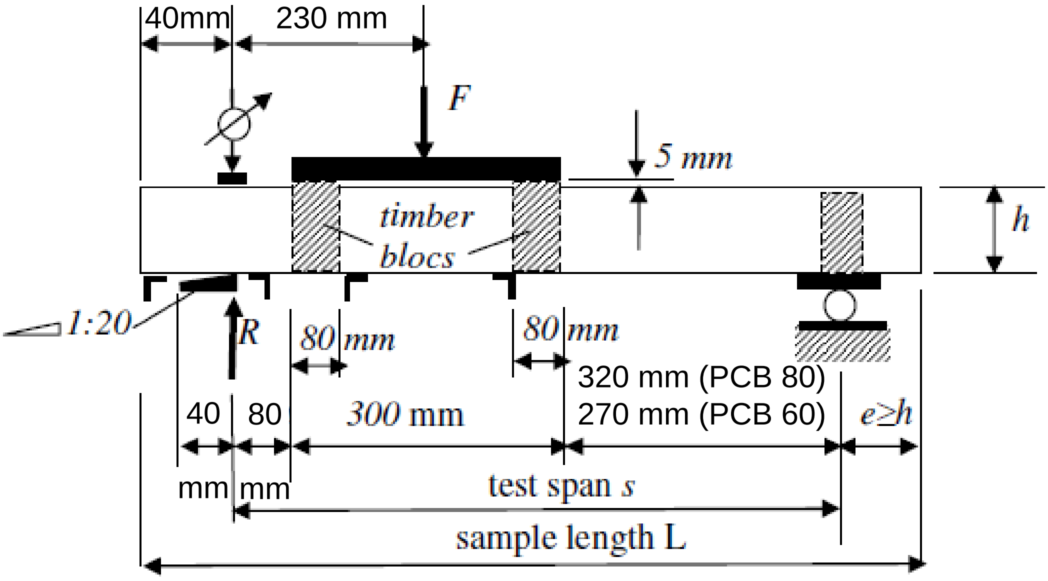


Figure D.1: Schematic test setup

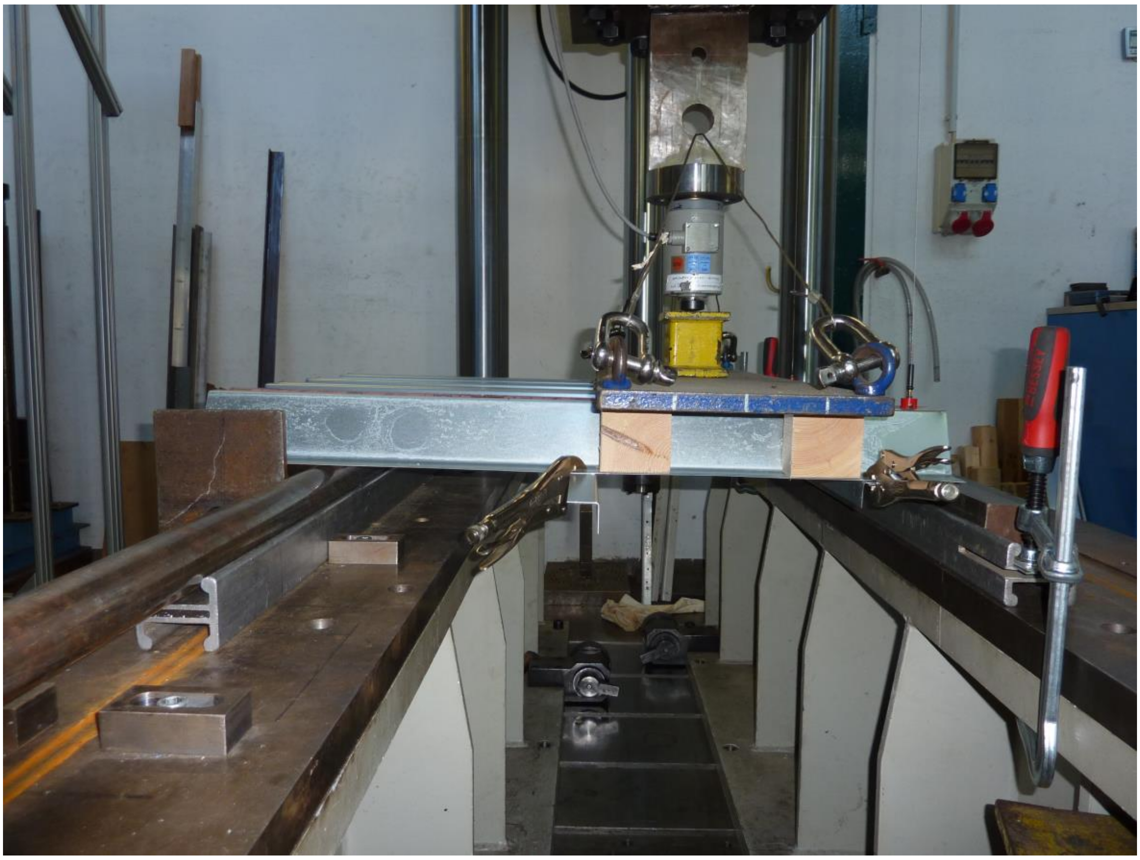


Figure D.2: Side view of the test setup (exemplary for PCB 80, t_N = 0.75 mm without embossments)

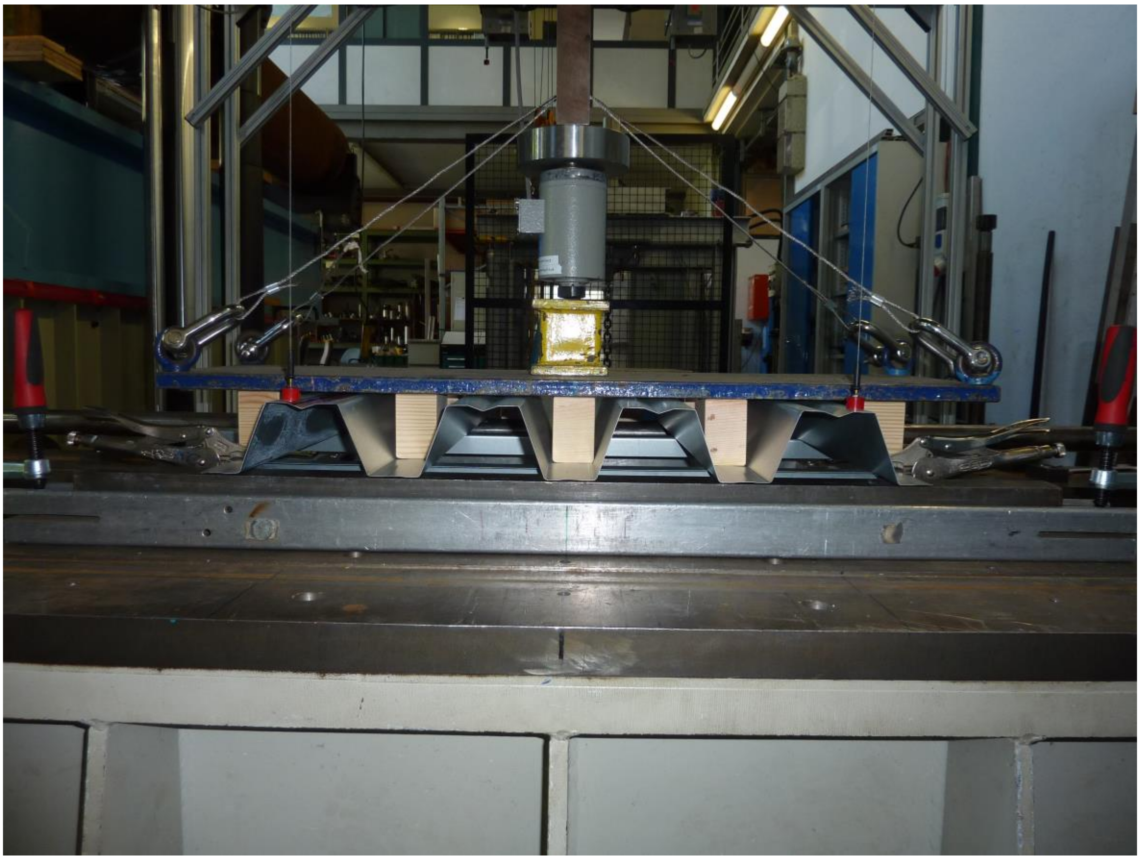


Figure D.3: View of the test setup (exemplary for PCB 80, t_N = 0.75 mm without emboss-
ments)

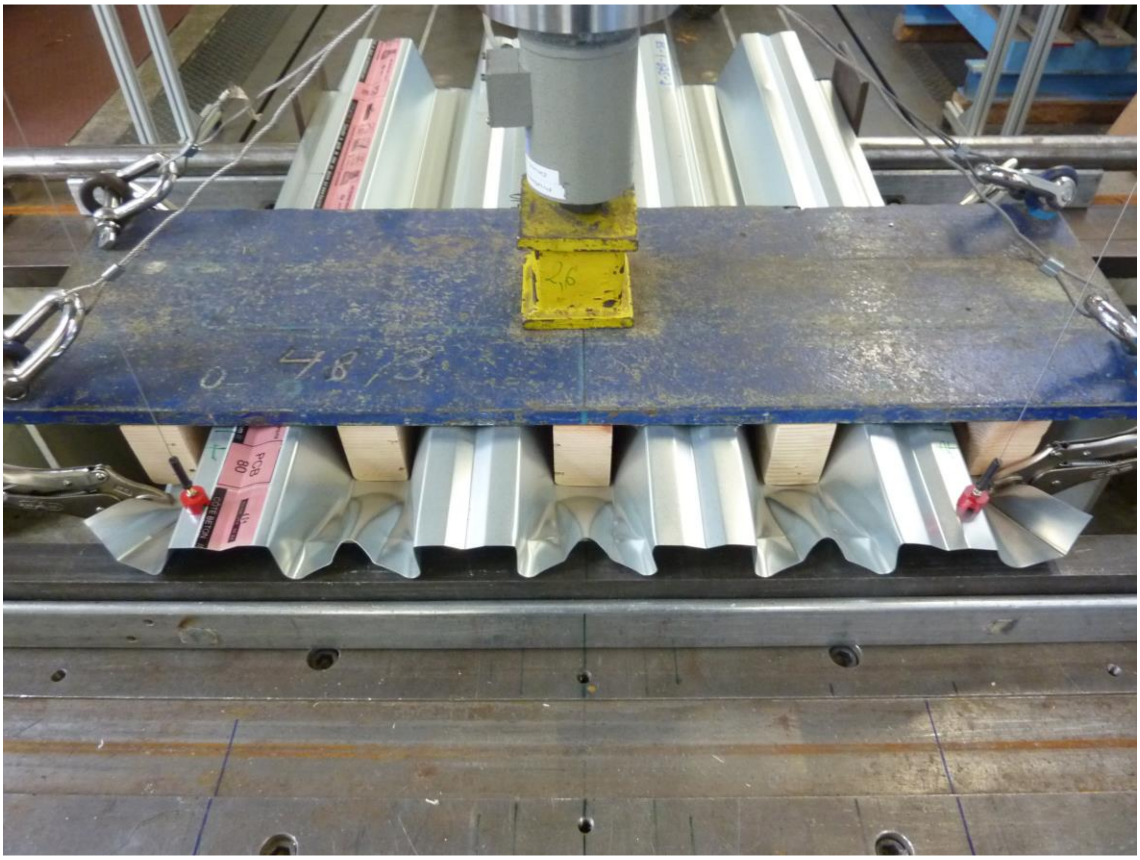


Figure D.4: Web-crippling (PCB 80 t_N = 0.75 mm without embossments)

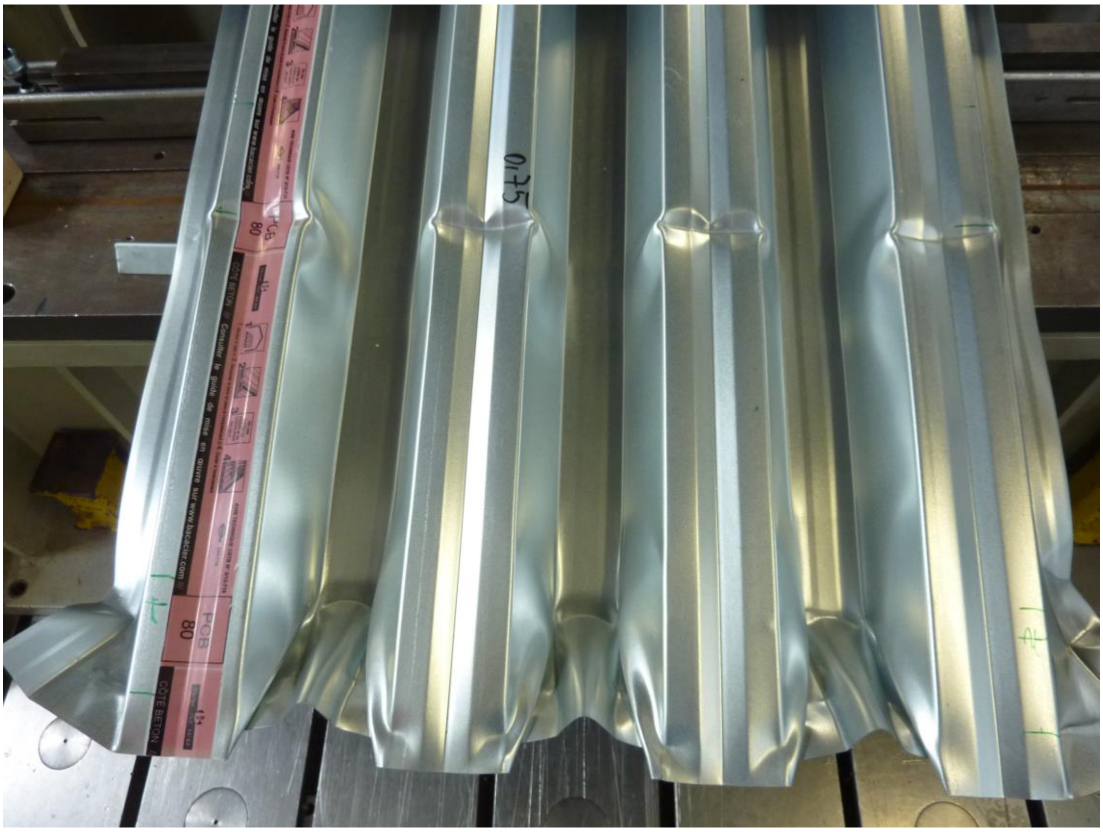


Figure D.5: Deformation of the profile after the test (PCB 80 t_N = 0.75 mm without embossments)

Figure D.6: Web-crippling (PCB 80 t_N = 0.75 mm with embossments)

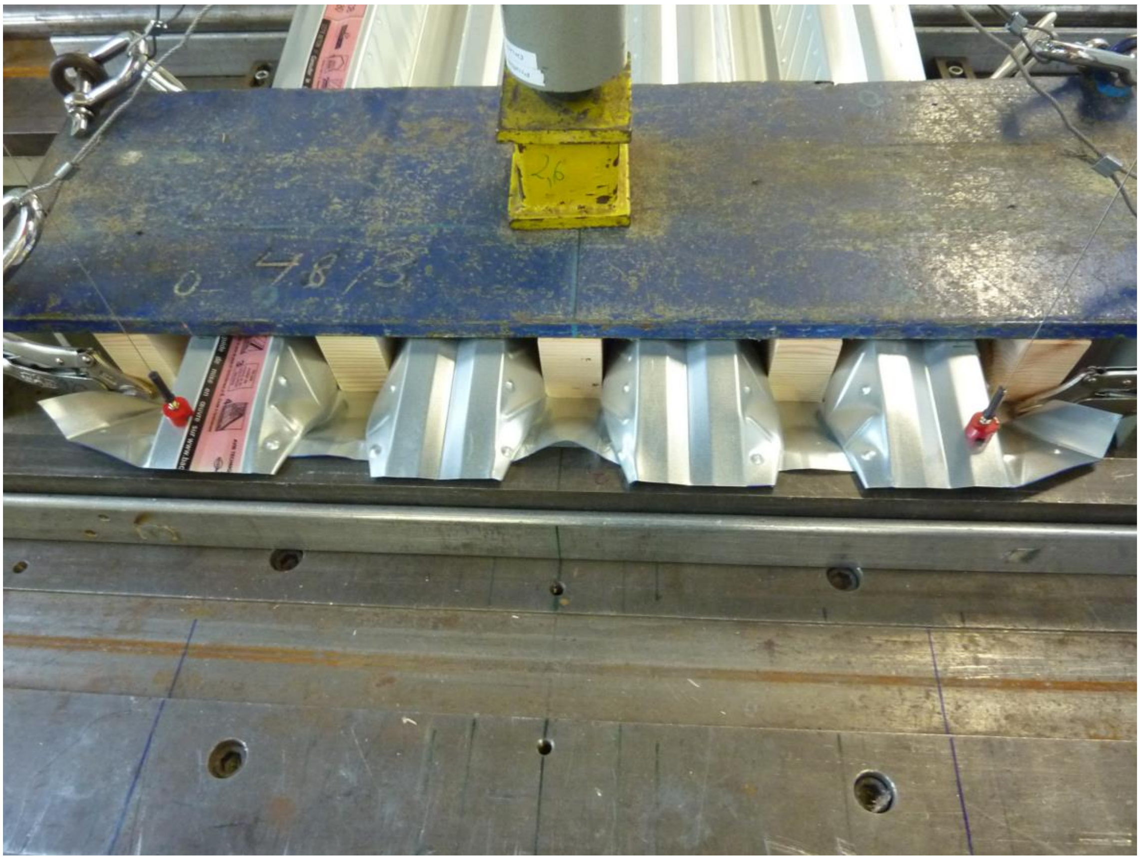


Figure D.7: Deformation of the webs during the load increase after the first peak (PCB 80, t_N = 0.75 mm with embossments)

Figure D.8: Buckling of the upper flanges (PCB 80, t_N = 0.75 mm with embossments)

Figure D.9: Deformation at the end of the test (PCB 80, t_N = 0.75 mm with embossments)

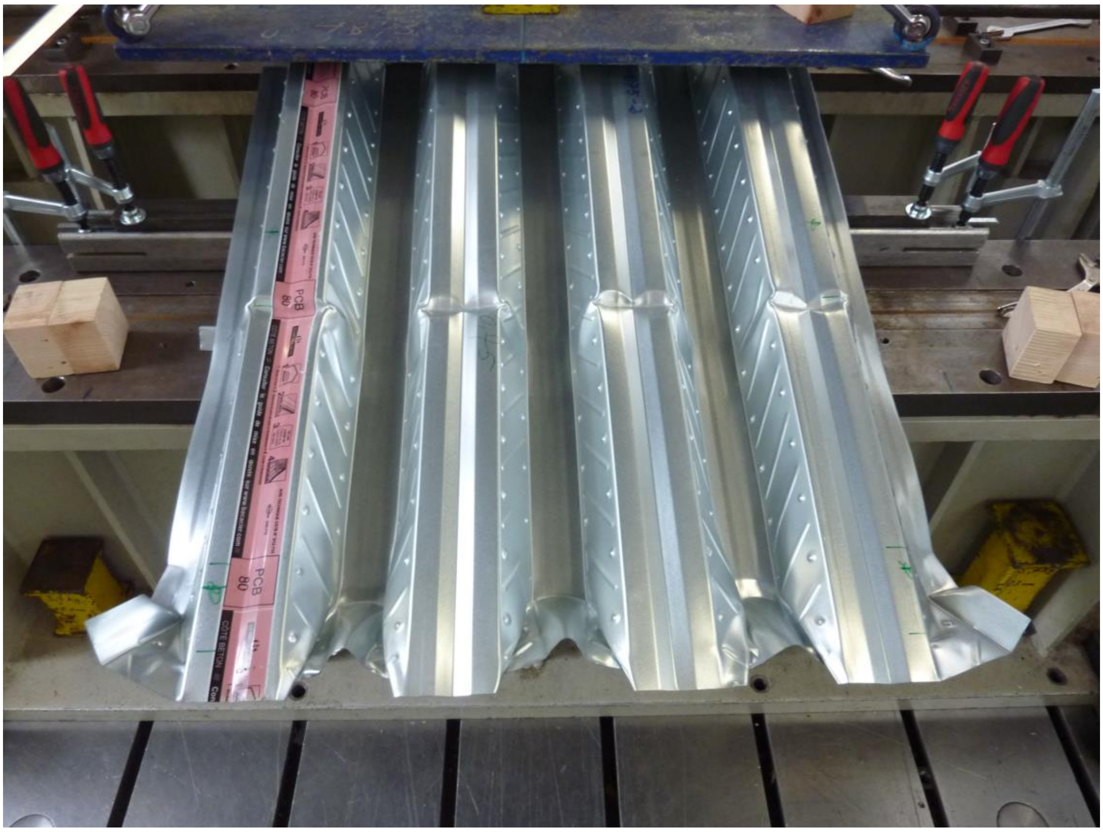


Figure D.10: Deformation of the profile after the test (PCB 80 t_N = 0.75 mm with embossments)

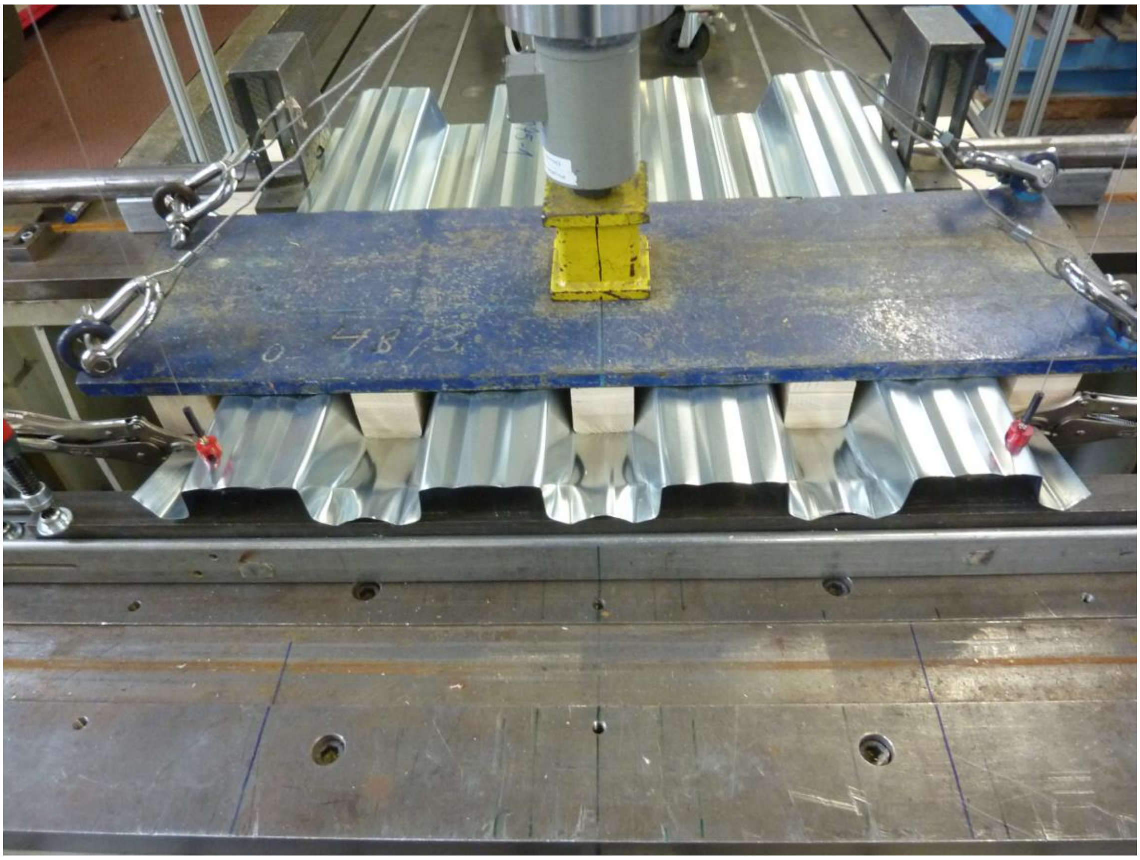


Figure D.11: Web-crippling (PCB 60 t_N = 0.75 mm without embossments)

Figure D.12: Buckling of the upper flanges (PCB 60, t_N = 0.75 mm without embossments)

Figure D.13: Web-crippling (PCB 60 t_N = 1.00 mm without embossments)

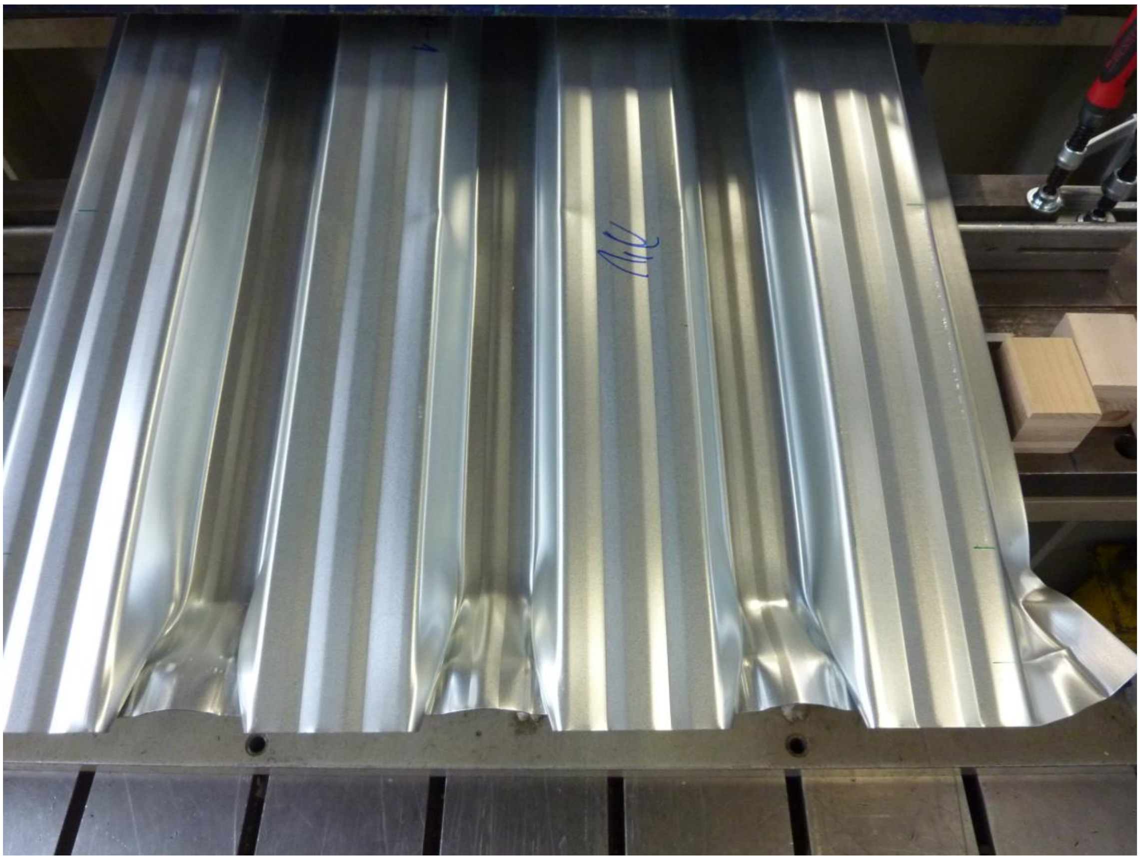


Figure D.14: No buckling of the upper flanges (PCB 60, t_N = 1.00 mm without embossments, test 1 and test 2)

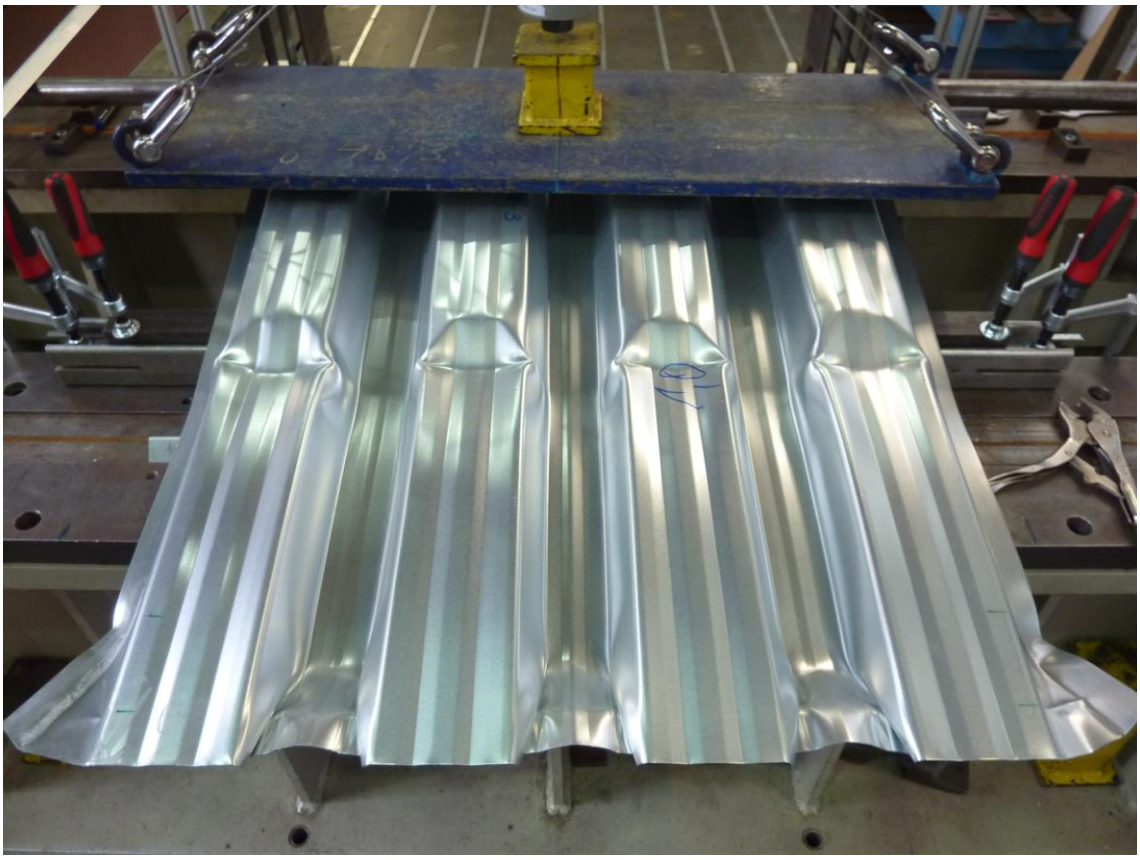


Figure D.15: Buckling of the upper flanges (PCB 60, t_N = 1.00 mm without embossments, test 3)

