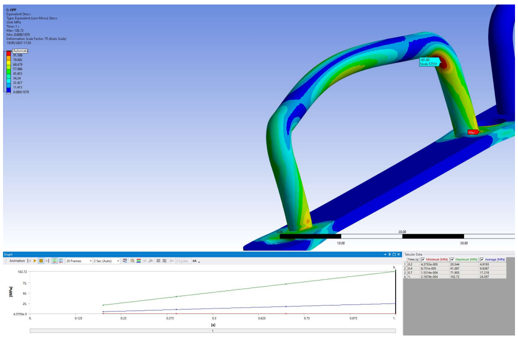
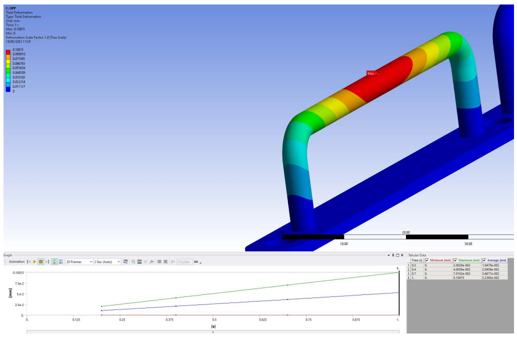
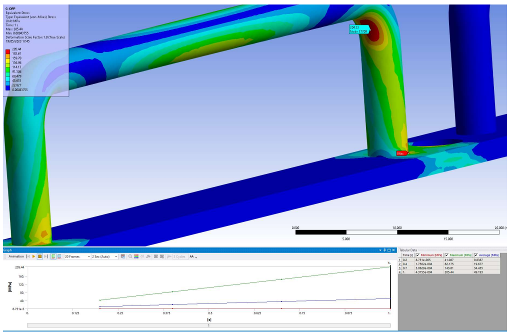
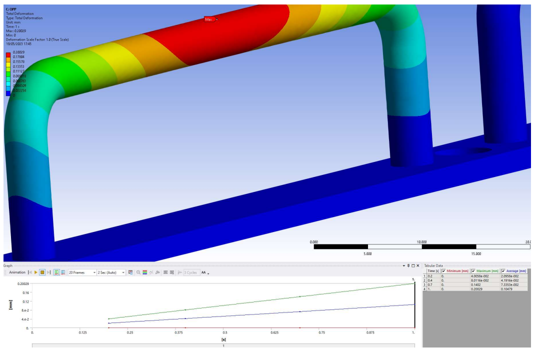
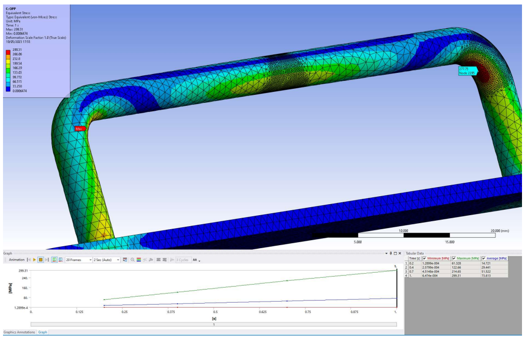
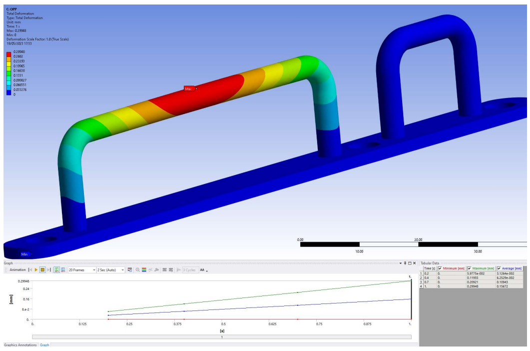
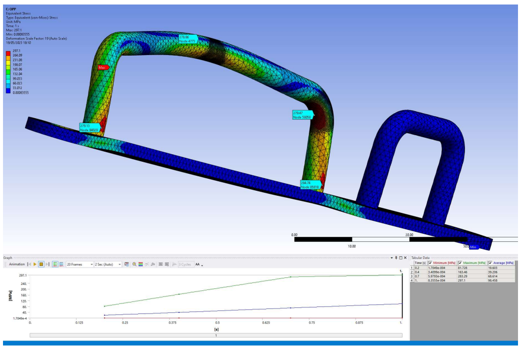
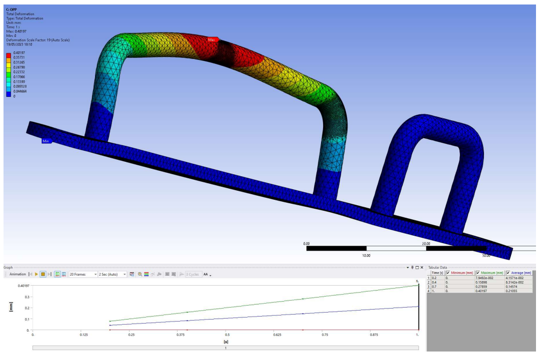
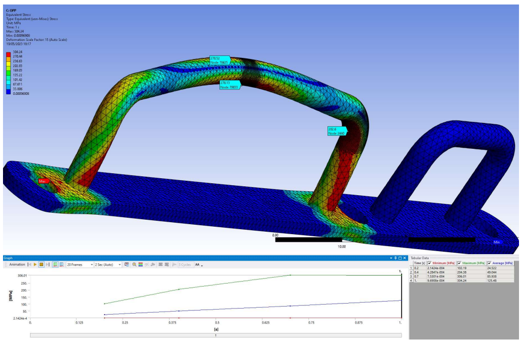
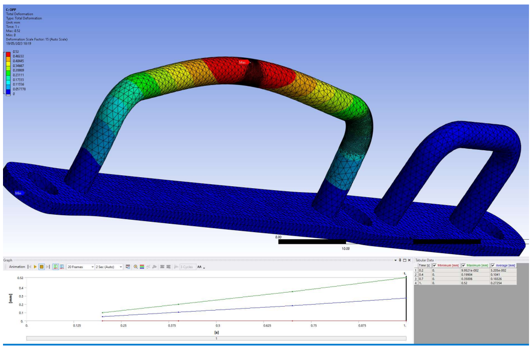
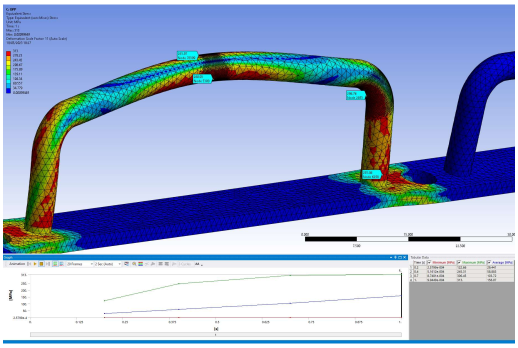
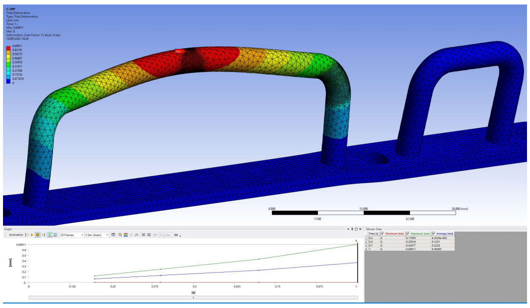
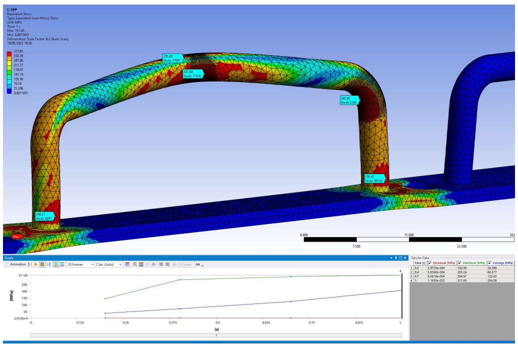
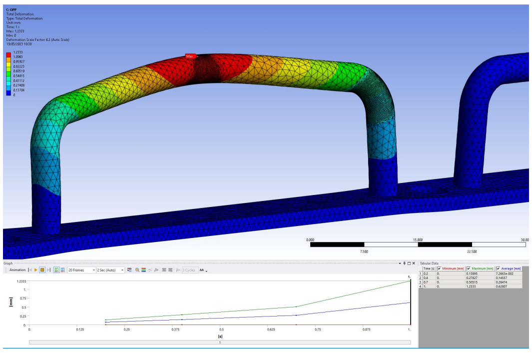
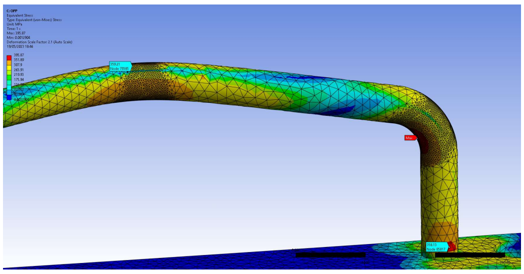
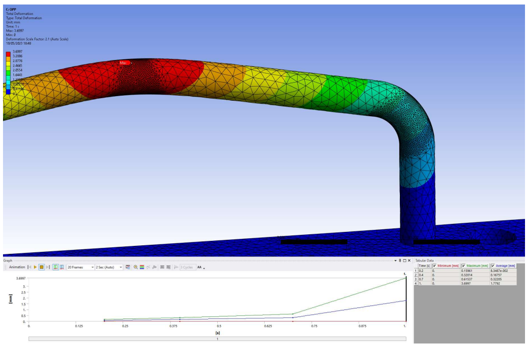
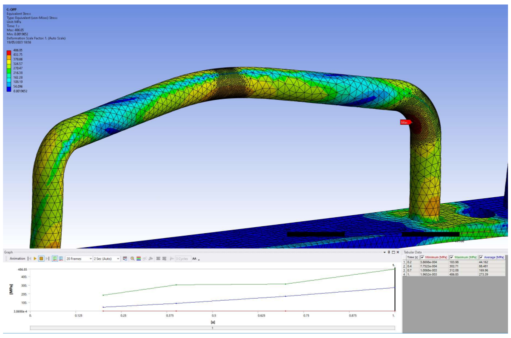
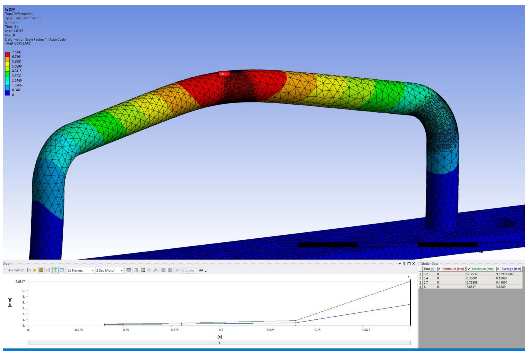
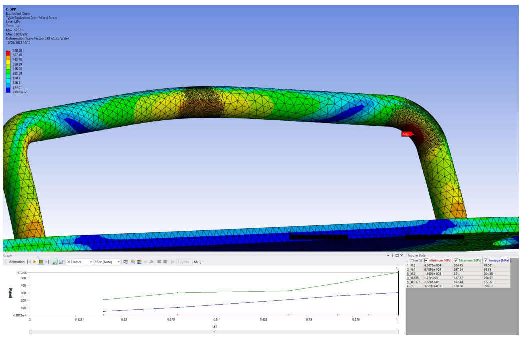
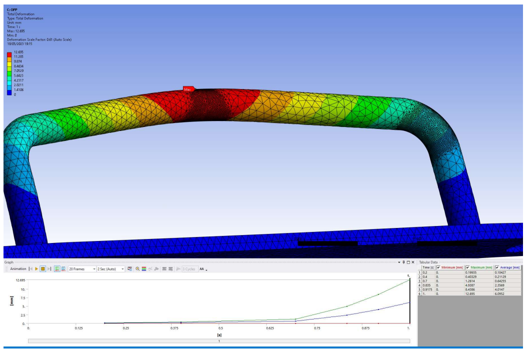
Attatchments

