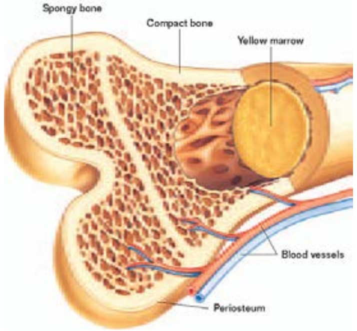
AGENDA:

- What is composite
- Composite Structure types
- Comparing Density and tensile strength
- Fiber types, Carbon, Glass, Aramid. And other fibers.
- Dry fibers, prepreg types and adhesive films.
- Cobber and aluminum mesh.
- Matrix material: Thermoset and thermo plastic. (and deferent types of resins) (Plastic Law)
- Matrix handling and calculation.
- Filler materials
- Core material types.
- Composite and robotic.

WHAT ARE COMPOSITE

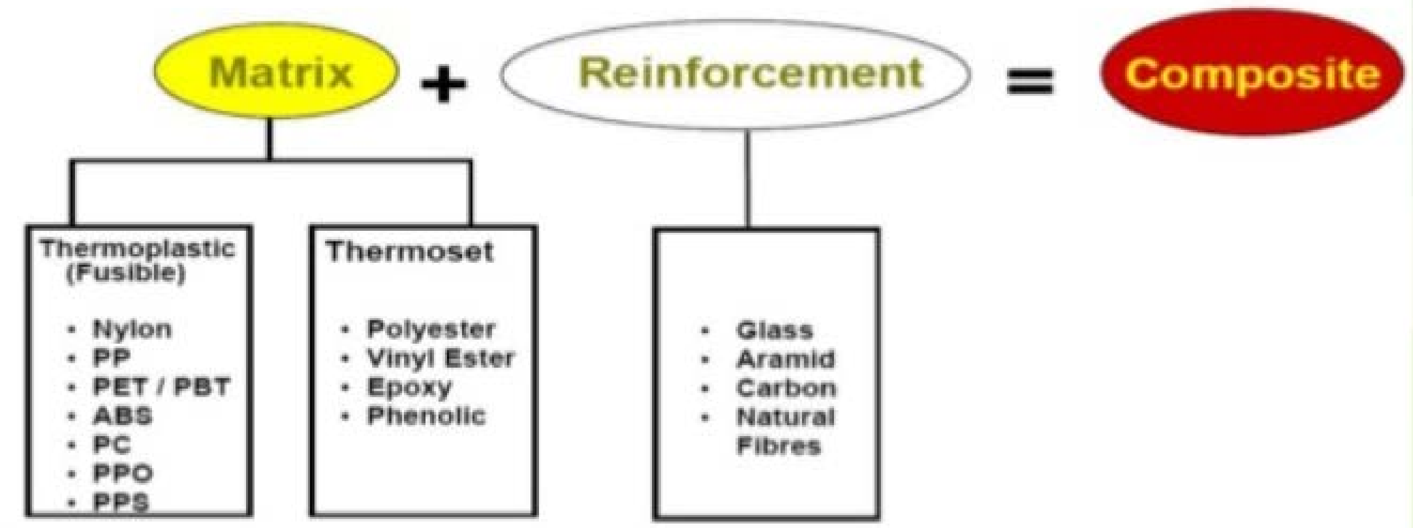
Composite are materials produced by combining two or more other materials

Natural:



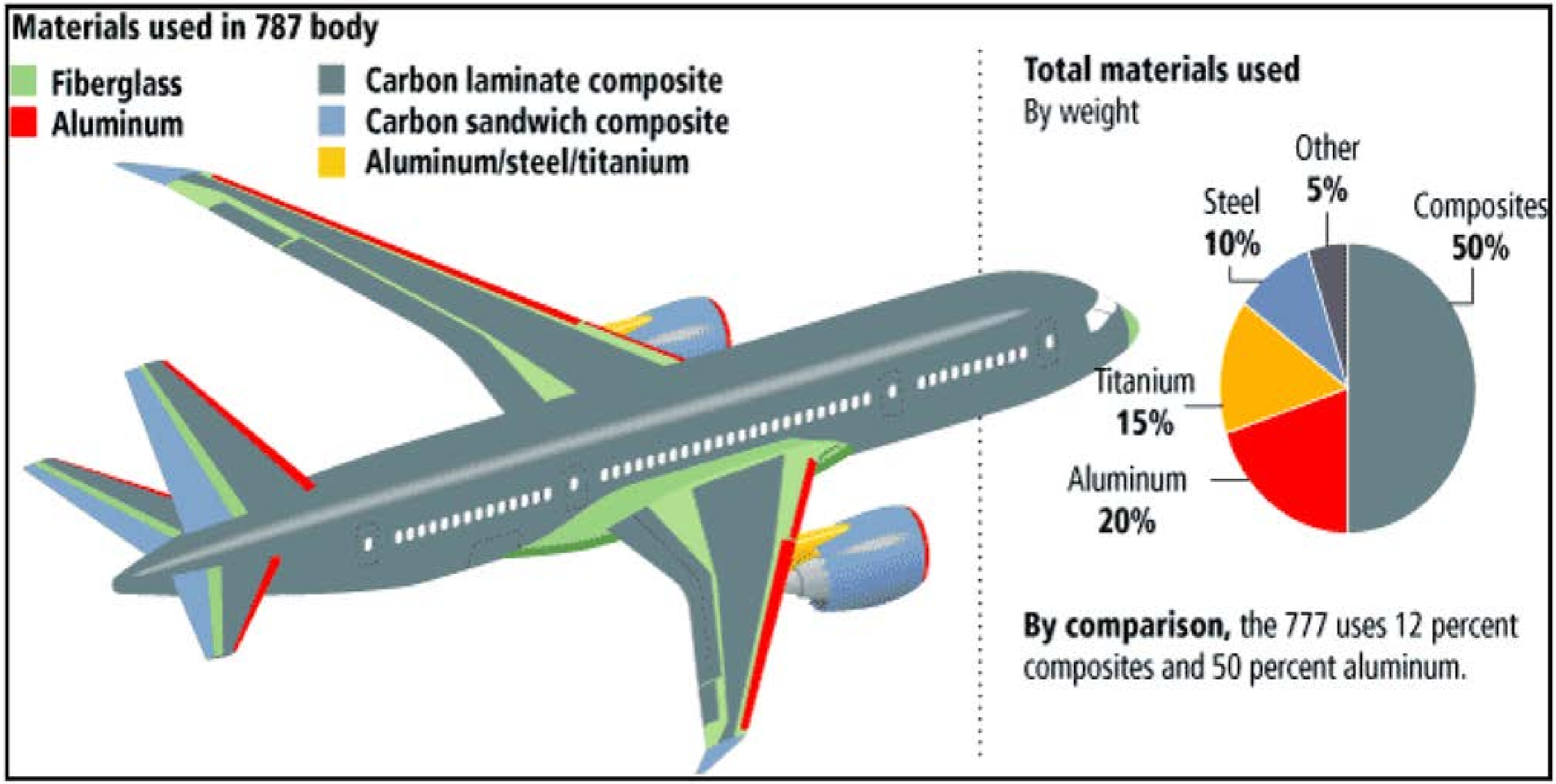
Man-made Composite:

WHAT ARE COMPOSITE

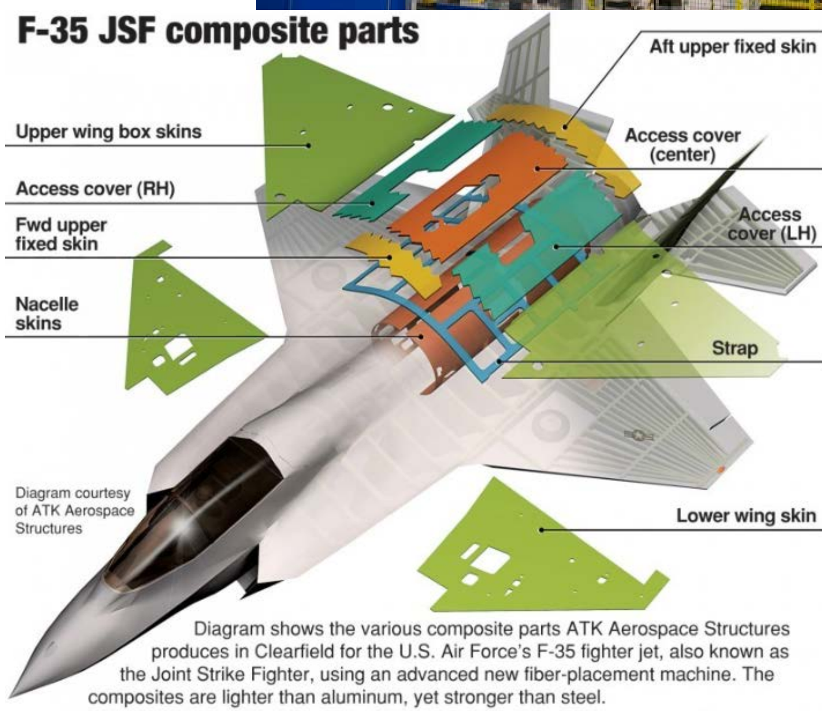


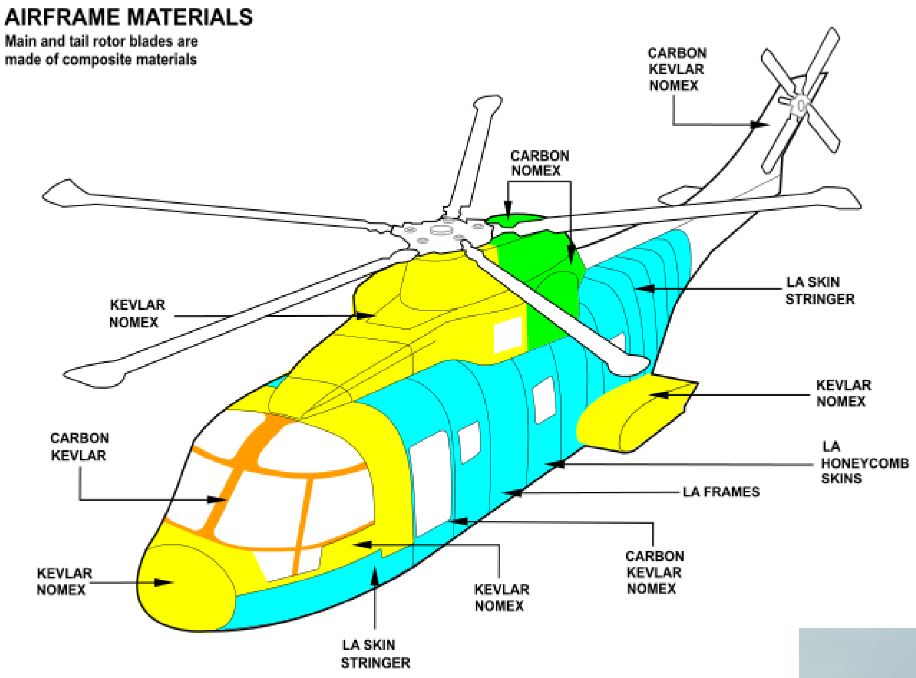

Alu alloy
CFRP Monolithic
CFRP Sandwich
Quartz, Glass
Misc.
8%
Al/Al-Li
19%
6%
Steel
53%
Composite
14%
Titanium
A350 XWB
AIRBUS
AN EADS COMPANY