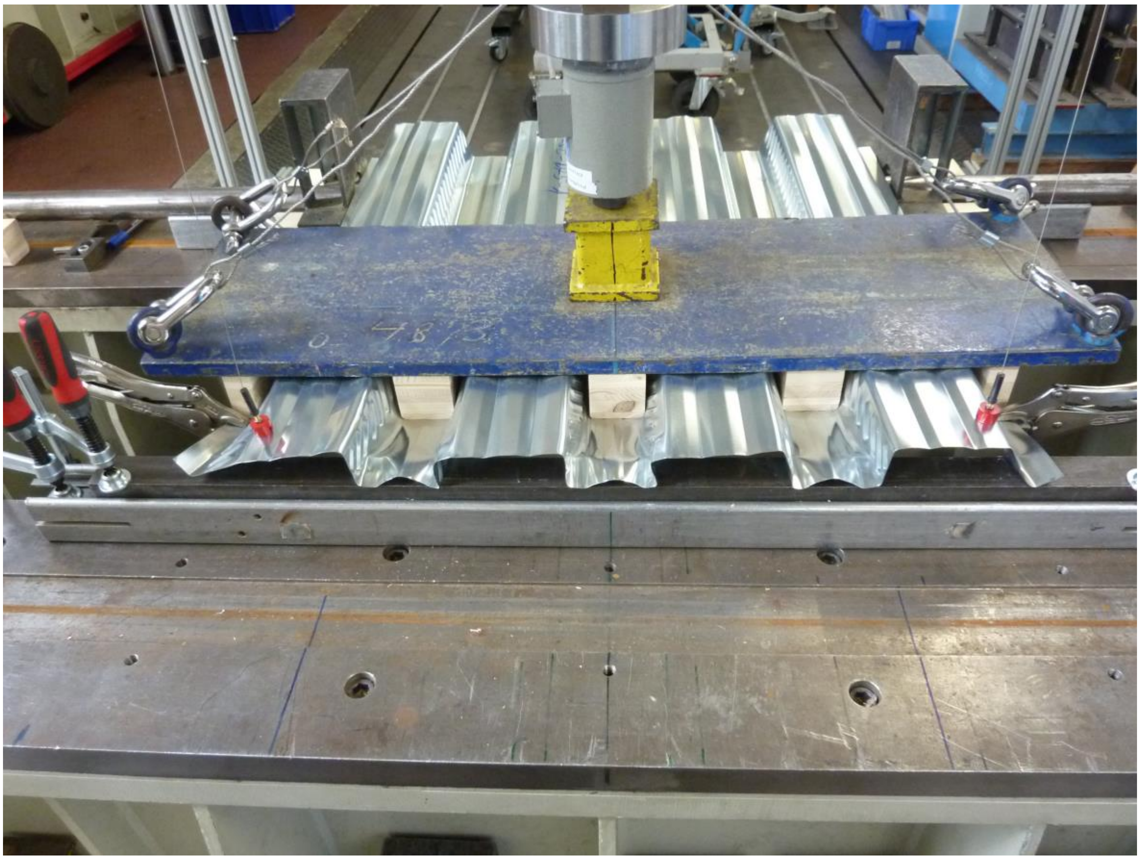
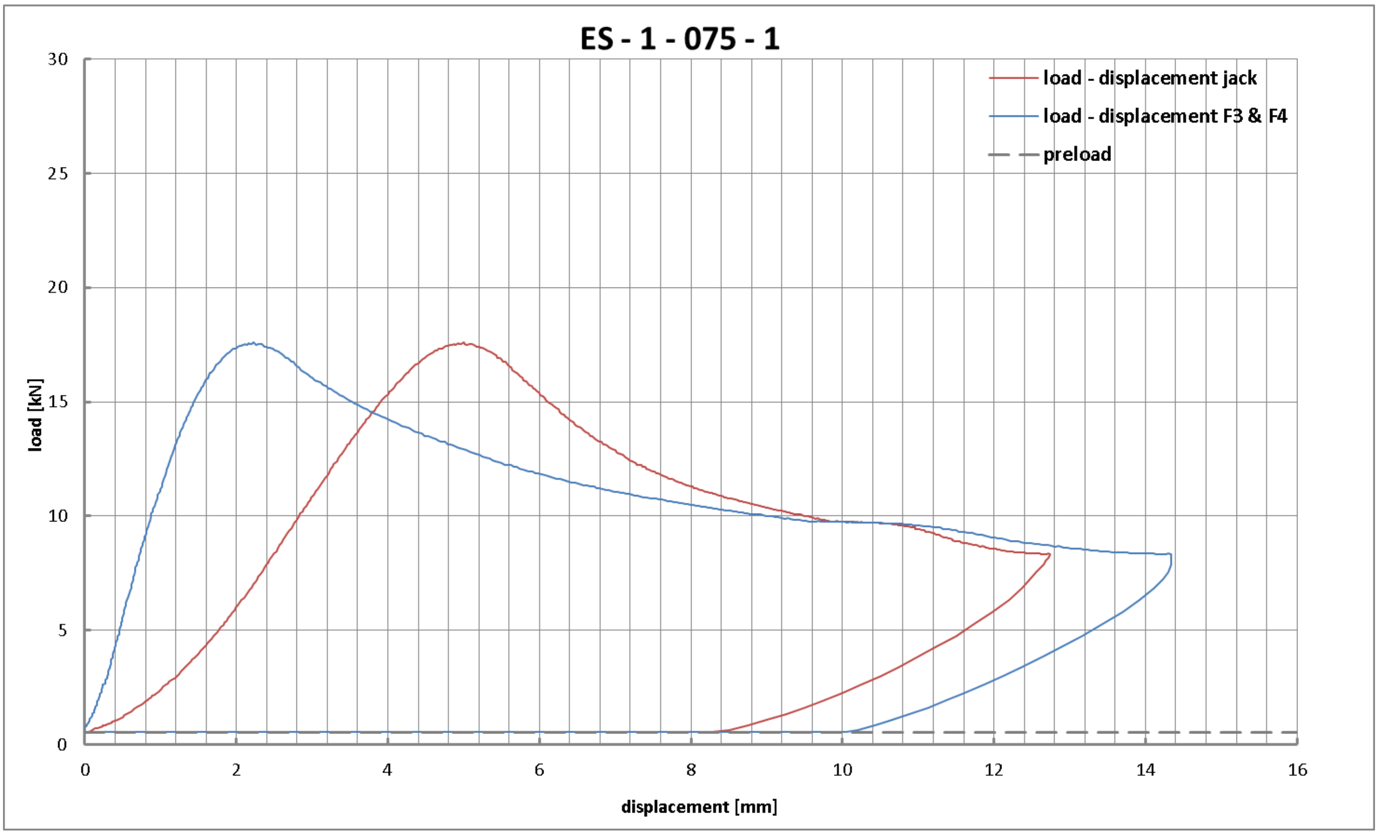
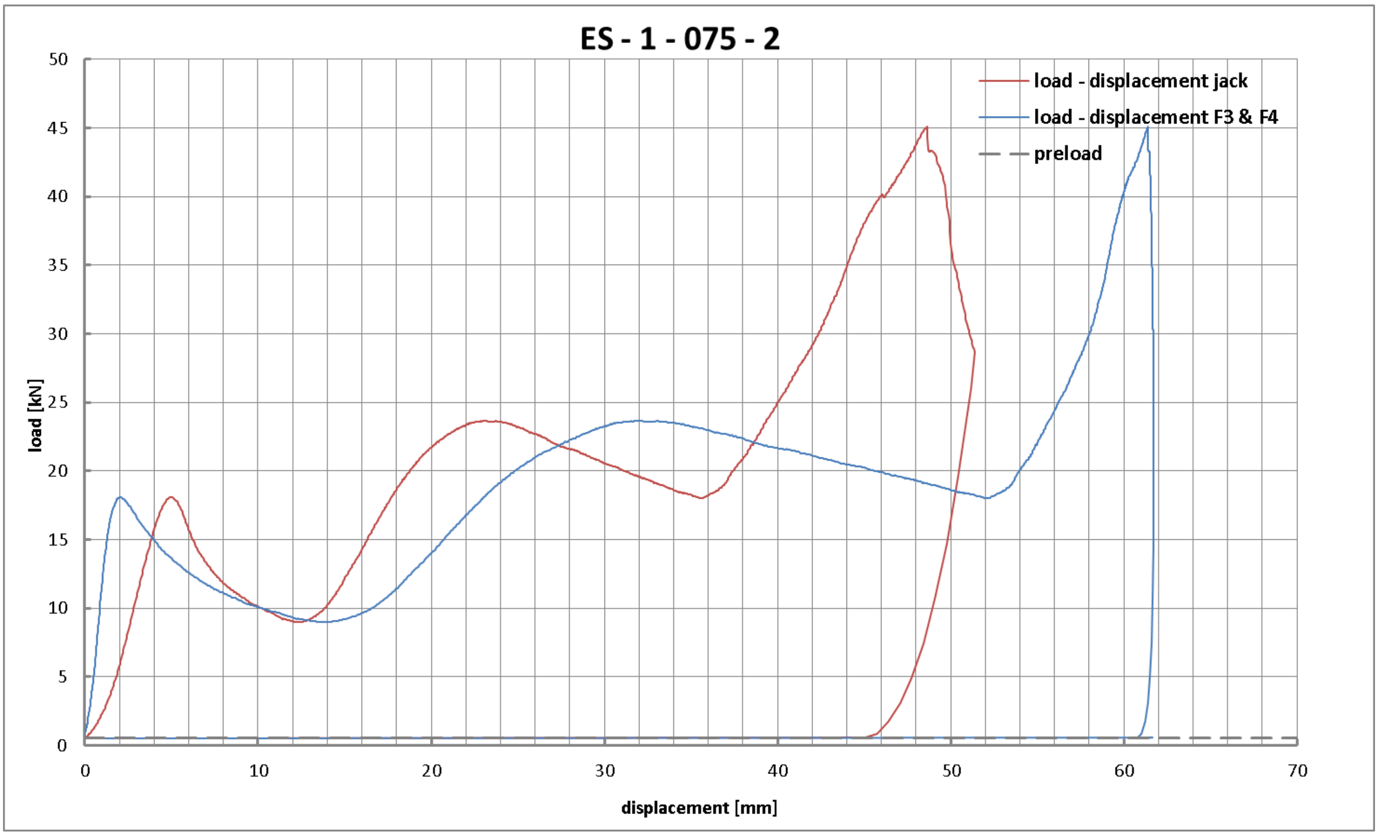


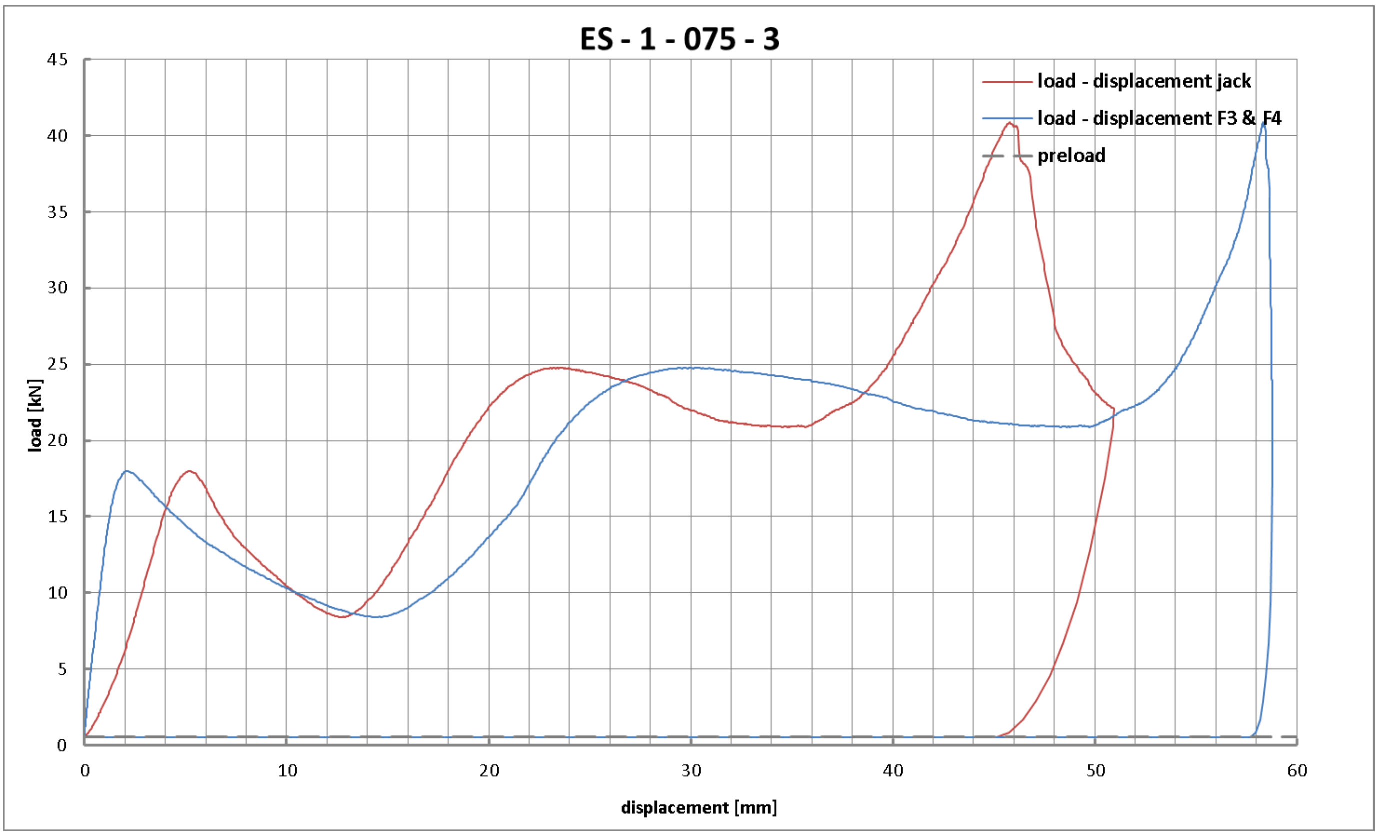
Figure D.16: Web-crippling (PCB 60 t_N = 0.75 mm with embossments)

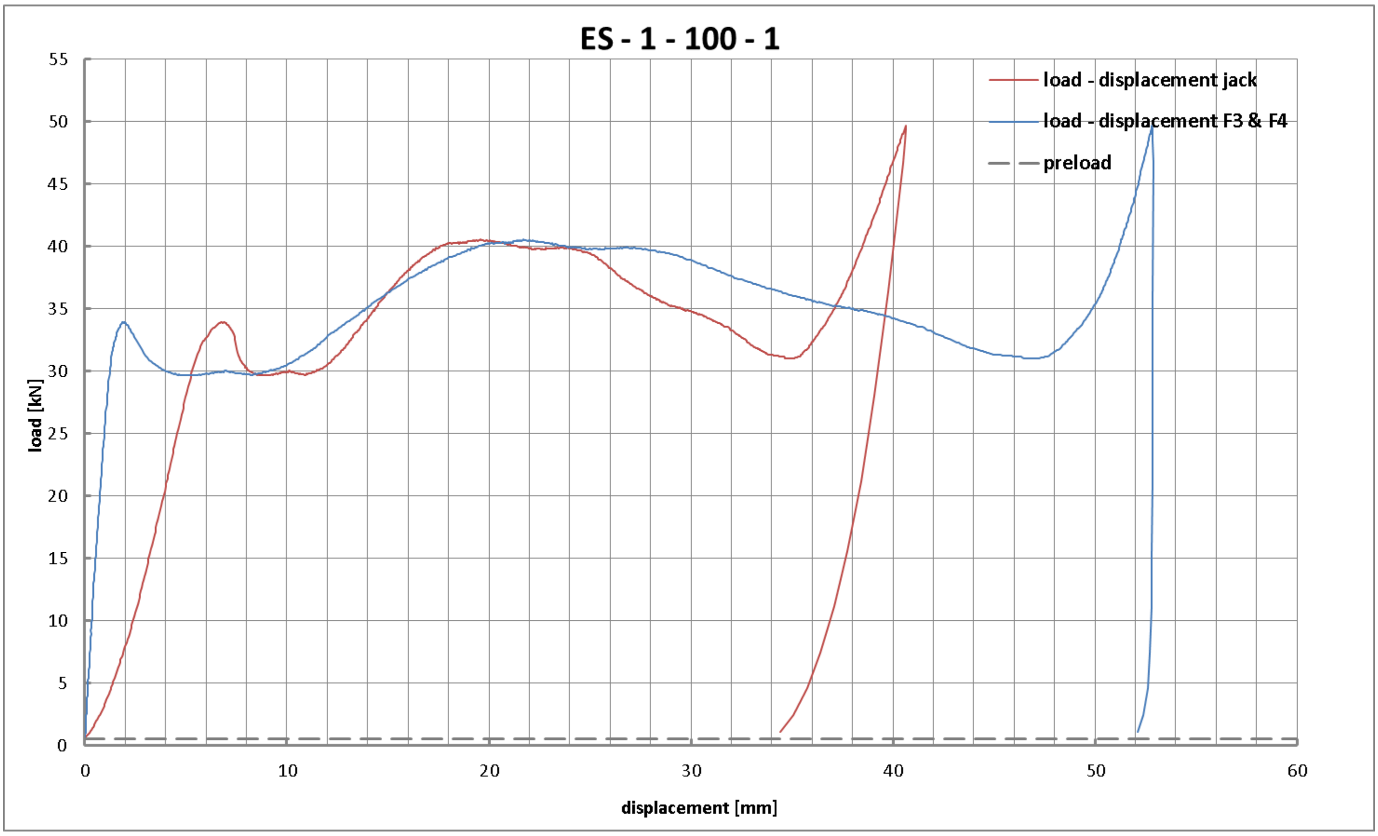
Figure D.17: Buckling of the upper flanges (PCB 60, t_N = 0.75 mm with embossments)

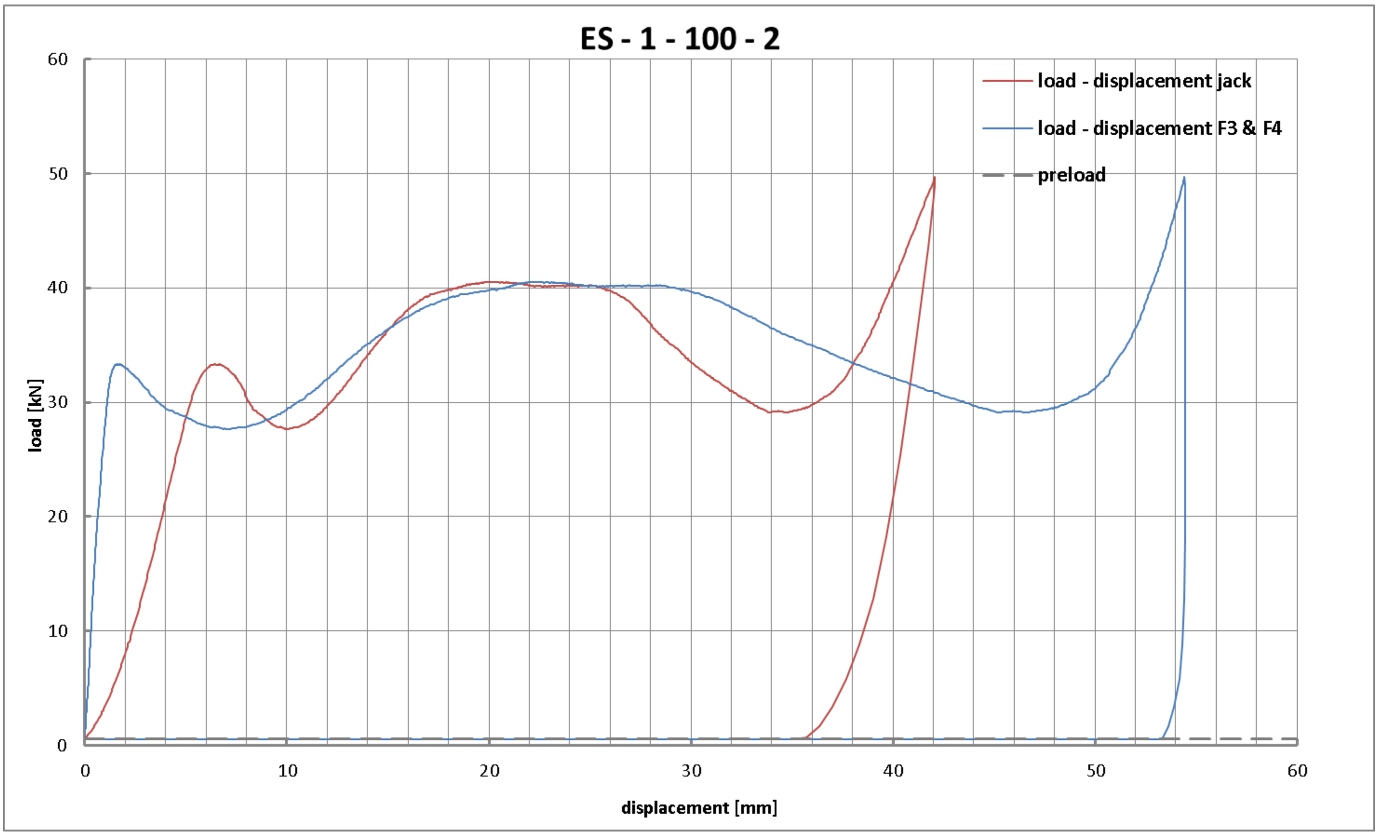
<u>Load-deflection curves:</u>

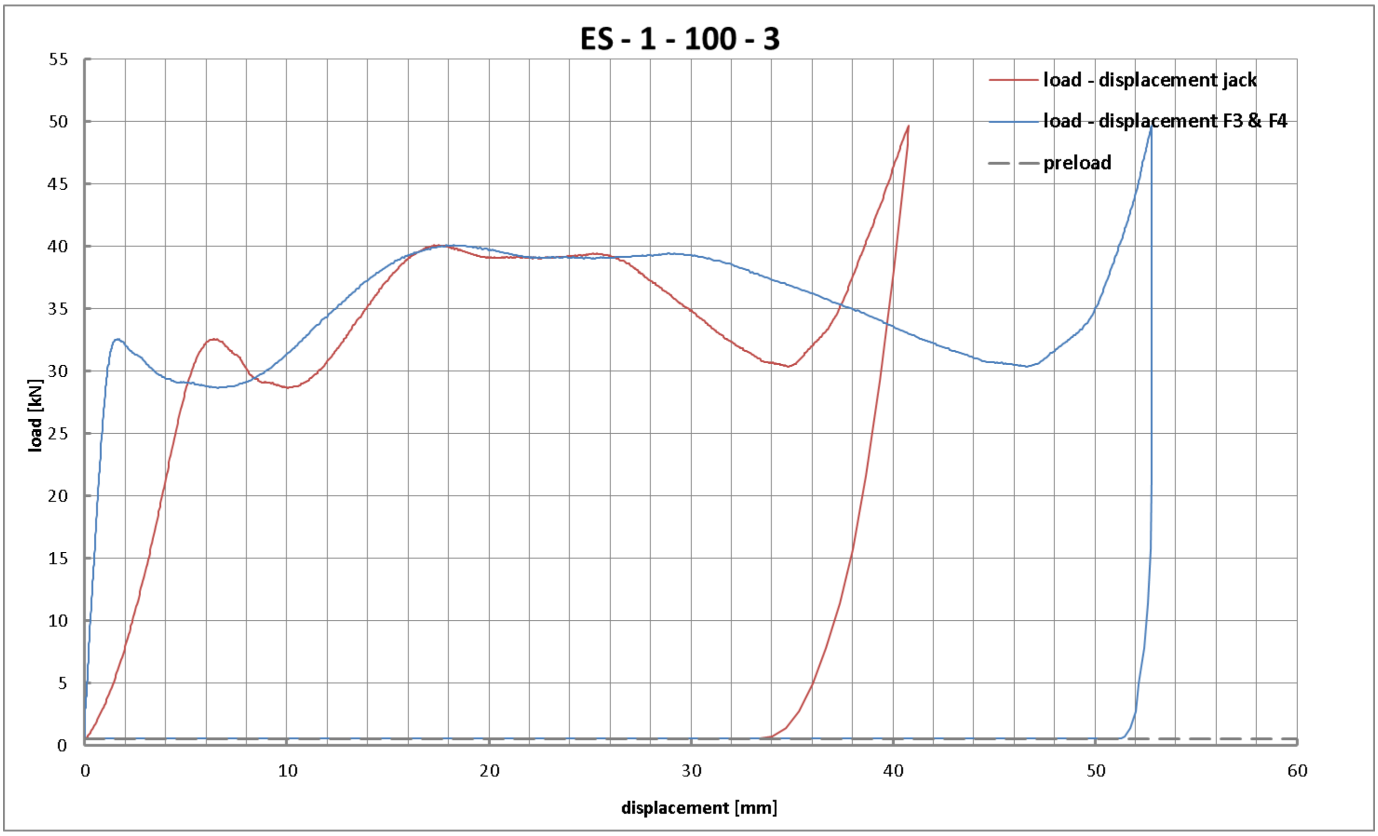


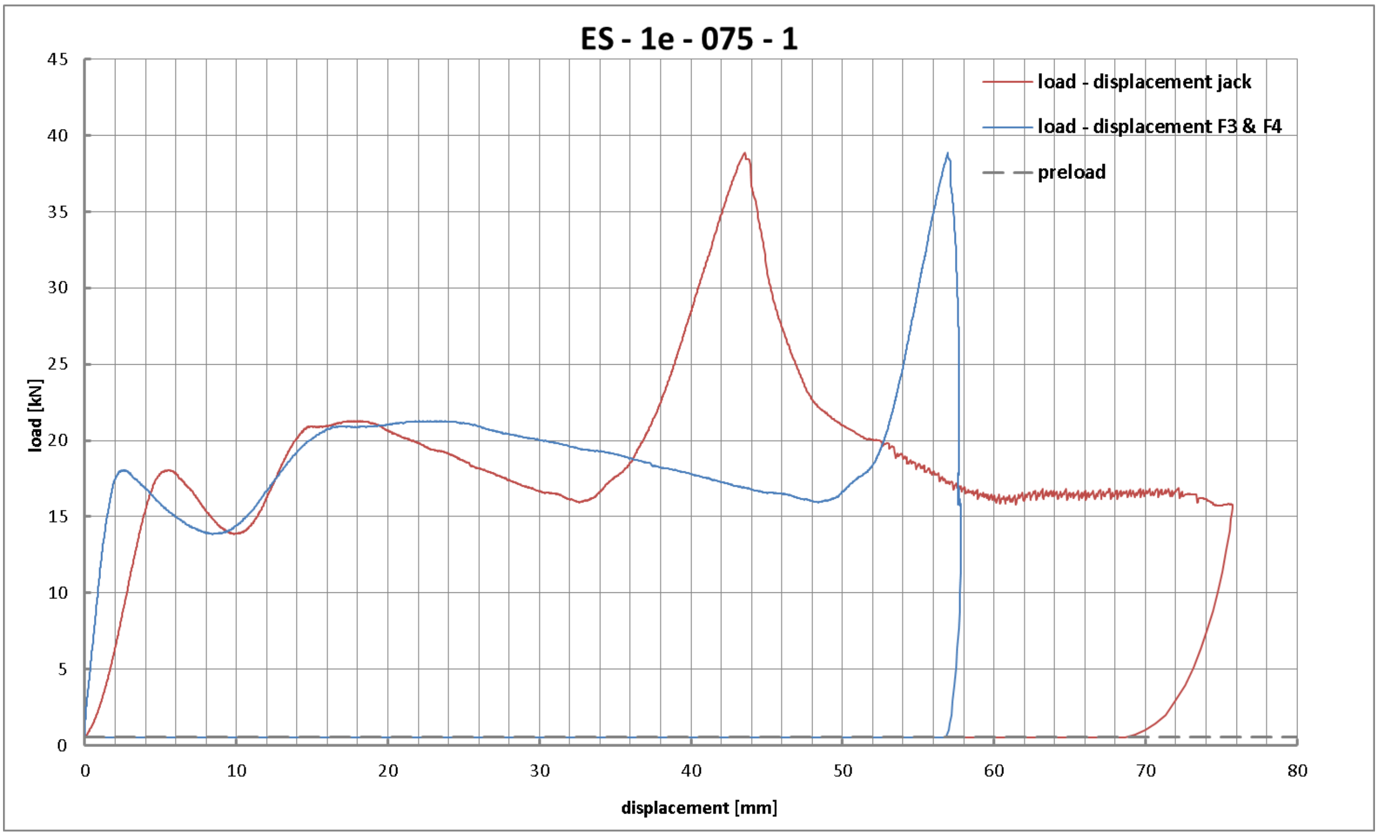

ES - 1 - 075 - 2
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45
50
0
10
20
30
40
50
60
70

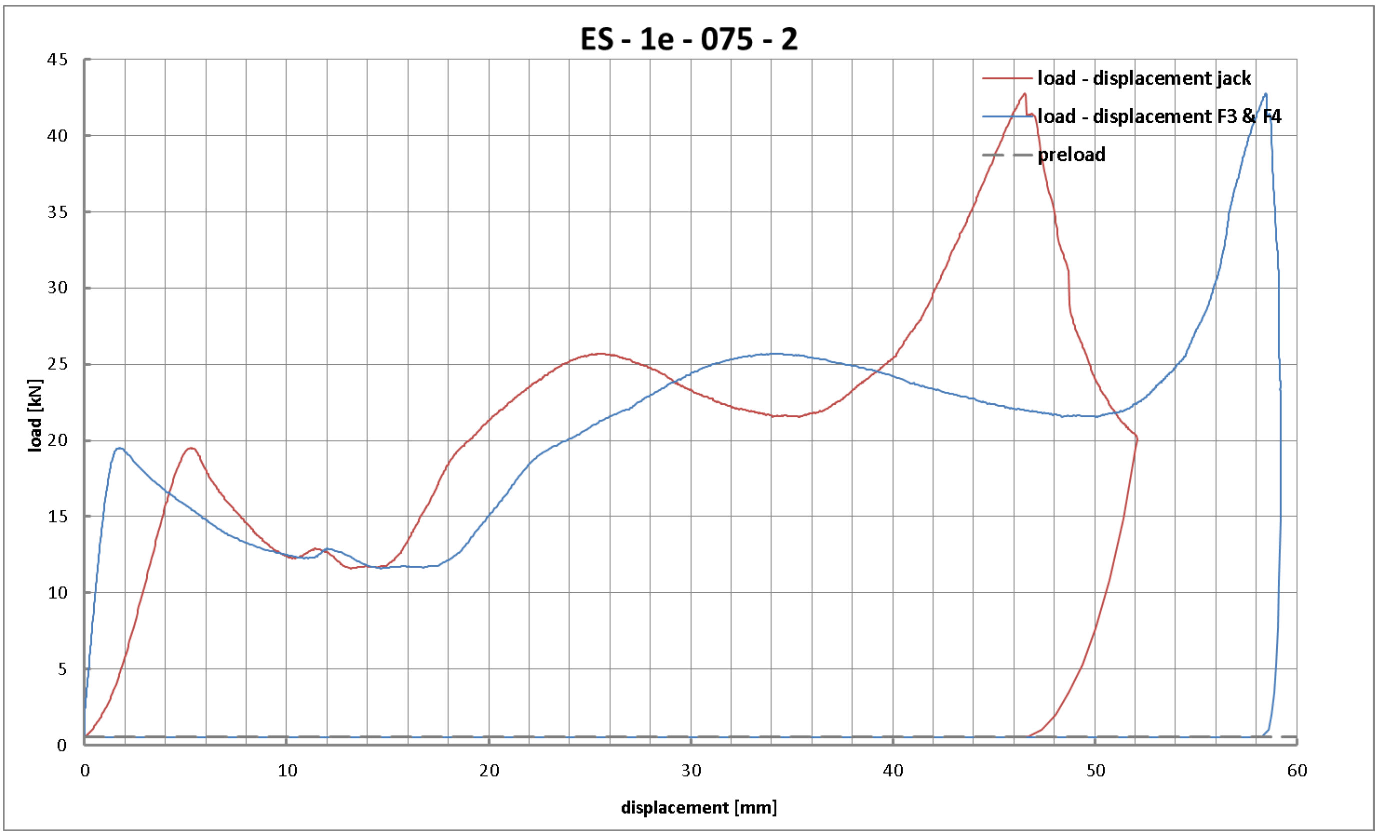

ES - 1 - 075 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60


ES - 1 - 100 - 1
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45
50
55
0
10
20
30
40
50
60