1. readout from FEM of fasteners
2. Deduction of formula for E-mod in composite material
3. Datasheet core material
4. Forces in the 8 systems
5. Aluminium 7076-t6
6. Hexply

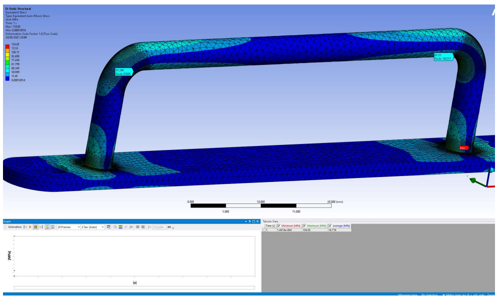
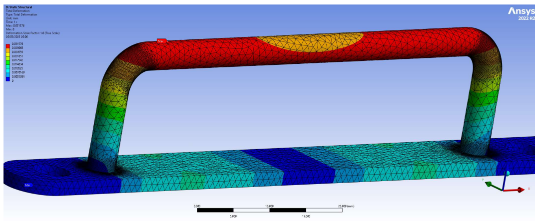
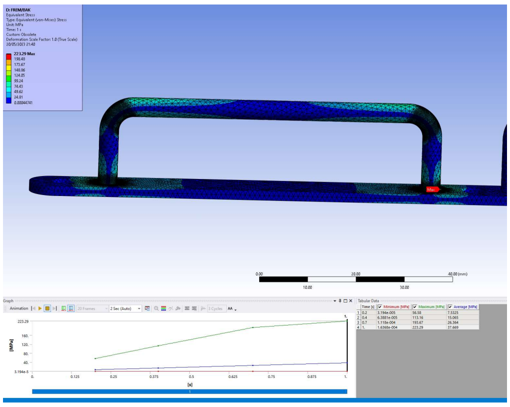
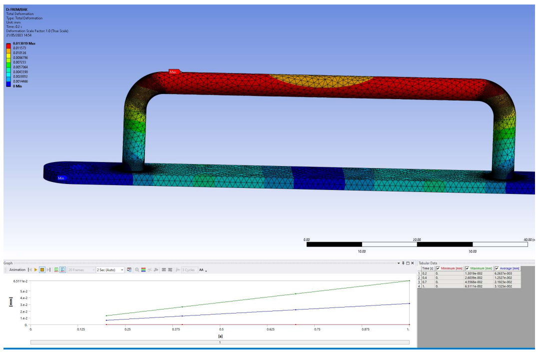
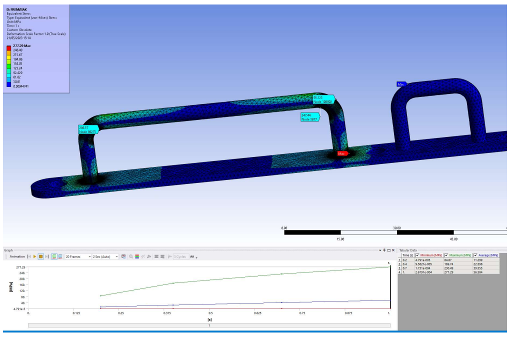
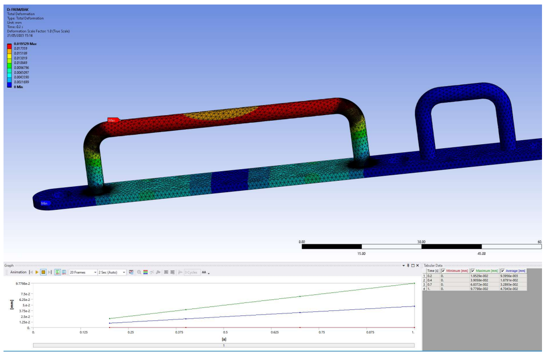
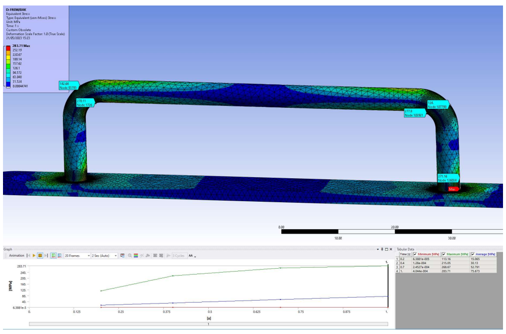
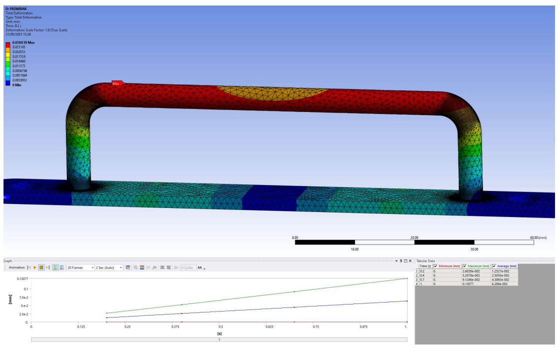
UP

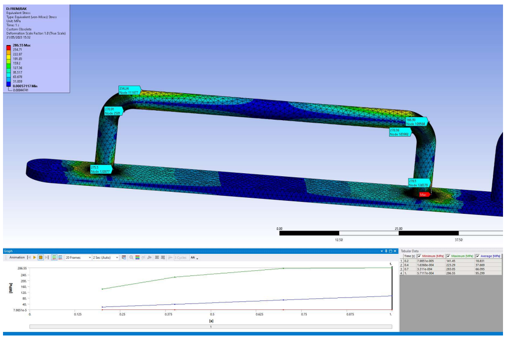
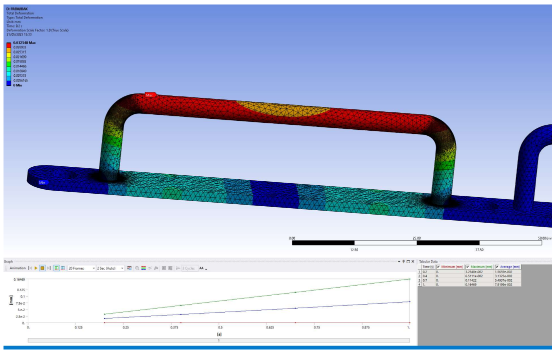
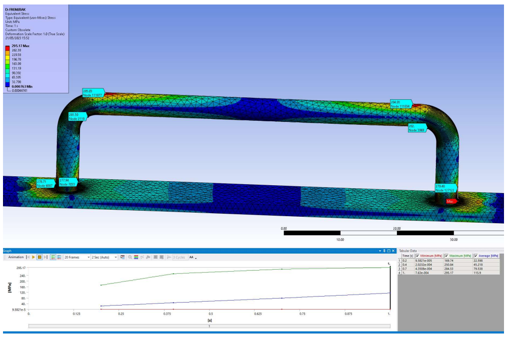
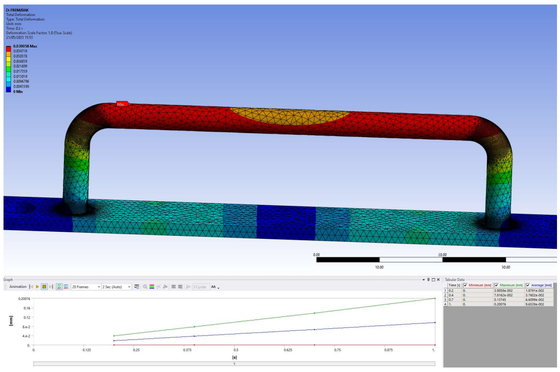
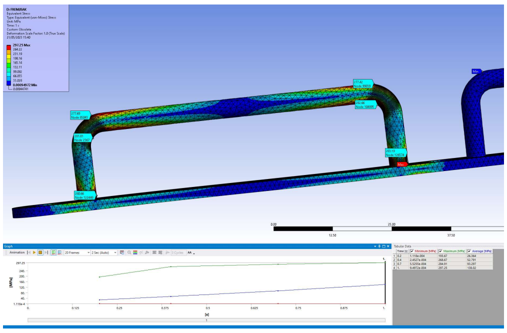
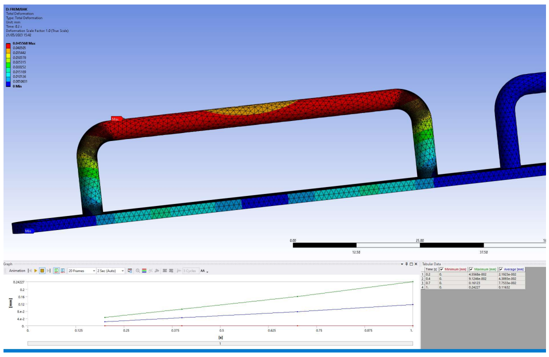
N	Stress	deformation
100N		
200N		
300N		
400N		