S18
S22
S23
S24
S25
S26

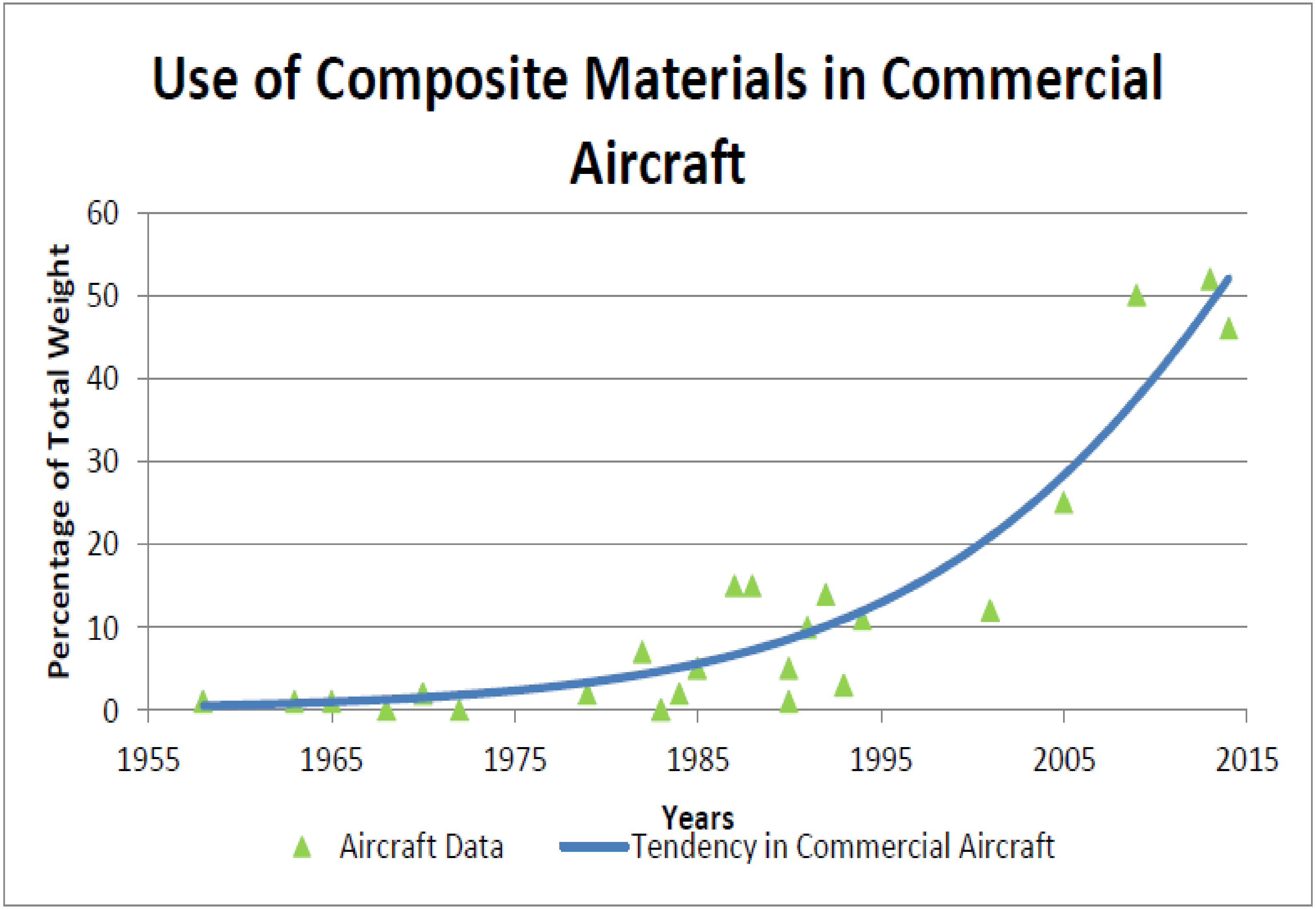

Materials used in 787 body
Fiberglass
Aluminum
Carbon laminate composite
Carbon sandwich composite
Aluminum/steel/titanium
Total materials used
By weight
Other 5%
Steel 10%
Composites 50%
Titanium 15%
Aluminum 20%
By comparison, the 777 uses 12 percent composites and 50 percent aluminum.

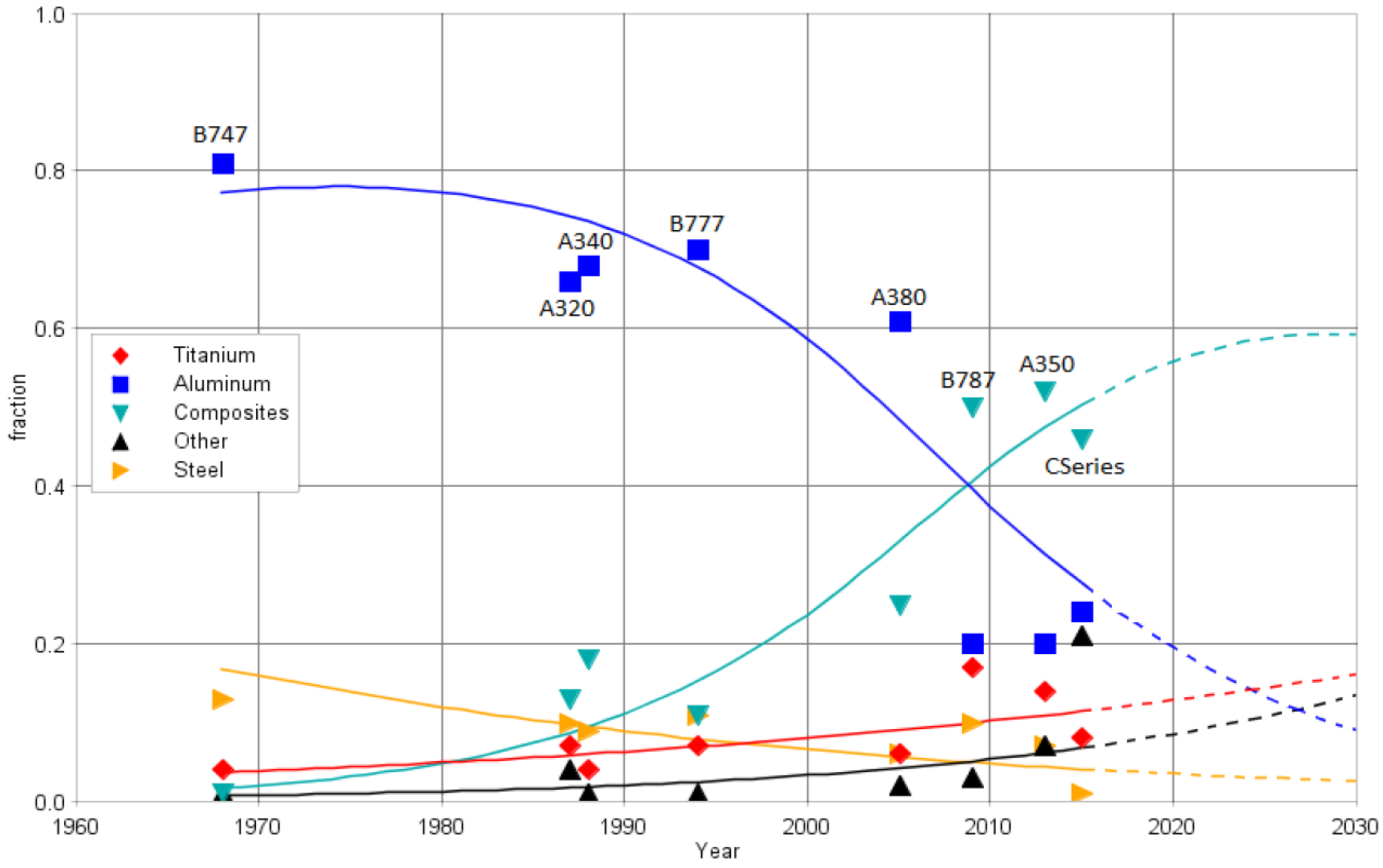
F35
Joint Strike Fighter





EH 101 MERLIN


Use of Composite Materials in Commercial Aircraft
Percentage of Total Weight
60
50
40
30
20
10
0
1955
1965
1975
1985
1995
2005
2015
Years
Aircraft Data
Tendency in Commercial Aircraft



Tendency of the mix of materials used in aircraft construction.

Galvanic Corrosion

GALVANIC SERIES IN SEA WATER
CORRODED END (Anodic)

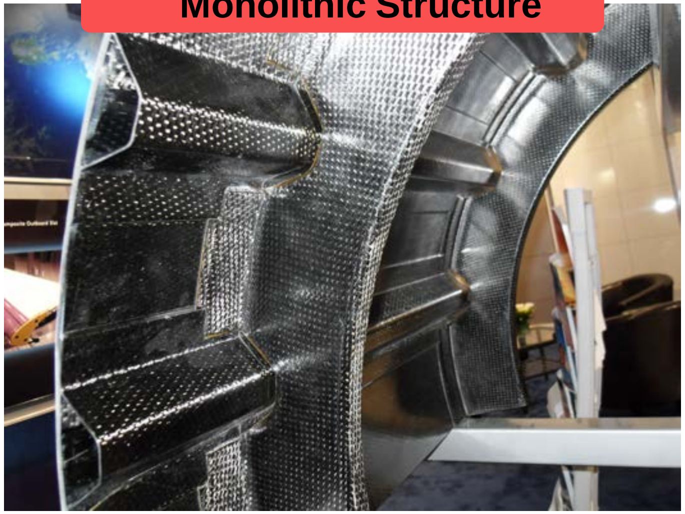
Magnesium
Zinc
7075 Clad Aluminum Alloy
5056 Aluminum Alloy
Pure Aluminium
2024 Clad Aluminum Alloy
Cadmium
2024 Aluminum Alloy
Mild Steel
Cast Iron
Chromium Steel > 11% Cr
Stainless Steels 18/8 (Active)
Stainless Steels Mo 18/8 (Active)
Lead-Tin Solders
Lead
Tin
Nickel (Active)
Inconel (Active)
Hastelloy B
Brass
Copper
Bronce
Monel
Silver Solder
Nickel (Passive)
Inconel (Passive)
Chromium Steel (Passive)
18-8 Stainless Steel (Passive)
18-8 Mo Stainless Steel (Passive)
Hastelloy
Silver
Titanuim
Graphite
Gold
Platinum

PROTECTED END (Cathodic)

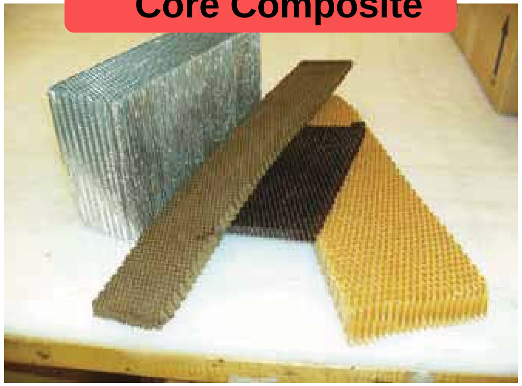
- Composite materials consist of a combination of materials that are mixed together to achieve specific structural properties.
    - Glass GFRP, Carbon CFRP and Aramid AFRP.
    - Matrix, Thermosetting and Thermoplastics.
    - Core materiel.