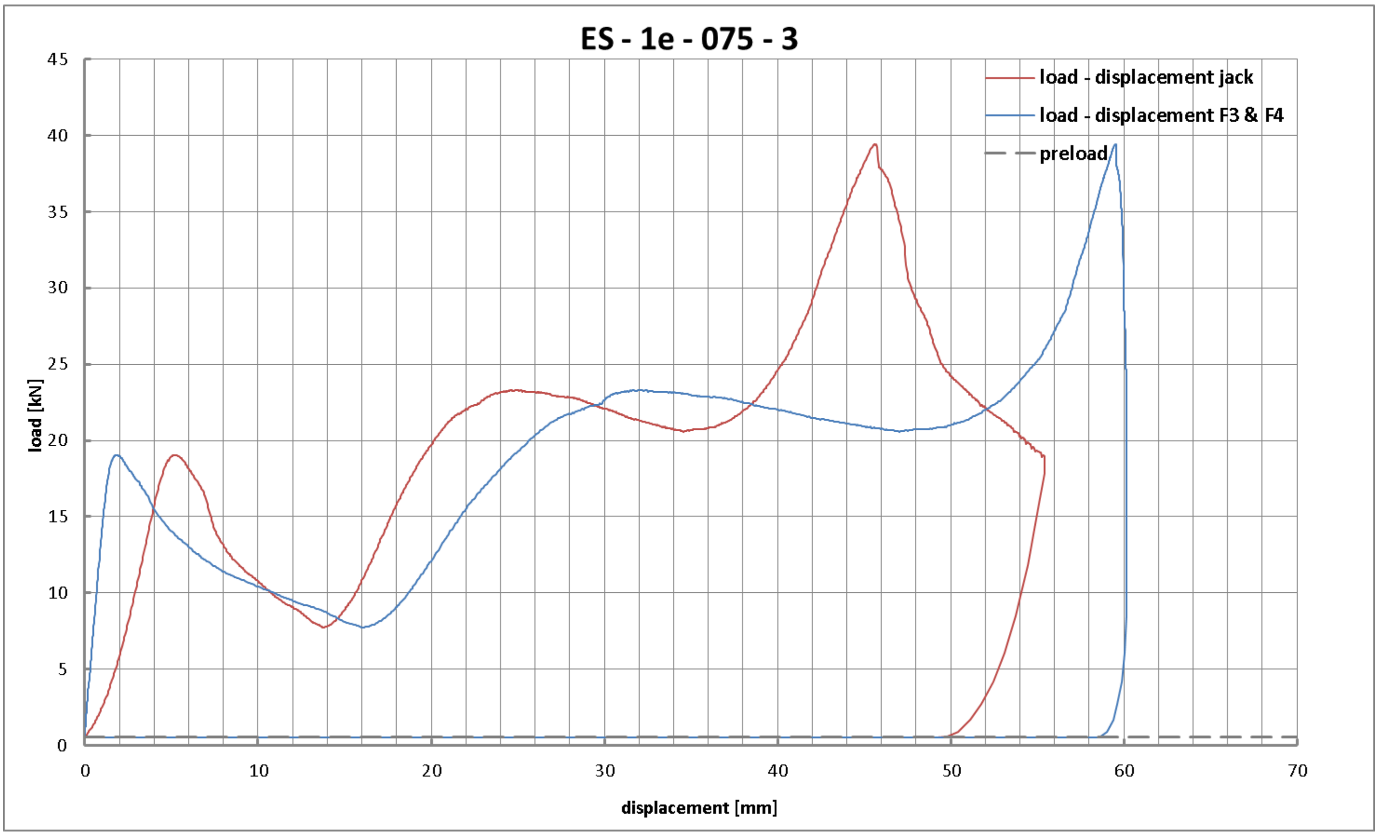

ES - 1 - 100 - 2
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60
0
10
20
30
40
50
60


ES - 1 - 100 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45
50
55
0
10
20
30
40
50
60

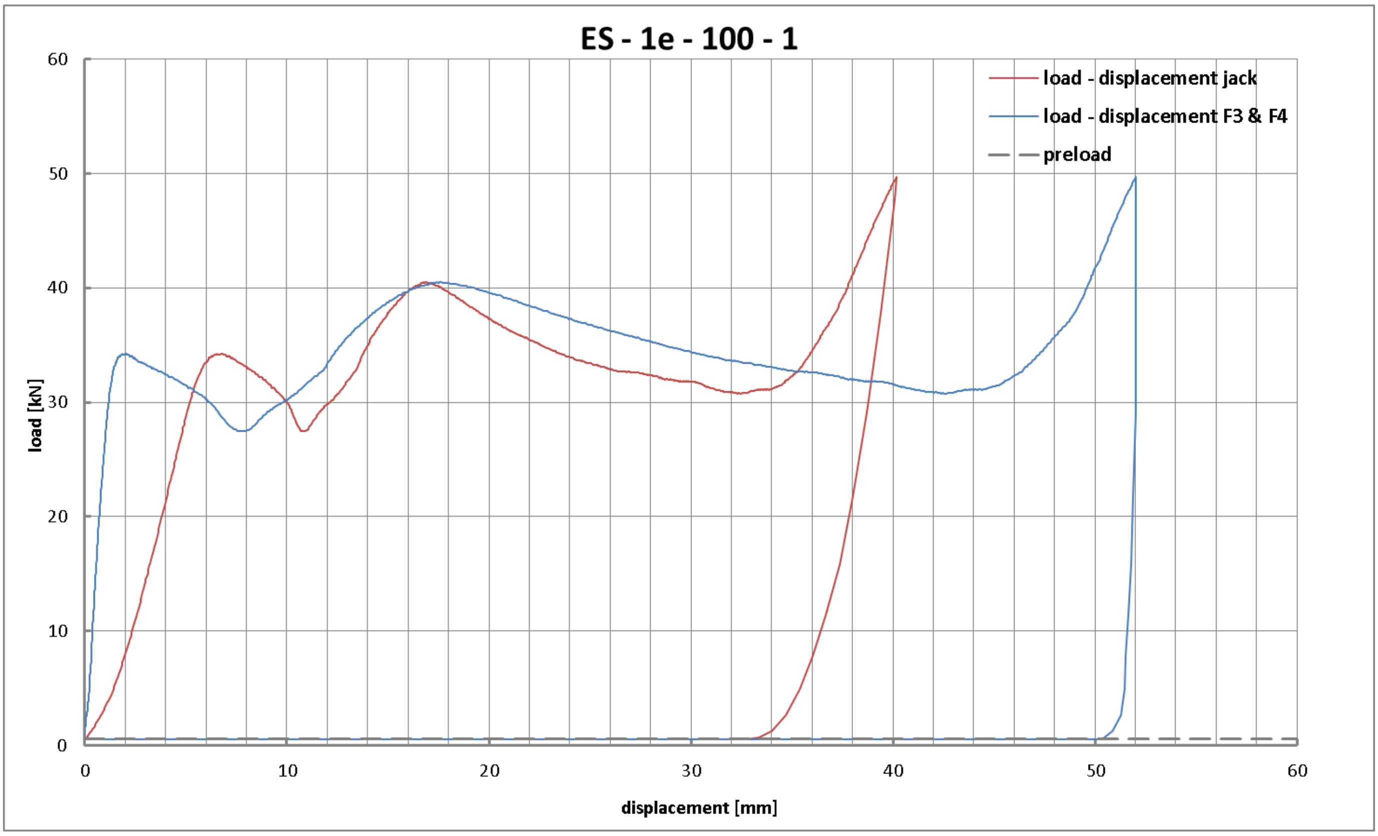

ES - 1e - 075 - 1
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80

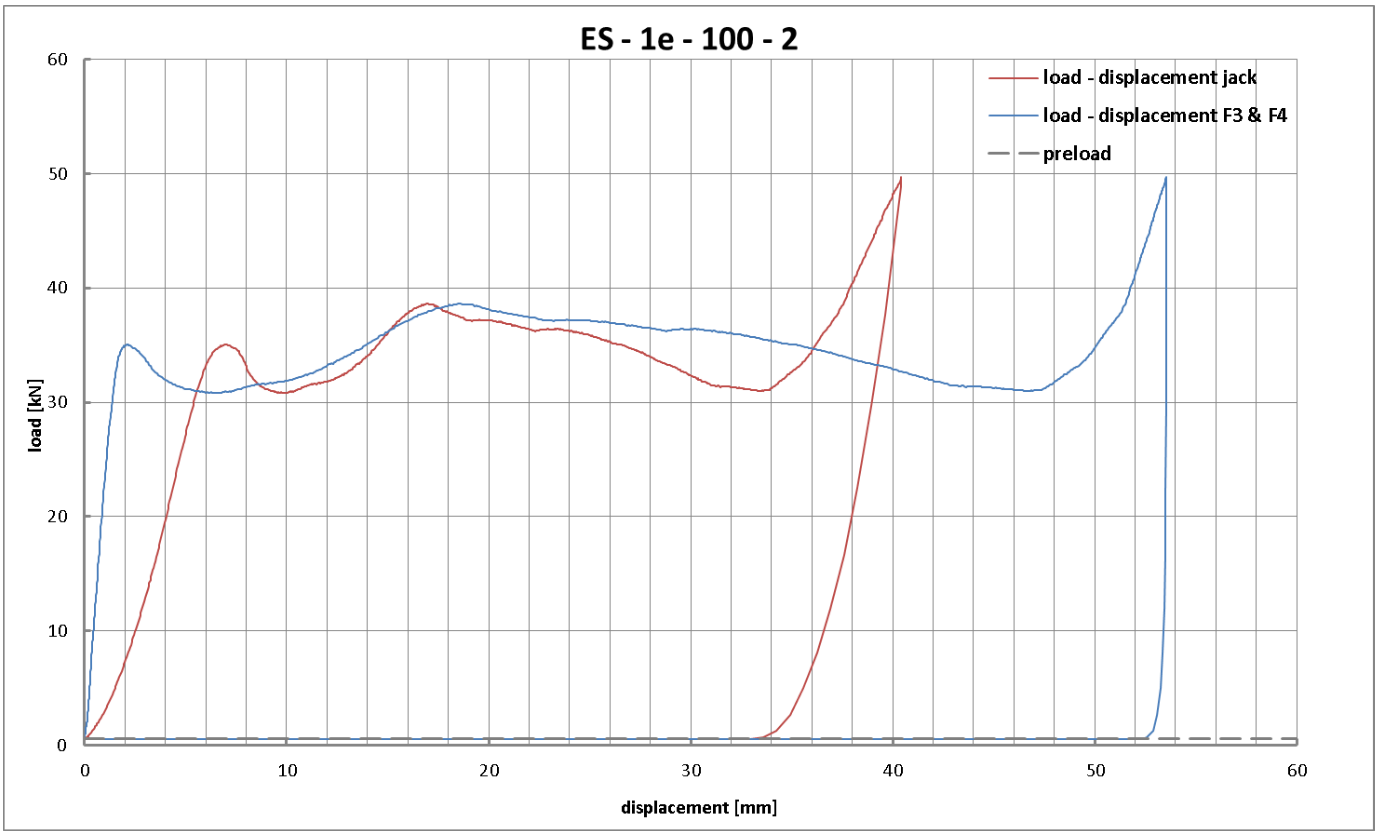


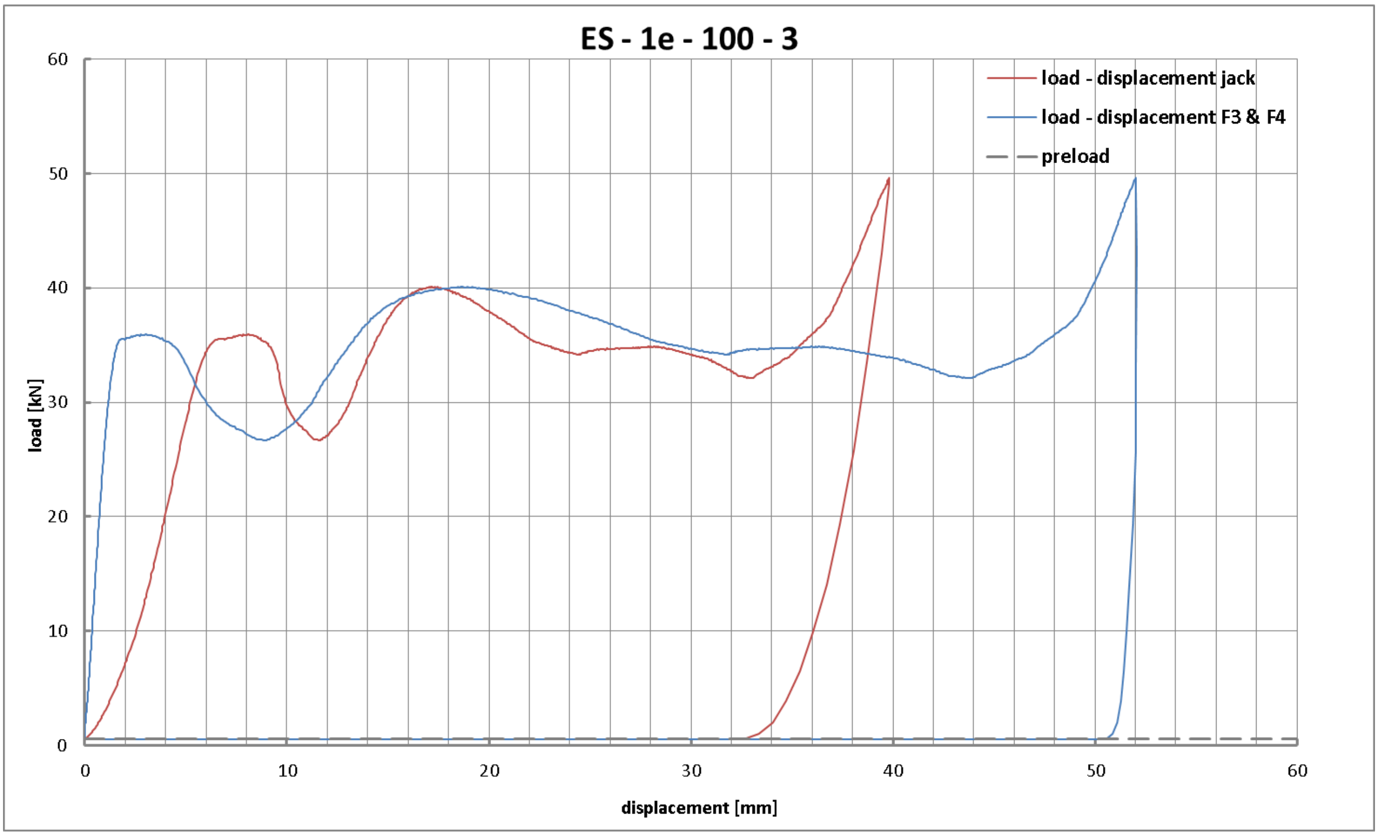
ES - 1e - 075 - 2
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60



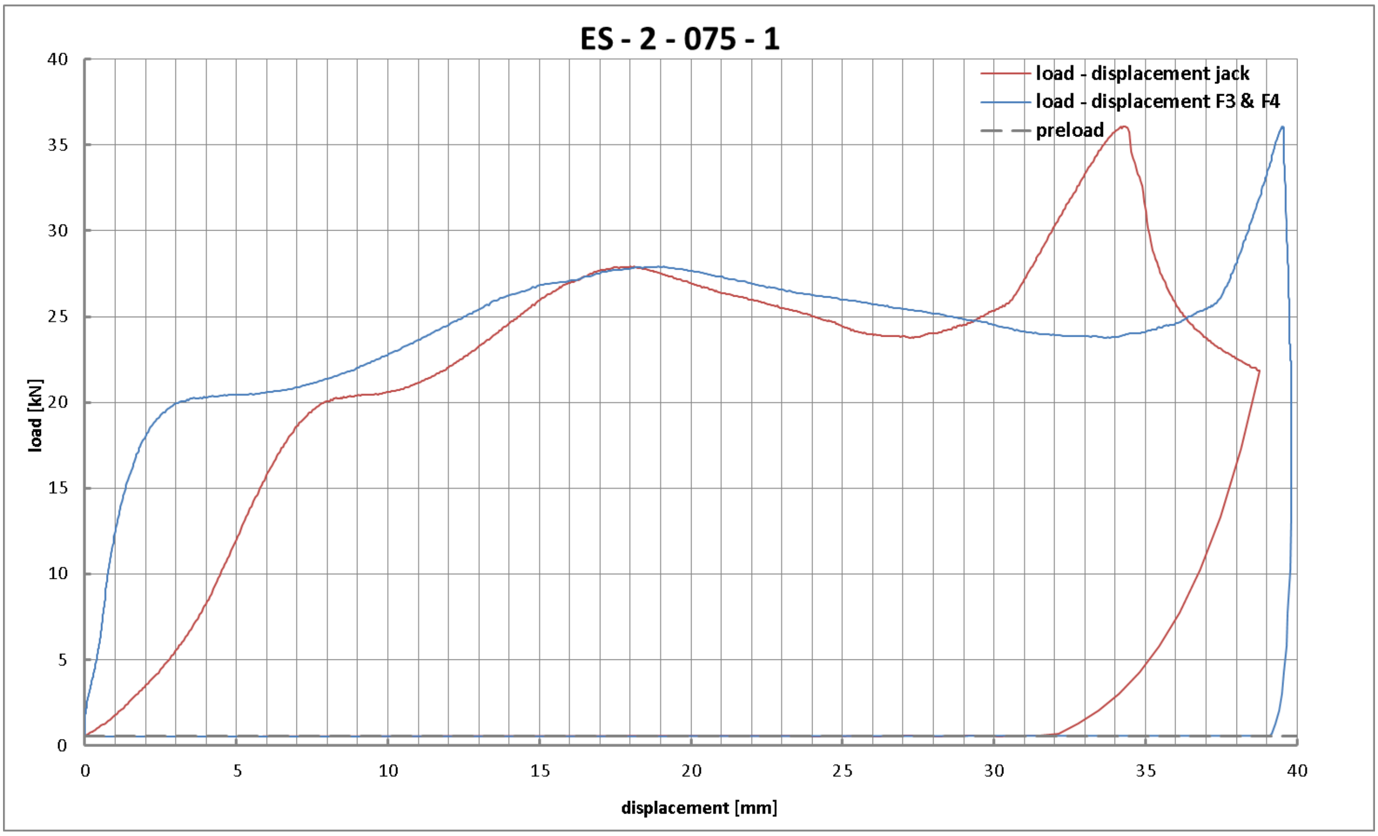
ES - 1e - 075 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70


ES - 1e - 100 - 1
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60

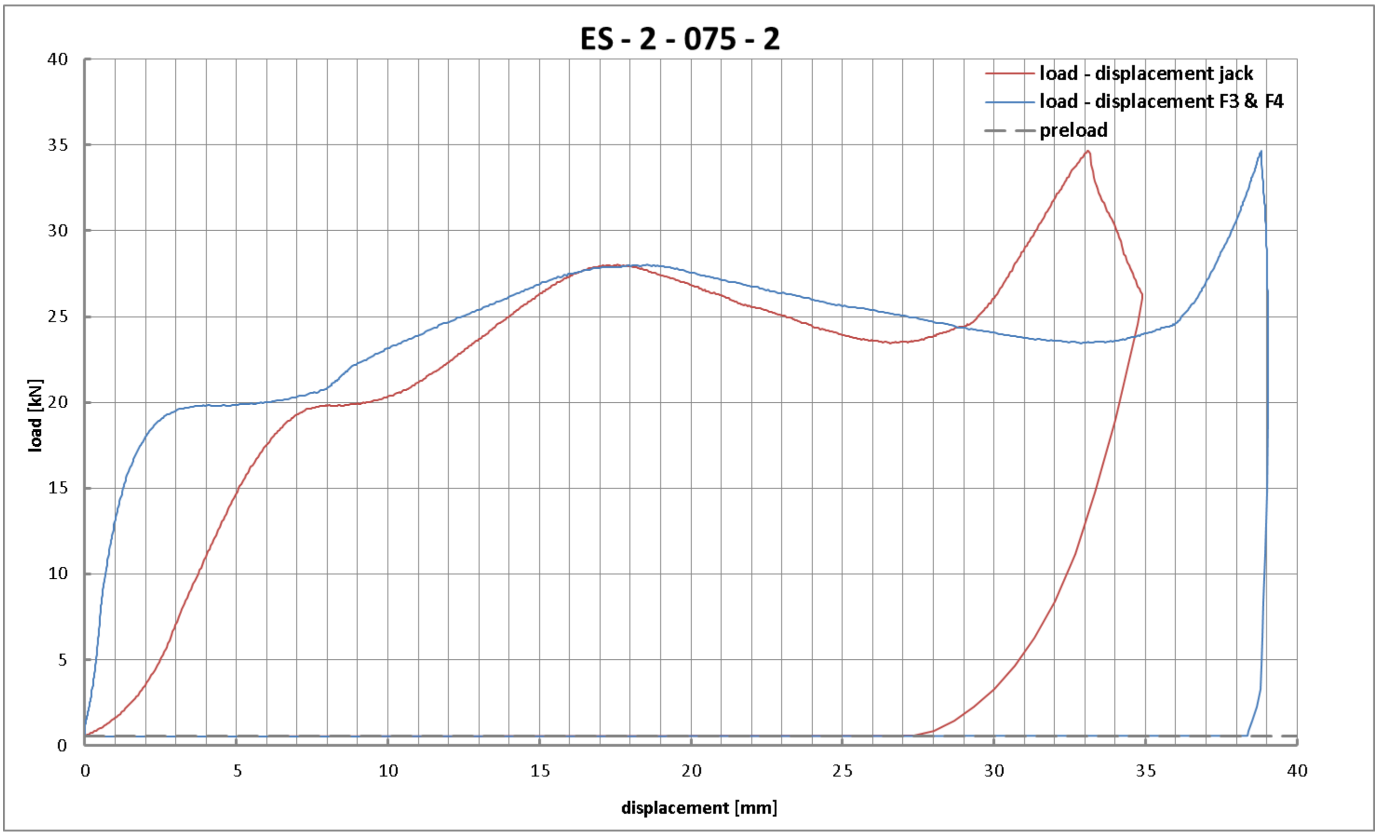

ES - 1e - 100 - 2
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60

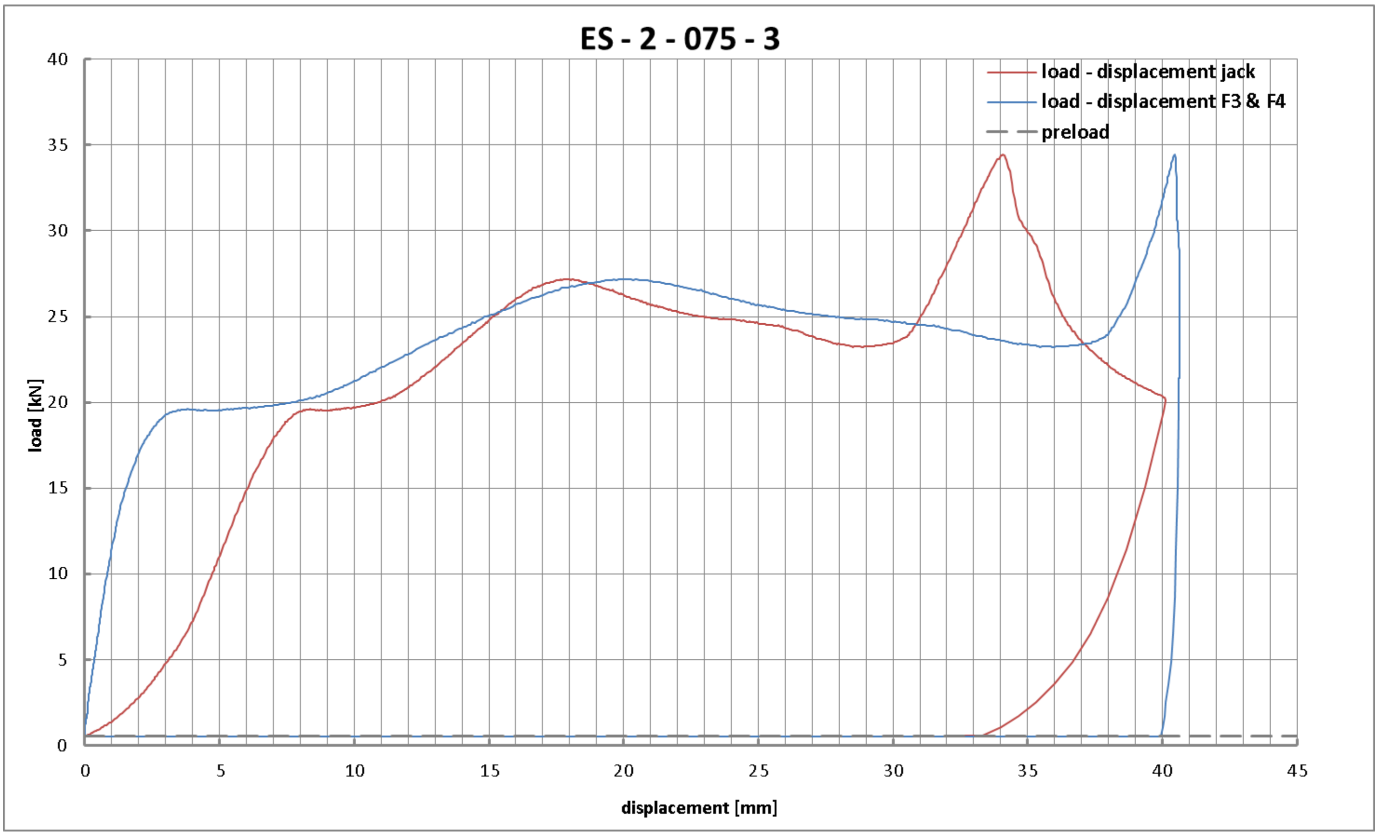


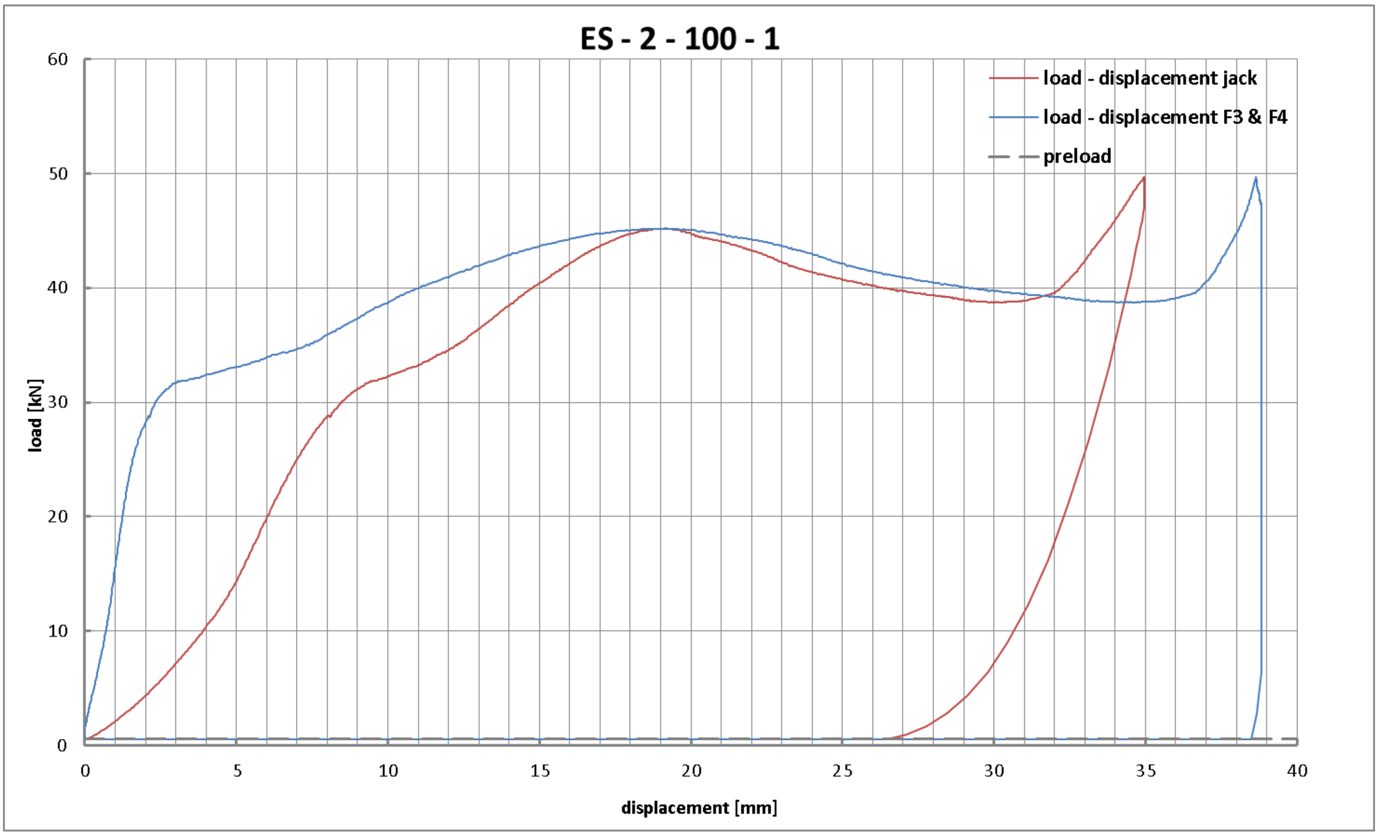
ES - 1e - 100 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60