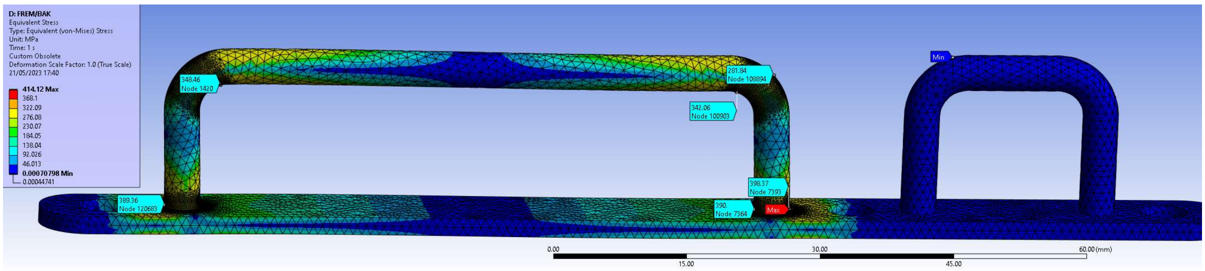
500N		
600N		
700N		
800N		

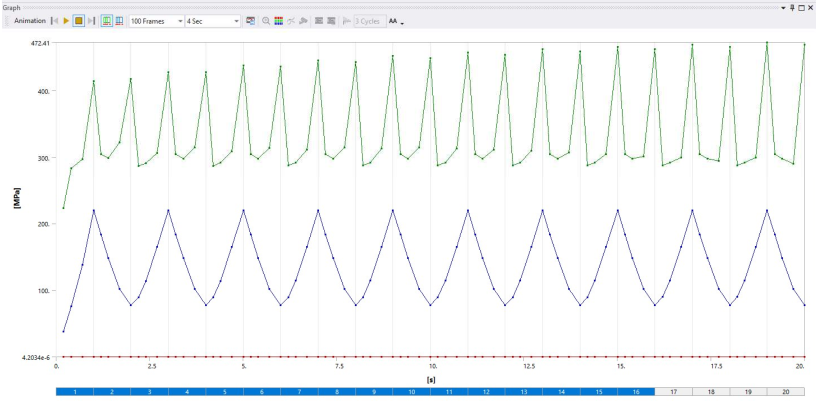
900N		
1000N		

Along Y

N	Stress	deformation
100N		
200N		
300N		
400N		

500N		
600N		
700N		
800N		
900N		
1000N		





Tabular Data

	Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	0.2	1.6368e-004	223.29	37.669
2	0.4	4.038e-004	283.71	75.672
3	0.7	9.5165e-004	297.25	138.02
4	1.	7.0798e-004	414.12	219.68
5	1.2	8.6945e-004	304.92	183.73
6	1.4	7.5189e-004	298.6	148.43
7	1.7	1.3285e-004	322.71	101.99
8	2.	1.1628e-005	417.36	77.082
9	2.2	1.5729e-004	287.34	89.082
10	2.4	2.2363e-004	291.69	113.92
11	2.7	7.9487e-004	306.38	164.82
12	3.	6.8599e-004	427.97	219.6
13	3.2	8.3265e-004	304.79	183.64
14	3.4	7.8828e-004	298.22	148.3
15	3.7	1.3382e-004	315.18	101.93
16	4.	1.4434e-005	427.95	77.22
17	4.2	1.5739e-004	287.5	89.265
18	4.4	2.26e-004	291.87	114.08
19	4.7	8.0478e-004	308.82	164.91
20	5.	6.7774e-004	437.75	219.56
21	5.2	8.1837e-004	304.8	183.59
22	5.4	8.0268e-004	298.12	148.23
23	5.7	1.343e-004	313.85	101.89
24	6.	1.0698e-005	436.29	77.313
25	6.2	1.6133e-004	287.62	89.388
26	6.4	2.2971e-004	292.	114.18
27	6.7	8.1228e-004	311.37	164.97
28	7.	6.7334e-004	445.42	219.53
29	7.2	8.1042e-004	304.8	183.55
30	7.4	8.1093e-004	298.05	148.18
31	7.7	1.3476e-004	314.58	101.86
32	8.	9.2354e-006	443.27	77.383
33	8.2	1.6612e-004	287.7	89.481
34	8.4	2.3354e-004	292.09	114.27
35	8.7	8.2015e-004	313.33	165.01
36	9.	6.705e-004	451.92	219.5
37	9.2	8.0512e-004	304.8	183.52
38	9.4	8.1655e-004	297.99	148.13

	Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	0.2	1.6368e-004	223.29	37.669
2	0.4	4.038e-004	283.71	75.672
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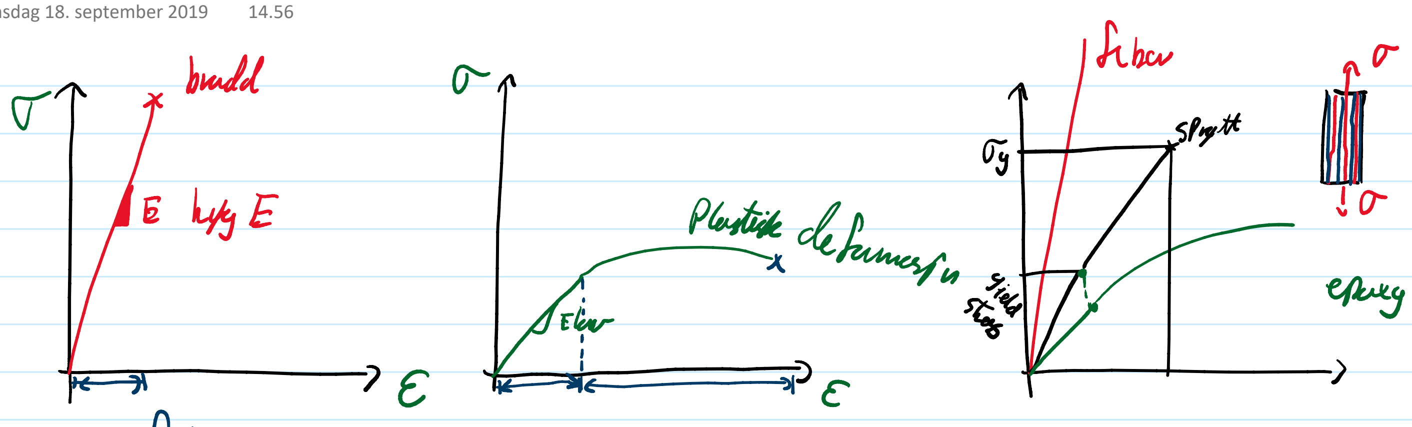
5	1.2	8.6945e-004	304.92	183.73
6	1.4	7.5189e-004	298.6	148.43
7	1.7	1.3285e-004	322.71	101.99
8	2.	1.1628e-005	417.36	77.082
9	2.2	1.5729e-004	287.34	89.082
10	2.4	2.2363e-004	291.69	113.92
11	2.7	7.9487e-004	306.38	164.82
12	3.	6.8599e-004	427.97	219.6
13	3.2	8.3265e-004	304.79	183.64
14	3.4	7.8828e-004	298.22	148.3
15	3.7	1.3382e-004	315.18	101.93
16	4.	1.4434e-005	427.95	77.22
17	4.2	1.5739e-004	287.5	89.265
18	4.4	2.26e-004	291.87	114.08
19	4.7	8.0478e-004	308.82	164.91
20	5.	6.7774e-004	437.75	219.56
21	5.2	8.1837e-004	304.8	183.59
22	5.4	8.0268e-004	298.12	148.23
23	5.7	1.343e-004	313.85	101.89
24	6.	1.0698e-005	436.29	77.313
25	6.2	1.6133e-004	287.62	89.388
26	6.4	2.2971e-004	292.	114.18
27	6.7	8.1228e-004	311.37	164.97
28	7.	6.7334e-004	445.42	219.53
29	7.2	8.1042e-004	304.8	183.55
30	7.4	8.1093e-004	298.05	148.18
31	7.7	1.3476e-004	314.58	101.86
32	8.	9.2354e-006	443.27	77.383
33	8.2	1.6612e-004	287.7	89.481
34	8.4	2.3354e-004	292.09	114.27
35	8.7	8.2015e-004	313.33	165.01
36	9.	6.705e-004	451.92	219.5
37	9.2	8.0512e-004	304.8	183.52
38	9.4	8.1655e-004	297.99	148.13
39	9.7	1.3504e-004	314.99	101.82
40	10.	4.2034e-006	449.23	77.44
41	10.2	1.7112e-004	287.77	89.557
42	10.4	2.3737e-004	292.16	114.34
43	10.7	8.2727e-004	313.27	165.05
44	11.	6.684e-004	457.3	219.47
45	11.2	8.0119e-004	304.8	183.49
46	11.4	8.2074e-004	297.93	148.1
47	11.7	1.353e-004	311.85	101.78
48	12.	6.6018e-006	454.27	77.488
49	12.2	1.7583e-004	287.82	89.62
50	12.4	2.4093e-004	292.22	114.4
51	12.7	8.3384e-004	309.61	165.08
52	13.	6.6688e-004	461.89	219.45
53	13.2	7.9825e-004	304.8	183.46