Sandwich Structure

Monolithic Structure



Core Composite



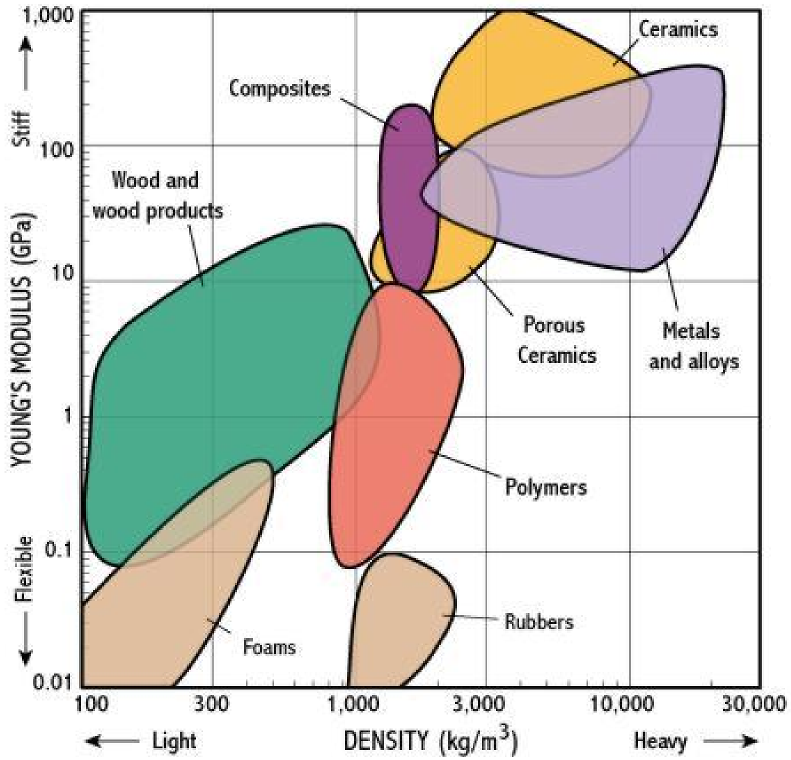
Matrix, Thermo Setting

- **Advantages of Composites:**
  - Do not corrode
  - Smooth surfaces relatively easy to achieve
  - Many manufacturing methods available:
    - Hand layup, Vacuum bagging, Resin Transfer Molding (RTM), Pultrusion, Filament winding, Resin infusion
  - High strength/stiffness-to-weight ratios possible
    - 4-10 times that of metals
  - Structures can be “tailored” to meet specific applications
    - Orienting fibers to carry specific loads

DENSITY / VÆGT FYLDE

Matrix vægt %	Massefylde		
40	Fibre	Matrix	I alt
Type	g/cm3	g/cm3	g/cm3
E glas/epoxy	2,5	1,1	1,66
S glas/epoxy	2,5	1,1	1,66
HS kul/epoxy	1,8	1,1	1,43
IM kul/epoxy	1,8	1,1	1,43
HM aramid/epoxy	1,45	1,1	1,29

Materiale	Betegnelse	Smeltepunkt	Vægtfylde
Aluminium	Al	658 °C	2,7 g/cm³
Antimon	Sb	630°C	6,7 g/cm³
Beryllium	Be	1280°C	1,8 g/cm³
Bly	Pb	327 °C	11,3 g/cm³
Bronze	G Bz 20	900 °C	8,8 g/cm³
Cadmium	Cd	1800 °C	7,1 g/cm³
Guld	Au	1064 °C	19,3 g/cm³
Iridium	Ir	2350 °C	22,4 g/cm³
Jern	Fe	1520 °C	7,86 g/cm³
Kadmium	Cd	321 °C	8,6 g/cm³
Kobber	Cu	1084 °C	8,9 g/cm³



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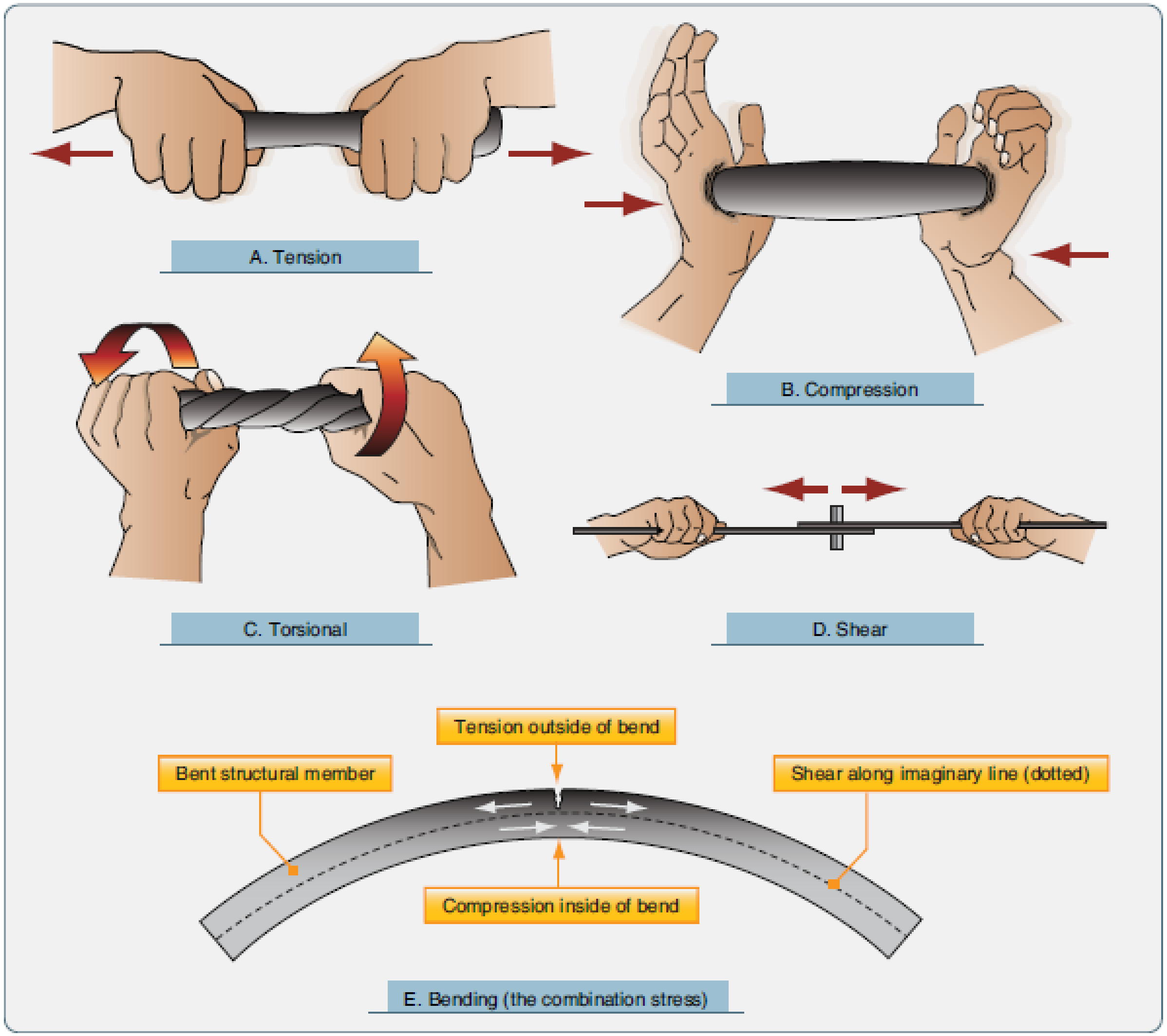
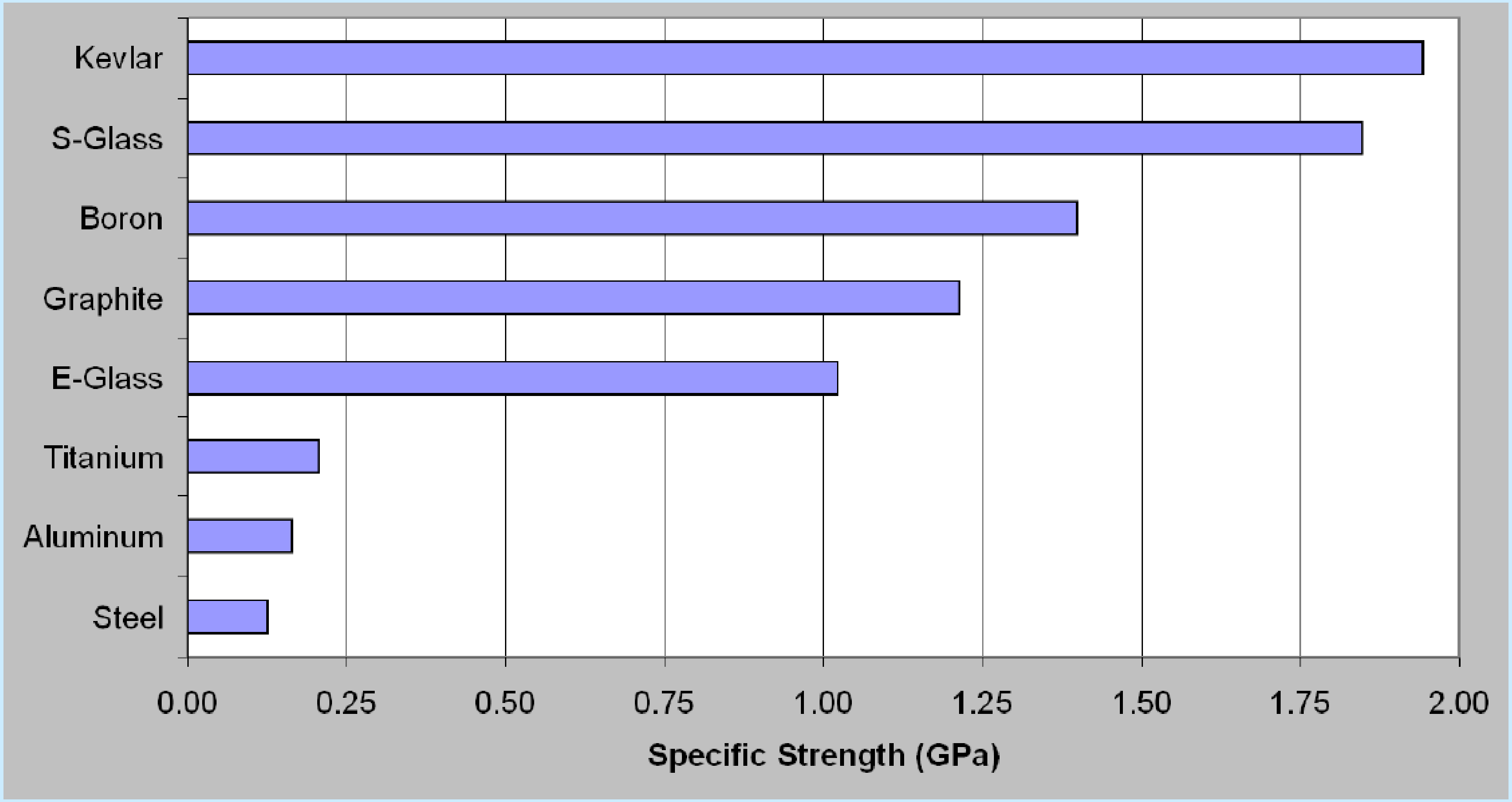
Tensile Strength Compared to Density