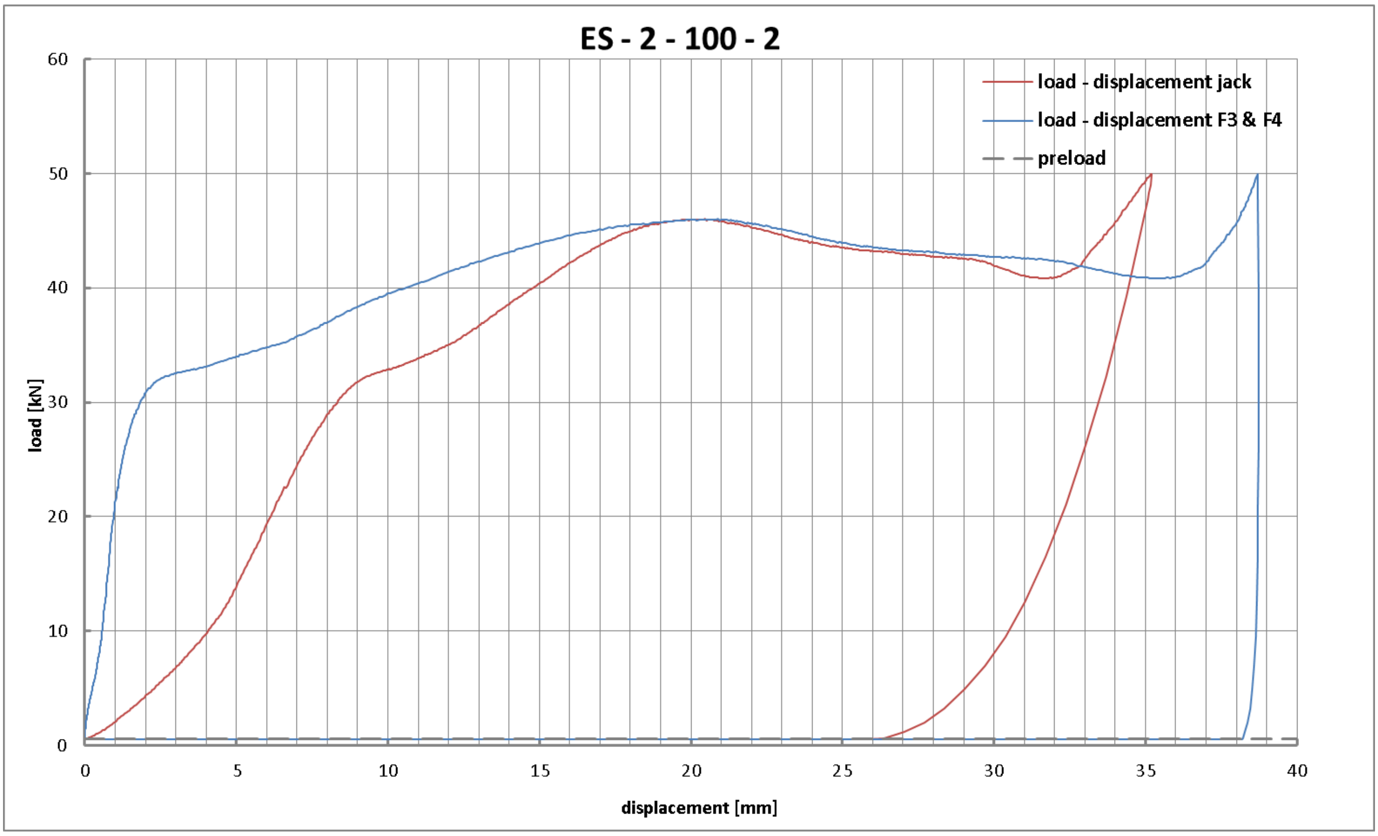


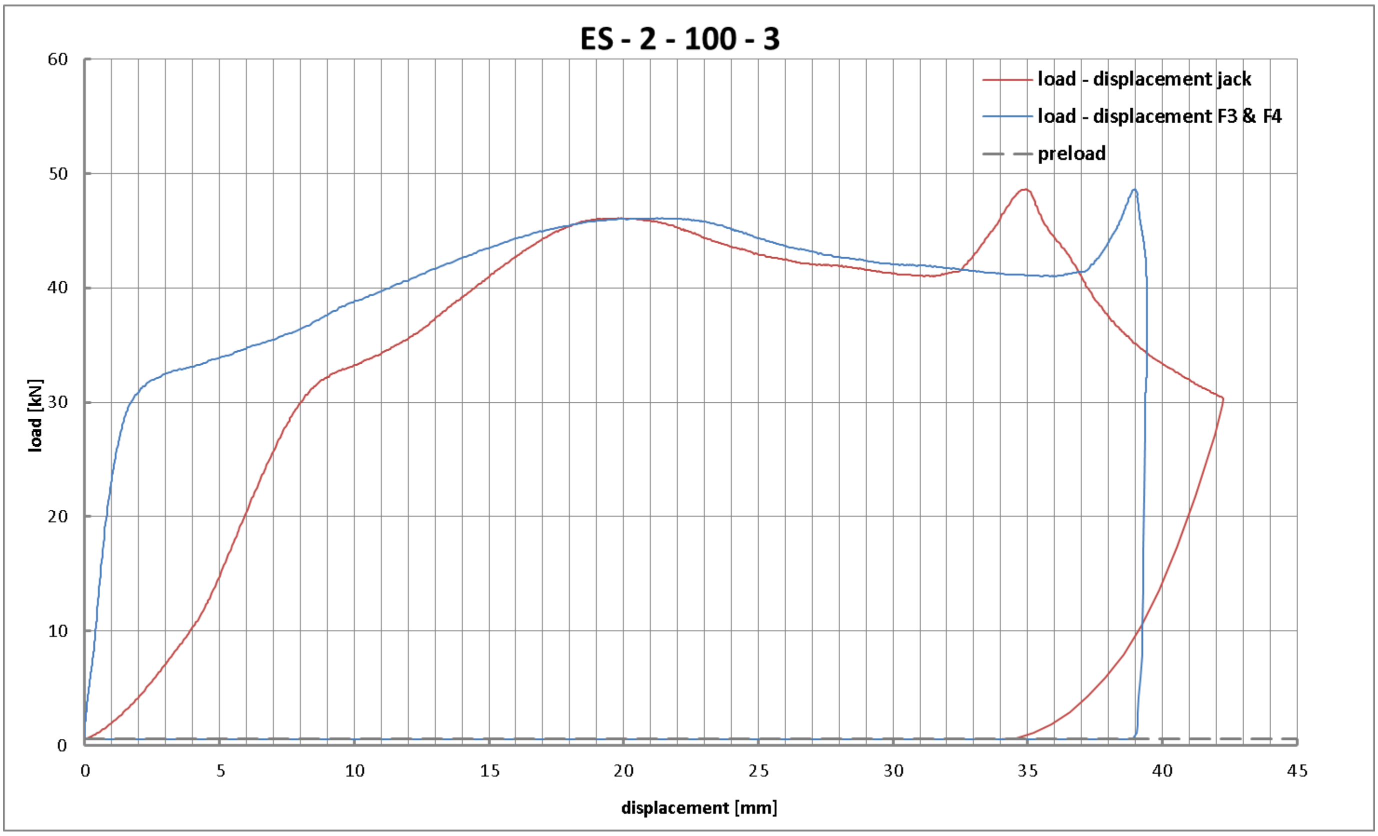
ES - 2 - 075 - 1
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40

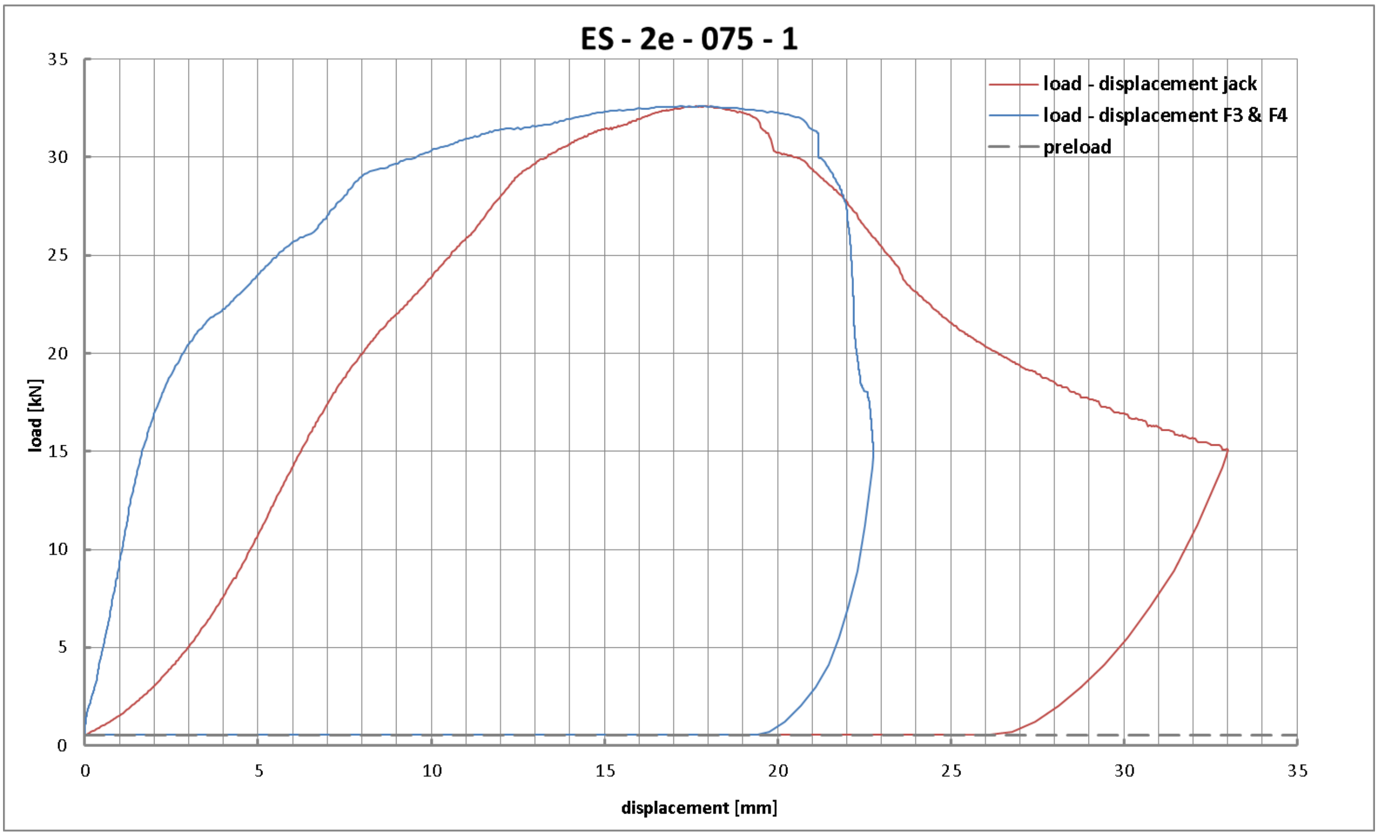

ES - 2 - 075 - 2
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40

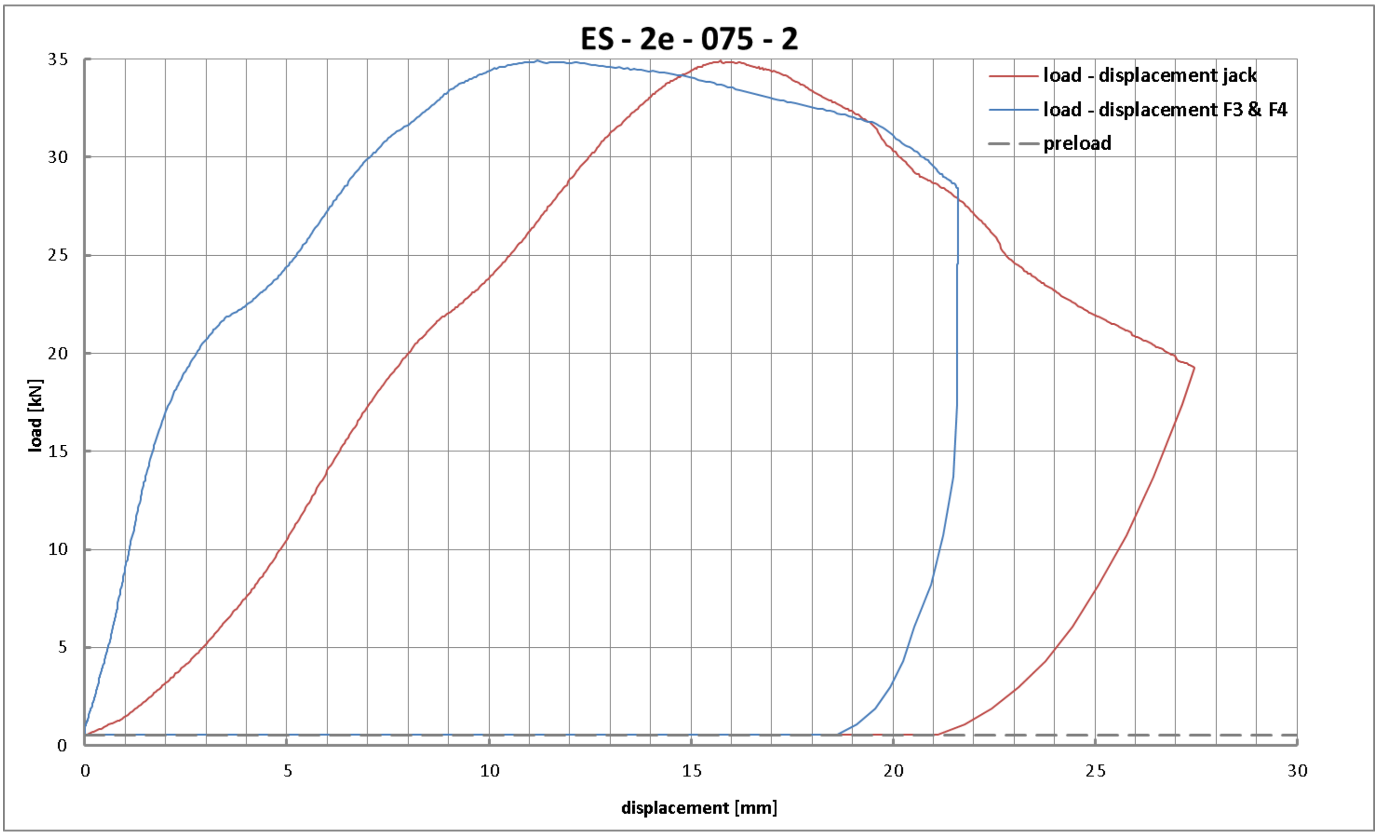

ES - 2 - 075 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
40
45

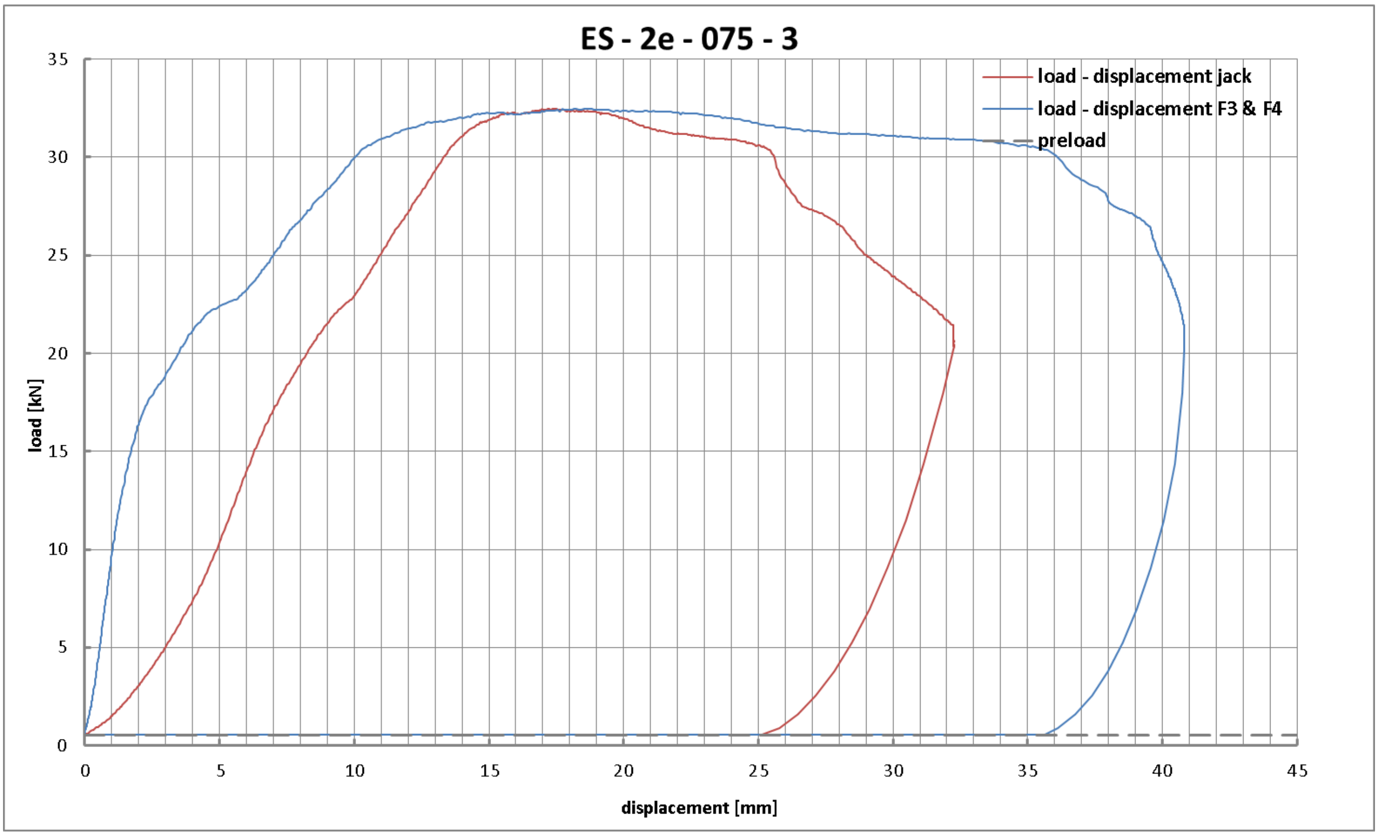

ES - 2 - 100 - 1
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40

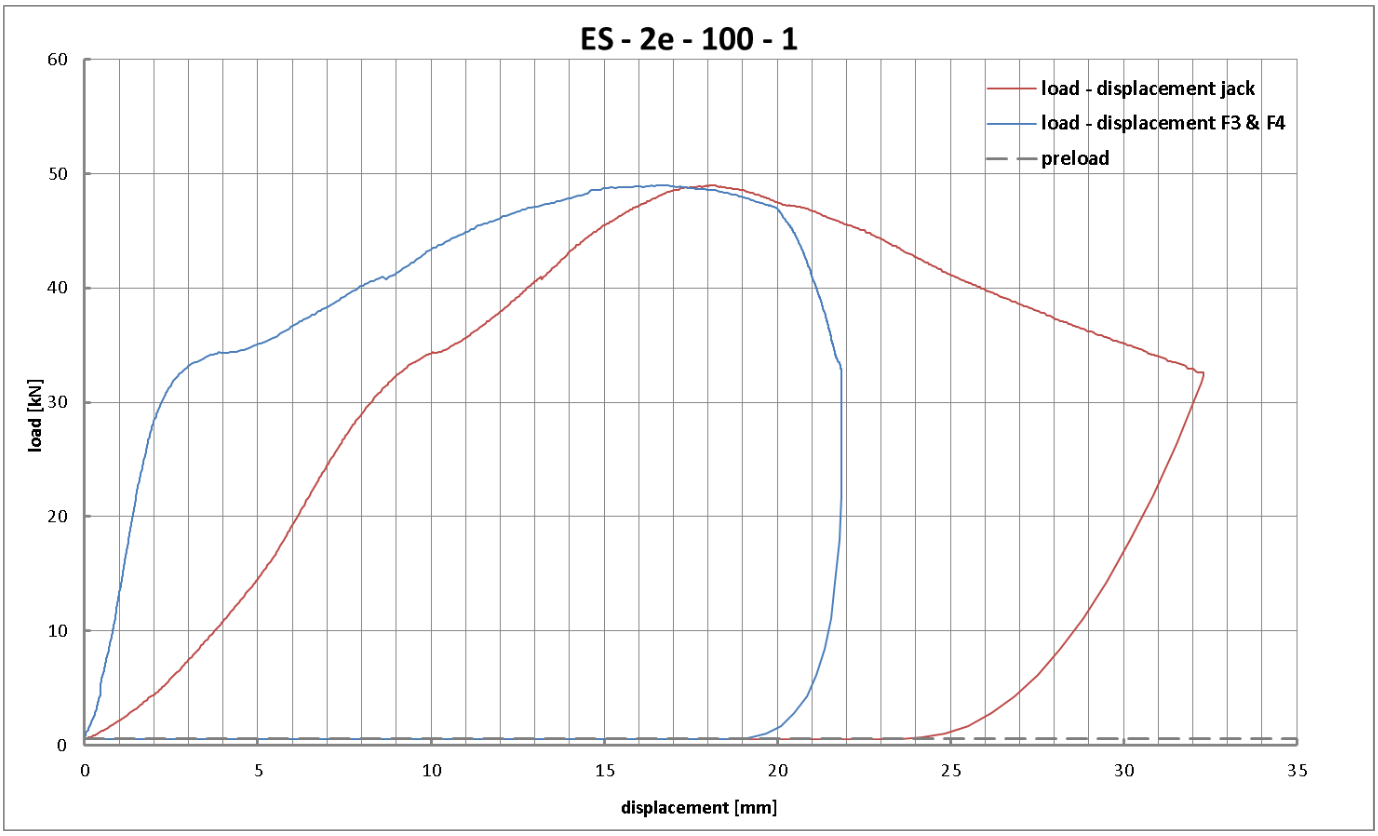

ES - 2 - 100 - 2
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40

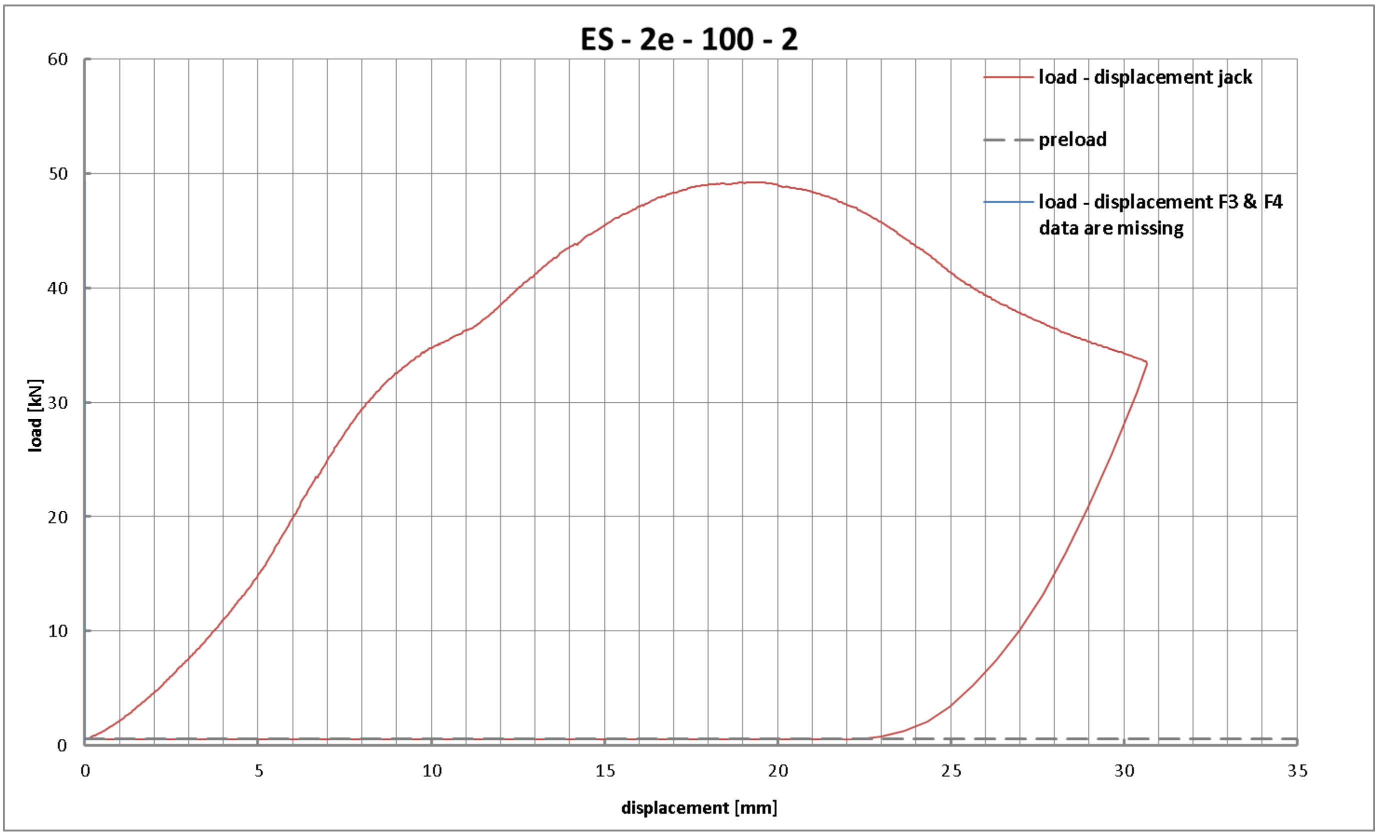

ES - 2 - 100 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40
45

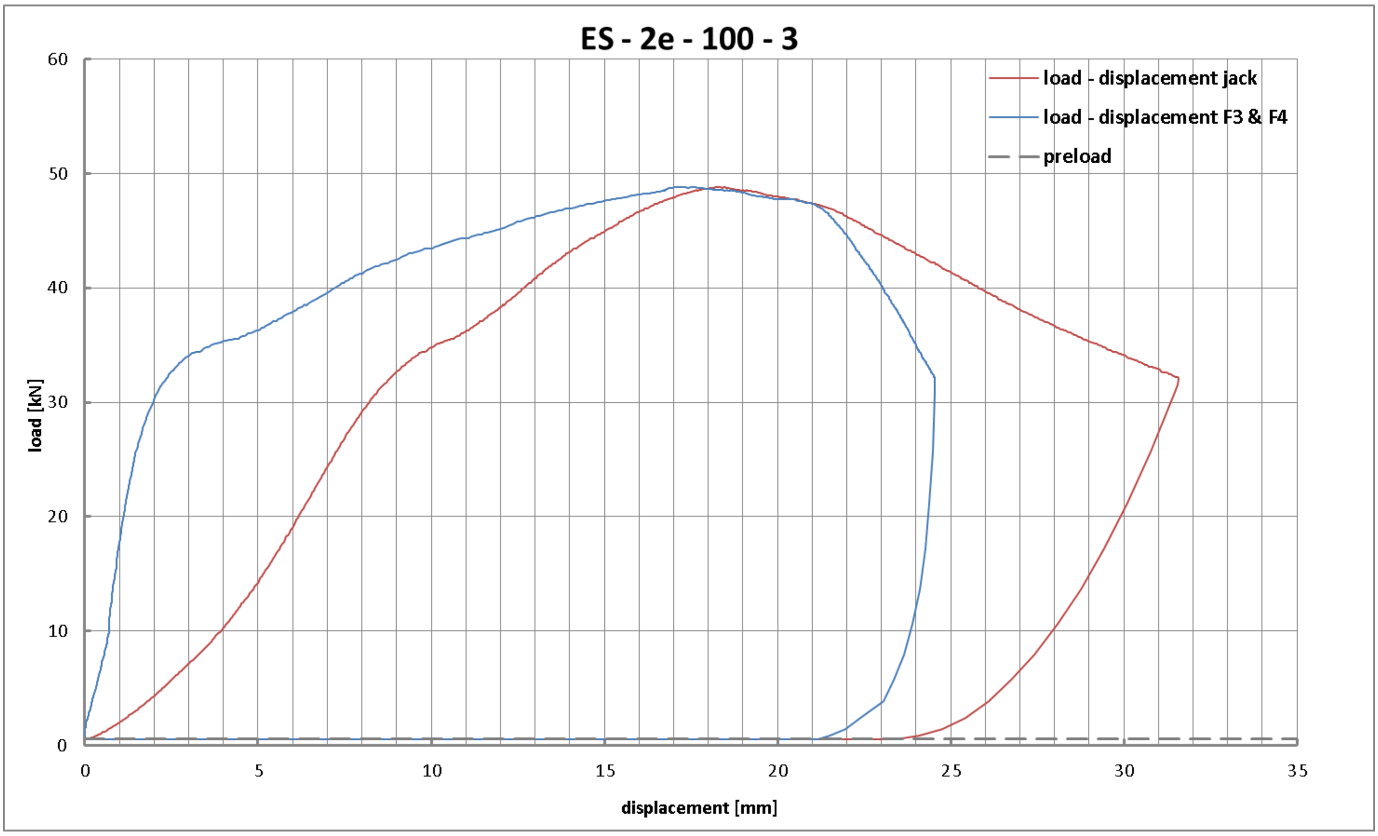

ES - 2e - 075 - 1
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
0
5
10
15
20
25
30
35


ES - 2e - 075 - 2
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
0
5
10
15
20
25
30


ES - 2e - 075 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
5
10
15
20
25
30
35
0
5
10
15
20
25
30
35
40
45