54	13.4	8.2389e-004	297.89	148.07
55	13.7	1.356e-004	307.5	101.75
56	14.	9.6869e-006	458.64	77.529
57	14.2	1.7997e-004	287.86	89.674
58	14.4	2.4402e-004	292.26	114.45
59	14.7	8.3962e-004	305.19	165.11
60	15.	6.656e-004	465.85	219.43
61	15.2	7.9587e-004	304.8	183.44
62	15.4	8.2645e-004	297.85	148.04
63	15.7	1.3587e-004	301.4	101.72
64	16.	1.042e-005	462.42	77.565
65	16.2	1.8372e-004	287.9	89.721
66	16.4	2.4682e-004	292.3	114.49
67	16.7	8.4498e-004	299.66	165.14
68	17.	6.6458e-004	469.34	219.41
69	17.2	7.9391e-004	304.79	183.42
70	17.4	8.2857e-004	297.82	148.02
71	17.7	1.3631e-004	294.69	101.69
72	18.	9.0152e-006	465.75	77.596
73	18.2	1.8715e-004	287.93	89.762
74	18.4	2.4938e-004	292.34	114.53
75	18.7	8.4995e-004	299.69	165.16
76	19.	6.6373e-004	472.41	219.4
77	19.2	7.9226e-004	304.79	183.41
78	19.4	8.3035e-004	297.79	148.
79	19.7	1.3685e-004	290.64	101.66
80	20.	8.1613e-006	468.66	77.623

Mekanisk styrke for kompositter

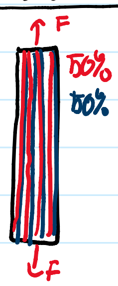
onsdag 18. september 2019 14.56



Fiber
– sprøtt

Epoxy
– mykt

Kraft fordeling



$$F = F_{fiber} + F_{epoxy}$$
$$= \sigma_F \cdot A_1 + \sigma_E \cdot A_2$$
$$= E_F \cdot \varepsilon_F \cdot A_1 + E_E \cdot \varepsilon_E \cdot A_2$$

iso strain
$\varepsilon_1 = \varepsilon_2$

$$\frac{F_F}{F_{tot}} = \frac{E_F \cdot \varepsilon_F \cdot A_1}{E_F \cdot \varepsilon_F \cdot A_1 + E_E \cdot \varepsilon_E \cdot A_2} = \frac{E_F \cdot A_1/A}{E_F \frac{A_1}{A} + E_E \frac{A_2}{A}} \Rightarrow \frac{F_F}{F} = \frac{E_F V_F}{E_F V_F + E_E V_F}$$

$$F_F = E_F \varepsilon_F A_1$$
$$F_E = E_E \varepsilon_E A_2 \Rightarrow \boxed{\frac{F_F}{F_E} = \frac{E_F \varepsilon_F A_1/A}{E_E \varepsilon_E A_2/A} = \frac{E_F \cdot V_F}{E_E V_E}}$$

$$\frac{F_{karbon}}{F_{Epoxy}} = \frac{230 \cdot 50\%}{69 \cdot 50\%} = 33$$

$$\Rightarrow \frac{F_{karbon}}{F_{tot}} = \frac{33}{33+1} = 98\%$$

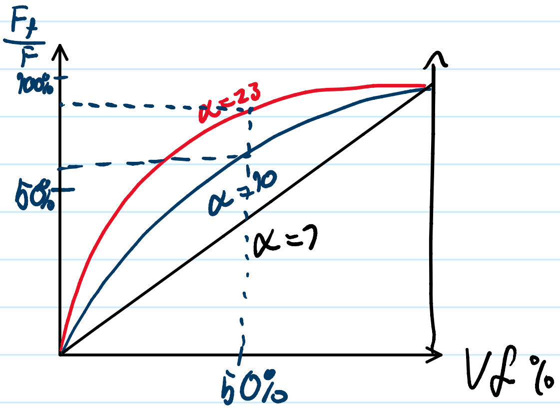
karbon tar 98% av lasten

$$\boxed{\left(\frac{F_F}{F}\right)\% = \frac{\alpha}{\alpha+1}}$$

Super formel :)

$$E_{comp} = E_{fiber} \cdot V_f + E_{matrix} \cdot (1 - V_f)$$

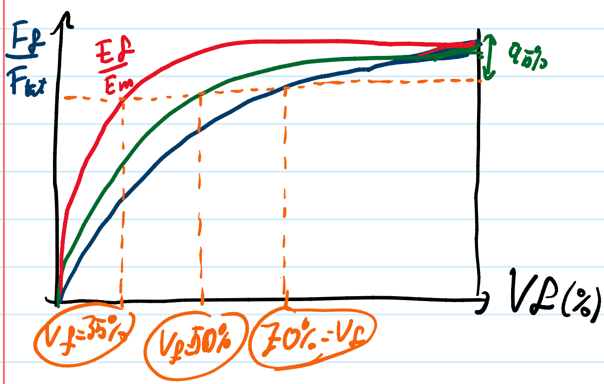
$$\left(\frac{F_{fiber}}{F}\right) = \frac{\alpha}{\alpha + 1} \quad \text{der} \quad \alpha = \frac{E_f V_f}{E_m V_m}$$



① $F_f \sim F_{tot} = F_f + F_m$

$$\frac{F_f}{F_{tot}} = \frac{F_f}{F_f + F_m} = \frac{F_f/F_m}{F_f/F_m + 1} = \frac{\left(\frac{E_f}{E_m}\right)\left(\frac{V_f}{V_m}\right)}{\left(\frac{E_f}{E_m}\right)\left(\frac{V_f}{V_m}\right) + 1} = \frac{E_f}{E_m} \cdot \frac{\left(\frac{V_f}{V_m}\right)}{\left(\frac{V_f}{V_m}\right) + \left(\frac{E_m}{E_f}\right)} \quad / \cdot V_m$$

$$\Rightarrow \frac{E_f}{E_m} \cdot \frac{V_f}{V_f + \left(\frac{E_m}{E_f}\right) + (1 - V_f)}$$



dersom $E_f/E_m = 1 \Rightarrow \frac{F_f}{F_m} = V_f$

② Langsgående model

$$E_c = E_f V_f + E_m V_m$$

* $E_{carbon/epoxy} = 230\,GPa \cdot 50\% + 6,9\,GPa \cdot 50\% = 118,5\,GPa$

230

* $E_{carbon/epoxy\ 230} = 230\ GPa \cdot 50\% + 6{,}4\ GPa \cdot 50\% = 118{,}5\ GPa$

* $E_{carbon/epoxy\ 340} = 173\ GPa$
* $E_{glass/epoxy} = 49{,}5\ GPa$

③ Tverrgående modell

$$E_c^{\to} = E_f^{\to} V_f + E_m^{\to} V_m$$

$$\frac{1}{E_c} = \frac{V_f}{E_f} + \frac{V_m}{E_m}$$

$$\boxed{E_c = \frac{E_f E_m}{E_f V_m + E_m V_f}}$$

$$E_c = \frac{2 E_f E_m}{E_f + E_m} \Big/ \frac{1}{E_m}$$

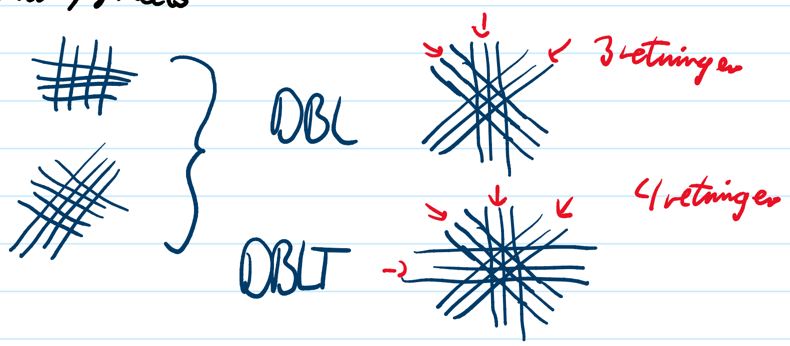
$$E_c = 2 \cdot \frac{E_f}{\frac{E_f}{E_m} + 2}$$

* $E_{carbon/epoxy\ 230} = 13{,}4\ GPa$ ← Anisotropi på elastisk egenskap
* $E_{carbon/epoxy\ 340} = 13{,}5\ GPa$ ←
* $E_{glass/epoxy} = 12{,}7\ GPa$ ←

④ Kompositt laminat/sheets

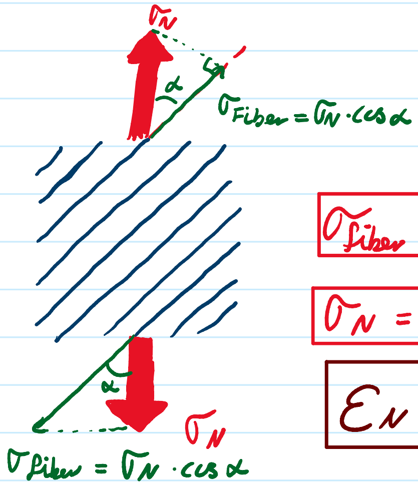
① LT veving

② DB veving (double bias)



⑤ E-modul for laminat

⑤ E-modul for laminat



$$\boxed{\sigma_{Fiber} = \sigma_N \cdot \cos^2\alpha}$$

$$\Downarrow$$

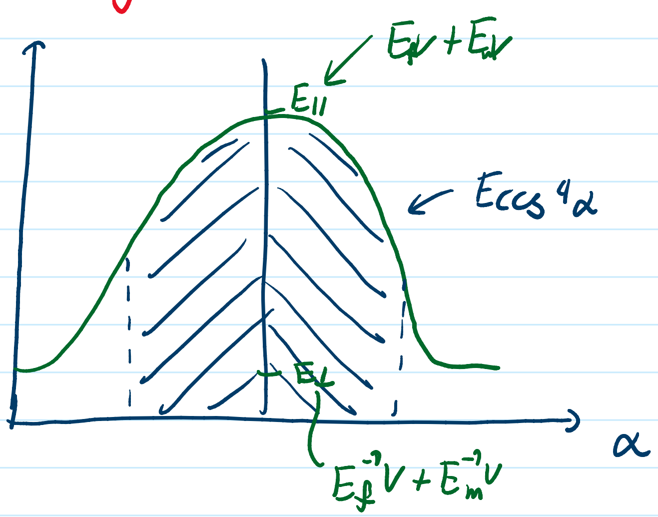
$$\boxed{\sigma_N = \sigma_{comp} \cdot \cos^2\alpha}$$

$$\boxed{\varepsilon_N = \varepsilon_{comp} / \cos^2\alpha}$$

$$E_{N,\alpha} = \frac{\sigma_N}{\varepsilon_N} = \left(\frac{\sigma_{comp}}{\varepsilon_{comp}}\right) \cdot \frac{\cos^2\alpha}{1/\cos^2\alpha}$$

$$\boxed{E_\alpha = E_{comp} \cdot \cos^4\alpha}$$

E_{lang} & E_{trans}:



Eksempel: 4 lags laminat

OBLT:

	α	$\cos\alpha$	$\cos^4\alpha$	E_α
1.	+45	$\sqrt{2}/2$	(1/4)	$\frac{1}{4} E_K$ ~ $E_{\parallel}$ komposit
2.	0	1	1	E_K
3.	90	0	0	0 ← NB: ≈ 0
4.	−45	$-\sqrt{2}/2$	1/4	$\frac{1}{4} E_K$

E modul for dette laminatet

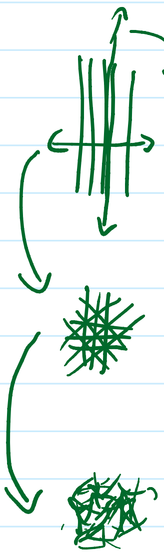
$$E = \sum E_i V_i = \left(\tfrac{1}{4} E_k\right) \cdot \tfrac{1}{4} + (E_k)\tfrac{1}{4} + (0) \cdot \tfrac{1}{4} + \left(\tfrac{1}{4} E_k\right)\tfrac{1}{4} = \left(\tfrac{1}{16} + \tfrac{1}{4} + \tfrac{1}{16}\right) E_k = \tfrac{3}{8} E_k$$

Laminat

$$E_\alpha = E_k \cdot \cos^4 \alpha = g \cdot E_k$$

(g: stivhets faktor)

$$E_L = \sum_i E_i V_i = \sum_i g_i E_k V_i = \left(\sum_i g_i V_i\right) E_k = g_{lam} \cdot E_k \quad \left(\tfrac{3}{8}\right)$$

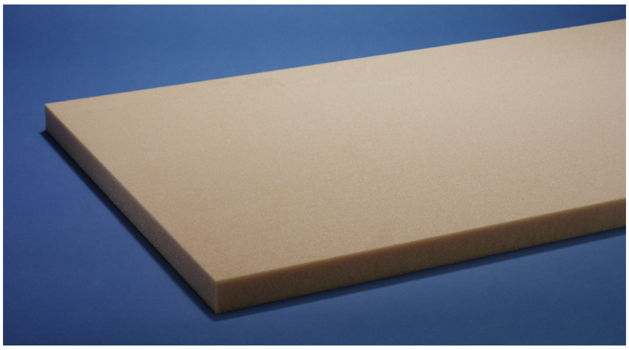


$E^{\parallel} = 170\ GPa$

$E^{\perp} = 13\ GPa$

$E^{-45,0,45,90} = 64\ GPa$

Quasi-isotropic laminat med korte fiber



TECHNICAL DATA

Divinycell H

HIGH PERFORMANCE PVC CORE MATERIAL

Divinycell H provides excellent mechanical properties to low weight. The unique PVC chemical structure, yields impressive mechanical performance to a low weight. Divinycell H has been widely used and has a proven track record in virtually every application area where sandwich composites are employed including the marine (leisure, military and commercial), land transportation, wind energy, civil engineering/infrastructure and general industrial markets.

Divinycell H is ideal for applications subject to fatigue, slamming or impact loads. Other key features of Divinycell H include consistent high quality, excellent adhesion/peel strength, excellent chemical resistance, low water absorption and good thermal/acoustic insulation. Divinycell H is compatible with virtually all commonly used resin and manufacturing systems.
Divinycell PVC foams also feature very low resin uptake, enabling weight and cost saving.

MECHANICAL PROPERTIES DIVINYCELL® H

Property	Test Procedure	Unit		H45	H60	H80	H100	H130	H160	H200	H250
Compressive Strength[1]	ASTM D 1621	MPa	Nominal	0.6	0.9	1.4	2.0	3.0	3.4	5.4	7.2
			Minimum	0.5	0.7	1.15	1.65	2.4	2.8	4.5	6.1
Compressive Modulus[1]	ASTM D1621-B-73	MPa	Nominal	50	70	90	135	170	200	310	400
			Minimum	45	60	80	115	145	175	265	350
Tensile Strength[1]	ASTM D 1623	MPa	Nominal	1.4	1.8	2.5	3.5	4.8	5.4	7.1	9.2
			Minimum	1.1	1.5	2.2	2.5	3.5	4.0	6.3	8.0
Tensile Modulus[1]	ASTM D 1623	MPa	Nominal	55	75	95	130	175	205	250	320
			Minimum	45	57	85	105	135	160	210	260
Shear Strength	ASTM C 273	MPa	Nominal	0.56	0.76	1.15	1.6	2.2	2.6	3.5	4.5
			Minimum	0.46	0.63	0.95	1.4	1.9	2.2	3.2	3.9
Shear Modulus	ASTM C 273	MPa	Nominal	15	20	27	35	50	60	73	97
			Minimum	12	16	23	28	40	50	65	81
Shear Strain	ASTM C 273	%	Nominal	12	20	30	40	40	40	45	45
Density	ISO 845	kg/m³	Nominal	48	60	80	100	130	160	200	250

All values measured at +23°C
1. Properties measured perpendicular to the plane.

Nominal value is an average value of a mechanical property at a nominal density.
Minimum value is a minimum guaranteed mechanical property a material has independently of density.

PRODUCT CHARACTERISTICS

- Low water absorption
- Superior damage tolerance
- Fast and easy to process
- Good chemical resistance
- Excellent fatigue properties
- Low resin uptake
- Wide range of properties
- Provides excellent mechanical properties to a low weight
- Good temperature resistance

TECHNICAL CHARACTERISTICS

TECHNICAL CHARACTERISTICS DIVINYCELL® H

Characteristics[1]	Unit	H45	H60	H80	H100	H130	H160	H200	H250	Test method
Density variation	%	+15/-10%	+15/-10%	+9/-16%	+15/-10%	+15/-10%	+15/-10%	+15/-10%	+16/-10%	-
Thermal conductivity[2]	W/(m-K)	0.028	0.029	0.031	0.033	0.036	0.040	0.044	0.049	EN 12667
Coeff, linear heat expansion	$x10^{-6}/°C$	40	40	40	40	40	40	40	40	ISO 4897
Heat Distortion Temperature	°C	+125	+125	+125	+125	+125	+125	+125	+125	DIN 53424
Continous temp range	°C	-200/+70	-200/+70	-200/+70	-200/+70	-200/+70	-200/+70	-200/+70	-200/+70	-
Max process temp	°C	+90	+90	+90	+110	+110	+110	+110	+110	-
Dissipation factor	-	0.0002	0.0003	0.0005	0.0006	0.0009	0.0012	0.0015	0.0019	ASTM D 2520
Dielectric constant	-	1.05	1.06	1.09	1.11	1.15	1.18	1.23	1.29	ASTM D 2520
Poissons ratio[3]	-	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	D638-08

1. Typical values
2. Thermal conductivity at +20°C
3. Standard deviation is 0.045

Continuous operating temperature is typically -200°C to +70°C. The foam can be used in sandwich structures, for outdoor exposure, with external skin temperatures up to +85°C. For optimal design of applications used in high operating temperatures in combination with continuous load, please contact Diab Technical Services for detailed design instructions.

Maximum processing temperature is dependent on time, pressure and process conditions. Therefore users are advised to contact Diab Technical Services to confirm that Divinycell H is compatible with their particular processing parameters.

OTHER CHARACTERISTICS DIVINYCELL® H

Format		Unit	H45	H60	H80	H100	H130	H160	H200	H250
Plain sheets	Length	mm	2440	2440	2440	2160	1960	1860	1730	1640
	Width	mm	1220	1220	1220	1070	970	915	850	800
GS sheet	Length	mm	1220	1220	1220	1080	980	930	865	-
	Width	mm	813	813	813	1070	970	915	850	-
GS sheet	Length	mm	1220	1220	1220	-	-	-	-	-
	Width	mm	1220	1220	1220	-	-	-	-	-

STORAGE OF PRODUCT

The shelf life of Divinycell is unlimited when it is stored in its original package on ambient indoor storage conditions and protected against UV exposure.

Disclaimer:
This data sheet may be subject to revision and changes due to development and changes of the material. The data is derived from tests and experience. If not stated as minimum values, the data is average data and should be treated as such. Calculations should be verified by actual tests. The data is furnished without liability for the company and does not constitute a warranty or representation in respect of the material or its use. The company reserves the right to release new data sheets in replacement.