Material	Tensile strength (MPa)	Density (g/cm³)	Specific strength (kN·m/kg or KYuri)	Breaking length (km)	Source
1 µm iron whiskers	14000	7.87	1800	183	[14]
Aluminium alloy (6061-T6)	310	2.70	115	11.70	[8]
Aluminium alloy (7075-T6)	572	2.81	204	20.8	[12]
Bainite	2500	7.87	321	32.4	[14]
Balsa	73	0.14	521	53.2	[15]
Basalt fiber	4840	2.70	1790	183	[18]
Brass	580	8.55	67.8	6.91	[4]
Carbon fiber (AS4)	4300	1.75	2457	250	[13]
Carbon nanotube (see note below)	62000	.037-1.34	46268-N/A	4716-N/A	[22][23]
Carbon-epoxy composite	1240	1.58	785	80.0	[16]

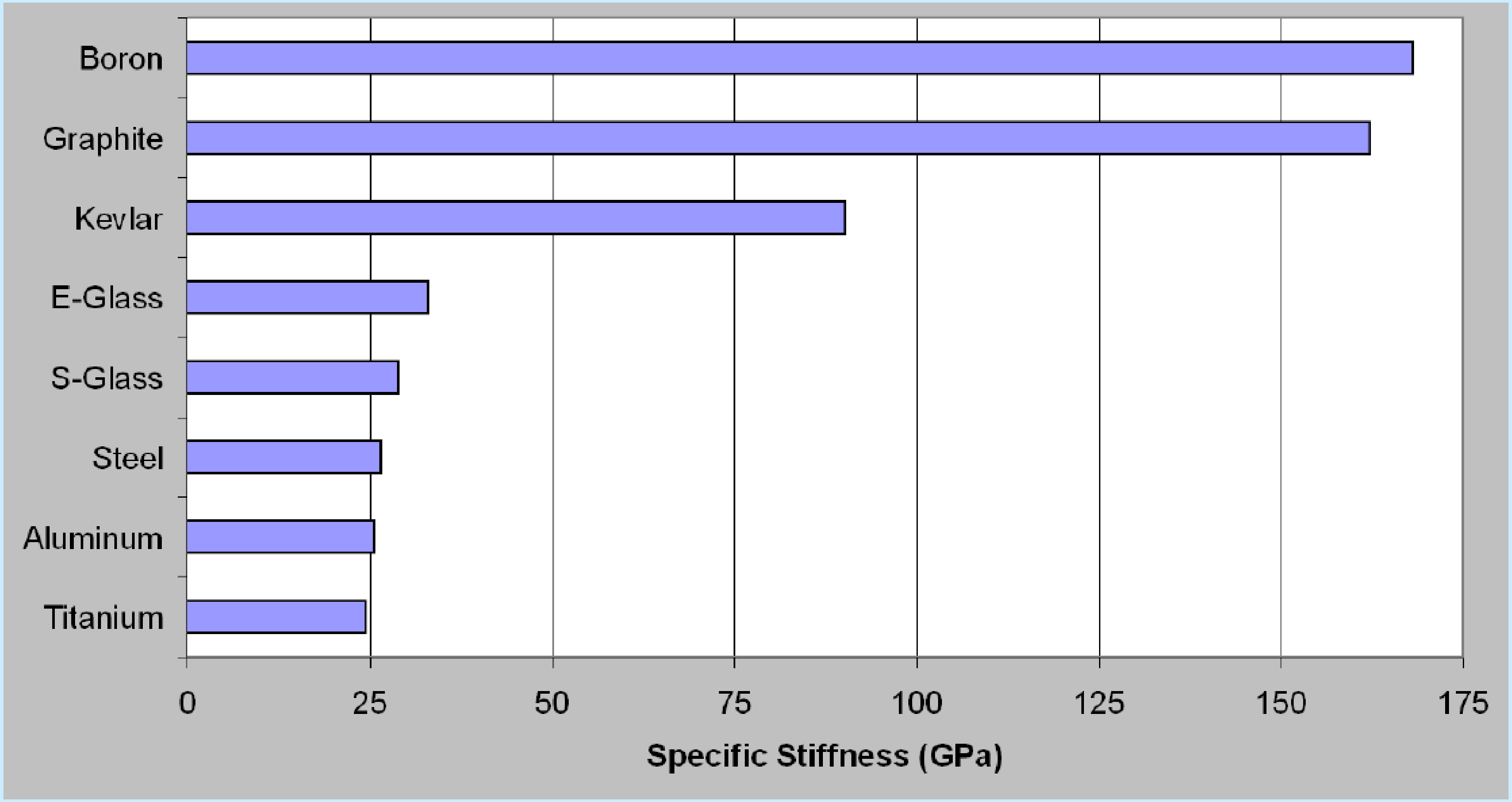
THE FIVE STRESSES THAT MAY ACT ON AN AIRCRAFT AND ITS PARTS.



- # Specific Strength:

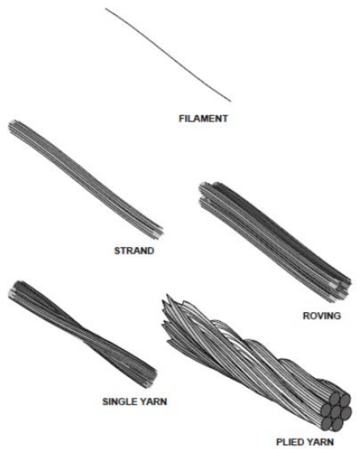


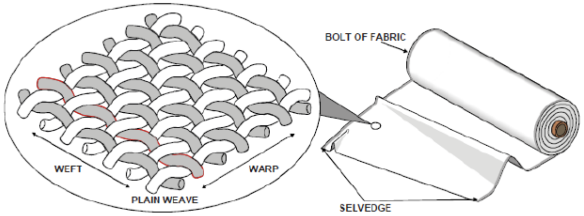
- **Specific Stiffness:**



GLASS FIBRE.

- **Glass Fibers GFRP:**
  - **First used in 1940 for radome structure which was transparent to Microwaves.**
  - **Used as secondary structure.**
    - **Medium resistance against tension and compression.**
    - **Medium impact resistance.**
    - **Good elasticity.**
  - **E-Glass, most common used.**
    - **"E" because of initial Electrical application.**
    - **Not resistant against Acids.**
    - **Alumino-borosilicate Glass, with less than 1 % alkali oxides.**
  - **S-Glass used for aerospace high performance application only, temp. stable up to 700°C.**





Types and qualities of glass

Fiberglass reinforcements are classified according to their properties. There are six major types of glass used to make fibers.

1. E-glass is the most common type used for fiberglass production today (more than 50% of the fibers made are from E-glass.) 'E' implies that it is an electrical insulator. It is inexpensive and appropriate for general purposes.

2. S-glass, S2-glass, ('S' comes from Strength,) is (15%-25%) stronger than E-glass, has higher modulus, improved mechanical properties, higher melt temperature and is considerably more expensive.

3. C-glass or T-glass is very resistant to chemicals and corrosion.

4. A-glass is a high-alkali glass. It offers good chemical resistance, but has lower electrical properties.

5. D-glass has a low dielectric constant and is used in circuit boards.

6. AR-glass is resistant to alkali environment.

Main advantages

Fiberglass' main properties are:

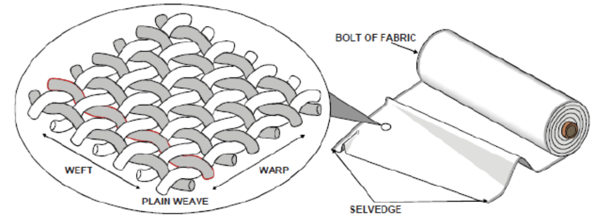
- Dimensional stability
- Moisture resistance
- High strength
- Fire and heat resistance
- Chemical resistance
- Electrical insulation
- Freedom of design
- Good acoustic and vibration insulation
- Good fatigue resistance
- Very good resin adhesion

Fiberglass applications

Fiberglass is widely used in applications such as:

- Automotive: Body parts for trucks and buses, roofs, air fairings, side fairings, doors.
- Aerospace: Interior panels, wall, separators, toilet compartments and furniture.
- Marine: Boat hulls, decks, internal and external components.
- Windmill blades.
- Military – defense: Protective equipment e.g. armor, helmets, clothing, vehicles, radomes.
- Construction: Structural reinforcement, roofing laminate, canopies, swimming pools and spas, hot tubs.
- Electrical and telecommunications industry: printed circuit board, insulation components.
- Sports: Surfboards, kayaks, beach rackets, bicycles, masts.
- Tubes, pipes and other profiles.
- Machinery and equipment enclosures.
- Storage tanks.