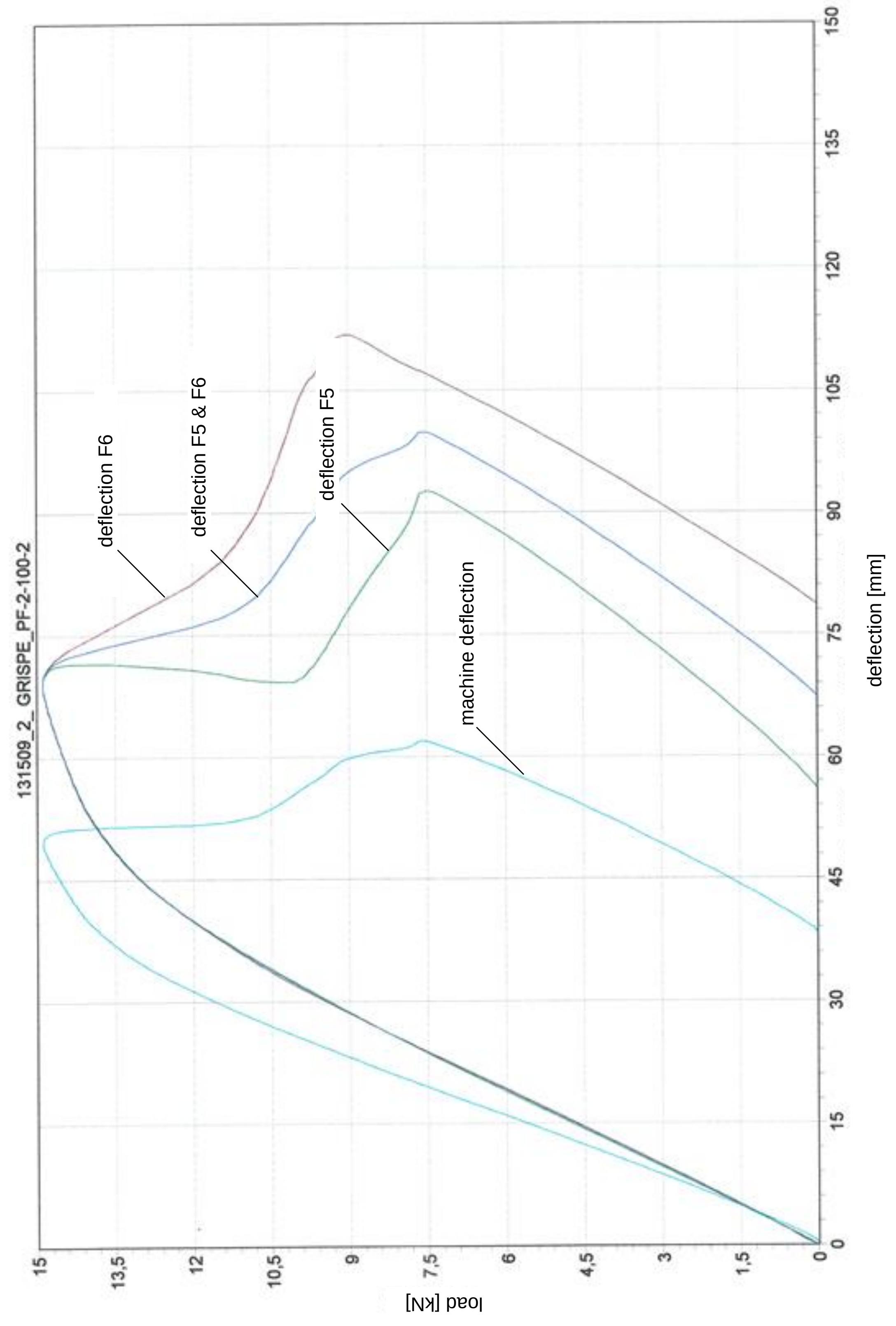

ES - 2e - 100 - 1
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35

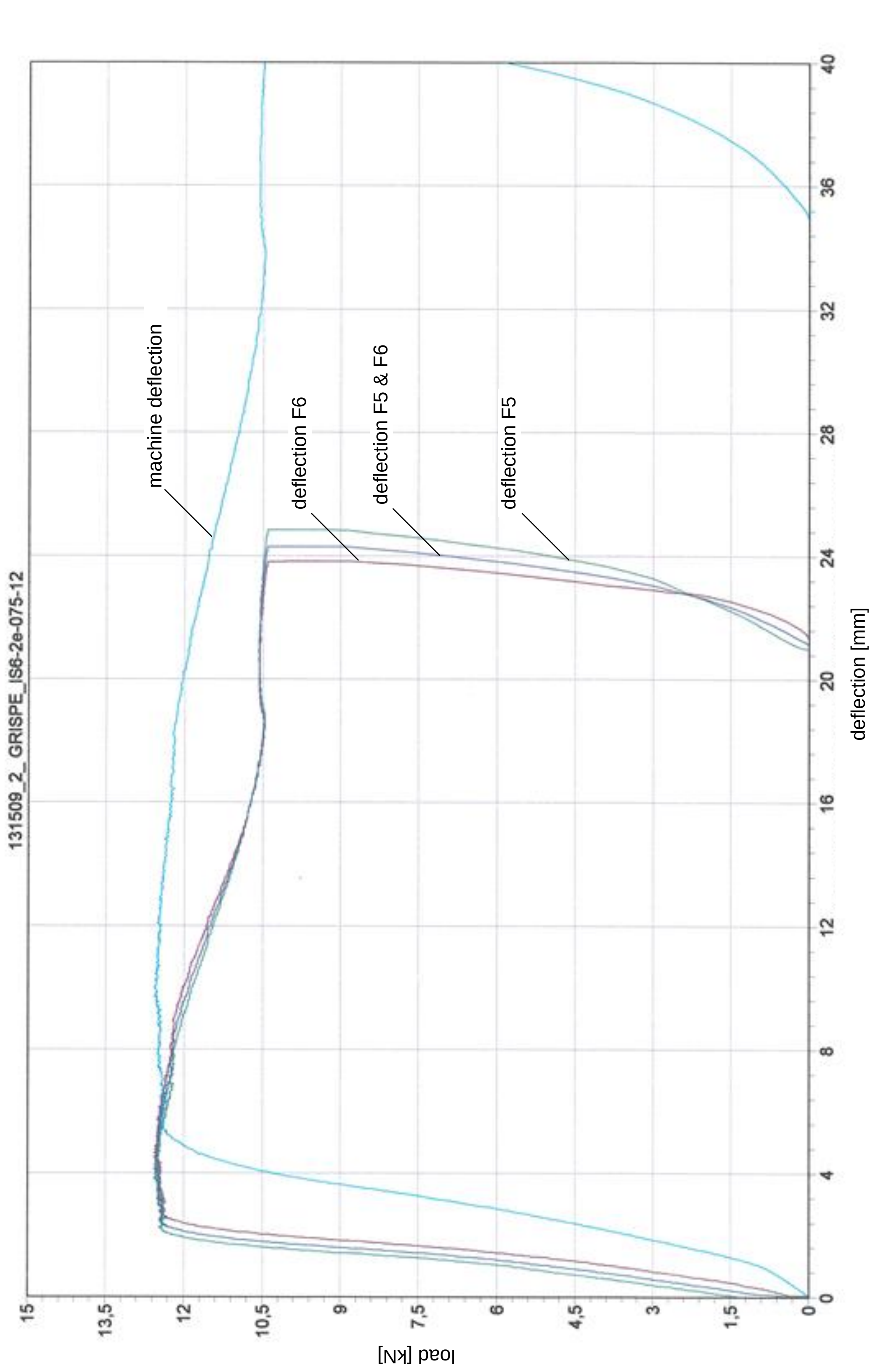

ES - 2e - 100 - 2
load - displacement jack
preload
load - displacement F3 & F4
data are missing
load [kN]
displacement [mm]
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35



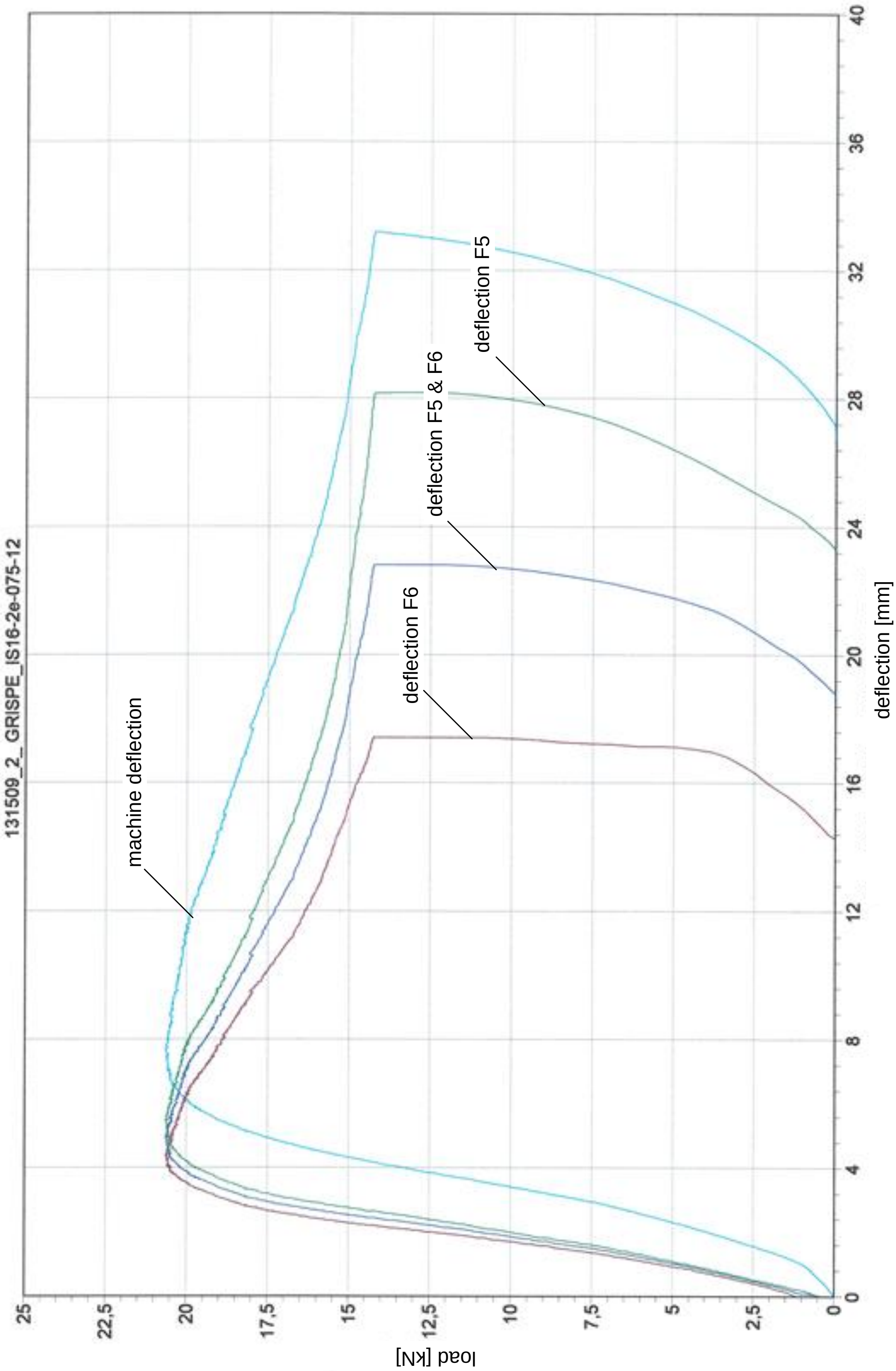
ES - 2e - 100 - 3
load - displacement jack
load - displacement F3 & F4
preload
load [kN]
displacement [mm]
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35

Annex E: Copies of the load-deflection curves

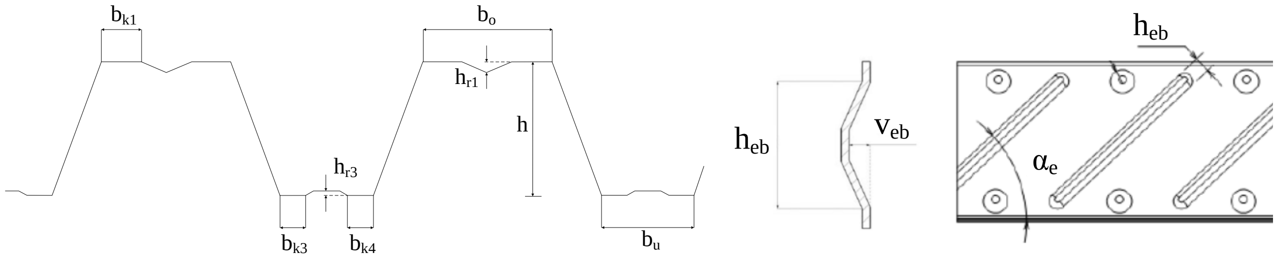




131509_2_ GRISPE_IS6-2e-075-12
machine deflection
deflection F6
deflection F5 & F6
deflection F5
load [kN]
deflection [mm]
0
1,5
3
4,5
6
7,5
9
10,5
12
13,5
15
0
4
8
12
16
20
24
28
32
36
40

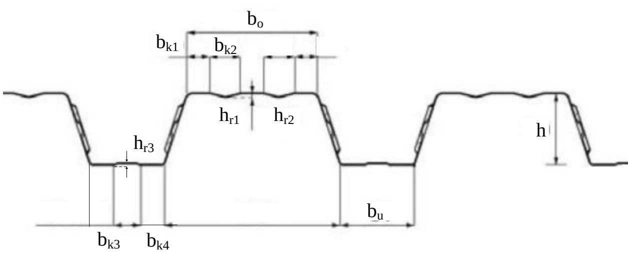

131509_2_ GRISPE_IS16-2e-075-12
machine deflection
deflection F6
deflection F5 & F6
deflection F5
load [kN]
deflection [mm]
0
2,5
5
7,5
10
12,5
15
17,5
20
22,5
25
0
4
8
12
16
20
24
28
32
36
40

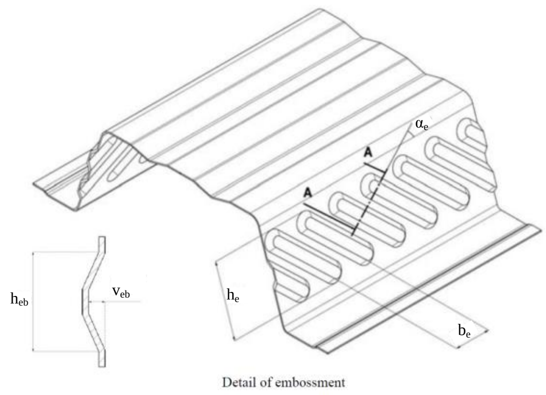
Annex F: Measurement of the profile geometry



	PCB 80 t_N = 0.75											
	1st Rib		2nd Rib		3rd Rib		1st Rib		2nd Rib		3rd Rib	
Thickness t_N	0,74		0,74		0,74		0,77		0,78		0,76	
Depth of profile h	77,8		77,0		78,1		77,3		78,1		77,0	
Depth of stiff. valley hr_3/hr_4	1,7	-	0,2	-	1,6	-	0,3	-	0,1	-	0,3	-
Depth of stiff. crown h_{r1}/h_{r2}	6,2	-	6,7	-	6,7	-	5,6	-	5,5	-	6,1	-
Widths of crown b_o	78,0		77,0		78,0		78,5		78,0		78,0	
Position of stiff. crown b_{k1}/b_{k2}	23,5	-	24,0	-	23,5	-	23,5	-	23,5	-	24,0	-
Position of stiff. valley b_{k3}/b_{k4}	17,5	17,5	17,5	17,5	17,5	17,5	14,0	14,5	14,0	14,0	14,5	14,0
Widths of valley b_u	55,0		54,0		55,0		55,0		54,5		54,5	
Radius of bends r_o	2,5		3,0		Radius of bends r_u				3,0/3,5		3,0	
Ancle of embossment α_e	-		-		-		45,0		45,0		45,0	
Widths of embossment h_{eb}	-		-		-		8,1		7,9		8,0	
Depth of embossment v_{eb}	-		-		-		1,8		1,7		1,9	

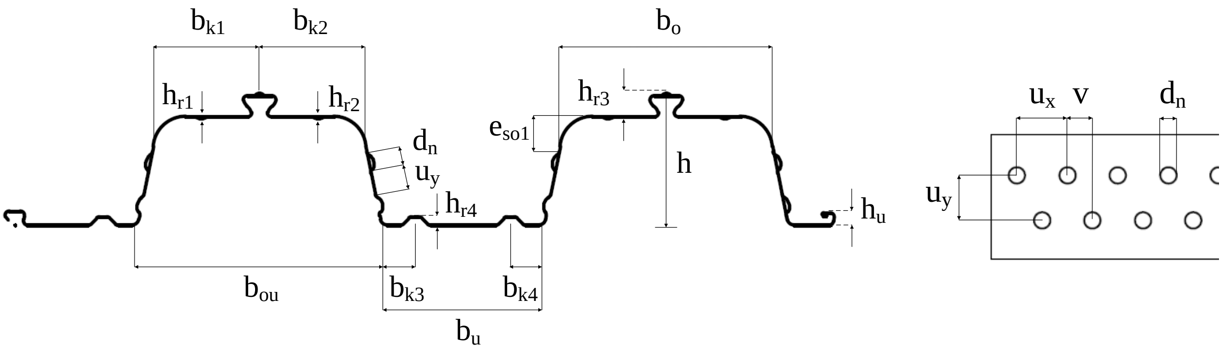
	PCB 80 t_N = 1.00											
	1st Rib		2nd Rib		3rd Rib		1st Rib		2nd Rib		3rd Rib	
Thickness t_N	0,98		0,98		0,98		0,97		0,99		1,00	
Depth of profile h	78,2		78,0		78,0		77,2		77,7		77,6	
Depth of stiff. valley hr_3/hr_4	1,3	-	0,1	-	1,4	-	0,5	-	0,1	-	0,4	-
Depth of stiff. crown h_{r1}/h_{r2}	5,2	-	5,2	-	5,4	-	6,0	-	5,4	-	5,5	-
Widths of crown b_o	78,0		77,5		78,0		79,5		78,0		79,0	
Position of stiff. crown b_{k1}/b_{k2}	23,0	-	22,5	-	23,0	-	23,5	-	23,0	-	23,5	-
Position of stiff. valley b_{k3}/b_{k4}	15,5	14,5	15,0	14,5	15,5	14,5	14,5	14,5	14,5	14,5	14,0	14,5
Widths of valley b_u	55,0		55,0		54,0		55,0		55,0		54,5	
Radius of bends r_o	3,0		2,5		Radius of bends r_u				3,0		3,0/3,5	
Ancle of embossment α_e	-		-		-		44,0		46,0		46,0	
Widths of embossment h_{eb}	-		-		-		7,7		8,0		7,9	
Depth of embossment v_{eb}	-		-		-		1,8		1,7		1,9	





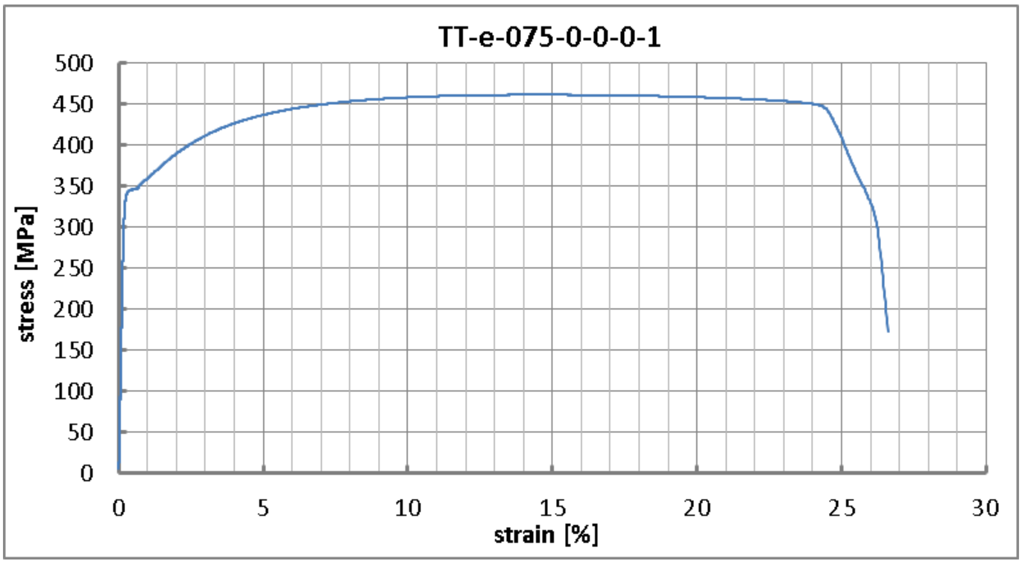
	PCB 60 t_N = 0.75											
	1st Rib		2nd Rib		3rd Rib		1st Rib		2nd Rib		3rd Rib	
Thickness t_N	0,72		0,73		0,73		0,76		0,74		0,74	
Depth of profile h	60,2		58,3		59,6		60,1		58,7		60,6	
Depth of stiff. valley hr_3/hr_4	1,1	-	1,3	-	0,7	-	0,6	-	1,4	-	1,4	-
Depth of stiff. crown h_{r1}/h_{r2}	1,7	2,8	2,0	2,5	2,3	2,3	2,5	2,3	2,6	2,1	-	-
Widths of crown b_o	107,0		107,0		107,0		106,0		106,0		-	
Position of stiff. crown b_{k1}/b_{k2}	21,5	26,0	20,0	25,0	20,0	25,0	21,0	25,5	20,0	25,5	-	-
Position of stiff. valley b_{k3}/b_{k4}	25,0	15,5	21,0	18,5	25,0	15,5	20,0		21,0		24,5	17,5
Widths of valley b_u	61,0		60,0		60,5		61,0		60,5		61,5	
Radius of bends r_o	5,5/6,0		5,0		Radius of bends r_u				6,0		5,5	
Ancle of embossment α_e	-		-		-		45,0		45,0		45,0	
Widths of embossment h_{eb}	-		-		-		12,8		12,9		13,1	
Depth of embossment v_{eb}	-		-		-		1,9		2,0		2,1	
height of embossment h_e	-		-		-		42,0		42,4		42,3	
distance of the embossments b_e	-		-		-		22,2		22,6		22,8	

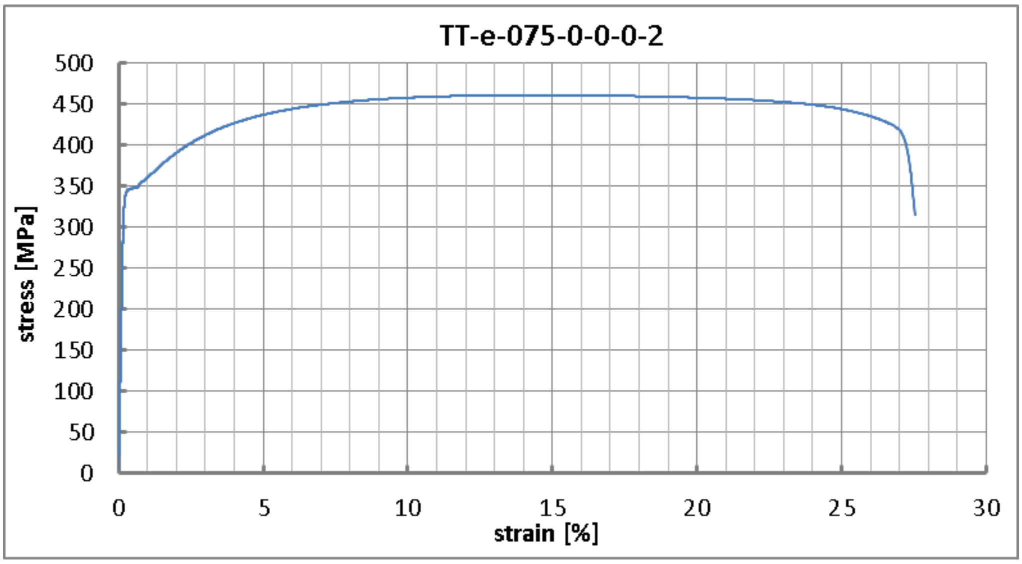
	PCB 60 t_N = 1.00											
	1st Rib		2nd Rib		3rd Rib		1st Rib		2nd Rib		3rd Rib	
Thickness t_N	0,97		0,96		0,96		1		0,98		0,97	
Depth of profile h	60,2		58,7		60,5		58,8		59,1		59,8	
Depth of stiff. valley hr_3/hr_4	0,7	-	1,1	-	1,2	-	1,4	-	1,2	-	1,4	-
Depth of stiff. crown h_{r1}/h_{r2}	2,2	2,3	2,6	2,0	-	-	-	-	1,9	2,6	2,4	2,1
Widths of crown b_o	107,0		107,0		-		-		105,0		106,0	
Position of stiff. crown b_{k1}/b_{k2}	-	-	21,0	24,0	21,5	23,5	-	-	19,5	26,0	20,0	24,5
Position of stiff. valley b_{k3}/b_{k4}	19,0	21,0	18,0	23,0	16,0	25,0	-	-	-	-	-	-
Widths of valley b_u	61,0		60,5		61,0		61,5		61,0		62,0	
Radius of bends r_o	6,0/6,5		6,0/6,5		Radius of bends r_u				5,5/6,0		5,5	
Ancle of embossment α_e	-		-		-		44,0		44,0		44,0	
Widths of embossment h_{eb}	-		-		-		12,8		12,9		13,1	
Depth of embossment v_{eb}	-		-		-		2,0		1,7		2,0	
height of embossment h_e	-		-		-		42,0		42,2		42,3	
distance of the embossments b_e	-		-		-		22,2		22,6		22,8	

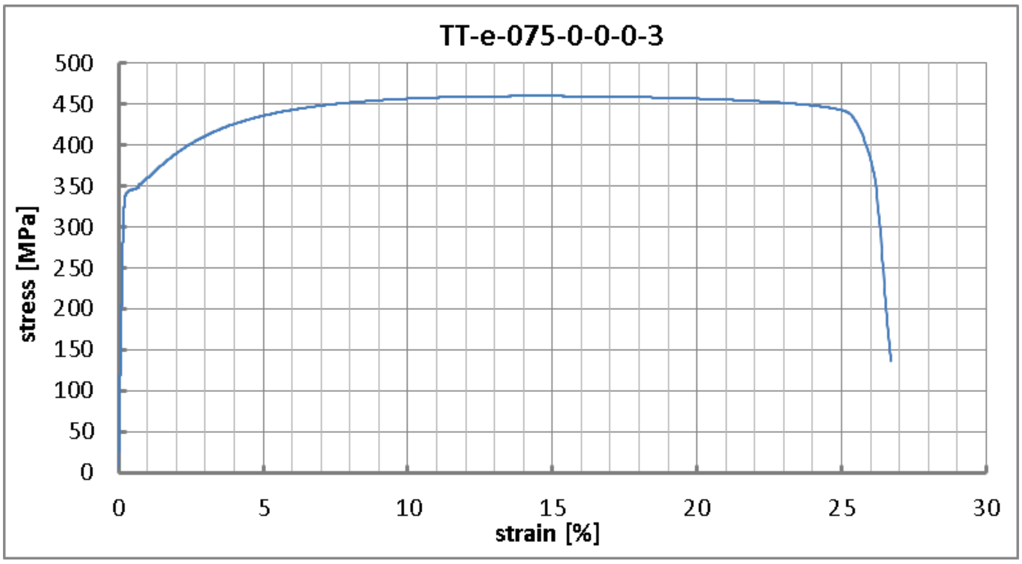


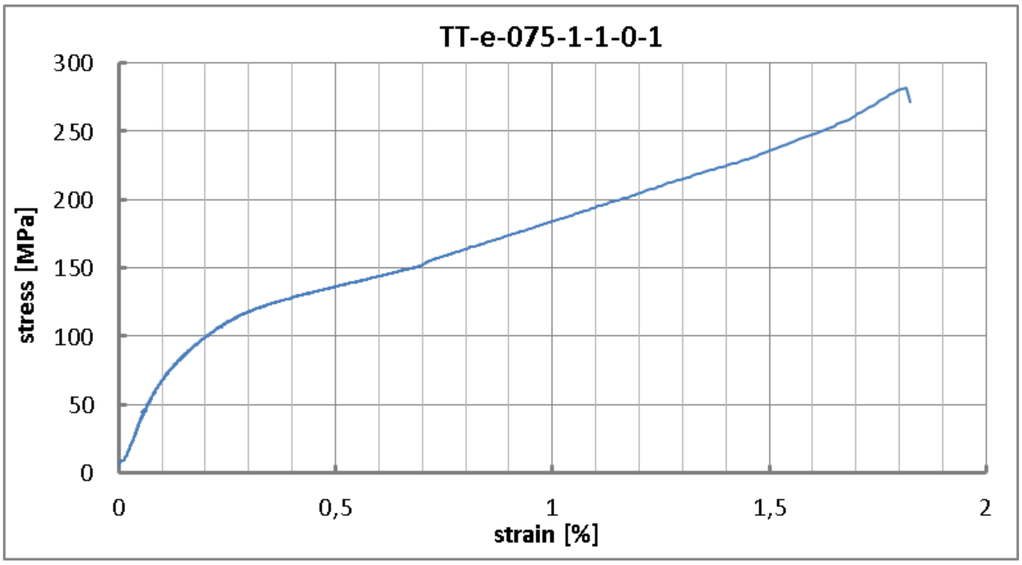
	ComFlor 80 t_N = 0.90 mm				ComFlor 80 t_N = 1.20 mm			
	1st Rib		2nd Rib		1st Rib		2nd Rib	
Thickness t_N	0,93		0,94		1,22		1,21	
Depth of profile h	96,2				98,7			
Depth of stiffeners h_{r1}/h_{r2}	3,9	2,9	2,7	2,9	3,1	2,9	2,7	2,6
Widths of crown b_o	142,0		141,5		142,0		143,0	
Position of stiffeners b_{k1}/b_{k2}	70,0	72,5	66,0	72,5	72,0	69,0	72,0	70,5
Position of stiffeners b_{k3}/b_{k4}	-	-	24,0	26,5	-	-	24,0	26,0
embossment diameter d_n	14,1	14,6	13,8	13,3	13,2	14,6	14,1	14,6
embossment pitch u_x	35,3	34,7	35,5	35,1	35,2	35,7	34,8	35,1
Offset v	18,0	17,5	16,9	19,4	18,9	20,2	18,3	18,6
Row spacing u_y	29,3	29,7	29,2	29,5	30,4	30,9	30,0	30,2
Edge spacing e_{so1}/e_{so1}	25,5	28,1	28,2	24,8	32,0	27,0	29,0	26,5
numbers of rows (transv.)	2,0				2,0			
numbers of rows/m (long.)	28,0				28,0			
Widths of valley b_u	120,0				120,5			
Depth of stiffeners h_{r3}/h_{r4}	15,5	8,1	16,0	-	14,2	8,3	16,4	-
Long. edge upstand h_u	17,5				17,5			
width of crown b_{ou}	186,0		184,0		184,5		189,0	
Radius of bends r_o	25,0	25,0	Radius of bends r_u				5,5	4,5