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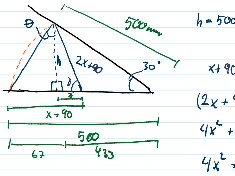
Tel +46 (0) 430 163 00
E-mail: info@diabgroup.com

30°

Ett sentrert stempel i massesenter 30°



$h = 500 \cdot \sin 30 = 250$

$x + 90 = 67 + z \Rightarrow z = x + 23$ (1)

$(2x+90)^2 = z^2 + h^2$

$4x^2 + 360x + 90^2 = z^2 + h^2$ (2)

$4x^2 + 360x + 90^2 = (x+23)^2 + h^2$ (3)

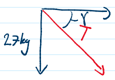
$4x^2 + 360x + 90^2 = x^2 + 92x + 23^2 + h^2$

$3x^2 + 314x + 90^2 - 23^2 - 250^2 = 0$

⇓ ABC

$x = 92{,}75\ mm \wedge$ ~~$-190{,}4\ mm$~~

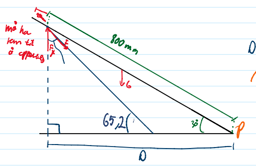
$\gamma = \tan^{-1} \frac{250}{92{,}75+23} = 65{,}2°$



$T = \frac{(27kg \cdot 9{,}81)}{\cos(90-\gamma)} = 291{,}9\ N$

Dersom 206 ≈ 5,8 kN

Dersom så langt frem som mulig



$D = 800 \cdot \cos 30 = 692{,}8\ mm$

$\circlearrowright \Sigma M_p = 0$

$F_y = \frac{G \cdot 433}{692{,}8} = 165{,}54\ N$

$F = \frac{F_y}{\sin \gamma} = 182{,}4\ N$

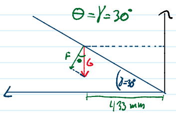
$800 \cdot \sin 30 = 400\ mm$

$\frac{400}{\cos 15} = 565\ mm$

Dersom 206 ≈ 3,6 kN

L =

Dersom vinkelrett på plan i massesenter



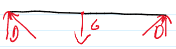
$F = \frac{G}{\cos 30°} = \frac{27 \cdot 9{,}81}{\cos 30°}$

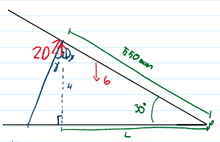
$F = 229{,}4\ N$

Dersom 206 ≈ 4,6 kN

Diagonalt stempel 30° Lengst unna P

Front





$L = 550 \cdot \cos 30 = 476{,}3$

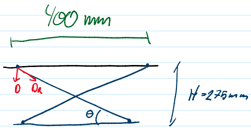
$D = \frac{D_y}{\cos 15} \Rightarrow D_y = D \cdot \cos 15$

$H = 550\ mm \cdot \sin 30 = 275\ mm$

$\gamma = \tan^{-1} \frac{550-476{,}3}{275} = 15°$

$\circlearrowright \Sigma MP = 0$

$2D_y \cdot 476{,}3 - G \cdot 433 \Rightarrow D_y = \frac{G \cdot 433}{2 \cdot 476{,}3} \Rightarrow D = \frac{G \cdot 433}{2 \cdot 476{,}3} \cdot \cos 15 = 116{,}3\ N$



$\theta = \tan^{-1} \frac{275}{400} = 34{,}5°$

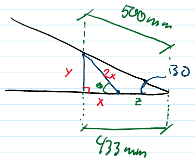
$D_R = \frac{D}{\sin \theta} = 205\ N$

Dersom 206 ≈ 4,1 kN Per stempel

Diagonalt Stempel 30° Nærmest P

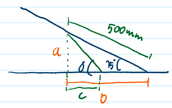
15°

Ett sentrert stempel i massesenter



$X = Y = 250\ mm$

$Z = 433 - X = 183\ mm$

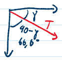


$a = 500 \cdot \sin 15 = 129{,}4\ mm$

$b = 500 \cdot \cos 15 = 483\ mm$

$c = b - 183 = 300\ mm$

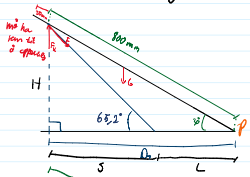
$\gamma = \tan^{-1}\left(\frac{a}{c}\right) = \tan^{-1}\left(\frac{129{,}4}{300}\right) = 23{,}3°$



$T = \left(\frac{27kg \cdot 9{,}81}{\cos 66{,}6}\right) = 666{,}9\ N$

Dersom 206 ≈ 13,3 kN

Dersom så langt frem som mulig

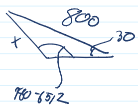


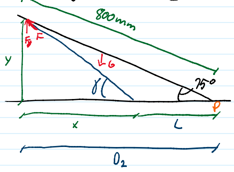
$D = 800 \cdot \cos 30 = 692{,}8\ mm$

$H = 800 \cdot \sin 30 = 400$

$S = z = x + 23 = 115{,}75\ mm$

$L = D - S = 577{,}05$





$y = \sin 15 \cdot 800 = 207\ mm$

$D_2 = 800 \cdot \cos 15 = 772{,}7\ mm$

$x = D_2 - L = 195{,}65\ mm$

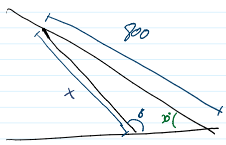
$\gamma = \tan^{-1}\left(\frac{y}{x}\right) = 46{,}6°$

$\circlearrowright \Sigma M_p = 0$

$F_y = \frac{G \cdot (900 \cdot \cos 15)}{772{,}7} = 264{,}9\ N$

$F = \frac{264{,}9}{\cos(46{,}6)} = 385{,}5\ N$

Dersom 206 ≈ 7,7 kN

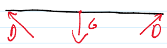


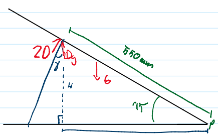
γ = 180-

$\frac{x}{\sin 30} =$

Stanglen

Diagonalt stempel 15°





$L = 550 \cdot \cos 15 = 531{,}3\ mm$

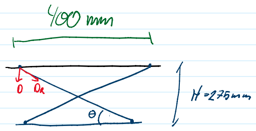
$D = \frac{D_y}{\cos \theta}$

$\gamma = \tan^{-1}\left(\frac{550-531{,}3}{142{,}35}\right) = 7{,}5°$

$H = 550 \cdot \sin 15 = 142{,}35$

$\circlearrowright \Sigma MP = 0$

$2D_y \cdot 550 = 27 \cdot 9{,}81 \cdot 433 \Rightarrow D = \frac{27 \cdot 9{,}81 \cdot 433}{2 \cdot 531{,}3} \cos \theta = 108\ N$

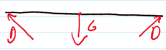


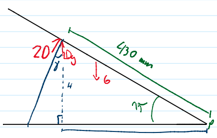
$\theta = \tan^{-1} \frac{142{,}3}{400} = 19{,}6°$

$D_R = \frac{D}{\sin \theta} = 321{,}8\ N$

Dersom 206 ≈ 6,4 kN

Diagonalt stempel 15° nærmest P





$L = 430 \cdot \cos 15 = 415{,}3\ mm$

$D = \frac{D_y}{\cos \theta}$

$\gamma = \tan^{-1}\left(\frac{430-L}{H}\right) = 7{,}5°$

$H = 430 \cdot \sin 15 = 111{,}3$

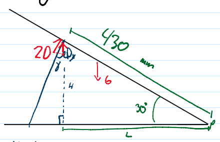
$- 65{,}2 = 114{,}8^{\circ}$

$\frac{800}{\sin 114{,}8} \Rightarrow x = \frac{800 \sin 30}{\sin 114{,}8} = 440{,}6$

gk: $\frac{440 - 90}{2} = 175\,mm$

Dersom 2G6 ≈ 4,1 kN Per stempel

Diagonalt Stempel 30° Nærmest P



$L = 430 \cdot \cos 30 = 372,4$

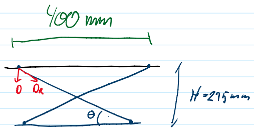
$D = \frac{D_y}{\cos 75} \Rightarrow D_y = D \cdot \cos 75$

$H = 430\,mm \cdot \sin 30 = 215\,mm$

$\gamma = \tan^{-1} \frac{430-372,4}{215} = 15°$

$\Sigma M_P = 0$

$2D_y \cdot 372,4 - 6 \cdot 433 \Rightarrow D_y = \frac{6 \cdot 433}{2 \cdot 372,4} \Rightarrow D = \frac{6 \cdot 433}{2 \cdot 372,4} \cdot \cos 75 = 148,7\,N$

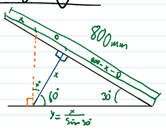


$\theta = \tan^{-1} \frac{215}{400} = 28,3°$

$D_R = \frac{D}{\sin\theta} = 314\,N$

2G6 ≈ 6,3 kN

Solseng 30°



Skjekk opp mot D

$180 - 30 - 90 = 60°$

$\cos 30° = \frac{\frac{x}{\sin 30}}{800 - x} = \frac{x}{800 \sin 30 - x \sin 30}$

$\sin 30 \cdot \cos 30 (800 - x) = x$

$800 \sin 30 \cos 30 = x + x \sin 30 \cos 30$

$800 \sin 30 \cos 30 = x(1 + \sin 30 \cos 30)$

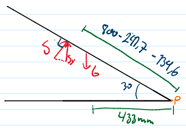
$x = \frac{800 \sin 30 \cos 30}{1 + \sin 30 \cos 30} = 247,7$

$y = \frac{x}{\sin 30}$

$\tan 30 = \frac{D}{x}$

$D = x \tan 30$

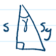
$D = 139,6\,mm$



$\Sigma M_P = 0$

$S_y (800 - 247,7 - 138,6) \cdot \cos 30 - 6 \cdot 433$

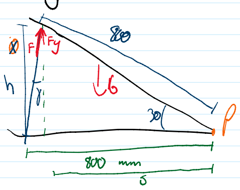
$S_y = \frac{6 \cdot 433}{413,7 \cos 30} = 316,3$

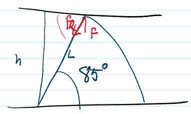


$S = S_y \cdot \cos 30 = 273,9\,N$

Dersom 2G6 ≈ 5,5 kN

Stag 30°





$h = 750 \cdot \sin 30 = 400\,mm$

$L = \frac{400}{\cos(90-85)} = 401,5$

$s = 800 \cdot \cos 30 = 692,8\,mm$

$\gamma = \tan^{-1}\left(\frac{800-L}{h}\right) = 15°$

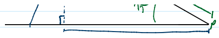
$\Sigma M_P = 0$

$F_y = \frac{6 \cdot 433}{692,8} = 165,5\,N$

$F = \frac{165,5}{\cos\gamma} = 171,3\,N$

$F_R = \frac{F}{\sin 85} = 172\,N$

Dersom 2G6 ≈ 3,4 kN

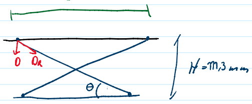


$\gamma = \tan^{-1}\left(\frac{430-L}{H}\right) = 7,5°$

$H = 430 \cdot \sin 15 = 111,3$

$\Sigma M_P = 0$

$2D_y \cdot 415,3 = 27 \cdot 9,81 \cdot 433 \Rightarrow D = \frac{27 \cdot 9,81 \cdot 433}{2 \cdot 415,3} \cos\theta = 138\,N$

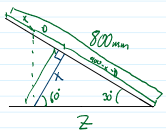


$\theta = \tan^{-1} \frac{111,3}{400} = 15,5°$

$D_R = \frac{D}{\sin\theta} = 514,8\,N$

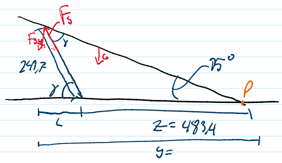
Dersom 2G6 ≈ 10,3 kN

Solseng 15°



$180 - 30 - 90 = 60°$

$Z = \frac{x}{\sin 30} = 483,4$



$\frac{\sin\gamma}{483,4\,mm} = \frac{\sin 15}{241,7\,mm} \Rightarrow \gamma = \sin^{-1}\left(\frac{483,4\,mm \cdot \sin 15}{241,7}\right) = 31,17°$

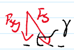
$L = 241,7 \cdot \cos 31,17 = 206,8\,mm$

$y = z + L = 690,2\,mm$

$\Sigma M_P = 0$

$F_{sy} \cdot 690,2 - 6 \cdot 440\,mm = 0$

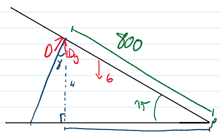
$\Rightarrow F_{sy} = \frac{6 \cdot 443}{690,2} = 166,2\,N$



$F_S = \frac{F_{sy}}{\sin\gamma} = 321,0\,N$

Dersom 2G6 ≈ 6,4 kN ?