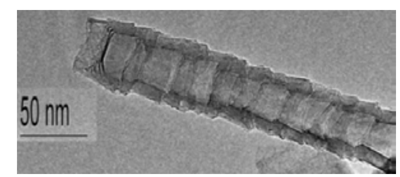
- **Carbon Fibres CFRP:**



  - **Developed in 1960 and first used on A/C in 1980.**
  - **3 to 10 times stronger then Glass Fiber.**
  - **Used for Floor beams, Stabilizer, Flight controls, primary Fuselage and Wing Structure.**

  - **Temperature coefficient negative and Low thermal expansion.**
  - **High - stiffness, tensile strength, low weight, high chemical resistance, high temperature tolerance and High Modulus.**

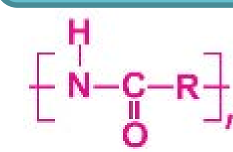
  - **Boren used as coating, extend the strength twice.**



  - **Poor impact resistance.**
  - **Lower conductivity the Aluminum, therefor Wire mesh are added as coating to protect against Lightning strike.**
  - **High Cost.**

  - **High potential for causing galvanic corrosion with metallic fastener.**

Polyamide coated



Main Carbon Advantages

Over other materials, carbon fiber offers many advantages. The main advantageous characteristics are:

- High strength
- Light in weight
- Corrosion resistance
- Excellent creep resistance
- Good thermal and electrical conductivity
- Compatible with most resin systems
- Very high dimensional stability
- Low thermal expansion coefficient
- X-ray permeability

Carbon applications

- Sporting goods: Surf boards, bikes, fishing rods, tennis rackets, hokey sticks, running shoes.
- Automotive – motor racing: Bodywork parts (like doors, hoods etc,) structural components (like chassis,) mechanical (like drive shafts) and protection (like helmets, shock absorbers.)
- Marine: Manufacturing of boats, yachts and ships, structural and non structural parts.
- Defense and aerospace: Aircrafts, vehicles, armor etc.
- Musical instruments: Guitars (and other stringed,) drums, as well as wind instruments.
- Wind industry: Turbine blades.
- Electronic fields: Printed circuit, house electronic equipment, PCs, camera bodies.
- Medical science: Wheel chairs, artificial body parts, x-ray transparent operation tables.
- Construction: Bridge building, building close to sea and harsh weather conditions, old building rehabilitation.
- Environment and energy fields: Fuel batteries, oil industry.

ARAMID FIBRE.

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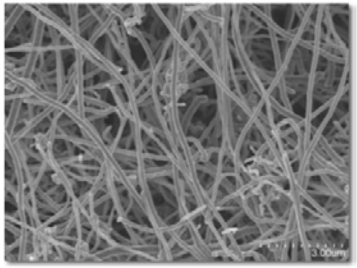
- **Aramid Fibers AFRP:**
  - **Made from Aromatic polyamide. (Nylon) DuPont Kevlar.**
    - **Long chain molecules in regular, parallel lines.**
  - **Two types used in aviation Kevlar 49 has a high stiffness and Kevlar 49 has a Stiffness.**
  - **Used where high possibility for impact.**
  - **Very high impact strength.**
  - **Absorbs moisture/Water easy up to 8 % of own Weight.**
  - **Du not resist flame.**
  - **Du not absorb resin as glass and carbon fibers.**
  - **Easy delamination.**

Aramid applications

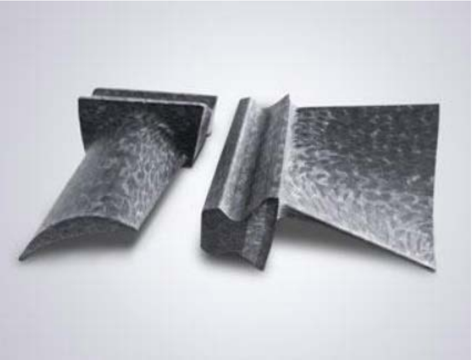
- Various forms of composite materials
- Sail cloth
- Snowboards
- Protective gloves, helmets, body armor
- Filament wound pressure vessels
- Flame and cut resistant clothing
- Asbestos replacement
- Ropes and cables
- Optical fiber cable systems
- Jet engine enclosures
- Tennis strings and hokey sticks
- Wind instrument reeds
- Reinforced tyres and rubber goods
- Circuit board reinforcement

OTHER FIBERS

- **BOREN FIBERS:**
  - **Very Stiff, have a high tensile and Compressive strength.**
  - **Epoxy matrix used together with Boren fibers.**
  - **Used to repair crack on aluminum skin because the thermal expansion are close to Aluminum.**
  - **Very expensive and hazardous to personnel.**
  - **Primarily used in military aviation.**



- **CERAMIC FIBERS:**
  - **For high temperature application up to 2200 °F.**
  - **Turbine blades in gas turbine engine.**

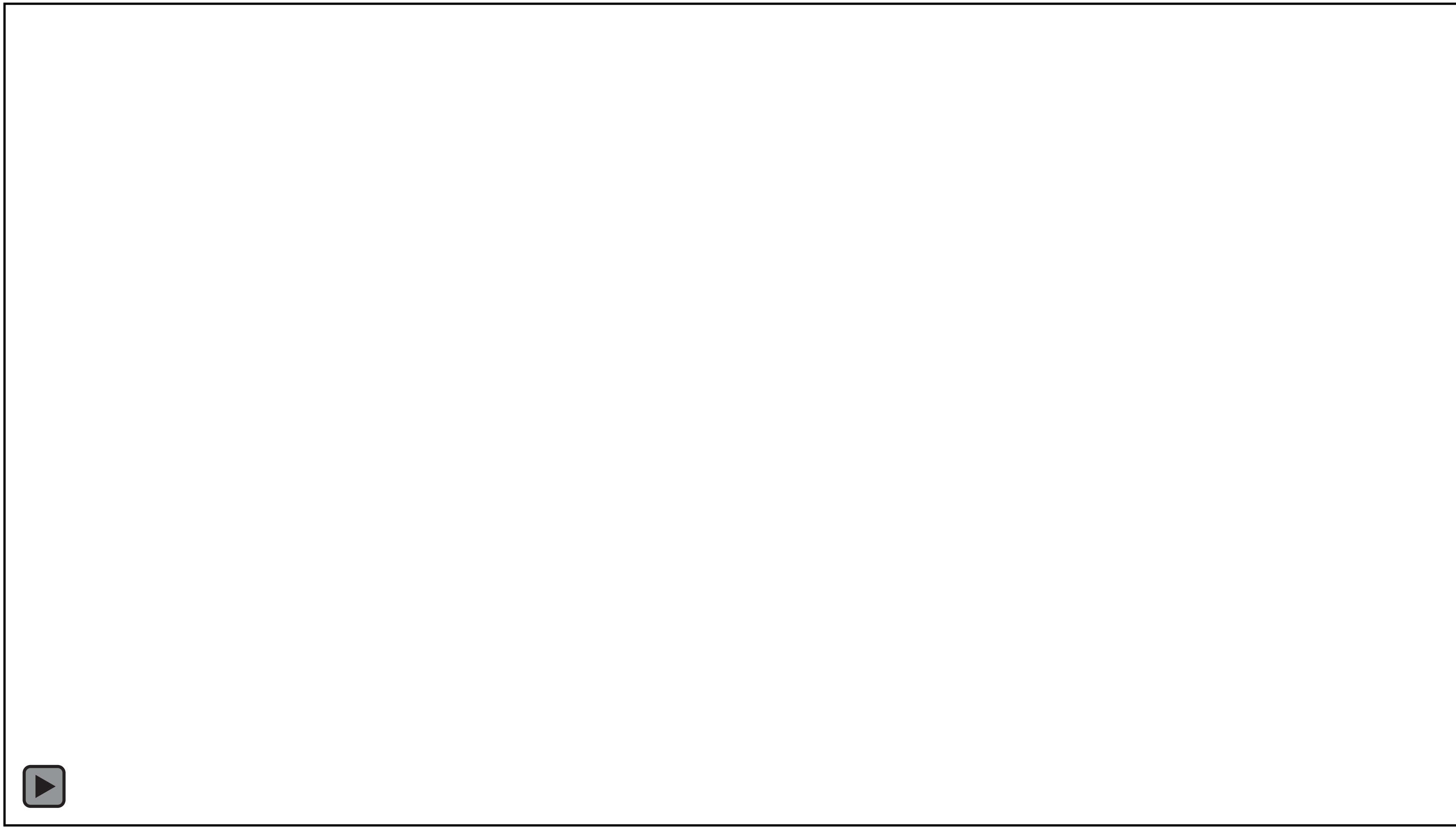


- **LIGHTNING PROTECTION FIBERS:**
  - **Metallic Wire mesh.**

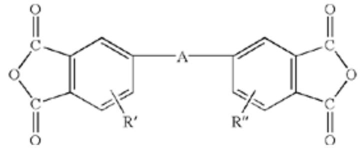
- **Polyester**
  - **For surface finish.**

- **Polyethylene**
  - **vand- og afløbsrør, flasker, baljer, spande og legetøj.**

- **Natural Fibers.**
  - **Plant Fibers.**



MATRIX MATERIALER.



(III)

- Epoxy thermo setting Resins are common used on aircraft industri.
- Epoxy thermo setting Resins are common 2 part mix ratio.
- Properties such as heat resistant, flame proofing in a calculation in design stage.
- Have good Wettability to the fibers or surface to be bonded (substrate) and develop very good adhesion upon cure.
- Should not give off volatiles (volcano) of any cure products during cure, and not sinking during cure.
- Should have a simple cure cycle process.
- Should have ambient cure cycle storage.
- Should be tolerant of imperfect processing –should be robust.