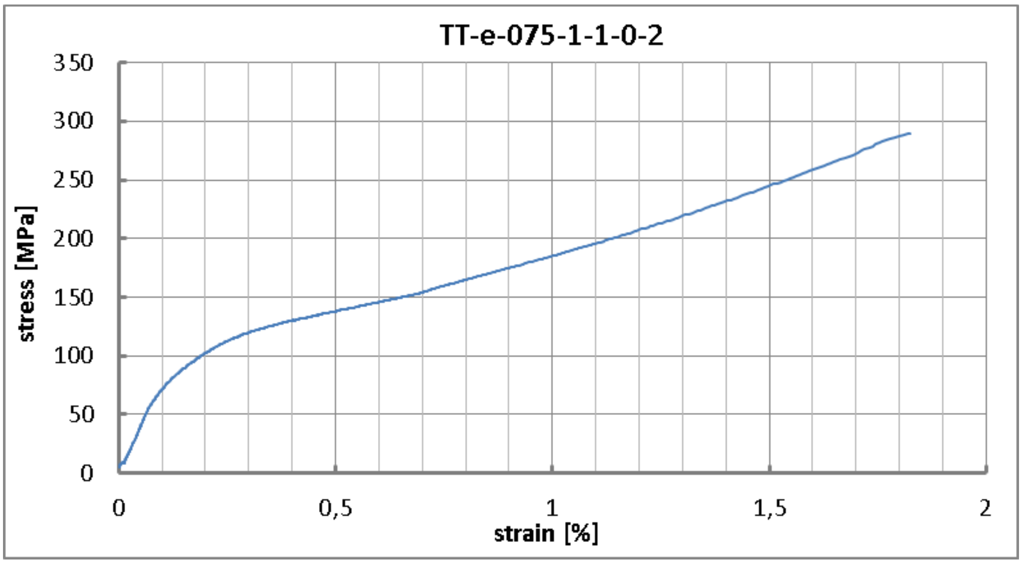
Annex G: Coupon tests with embossments

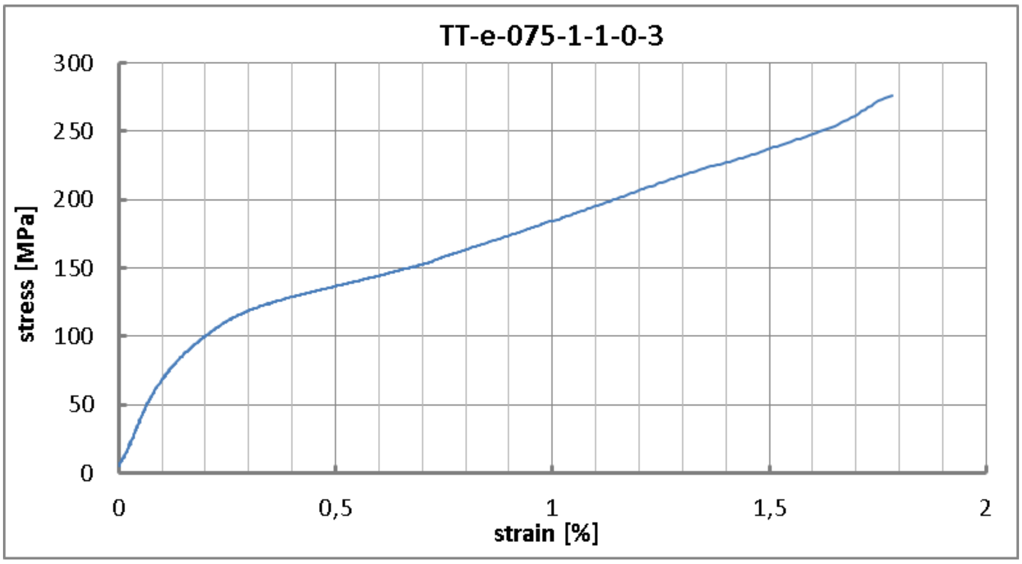


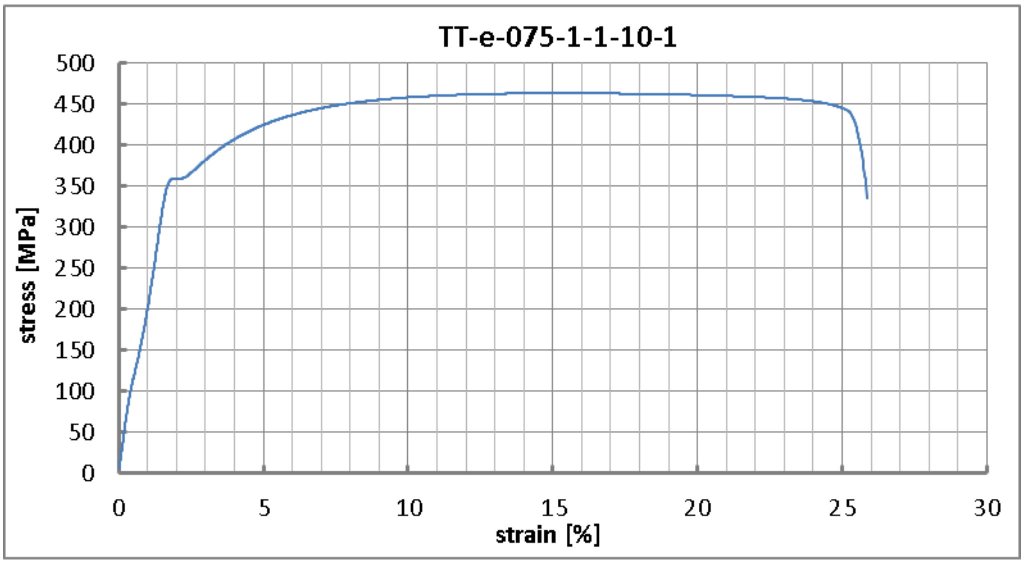


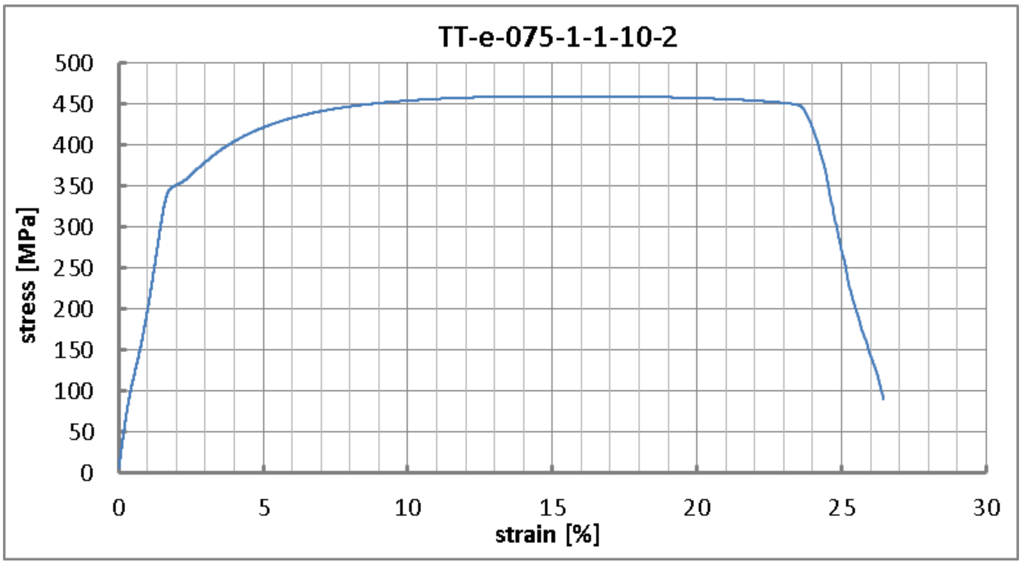


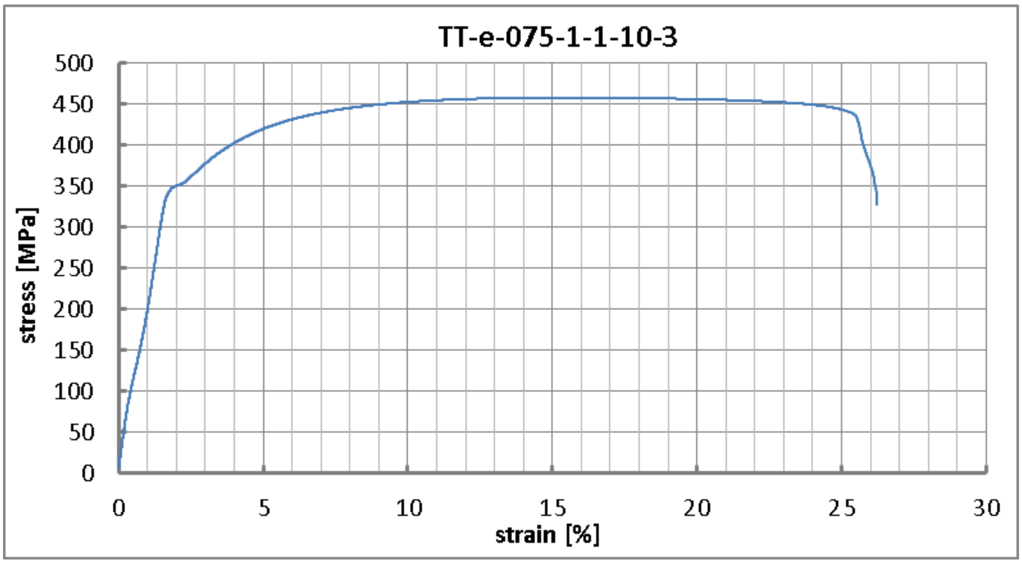

TT-e-075-1-1-0-1
300
250
200
150
100
50
0
stress [MPa]
0
0,5
1
1,5
2
strain [%]

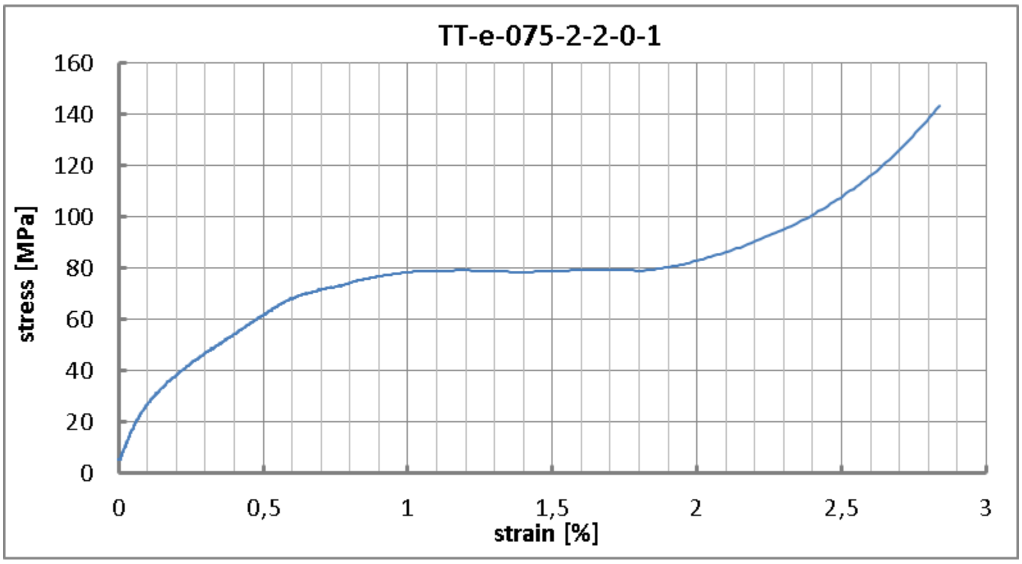

TT-e-075-1-1-0-2
350
300
250
200
150
100
50
0
stress [MPa]
0
0,5
1
1,5
2
strain [%]

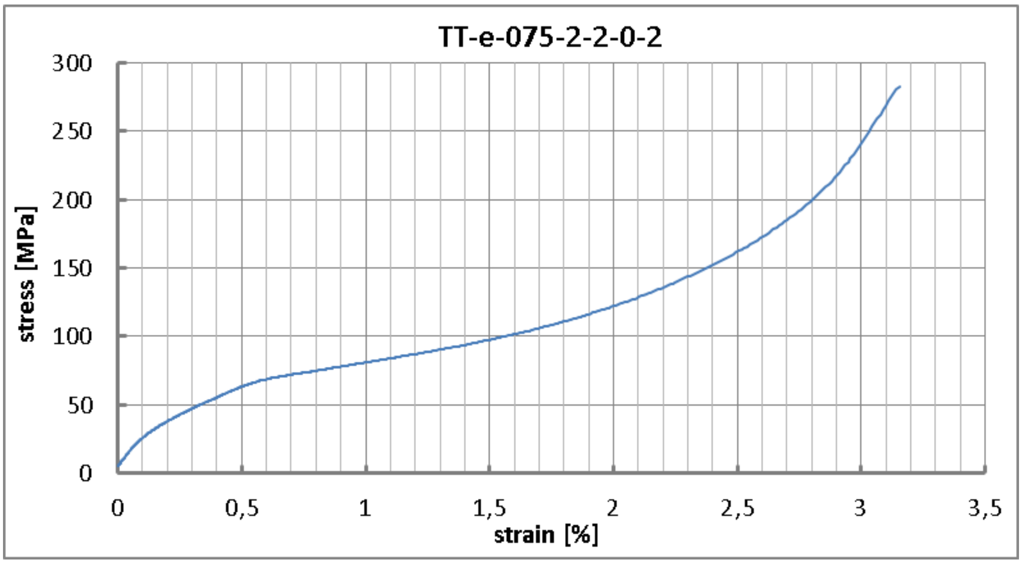

TT-e-075-1-1-0-3
300
250
200
150
100
50
0
stress [MPa]
0
0,5
1
1,5
2
strain [%]

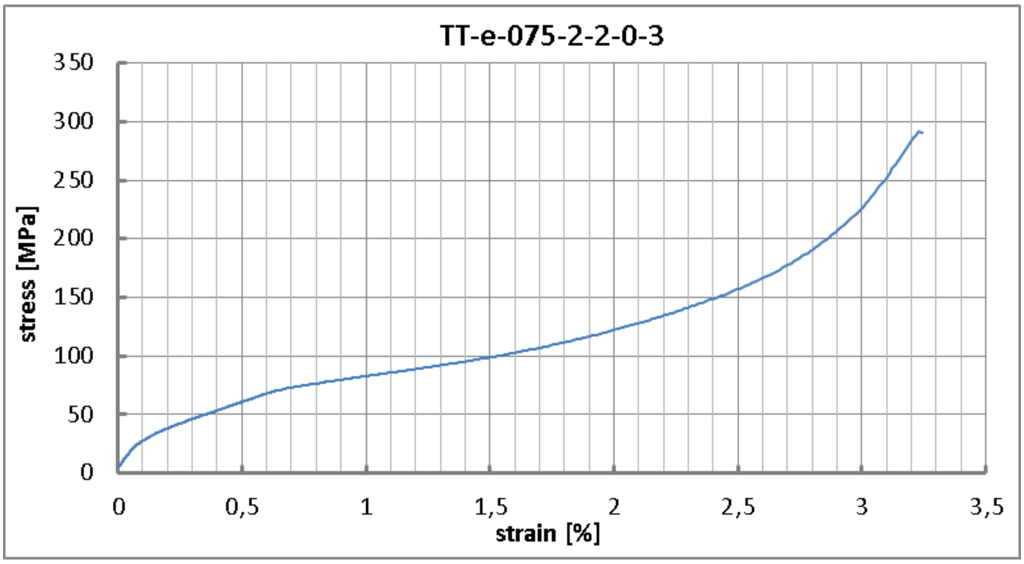

TT-e-075-1-1-10-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

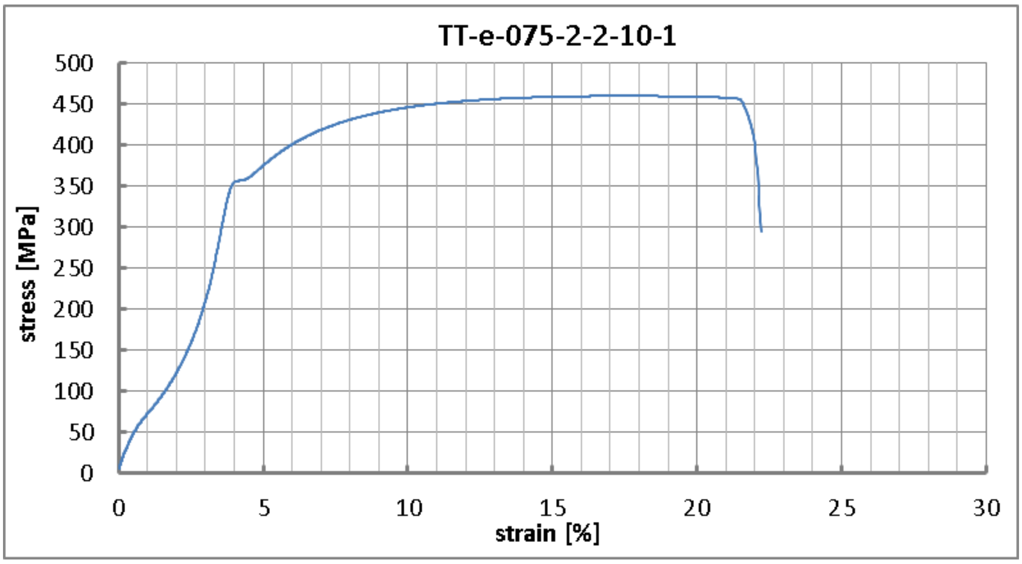

TT-e-075-1-1-10-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

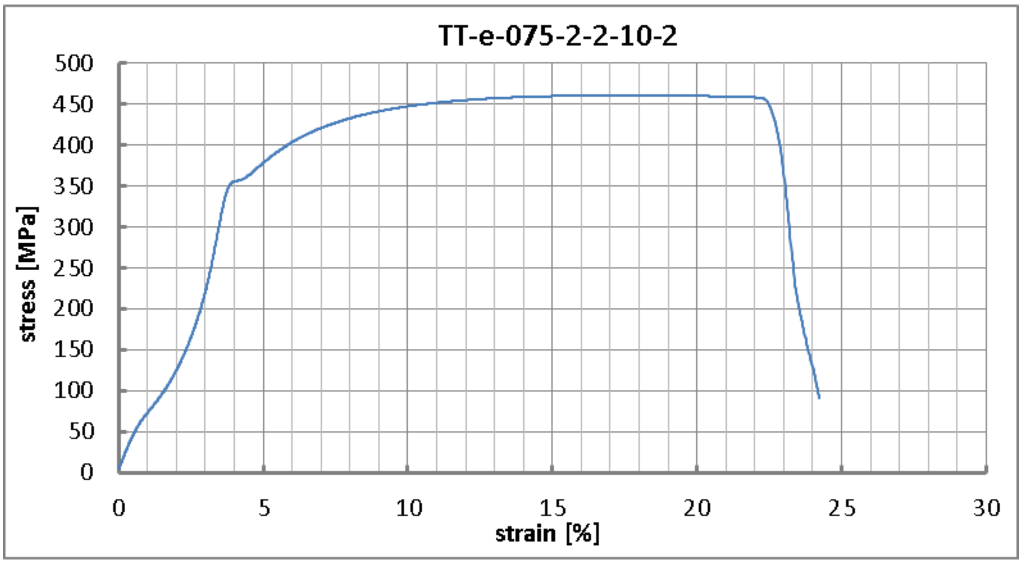

TT-e-075-1-1-10-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

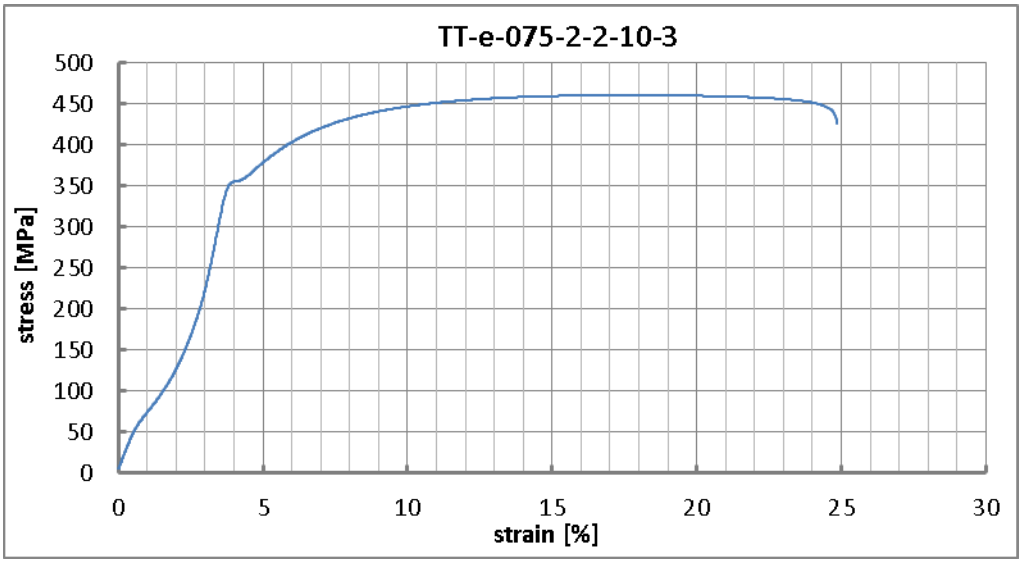

TT-e-075-2-2-0-1
stress [MPa]
160
140
120
100
80
60
40
20
0
0
0,5
1
1,5
2
2,5
3
strain [%]

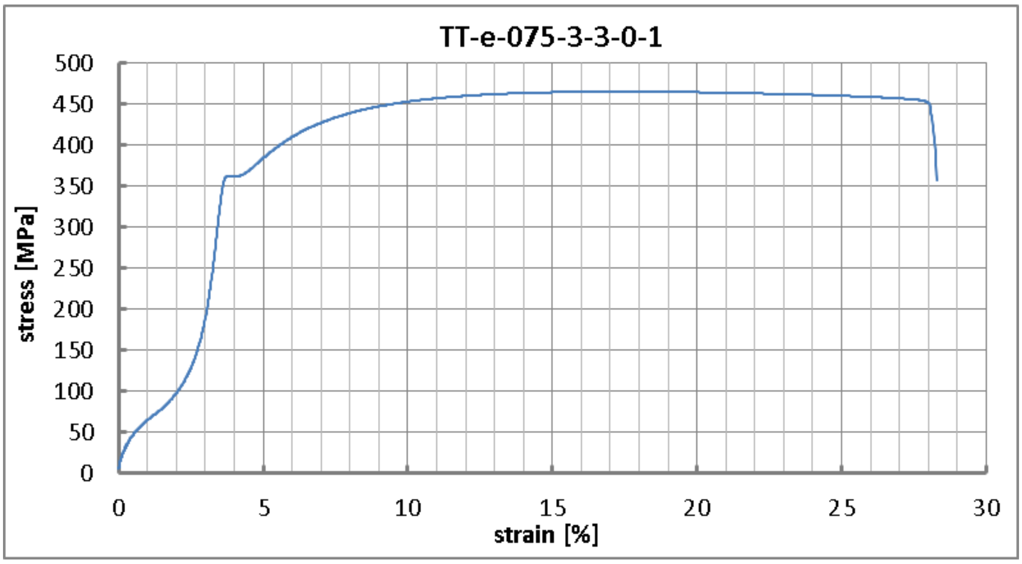

TT-e-075-2-2-0-2
stress [MPa]
300
250
200
150
100
50
0
0
0,5
1
1,5
2
2,5
3
3,5
strain [%]

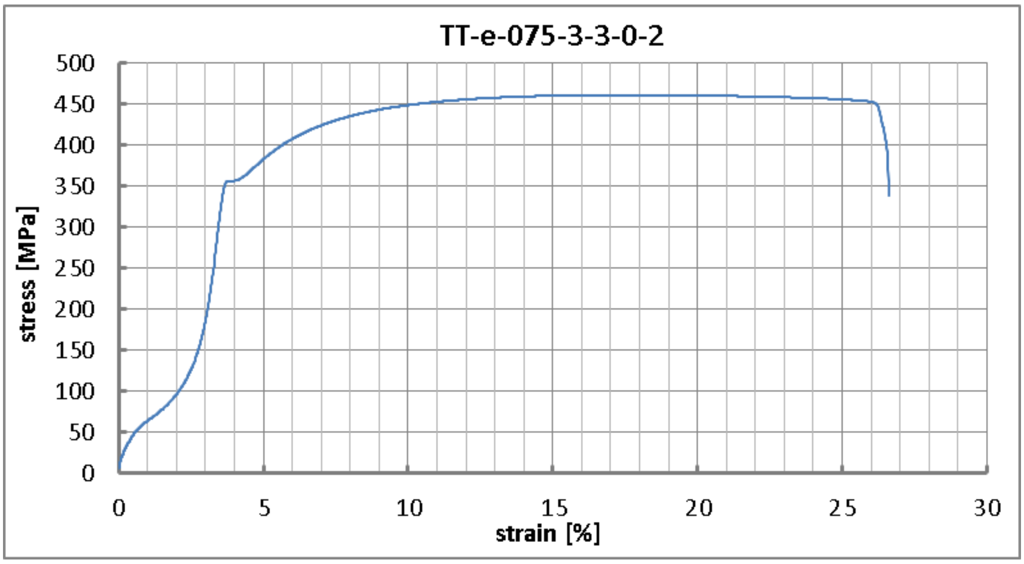

TT-e-075-2-2-0-3
stress [MPa]
350
300
250
200
150
100
50
0
0
0,5
1
1,5
2
2,5
3
3,5
strain [%]

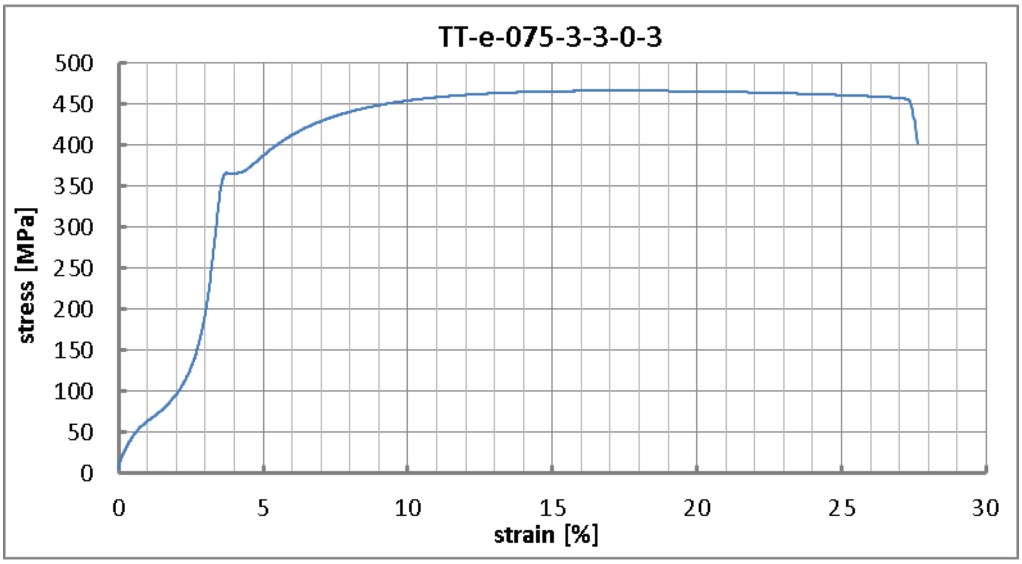

TT-e-075-2-2-10-1
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

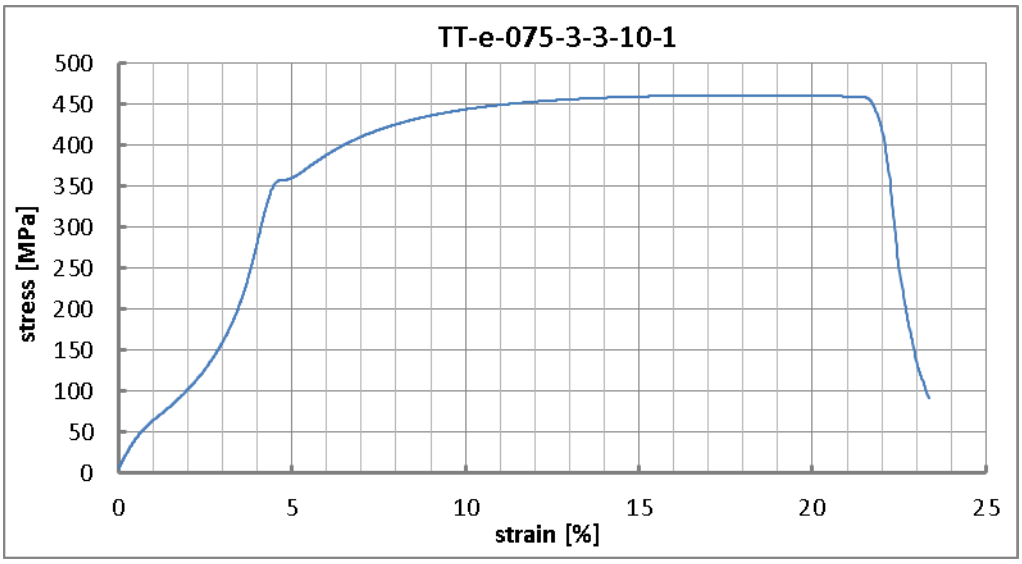

TT-e-075-2-2-10-2
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

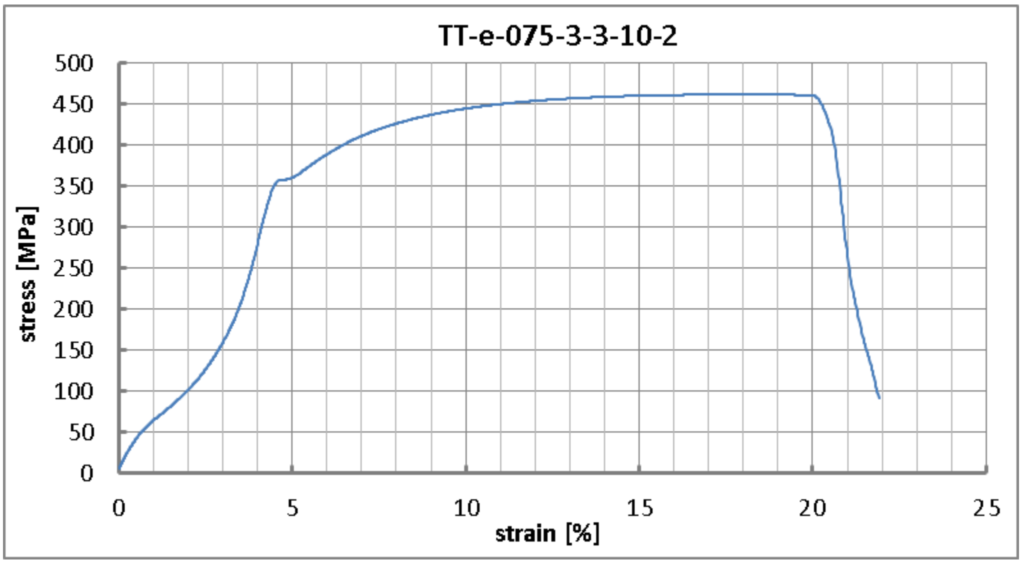

TT-e-075-2-2-10-3
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

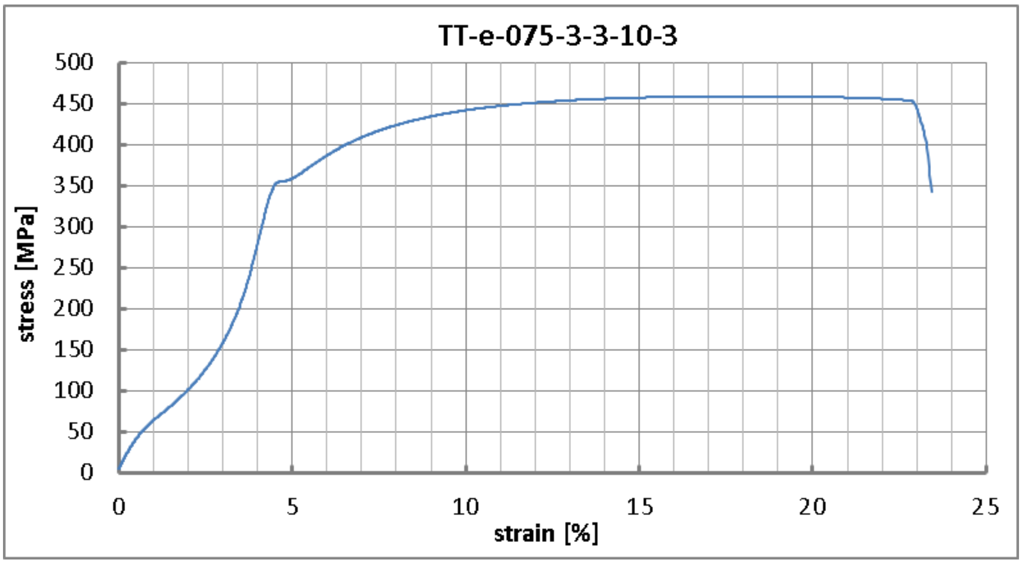

TT-e-075-3-3-0-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

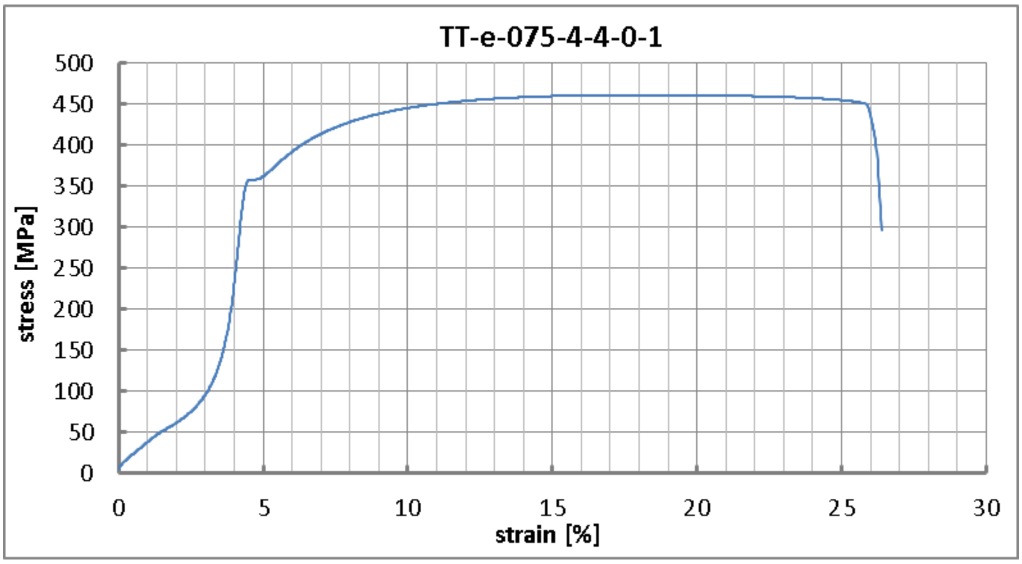

TT-e-075-3-3-0-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

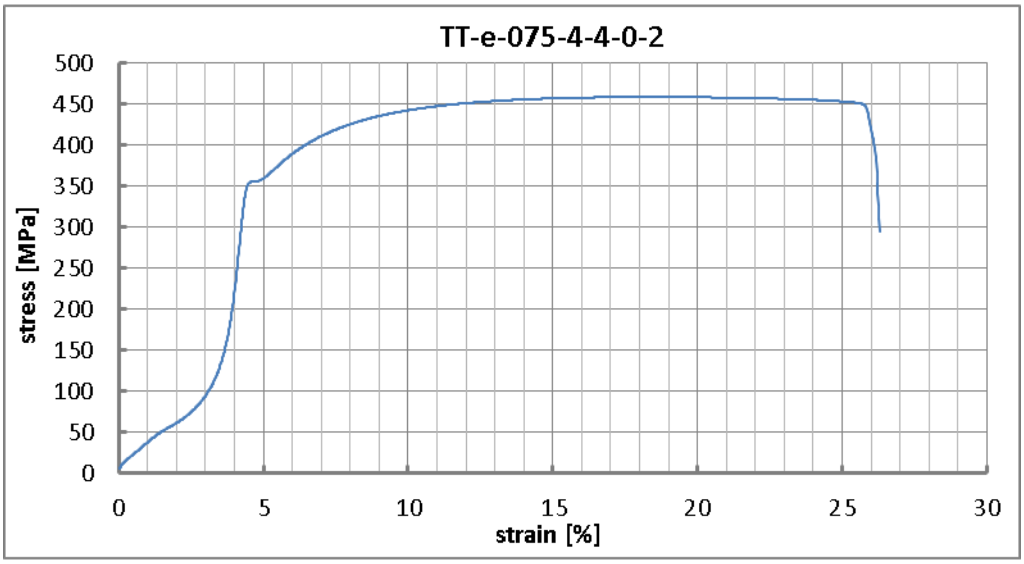

TT-e-075-3-3-0-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

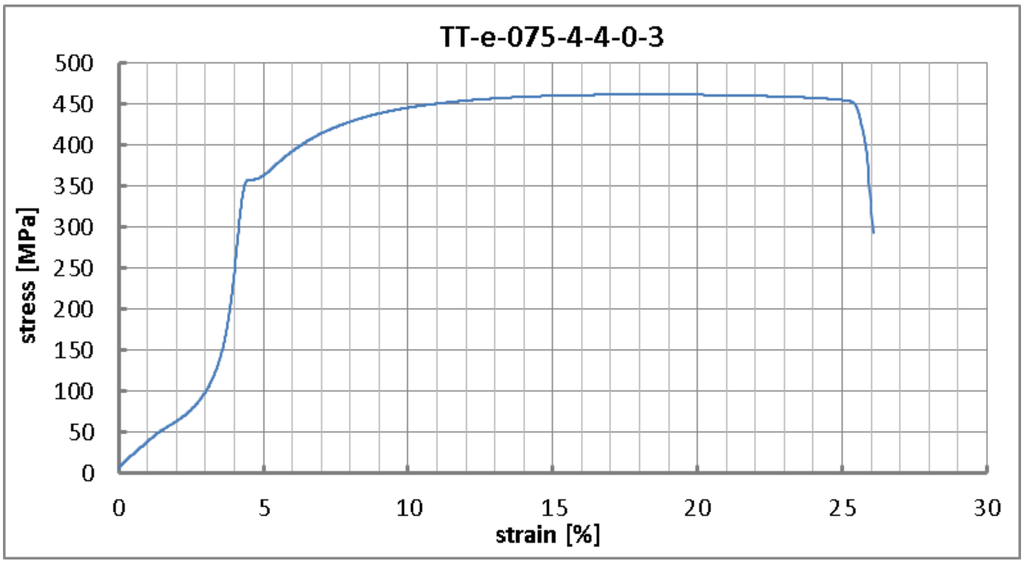

TT-e-075-3-3-10-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
strain [%]