Fast stag 15°



$L = 800 \cdot \cos 15 = 772,7\,mm$

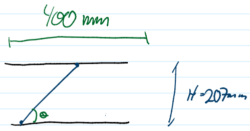
$D = \frac{D_y}{\cos\theta}$

$\gamma = \tan^{-1}\left(\frac{800-772,7}{207,1}\right) = 7,5°$

$H = 800 \cdot \sin 15 = 207,1$

$\Sigma M_P = 0$

$= 27 \cdot 9,81 \cdot 433 \Rightarrow D = \frac{27 \cdot 9,81 \cdot 433}{772,7} \cos\gamma = 147,3\,N$



$\theta = \tan^{-1} \frac{207,1}{400} = 27,4°$

$D_R = \frac{D}{\sin\theta} = 320\,N$

Dersom 2G6 ≈ 6,4 kN

Aluminum 7075-T6; 7075-T651

Categories: Metal; Nonferrous Metal; Aluminum Alloy; 7000 Series Aluminum Alloy

Material Notes: General 7075 characteristics and uses (from Alcoa): Very high strength material used for highly stressed structural parts. The T7351 temper offers improved stress-corrosion cracking resistance.

Applications: Aircraft fittings, gears and shafts, fuse parts, meter shafts and gears, missile parts, regulating valve parts, worm gears, keys, aircraft, aerospace and defense applications; bike frames, all terrain vehicle (ATV) sprockets.

Data points with the AA note have been provided by the Aluminum Association, Inc. and are NOT FOR DESIGN.

Composition Notes:
A Zr + Ti limit of 0.25 percent maximum may be used with this alloy designation for extruded and forged products only, but only when the supplier and the purchaser have mutually agreed.
Composition information provided by the Aluminum Association and is not for design.

Key Words: Aluminium 7075-T6; Aluminium 7075-T651, UNS A97075; ISO AlZn5.5MgCu; Aluminium 7075-T6; Aluminium 7075-T651; AA7075-T6; Al7075-T6

Vendors: **Click here to view all available suppliers for this material.**

Please click here if you are a supplier and would like information on how to add your listing to this material.

Physical Properties	Metric	English	Comments
Density	2.81 g/cc	0.102 lb/in³	AA; Typical

Mechanical Properties	Metric	English	Comments
Hardness, Brinell	150	150	AA; Typical; 500 g load; 10 mm ball
Hardness, Knoop	191	191	Converted from Brinell Hardness Value
Hardness, Rockwell A	53.5	53.5	Converted from Brinell Hardness Value
Hardness, Rockwell B	87	87	Converted from Brinell Hardness Value
Hardness, Vickers	175	175	Converted from Brinell Hardness Value
Tensile Strength, Ultimate	572 MPa	83000 psi	AA; Typical
	41.0 MPa @Temperature 371 °C	5950 psi @Temperature 700 °F	
	55.0 MPa @Temperature 316 °C	7980 psi @Temperature 601 °F	
	76.0 MPa @Temperature 260 °C	11000 psi @Temperature 500 °F	
	110 MPa @Temperature 204 °C	16000 psi @Temperature 399 °F	
	214 MPa @Temperature 149 °C	31000 psi @Temperature 300 °F	

	483 MPa @Temperature 100 °C	70100 psi @Temperature 212 °F	
	572 MPa @Temperature 24.0 °C	83000 psi @Temperature 75.2 °F	
	593 MPa @Temperature -28.0 °C	86000 psi @Temperature -18.4 °F	
	621 MPa @Temperature -80.0 °C	90100 psi @Temperature -112 °F	
	703 MPa @Temperature -196 °C	102000 psi @Temperature -321 °F	
	>= 462 MPa @Thickness 88.93 - 102 mm	>= 67000 psi @Thickness 3.501 - 4.00 in	Plate; T62, T651
	>= 490 MPa @Thickness 76.23 - 88.9 mm	>= 71100 psi @Thickness 3.001 - 3.50 in	Plate; T62, T651
	>= 496 MPa @Thickness 63.53 - 76.2 mm	>= 71900 psi @Thickness 2.501 - 3.00 in	Plate; T62, T651
	>= 510 MPa @Thickness 0.203 - 0.279 mm	>= 74000 psi @Thickness 0.00800 - 0.0110 in	Sheet
	>= 524 MPa @Thickness 0.305 - 0.991 mm	>= 76000 psi @Thickness 0.0120 - 0.0390 in	Sheet
	>= 524 MPa @Thickness 50.83 - 63.5 mm	>= 76000 psi @Thickness 2.001 - 2.50 in	Plate; T62, T651
	>= 531 MPa @Thickness 25.43 - 50.8 mm	>= 77000 psi @Thickness 1.001 - 2.00 in	Plate; T62, T651
	>= 538 MPa @Thickness 1.02 - 3.17 mm	>= 78000 psi @Thickness 0.0400 - 0.125 in	Sheet
	>= 538 MPa @Thickness 3.20 - 6.32 mm	>= 78000 psi @Thickness 0.126 - 0.249 in	Sheet
	>= 538 MPa @Thickness 6.35 - 12.7 mm	>= 78000 psi @Thickness 0.250 - 0.499 in	Plate; T62, T651
	>= 538 MPa @Thickness 12.7 - 25.4 mm	>= 78000 psi @Thickness 0.500 - 1.00 in	Plate; T62, T651
Tensile Strength, Yield	503 MPa	73000 psi	AA; Typical
	>= 372 MPa @Thickness 88.93 - 102 mm	>= 54000 psi @Thickness 3.501 - 4.00 in	Plate; T62, T651
	>= 400 MPa @Thickness 76.23 - 88.9 mm	>= 58000 psi @Thickness 3.001 - 3.50 in	Plate; T62, T651
	>= 421 MPa @Thickness 63.53 - 76.2 mm	>= 61100 psi @Thickness 2.501 - 3.00 in	Plate; T62, T651
	>= 434 MPa @Thickness 0.203 - 0.279 mm	>= 62900 psi @Thickness 0.00800 - 0.0110 in	Sheet
	>= 441 MPa @Thickness 50.83 - 63.5 mm	>= 64000 psi @Thickness 2.001 - 2.50 in	Plate; T62, T651
	>= 462 MPa @Thickness 0.305 - 0.991 mm	>= 67000 psi @Thickness 0.0120 - 0.0390 in	Sheet
	>= 462 MPa @Thickness 6.35 - 12.7 mm	>= 67000 psi @Thickness 0.250 - 0.499 in	Plate; T62, T651

	>= 462 MPa @Thickness 25.43 - 50.8 mm	>= 67000 psi @Thickness 1.001 - 2.00 in	Plate; T62, T651
	>= 469 MPa @Thickness 1.02 - 3.17 mm	>= 68000 psi @Thickness 0.0400 - 0.125 in	Sheet
	>= 469 MPa @Thickness 12.7 - 25.4 mm	>= 68000 psi @Thickness 0.500 - 1.00 in	Plate; T62, T651
	>= 476 MPa @Thickness 3.20 - 6.32 mm	>= 69000 psi @Thickness 0.126 - 0.249 in	Sheet
	32.0 MPa @Strain 0.200 %, Temperature 271 °C	4640 psi @Strain 0.200 %, Temperature 520 °F	
	45.0 MPa @Strain 0.200 %, Temperature 316 °C	6530 psi @Strain 0.200 %, Temperature 601 °F	
	62.0 MPa @Strain 0.200 %, Temperature 260 °C	8990 psi @Strain 0.200 %, Temperature 500 °F	
	87.0 MPa @Strain 0.200 %, Temperature 204 °C	12600 psi @Strain 0.200 %, Temperature 399 °F	
	186 MPa @Strain 0.200 %, Temperature 149 °C	27000 psi @Strain 0.200 %, Temperature 300 °F	
	448 MPa @Strain 0.200 %, Temperature 100 °C	65000 psi @Strain 0.200 %, Temperature 212 °F	
	503 MPa @Strain 0.200 %, Temperature 24.0 °C	73000 psi @Strain 0.200 %, Temperature 75.2 °F	
	517 MPa @Strain 0.200 %, Temperature -28.0 °C	75000 psi @Strain 0.200 %, Temperature -18.4 °F	
	545 MPa @Strain 0.200 %, Temperature -80.0 °C	79000 psi @Strain 0.200 %, Temperature -112 °F	
	634 MPa @Strain 0.200 %, Temperature -196 °C	92000 psi @Strain 0.200 %, Temperature -321 °F	
Elongation at Break	9.0 % @Temperature -196 °C	9.0 % @Temperature -321 °F	
	11 % @Temperature -80.0 °C	11 % @Temperature -112 °F	
	11 % @Temperature -28.0 °C	11 % @Temperature -18.4 °F	
	11 % @Temperature 24.0 °C	11 % @Temperature 75.2 °F	
	14 % @Temperature 100 °C	14 % @Temperature 212 °F	