- Should have excellent retention of room temperature properties when exposed to extremes of temperature and humidity.
- Should not have any toxicity hazards in either the uncured form or during decomposition as would occur for example in an aircraft passenger cabin fire

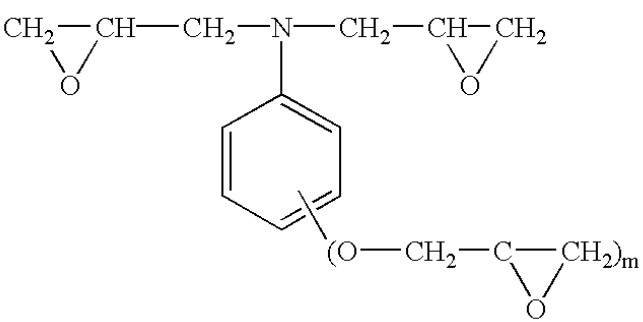
THERMOPLASTICS

- **Thermoplastics not common used as aeronautical composite resins.**

  - **Like metals, soften with heating and eventually melt, hardening again open cooling.**

  - **Material can be shaped by molding or extrusion when it is soft.**

  - **Can be reused as plastic.**



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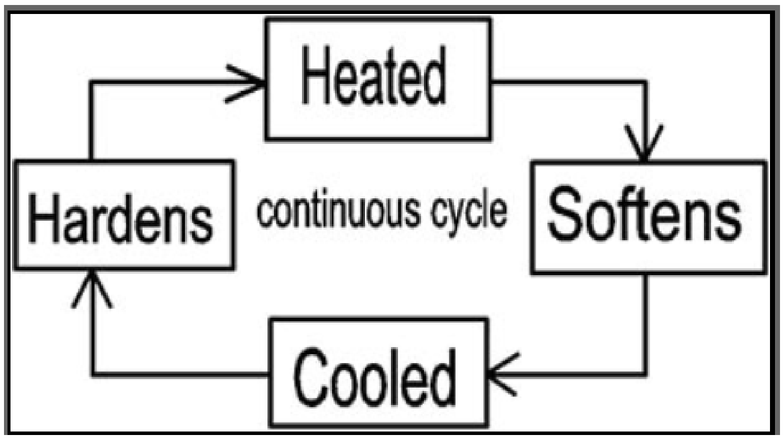
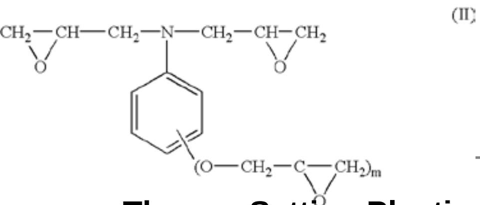
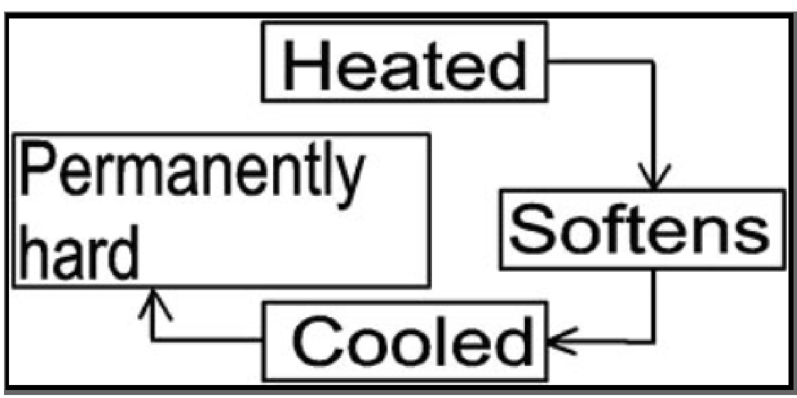
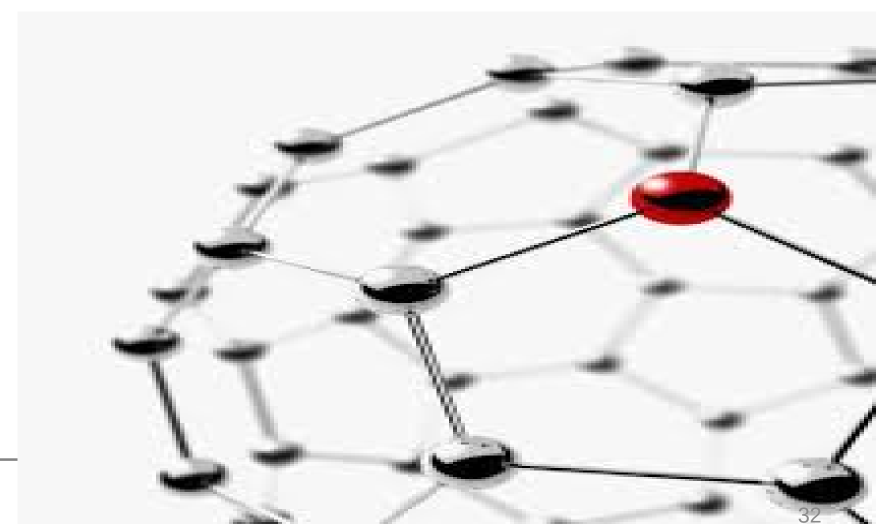




THERMO SETTING PLASTICS

- **Thermo Setting Plastics material (Thermosets):**
  - **Resin and Hardener are mixed and undergo a non-reversible chemical reaction to form hard, infusible crystalline polymer.**
  - **During Cure process most resins produce heat and can lead to runway exothermy and fire if incorrect mix ratio are not meet.**
  - **After Cure process Thermosets will not become liquid again.**
  - **Phenolic Resins:**
    - **Mostly metal to metal bonding, cabin furnishing where low smoke toxic gas is advantageous. (125°C to 150°C)**
  - **Epoxy Resins:**
    - **Most widely used for aerospace adhesive and composite application.**
    - **Room temperature cure process.**
    - **121°C cure process.**
    - **177°C cure process.**





Thermosetting Resins

As previously stated, these harden or cure by a process of chemical cross linking, whereby resins of low -molecular weight and good solubility grow into products of very high molecular weight and limited solubility. The cross linking is an irreversible process. Some examples of thermosetting resins:

Polyurethane	High toughness materials, sometimes hybridised with other resins, due to relatively low laminate mechanical properties in compression. Uses harmful isocyanates as curing agent. Little use in modern aircraft.
Polyester	Two or three part systems. Good environmental resistance. Heat resistant up to150ºC. Used as wet resin and prepreg, it produces toxic fumes (styrenes) during the cure process. Easily fire retarded but produces a lot of smoke when burning. Not as strong as epoxy. Was used extensively for aircraft but use now diminishing. Can be dangerous if mixed incorrectly (risk of explosion).
Epoxy	Very strong, good environmental resistance. Can have high temperature resistance (>200ºC). Used as wet resin, prepreg or adhesive film. Will usually burn readily and produces a lot of smoke when burning.
Phenolics	Fairly brittle system but has a good fire/smoke toxicity performance. Hence extensive use in interior passenger cabin composite components. Good heat resistance (>200ºc).
Cyanate Esters	Primarily used in the military aerospace industry. The material's excellent dielectric properties make it very suitable for use with low dielectric fibres such as quartz for the manufacture of high speed radomes. The material also has temperature stability up to around 200°C wet.
Bismaleimides (BMI)	Primarily used in aircraft composites where operation at higher temperatures (230°C wet/ 250°C dry) is required. e.g. engine inlets, high-speed aircraft flight surfaces.
Polyimides	Used where operation at higher temperatures than bismaleimides can stand is required (use up to 250°C wet/300°C dry). Typical applications include missile and aero-engine components. Extremely expensive resin, which uses toxic raw materials in its manufacture. Polyimides also tend to be hard to process due to their condensation reaction emitting water during cure, and are relatively brittle when cured.

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NOMENCLATURE	MATERIALS	USE	REFERENCE
Pre-cured sheet material or profiles	Cured carbon tape or fabric prepreg	Filler or doubler	Refer to Paragraph 6.B.(10) and Chapter 55-11-00 and Chapter 55-31-00 .
High speed tape	Self adhesive aluminum tape	Temporary protection cover	Bonding and adhesive compound (Material No. 08-052), refer to CML .
Dry fabric	Glass or carbon	Filler or repair plies	Refer to Paragraph 6.B.(8) .
Laminating resin	Epoxy low viscosity system	Impregnation of dry fabric	Refer to Paragraph 6.B.(2) Table 2 .
Adhesive paste	Epoxy system	Bonding or filling low temperature curing <90 °C (194 °F)	Refer to Paragraph 6.B.(1) Table 1 .
Adhesive film	Film	Bonding doublers, prepreg bonding, core bonding	Refer to Paragraph 6.B.(6) Table 6 .
Foaming adhesive	Film paste	Core splicing	Refer to Paragraph 6.B.(5) Table 5 .
Prepreg	Pre-impregnated glass or carbon fabric	Filler or repair plies	Refer to Paragraph 6.B.(9) Table 8 thru 11 .
Potting	Low density compound	Core filling or bonding	Refer to Paragraph 6.B.(4) Table 4 .
Potting	Resin and thickening agents	Smoother	Refer to CML .
Filler	Microballoons	Reduce the density	Material No. 05-057 or 05-067 , refer to CML .
Thickening agent	AEROSIL CABOSIL	Increase the viscosity of liquid resin system	Material No. 05-089 , refer to CML .
Finish coating	Antistatic paint, Top coat Primer	Paint restoration	Refer to Paragraph 6.B.(7) Table 7 and Chapter 51-75-00 .
Honeycomb core	Glass phenolic, Aramid phenolic, Metallic	Sandwich core	Refer to Paragraph 6.B.(11) Table 16 .

LAMINATING EPOXY RESIN

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	P:N:		Mixing ratio	Pot Life	Gel Time	Curing cycle
RESIN TYPE	MANUFACTURER/CODE	MATERIAL NO. (CML NO.)	MIXING RATIO (PARTS BY WEIGHT RESIN : HARDENER)	POT LIFE AT 25 °C (77 °F)	GEL TIME AT 25 °C (77 °F) (HOURS)	CURING CYCLE <5>
1	VANTICO / EPOCAST 52 A/B	08-098	100:41	60 min. for 100 g (3.5 oz)	<1>	2 hours at 93 °C (200 °F) <3>
2	HYSOL / EA9396, PART A AND B	08-070 or 20-022	100:30	75 to 90 min. for 450 g (16 oz)	<1>	2 hours at 80 °C (180 °F) <4>
2	VANTICO / ARALDITE LY5052 + Hardener HY5052 or ARALDITE LY5052 + Hardener ARADUR5052	08-090	100:38	220 to 260 min. for 100 g (3.5 oz)	<1>	2 hours at 80 °C (180 °F) <4>
3	VANTICO / ARALDITE LY560 + HARDENER HY560 or RENLAM LY560 + HARDENER REN HY560 or RENLAM LY560 + HARDENER ARADUR560	08-001C	100:25	Approx. 30 to 40 min. for 500 g (17.6 oz) amount	-	7 days at 25 °C (77 °F) or 14 hours at 65 °C (150 °F) <4>
3	or VANTICO / ARALDITE LY564-1 + Hardener HY560	-	100:27	20 min. for 250 g (8.8 oz)	3	7 days at 20 °C (68 °F) or 15 hours at 50 °C (120 °F) or 4 hours at 80 °C (180 °F) <4>
	SHELL / EPICOTE 816 + Hardener RTU or	08-030 08-030B	-	-	-	-
3	SHELL / EPICOTE 816 + ARALDITE HY943 (VANTICO)	Use materials: 08-070 08-090	-	-	-	-
	HYSOL / EA9390, PART A AND B	08-071	100:56	2 hours for 250 g (8.8 oz)	<1>	4 hours at 93 °C (200 °F) <3>
3	VANTICO / ARALDITE 501	20-018	100:15	80 min. for 100 g (3.5 oz)	<2>	7 days at 25 °C (77 °F) or 16 hours at 45 °C (115 °F) or 2 hours at 70 °C (160 °F) <4>

Laminating Resins

<1> Gelation at RT (Room Temperature) not required. Cure cycle can be applied directly.