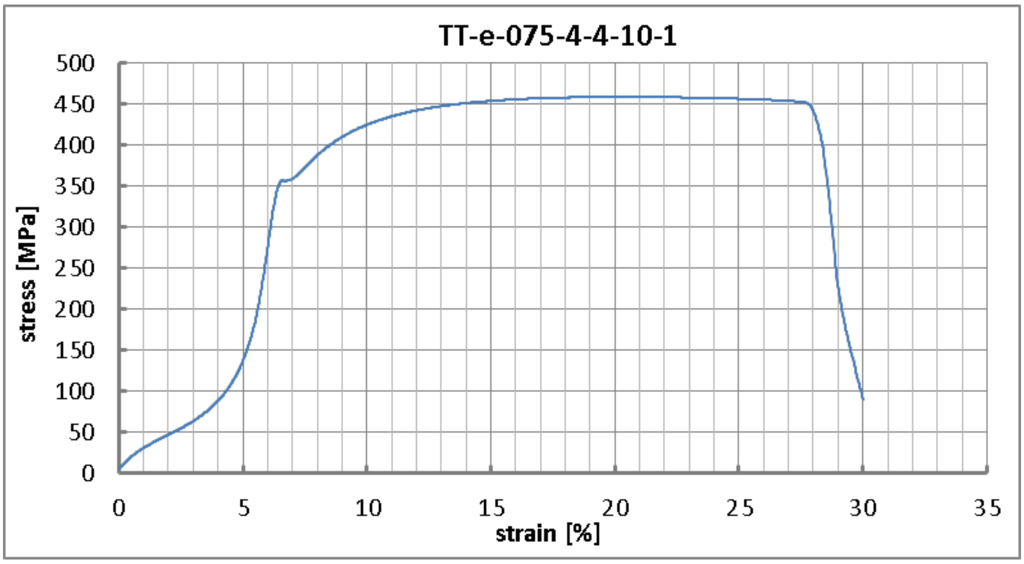

TT-e-075-3-3-10-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
strain [%]

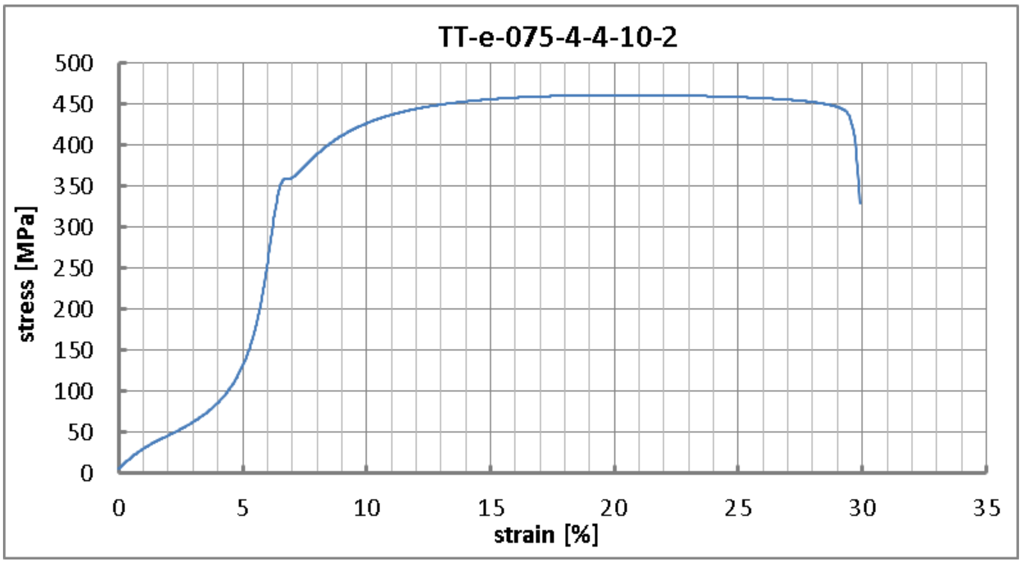

TT-e-075-3-3-10-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
strain [%]

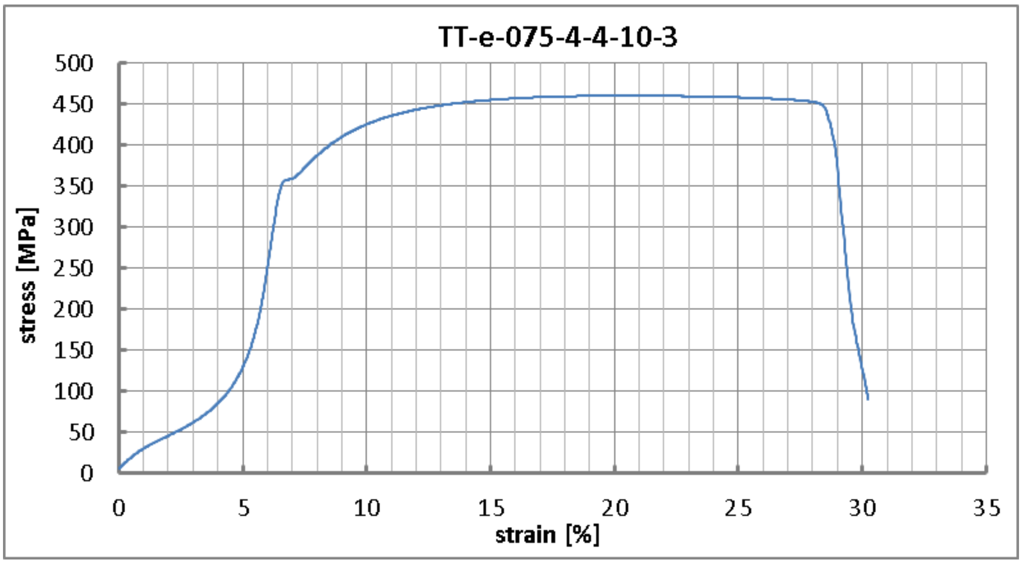

TT-e-075-4-4-0-1
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

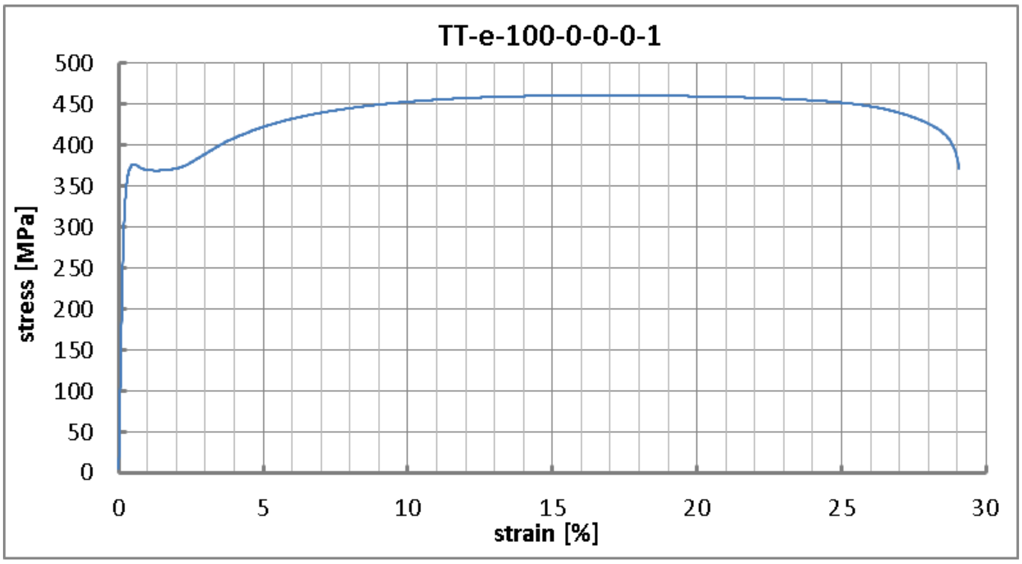

TT-e-075-4-4-0-2
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

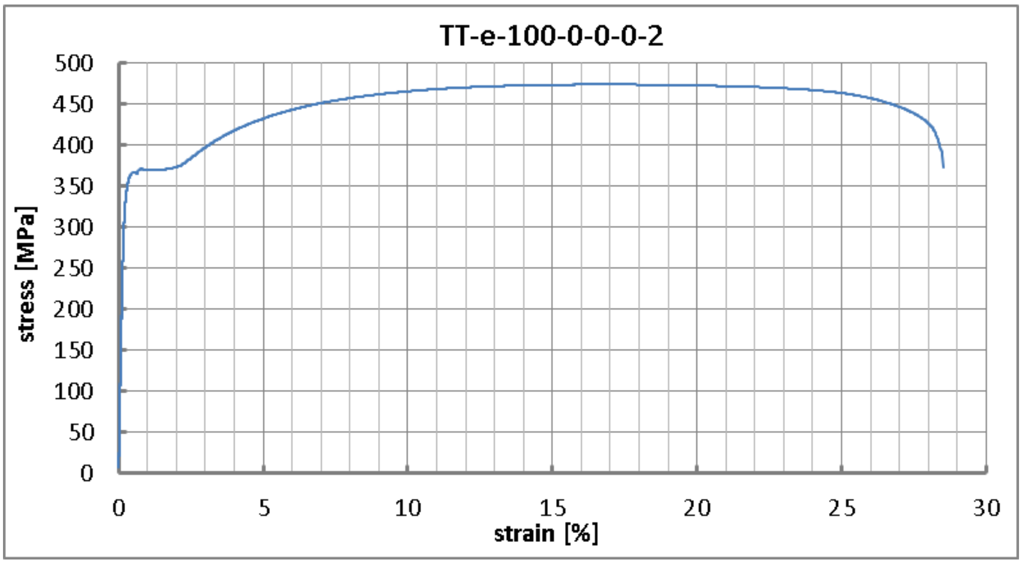

TT-e-075-4-4-0-3
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

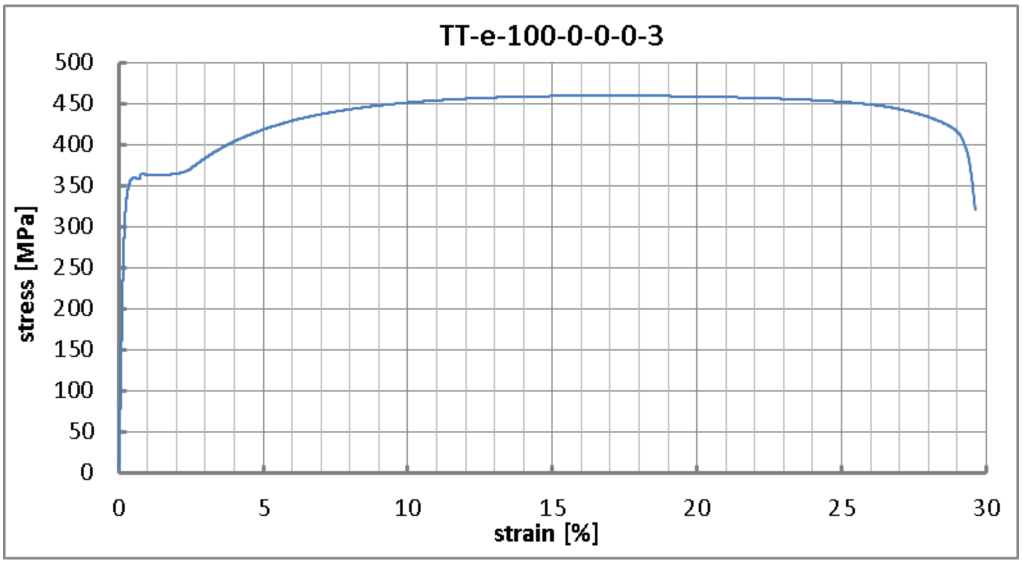

TT-e-075-4-4-10-1
stress [MPa]
strain [%]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35

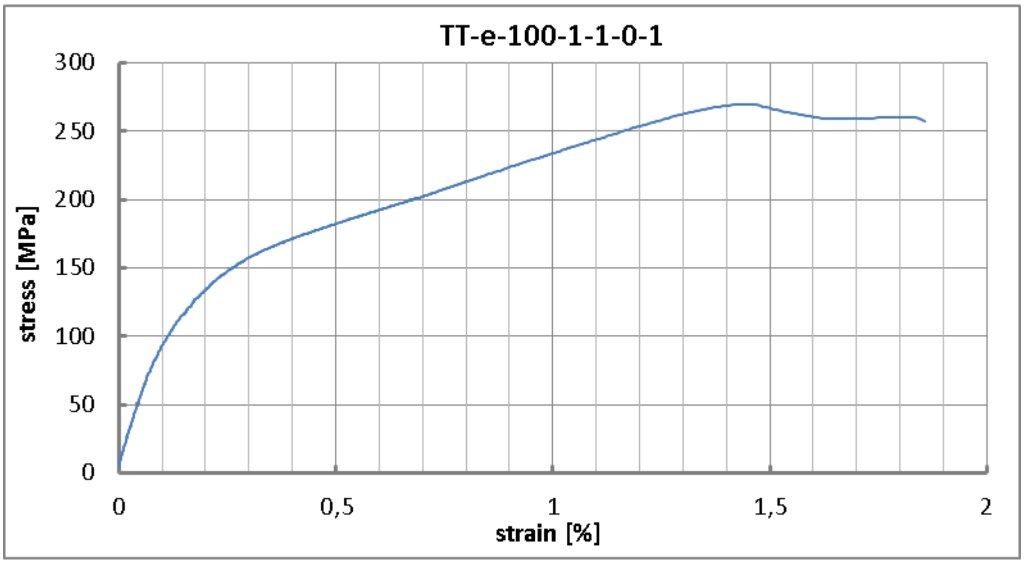

TT-e-075-4-4-10-2
stress [MPa]
strain [%]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35

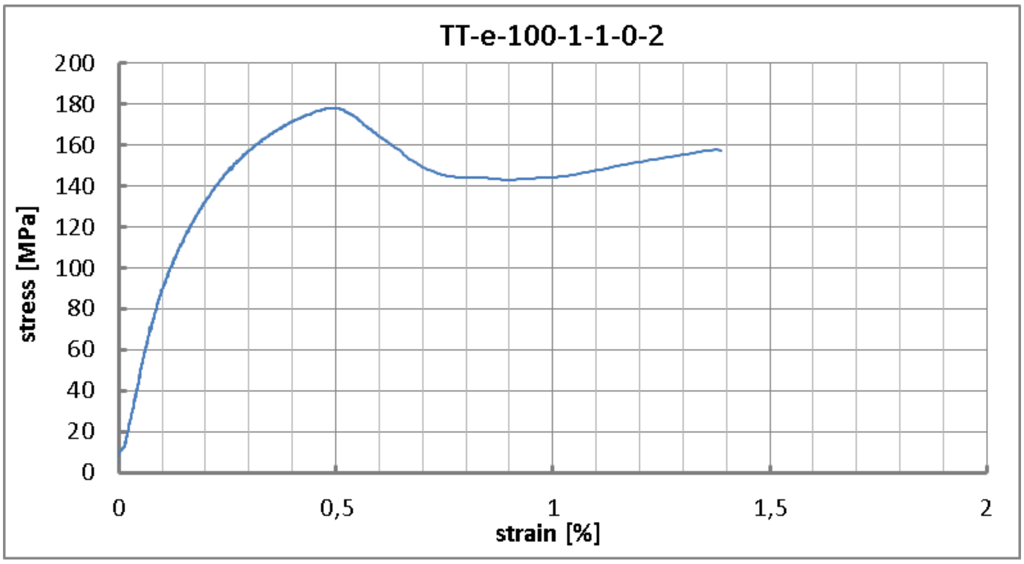

TT-e-075-4-4-10-3
stress [MPa]
strain [%]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35

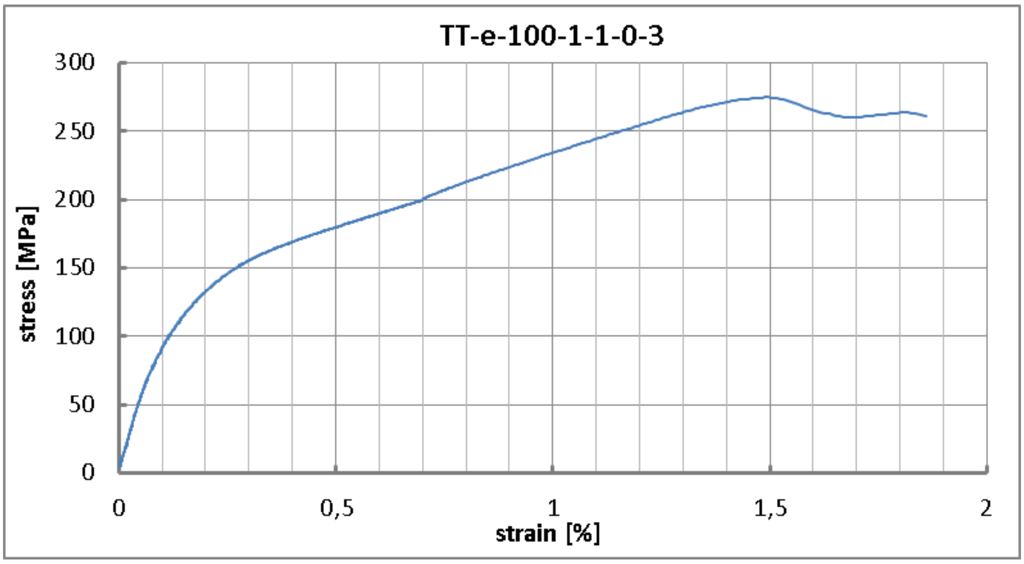

TT-e-100-0-0-0-1
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

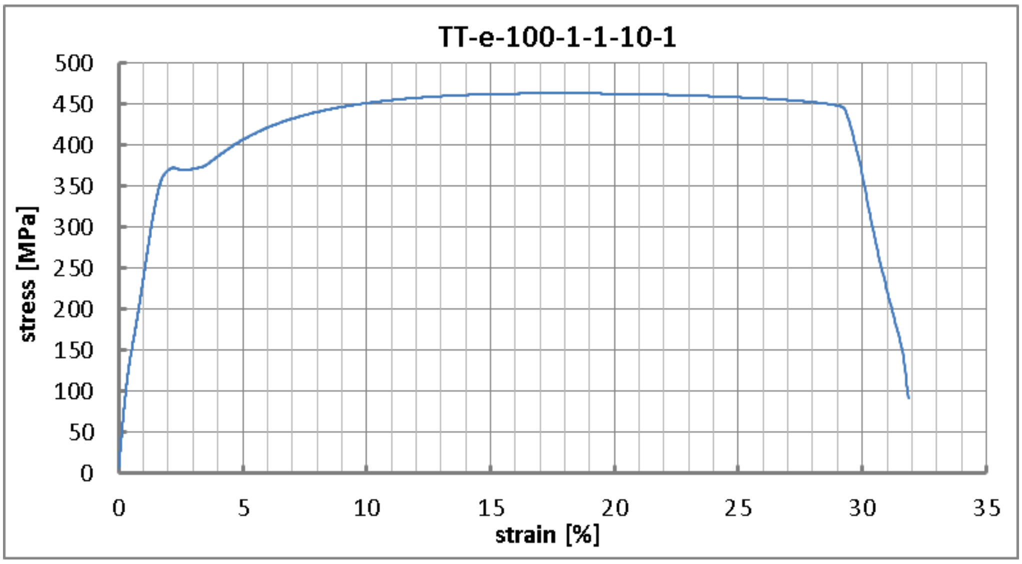

TT-e-100-0-0-0-2
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

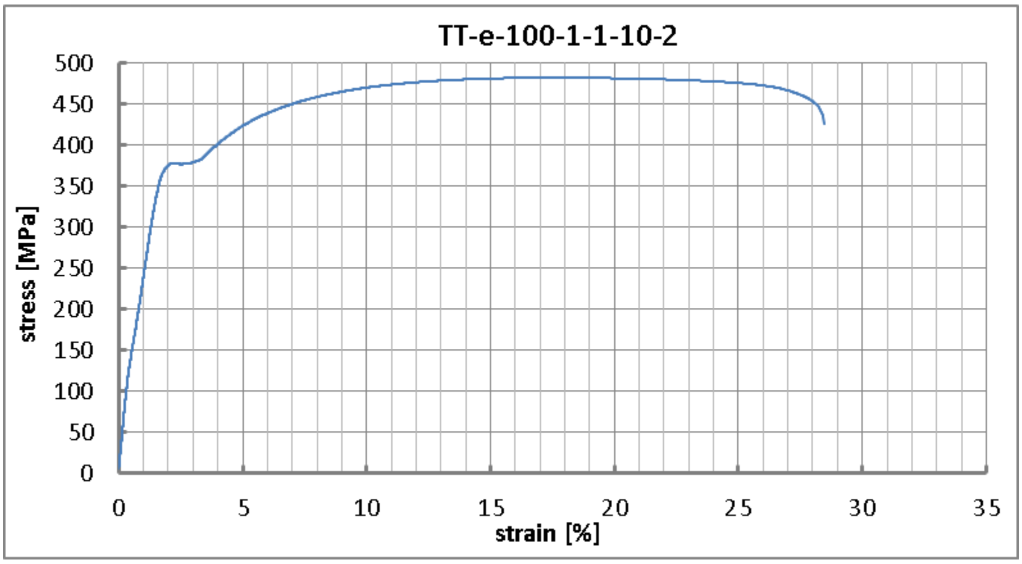

TT-e-100-0-0-0-3
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

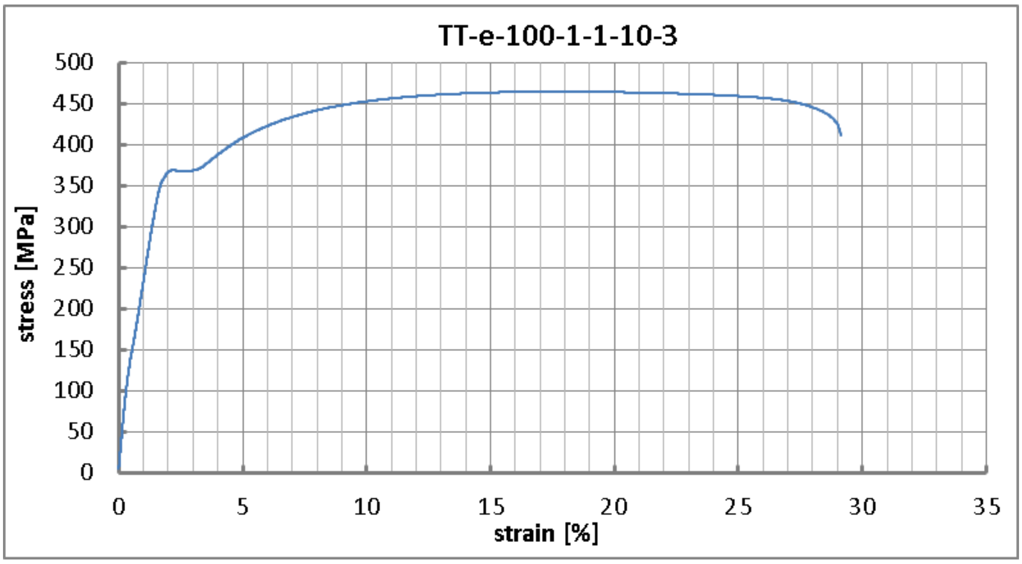

TT-e-100-1-1-0-1
300
250
200
150
100
50
0
stress [MPa]
0
0,5
1
1,5
2
strain [%]

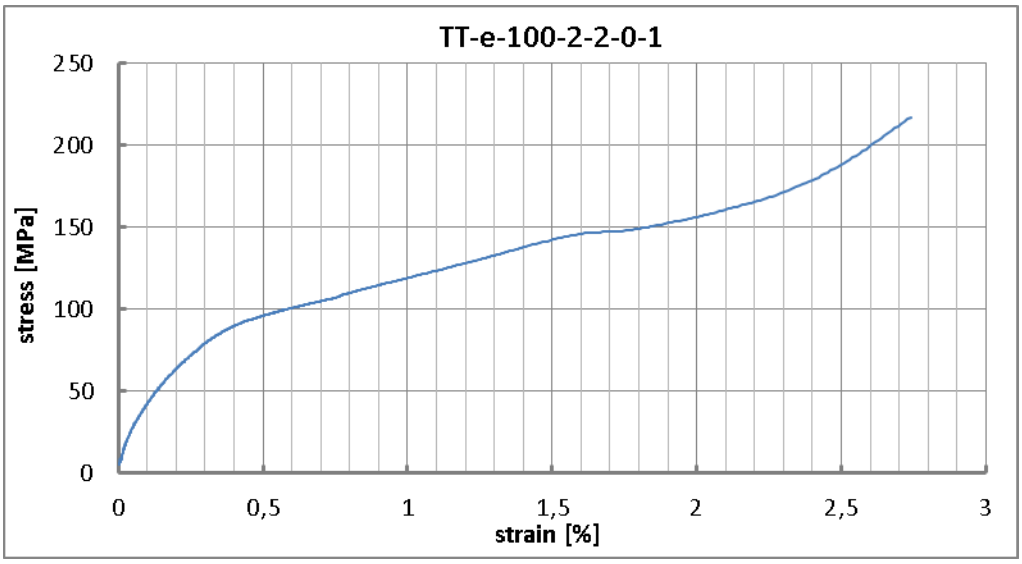

TT-e-100-1-1-0-2
200
180
160
140
120
100
80
60
40
20
0
stress [MPa]
0
0,5
1
1,5
2
strain [%]

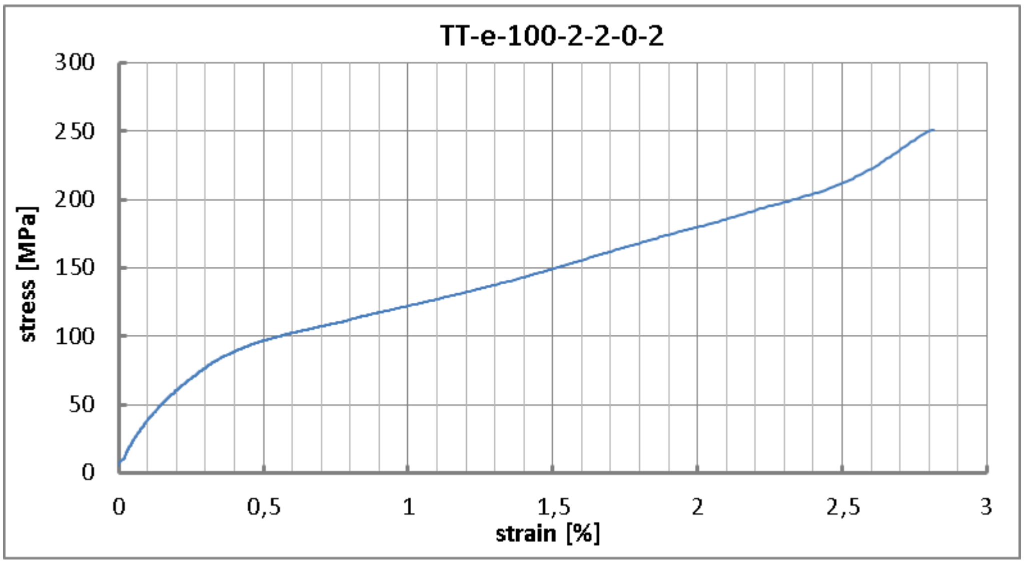

TT-e-100-1-1-0-3
300
250
200
150
100
50
0
stress [MPa]
0
0,5
1
1,5
2
strain [%]