	30 % @Temperature 149 °C	30 % @Temperature 300 °F	
	55 % @Temperature 204 °C	55 % @Temperature 399 °F	
	65 % @Temperature 260 °C	65 % @Temperature 500 °F	
	70 % @Temperature 316 °C	70 % @Temperature 601 °F	
	70 % @Temperature 371 °C	70 % @Temperature 700 °F	
	>= 3.0 % @Thickness 88.93 - 102 mm	>= 3.0 % @Thickness 3.501 - 4.00 in	Plate; T62, T651
	>= 5.0 % @Thickness 0.203 - 0.279 mm	>= 5.0 % @Thickness 0.00800 - 0.0110 in	Sheet
	>= 5.0 % @Thickness 50.83 - 63.5 mm	>= 5.0 % @Thickness 2.001 - 2.50 in	Plate; T62, T651
	>= 5.0 % @Thickness 63.53 - 76.2 mm	>= 5.0 % @Thickness 2.501 - 3.00 in	Plate; T62, T651
	>= 5.0 % @Thickness 76.23 - 88.9 mm	>= 5.0 % @Thickness 3.001 - 3.50 in	Plate; T62, T651
	>= 6.0 % @Thickness 25.43 - 50.8 mm	>= 6.0 % @Thickness 1.001 - 2.00 in	Plate; T62, T651
	>= 7.0 % @Thickness 0.305 - 0.991 mm	>= 7.0 % @Thickness 0.0120 - 0.0390 in	Sheet
	>= 7.0 % @Thickness 12.7 - 25.4 mm	>= 7.0 % @Thickness 0.500 - 1.00 in	Plate; T62, T651
	>= 8.0 % @Thickness 1.02 - 3.17 mm	>= 8.0 % @Thickness 0.0400 - 0.125 in	Sheet
	>= 8.0 % @Thickness 3.20 - 6.32 mm	>= 8.0 % @Thickness 0.126 - 0.249 in	Sheet
	>= 9.0 % @Thickness 6.35 - 12.7 mm	>= 9.0 % @Thickness 0.250 - 0.499 in	Plate; T62, T651
	11 % @Thickness 1.59 mm	11 % @Thickness 0.0625 in	AA; Typical
	11 % @Diameter 12.7 mm	11 % @Diameter 0.500 in	AA; Typical
Modulus of Elasticity	71.7 GPa	10400 ksi	AA; Typical; Average of tension and compression. Compression modulus is about 2% greater than tensile modulus.
Poissons Ratio	0.33	0.33	
Fatigue Strength	159 MPa @# of Cycles 5.00e+8	23000 psi @# of Cycles 5.00e+8	completely reversed stress; RR Moore machine/specimen
Fracture Toughness	17.6 MPa-m½	16.0 ksi-in½	T651; Plate; S-L; average
	16.5 - 19.8 MPa-m½	15.0 - 18.0 ksi-in½	T651; Plate; S-L
	18.7 MPa-m½	17.0 ksi-in½	T651; Forgings; S-L
	20.0 MPa-m½	18.2 ksi-in½	K(IC) in S-L Direction
	22.0 - 25.3 MPa-m½	20.0 - 23.0 ksi-in½	T651; Plate; T-L

	24.2 MPa-m½	22.0 ksi-in½	T651; Plate; T-L; average
	25.0 MPa-m½	22.8 ksi-in½	K(IC) in T-L Direction
	28.6 MPa-m½	26.0 ksi-in½	T651; Plate; L-T; average
	27.5 - 29.7 MPa-m½	25.0 - 27.0 ksi-in½	T651; Plate; L-T
	29.0 MPa-m½	26.4 ksi-in½	K(IC) in L-T Direction
Machinability	70 %	70 %	0-100 Scale of Aluminum Alloys
Shear Modulus	26.9 GPa	3900 ksi	
Shear Strength	331 MPa	48000 psi	AA; Typical

Electrical Properties	**Metric**	**English**	**Comments**
Electrical Resistivity	0.00000515 ohm-cm @Temperature 20.0 °C	0.00000515 ohm-cm @Temperature 68.0 °F	AA; Typical

Thermal Properties	**Metric**	**English**	**Comments**
CTE, linear	21.6 µm/m-°C @Temperature -50.0 - 20.0 °C	12.0 µin/in-°F @Temperature -58.0 - 68.0 °F	
	23.4 µm/m-°C @Temperature 20.0 - 100 °C	13.0 µin/in-°F @Temperature 68.0 - 212 °F	
	23.6 µm/m-°C @Temperature 20.0 - 100 °C	13.1 µin/in-°F @Temperature 68.0 - 212 °F	AA; Typical; average over range
	24.3 µm/m-°C @Temperature 20.0 - 200 °C	13.5 µin/in-°F @Temperature 68.0 - 392 °F	
	25.2 µm/m-°C @Temperature 20.0 - 300 °C	14.0 µin/in-°F @Temperature 68.0 - 572 °F	
Specific Heat Capacity	0.960 J/g-°C	0.229 BTU/lb-°F	
Thermal Conductivity	130 W/m-K	900 BTU-in/hr-ft²-°F	AA; Typical at 77°F
Melting Point	477 - 635.0 °C	890 - 1175 °F	AA; Typical range based on typical composition for wrought products >= 1/4 in. thickness. Homogenization may raise eutectic melting temperature 20-40°F but usually does not eliminate it.
Solidus	477 °C	890 °F	AA; Typical
Liquidus	635.0 °C	1175 °F	AA; Typical

Processing Properties	**Metric**	**English**	**Comments**
Annealing Temperature	413 °C	775 °F	
Solution Temperature	466 - 482 °C	870 - 900 °F	
Aging Temperature	121 °C	250 °F	

Component Elements Properties	**Metric**	**English**	**Comments**
Aluminum, Al	87.1 - 91.4 %	87.1 - 91.4 %	As remainder
Chromium, Cr	0.18 - 0.28 %	0.18 - 0.28 %	
Copper, Cu	1.2 - 2.0 %	1.2 - 2.0 %	
Iron, Fe	<= 0.50 %	<= 0.50 %	

Magnesium, Mg	2.1 - 2.9 %	2.1 - 2.9 %
Manganese, Mn	<= 0.30 %	<= 0.30 %
Other, each	<= 0.05 %	<= 0.05 %
Other, total	<= 0.15 %	<= 0.15 %
Silicon, Si	<= 0.40 %	<= 0.40 %
Titanium, Ti	<= 0.20 %	<= 0.20 %
Zinc, Zn	5.1 - 6.1 %	5.1 - 6.1 %

References for this datasheet.

HexPly® 1458
160-180°C curing epoxy matrix

HEXCEL®

Product Data Sheet

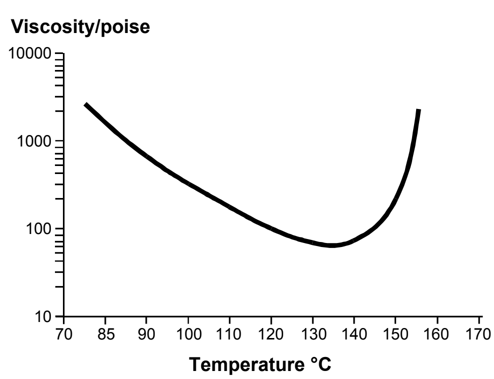
Description
HexPly 1458 is a self-extinguishing and self-adhesive modified epoxy resin system for monolithic and sandwich structures. HexPly 1458 has excellent temperature and moisture resistance. It has a versatile cure cycle at 160°C to 180°C and it has an excellent shelf life at room temperature.

HexPly 1458 prepregs are only available in fabric form.

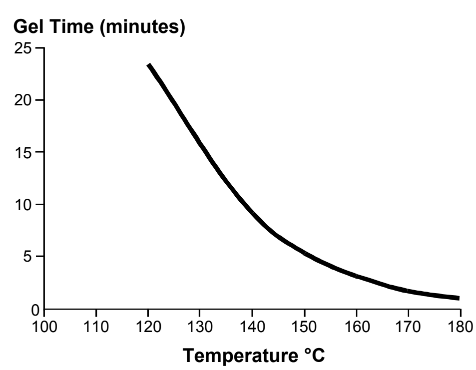
Benefits and Features
- Self extinguishing.
- Self adhesive on honeycomb and foam.
- Controlled flow matrix.
- Excellent tack life.
- Suitable for a range of pressure (0.8 to 5 bar).
- Versatile cure regime 160 - 180°C.

Resin Matrix Properties

Rheology



Gel Time



Cured Matrix Properties (cured at 175°C)

		Method
Fire behaviour	Pass	FAR 25853 apd F part 1
Glass Transition Temperature (°C)	145-155	DMA
Cured resin density	1.26 g/cm^3	

Prepreg Curing Conditions

HexPly 1458 can be cured using two alternative cycles, at a pressure between 0.8 and 5 bar.

Heat up rate 1°C to 3°C.

Temperature °C	*Time*
160	3 hours
180	2 hours

Prepreg Storage Life

- Out Life @ 23°C ± 2°C 60 days
- Guaranteed Shelf Life @ -18°C 12 months (maximum from date of manufacture)

Precautions for Use

The usual precautions when handling uncured synthetic resins and fine fibrous materials should be observed, and a Safety Data Sheet is available for this product. The use of clean disposable inert gloves provides protection for the operator and avoids contamination of material and components.

For more information

Hexcel is a leading worldwide supplier of composite materials to aerospace and industrial markets. Our comprehensive range includes:

- HexTow® carbon fibers
- HexForce® reinforcements
- HiMax® multiaxial reinforcements
- HexPly® prepregs
- HexMC®-i molding compounds
- HexFlow® RTM resins
- HexBond™ adhesives
- HexTool® tooling materials
- HexWeb® honeycombs
- Acousti-Cap® sound attenuating honeycomb
- Engineered core
- Engineered products
- Polyspeed® laminates & pultruded profiles
- HexAM® additive manufacturing

For US quotes, orders and product information call toll-free 1-800-688-7734. For other worldwide sales office telephone numbers and a full address list, please go to:

https://www.hexcel.com/contact

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