<2> Curing cycle can be applied after 60 minutes with full vacuum pressure and before 180 minutes.

<3> 93 °C (199 °F) is the minimum cure temperature, Tolerances: 0/+ 10 °C (18 °F) on curing temperature and 0/+15 minutes on curing time.

<4> Tolerances: ±5 °C (9 °F) on curing temperature and 0/+ 15 minutes on curing time.

<5> Heat up rate 1° C to 3° C (2° F to 6° F) per minute.
Cool down rate maximum 3° C (6° F) per minute.

TECHNICAL EDUCATION COPENHAGEN

TDS - Technical Data Sheet

HENKEL HYSOL EA 9396

Description

Hysol EA 9396 is a low viscosity, room temperature curing adhesive system with excellent strength properties at temperatures from -67°F to 350°F (-55°C to 177°C). Hysol EA 9396 has a shelf life of one year when stored @ 77°F/25°C for separate components. Qualified to MMM-A-132, Rev A, Type 1, Class 3.

Features

Low Viscosity
Room Temperature Cure
Room Temperature Storage
High Strength at Low and High Temperatures

Uncured Adhesive Properties

	Part A	Part B	Mixed
Color	Aqua-Blue	Light Amber Red - Purple (Gardner color 17+)	Green to Dark Purple
Viscosity @ 77°F	400 - 1,400 Poise	0.7 - 1.1 Poise	35 Poise
Brookfield, HBT	Spdl 4 @ 10 rpm	Spdl 1 @ 100 rpm	Spdl 1 @ 20 rpm
Viscosity @ 25°C	80 Pa ·S	0.1 Pa ·S	3.5 Pa ·S
Brookfield, HBT	Spdl 4 @ 2.1 rad/s	Spdl 1 @ 10.5 rad/s	Spdl 1 @ 2.1 rad/s
Density (g/ml)	1.19	1.00	1.14
Shelf life			
@ <40°F/4°C	1 year	1 year	
@ <77°F/25°C	1 year	1 year	

Mix Ratio	Part A	Part B
By Weight	100	30

TECHNICAL EDUCATION COPENHAGEN

Classroom task

Make a calculation:

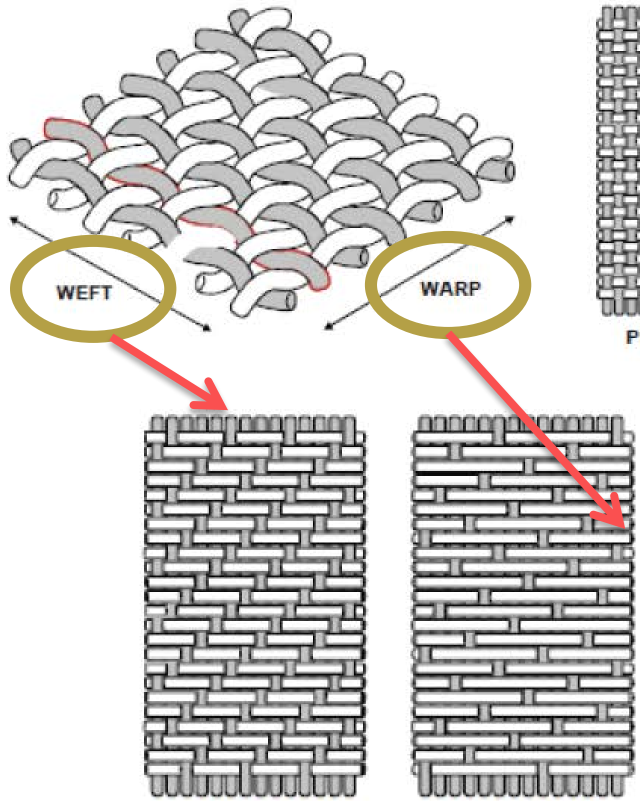
1. 112 g Glass fiber need resin 1.2 times with 2-part Epoxy resin (A/B) mixed by 100/35, how much gram resin and harder you need?

2. 80-gram Epoxy resin needed, calculate the needed harder and resin?

Resin/Harder Mix Ratio by Weight: 100/35
Calculation:
Total weight of Resin/hardener mixture is = Glass fabric gram * 1.2

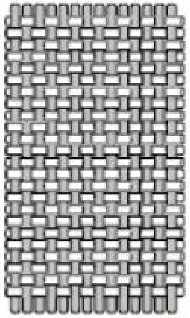
Weight of resin needed = 100/135 * Glass fabric gram * 1.2
Weight of hardener needed = 35/135 * Glass fabric gram * 1.2

FORUD-IMPRÆGNEREDE OG TØR FIBER MATERIALER.

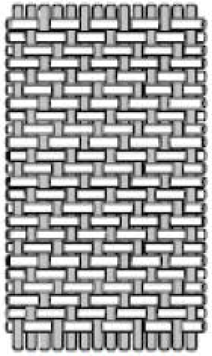


FOUR HARNESS SATIN WEAVE

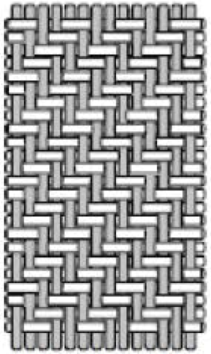
EIGHT HARNESS SATIN WEAVE



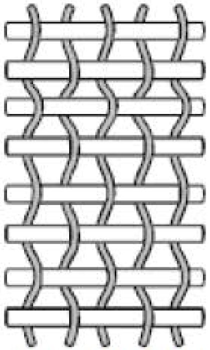
PLAIN WEAVE



TWILL WEAVE



2X2 TWILL WEAVE

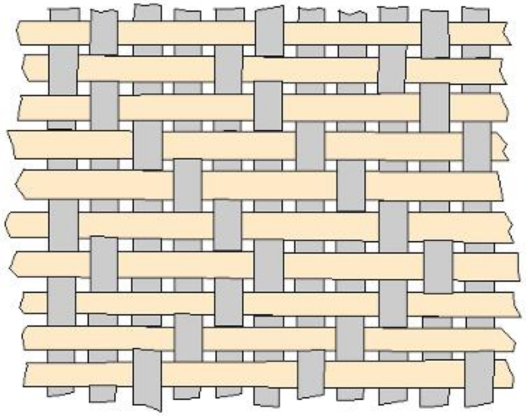


UNIDIRECTIONAL FABRIC

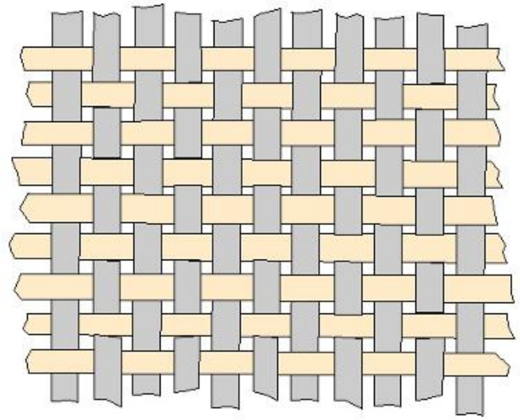
PROPERTY	PLAIN	TWILL	SATIN
Good Stability	****	***	**
Good Drape	**	***	*****
Low Porosity	***	****	*****
Smoothness	**	***	*****
Balance	****	****	**
Symmetrical	*****	***	*
Low Crimp	**	***	*****