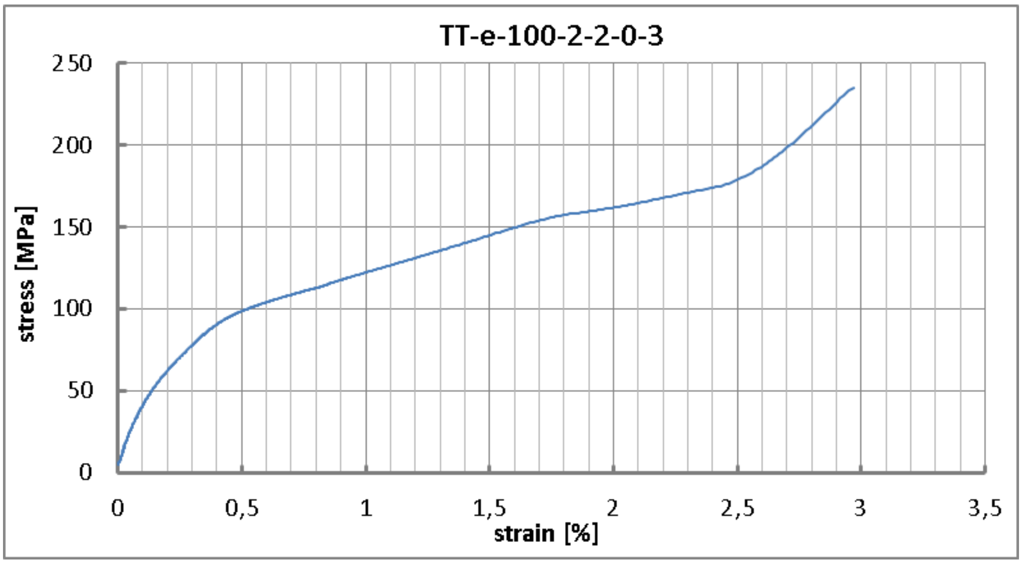

TT-e-100-1-1-10-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]

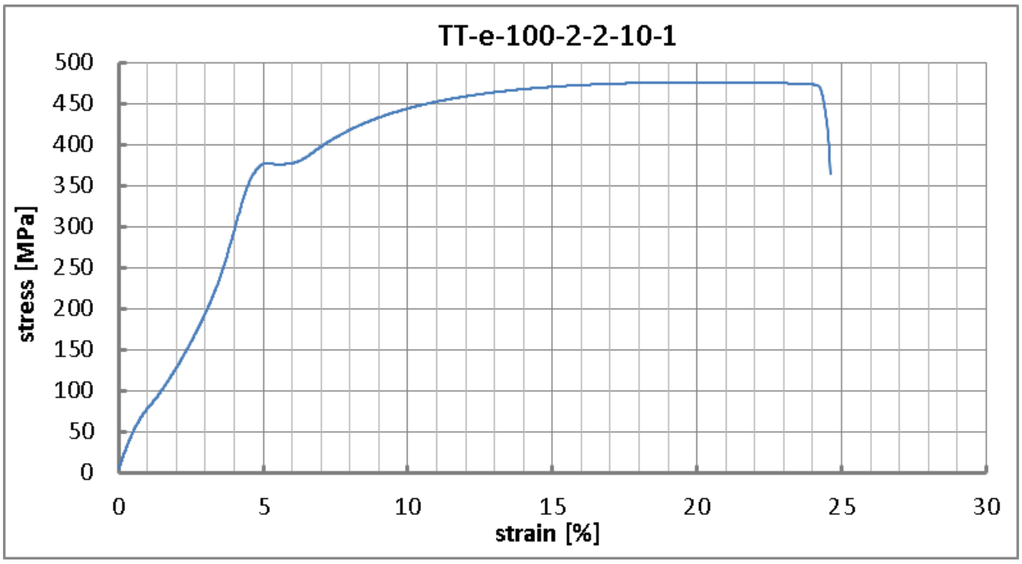

TT-e-100-1-1-10-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]

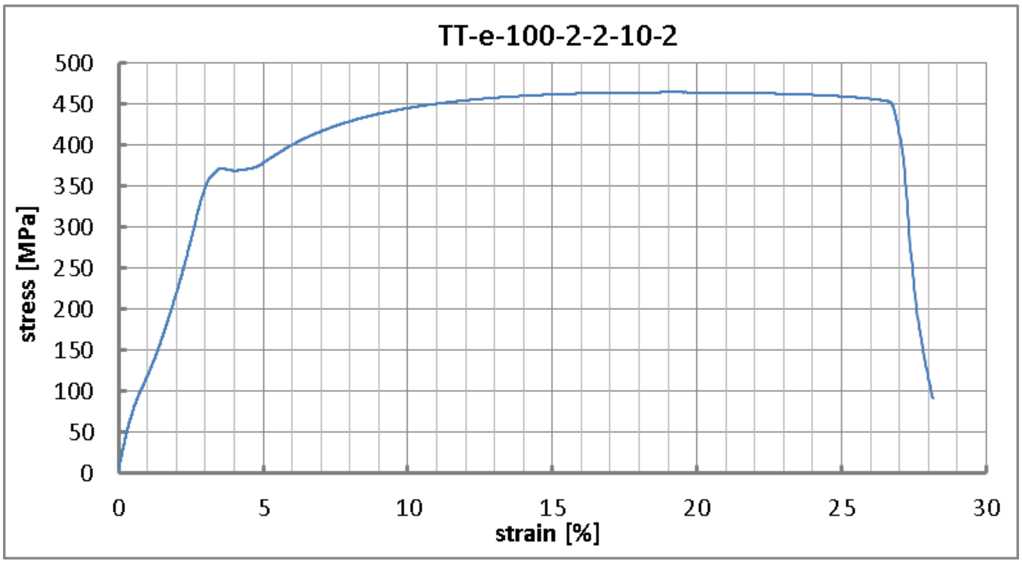

TT-e-100-1-1-10-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]

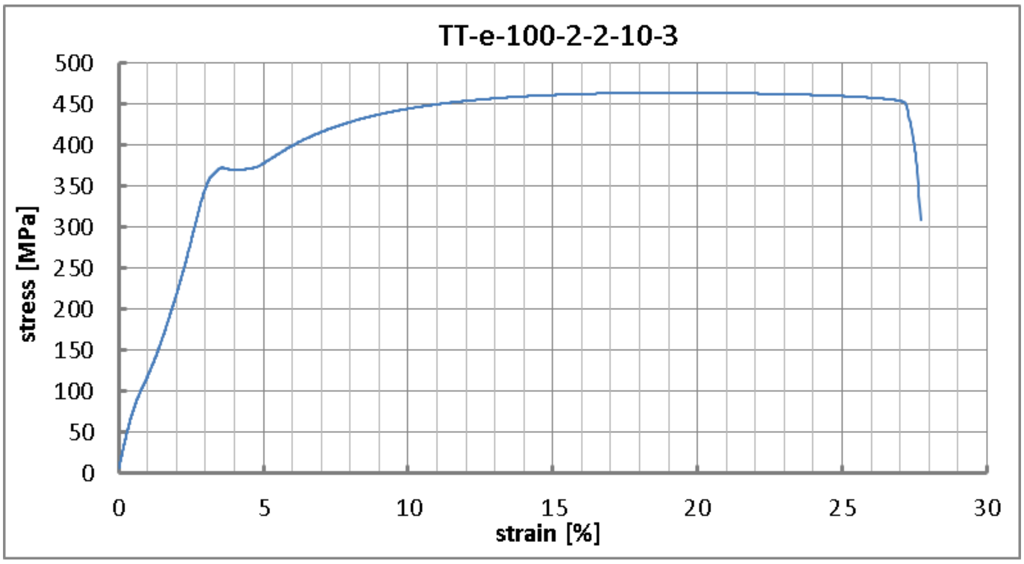

TT-e-100-2-2-0-1
stress [MPa]
250
200
150
100
50
0
0
0,5
1
1,5
2
2,5
3
strain [%]

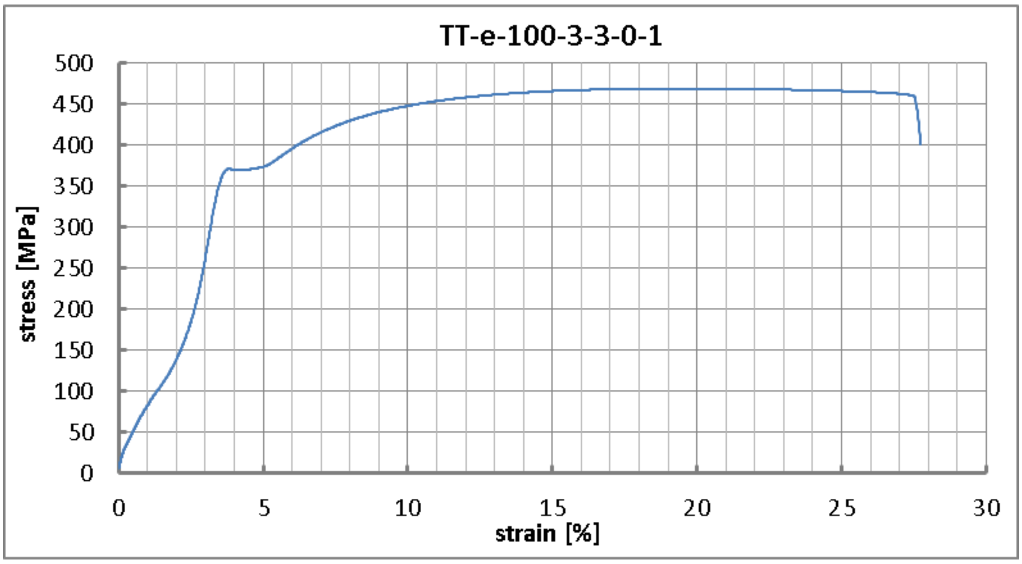

TT-e-100-2-2-0-2
stress [MPa]
300
250
200
150
100
50
0
0
0,5
1
1,5
2
2,5
3
strain [%]

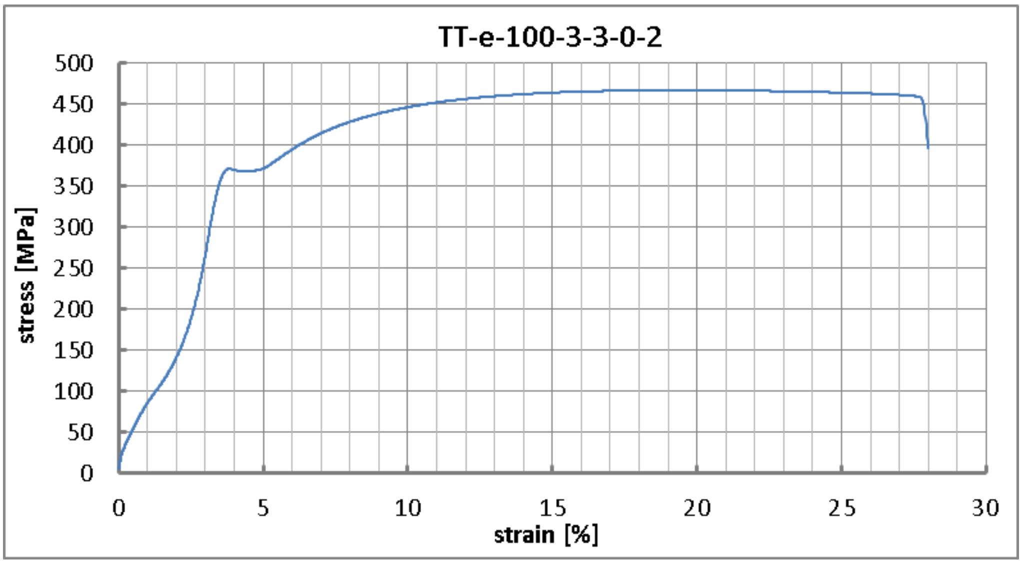

TT-e-100-2-2-0-3
stress [MPa]
250
200
150
100
50
0
0
0,5
1
1,5
2
2,5
3
3,5
strain [%]

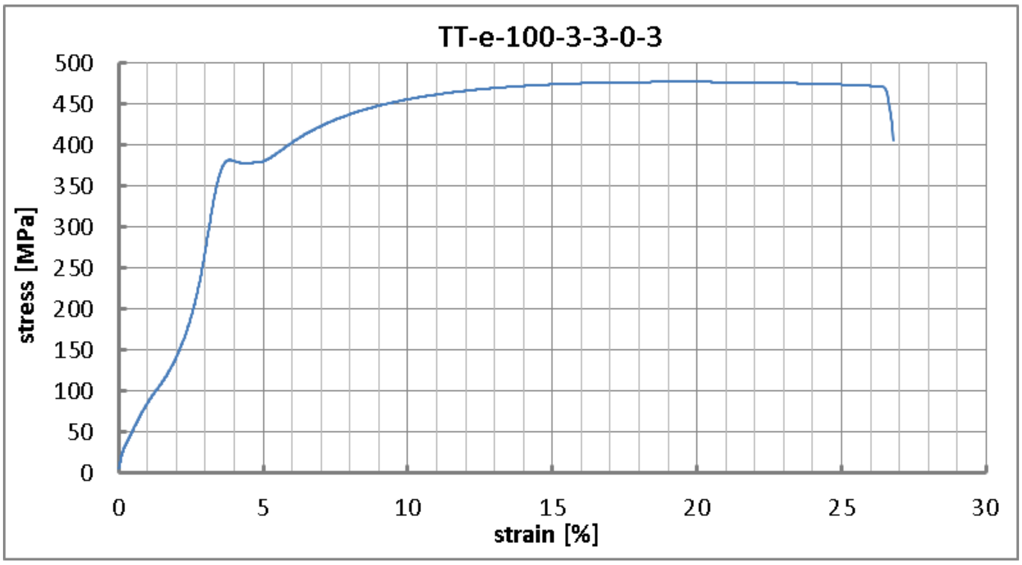

TT-e-100-2-2-10-1
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

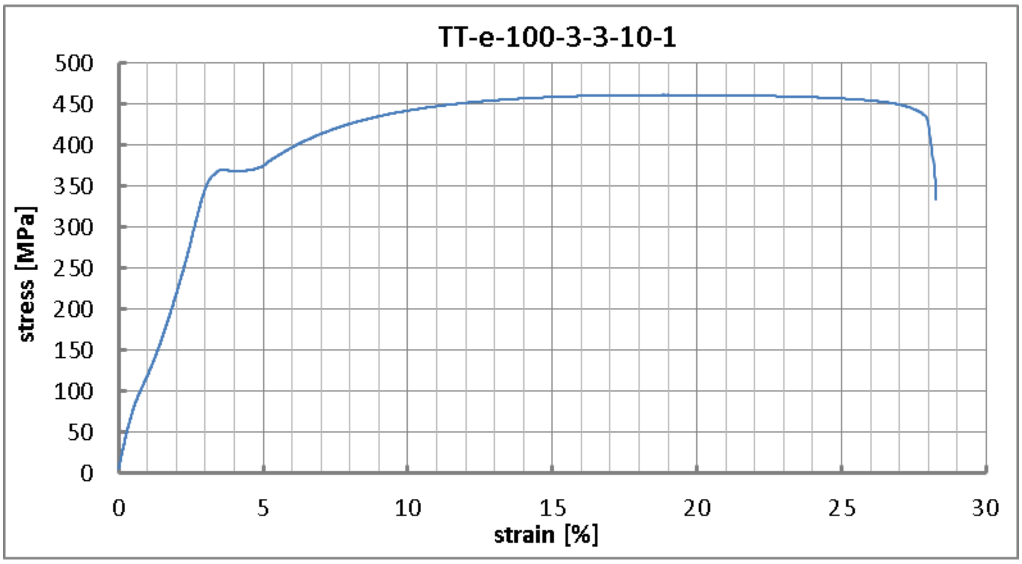

TT-e-100-2-2-10-2
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

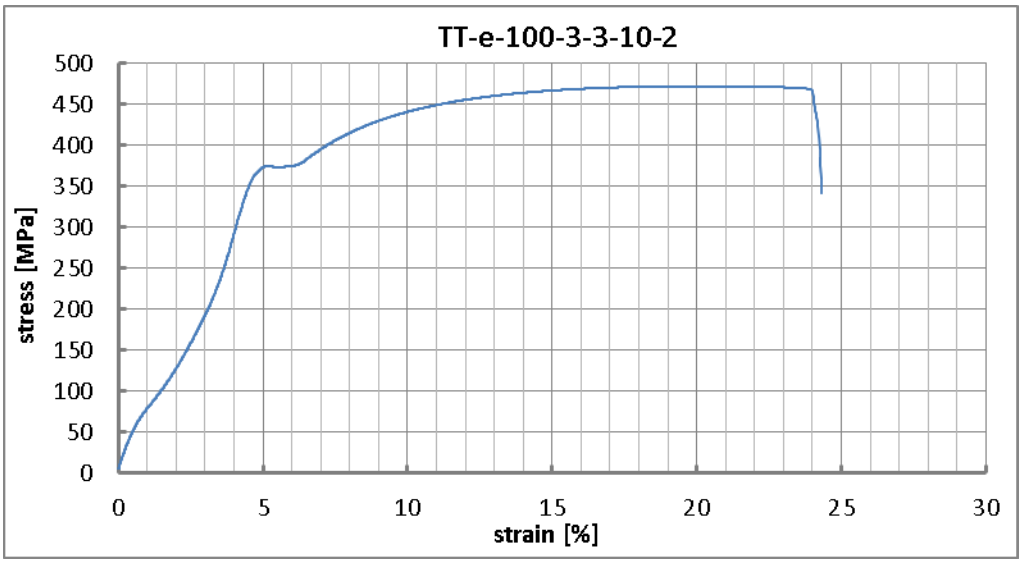

TT-e-100-2-2-10-3
stress [MPa]
strain [%]
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
30

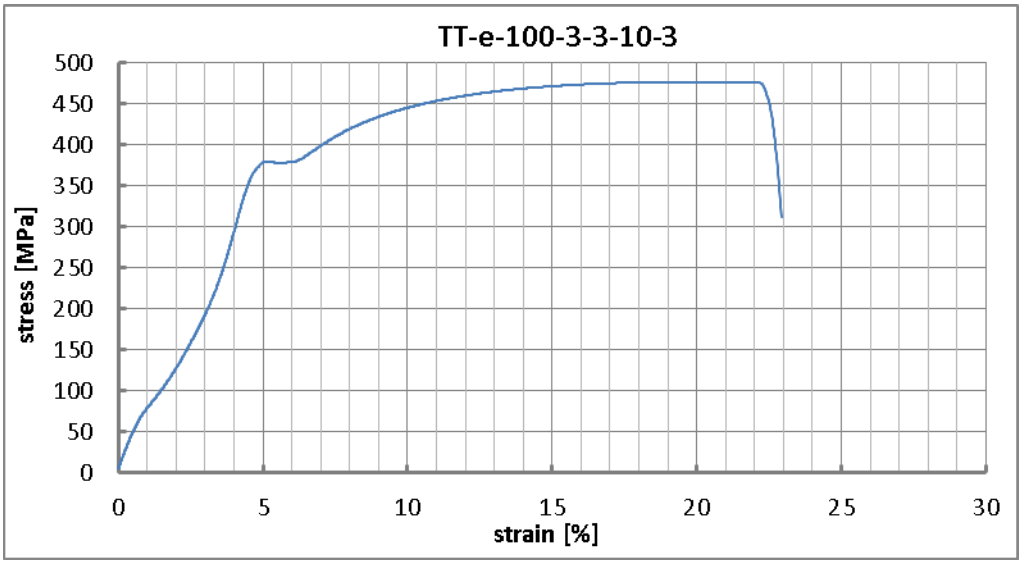

TT-e-100-3-3-0-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

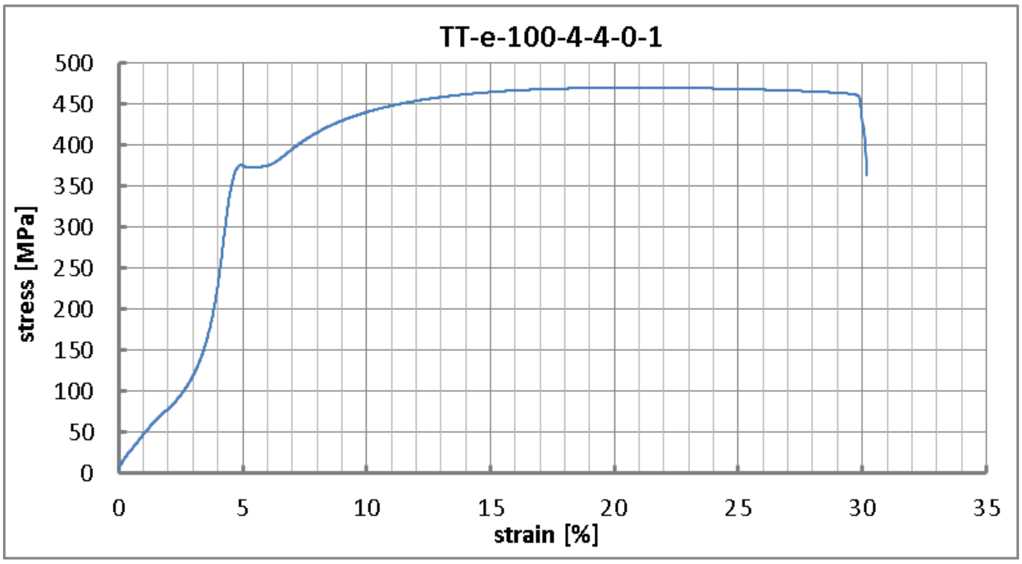

TT-e-100-3-3-0-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

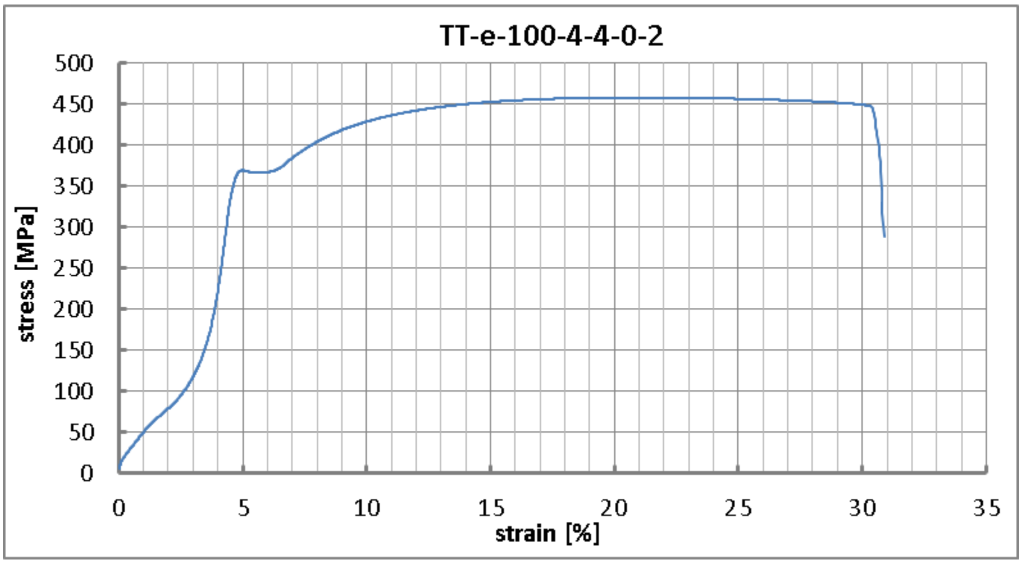

TT-e-100-3-3-0-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

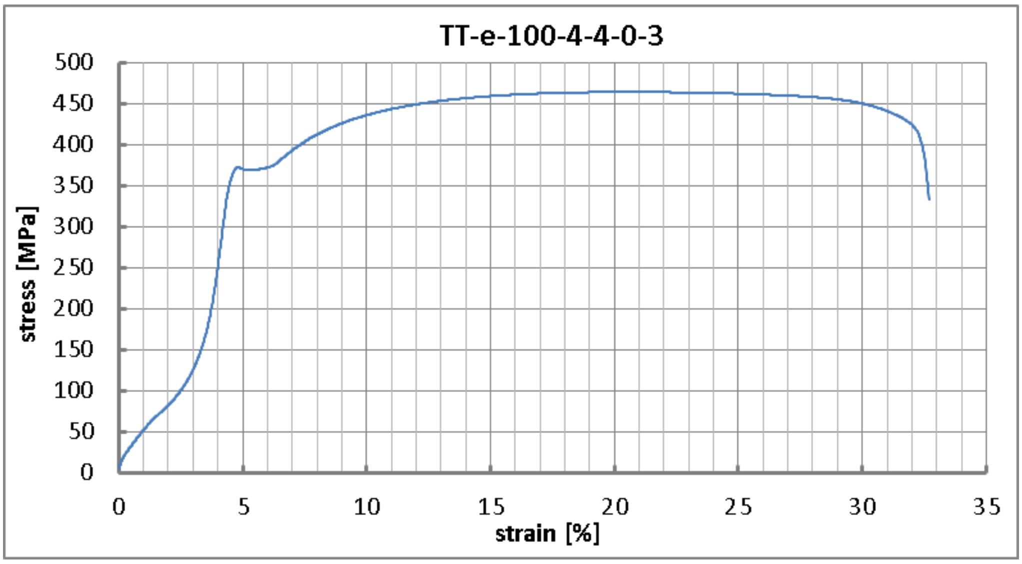

TT-e-100-3-3-10-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

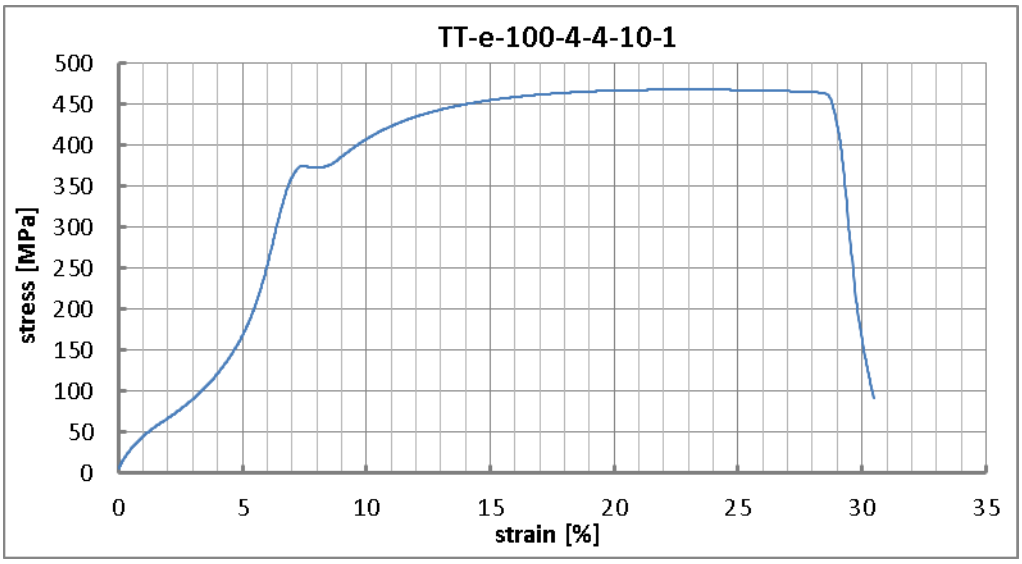

TT-e-100-3-3-10-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

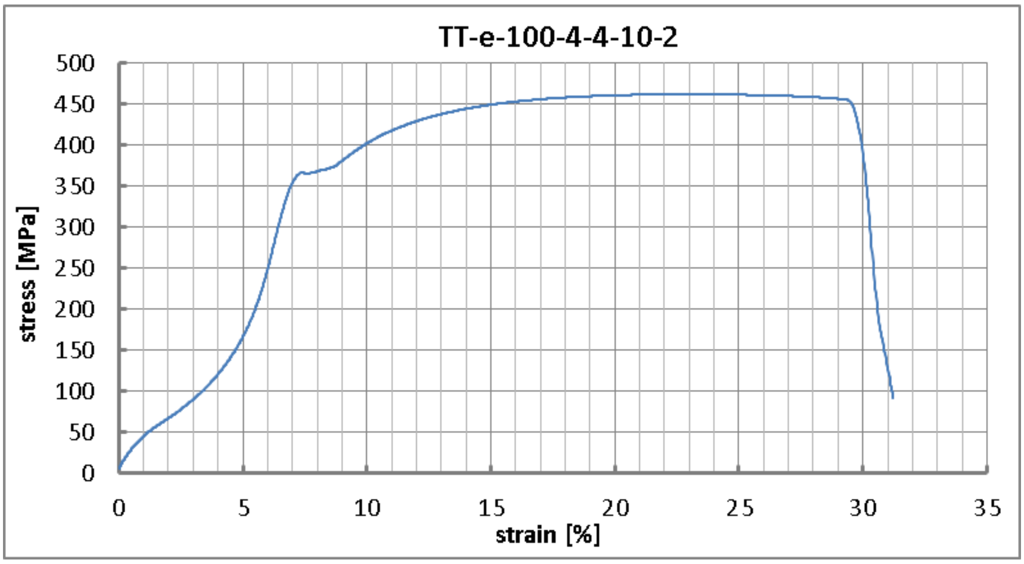

TT-e-100-3-3-10-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
strain [%]

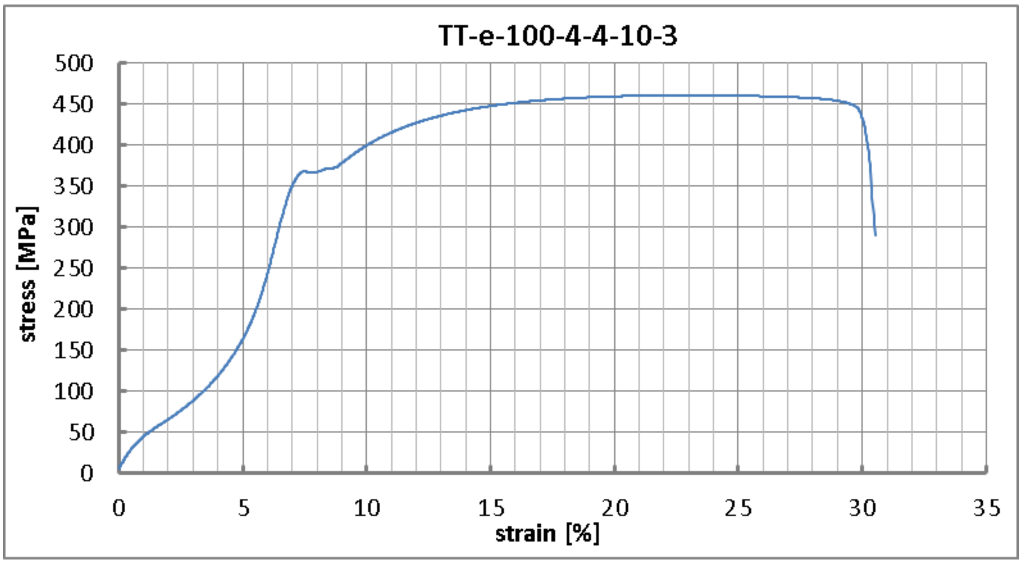

TT-e-100-4-4-0-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]


TT-e-100-4-4-0-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]


TT-e-100-4-4-0-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]


TT-e-100-4-4-10-1
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]


TT-e-100-4-4-10-2
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]


TT-e-100-4-4-10-3
stress [MPa]
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
strain [%]