***** = EXCELLENT **** = GOOD *** = ACCEPTABLE
** = POOR * = VERY POOR

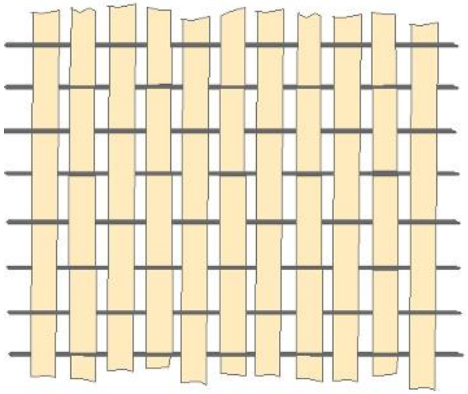
Fish



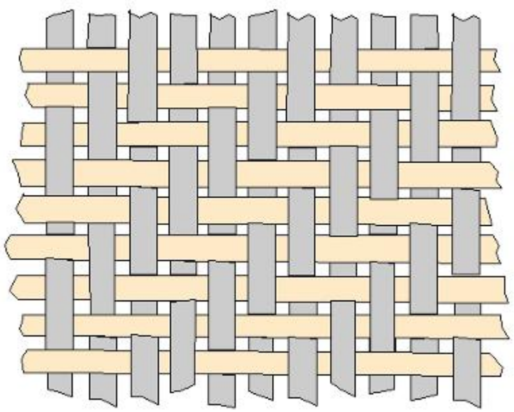
Plain Weave



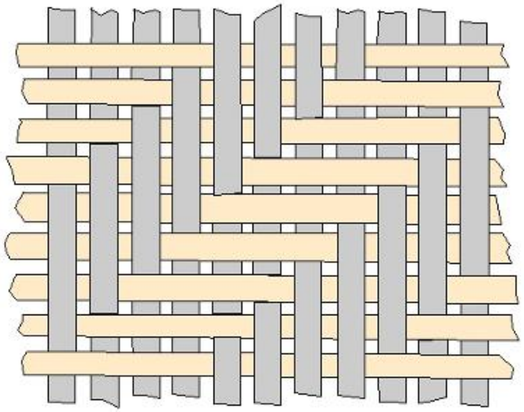
Unidirectional woven



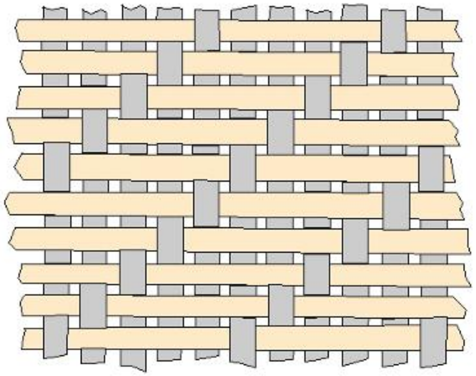
Twill 2 x 2



Twill 4 x 4



4H satin

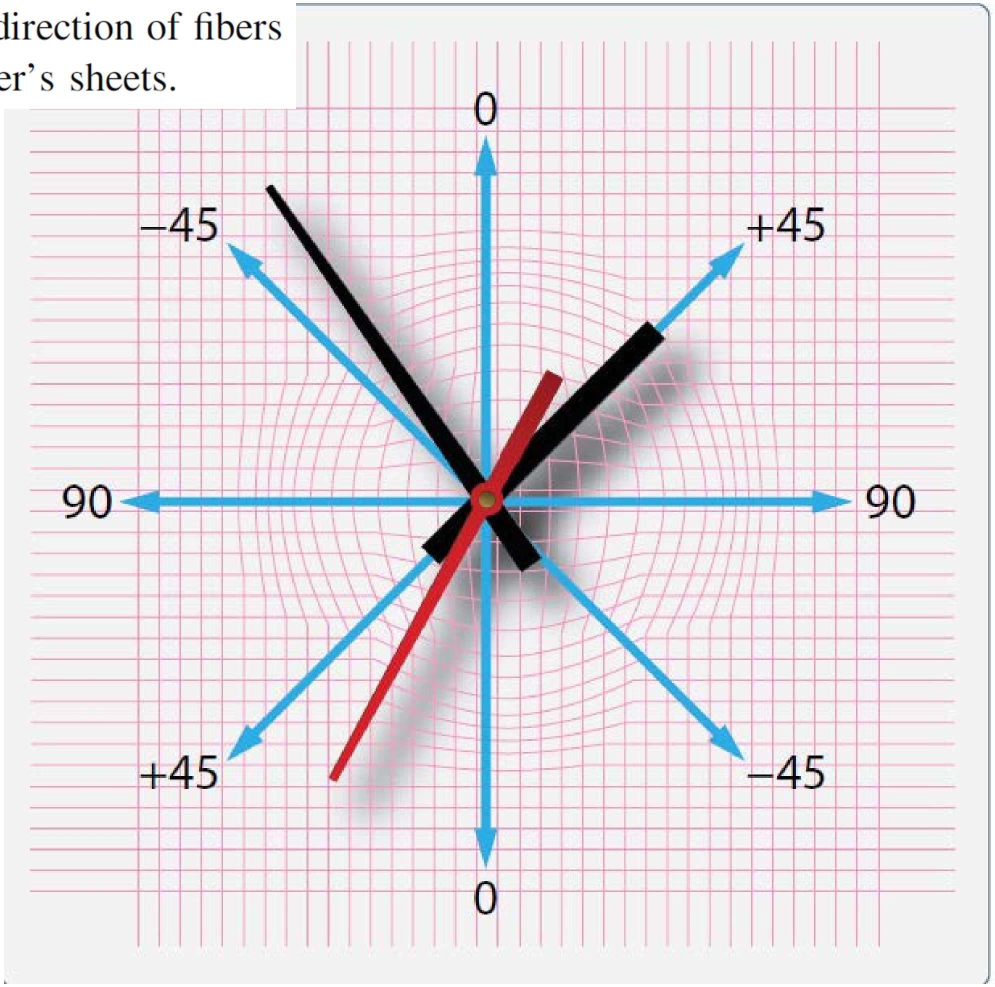


Fiber Orientation

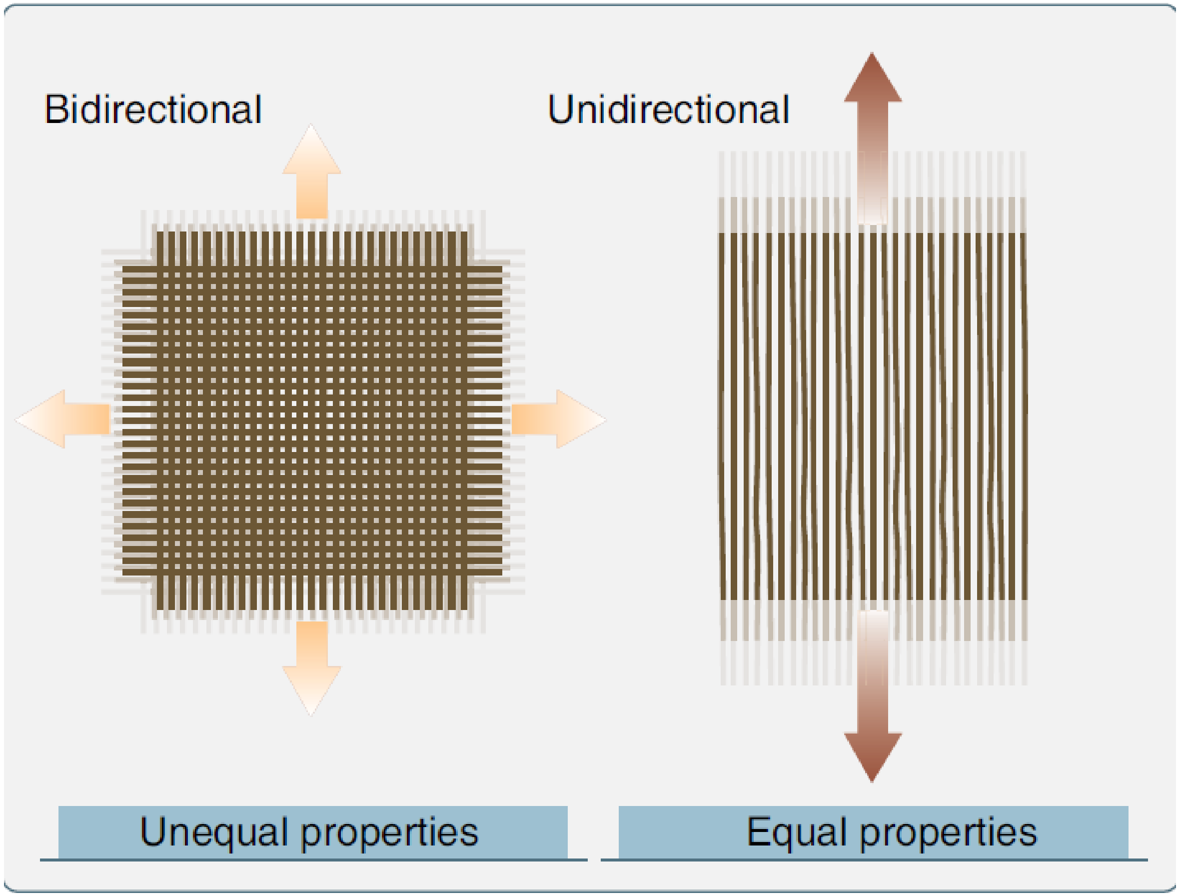
- Advanced Composites are by design
  - Orientation of fibers is proportional to properties
    - The more fibers in a given direction, the stronger and stiffer
      - Unidirectional (0) degrees for tension, compression, or bending
      - Bidirectional (+/- 45's) degrees for shear
      - Control fiber angles +/- 2 degrees
  - Sandwich Construction
    - Enhances performance by placing the load carrying fibers on the outside of the part

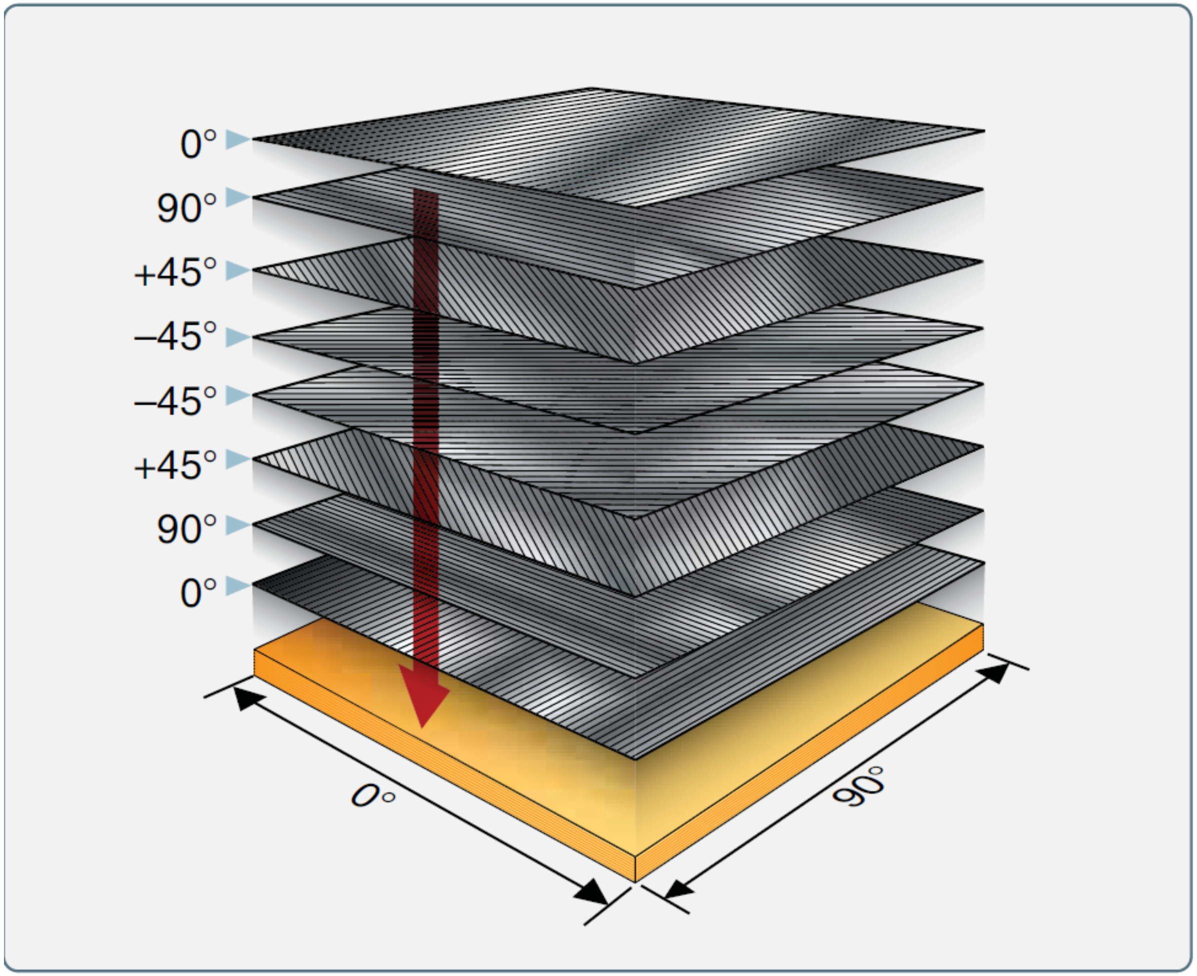
Warp Clock

Warp indicates the longitudinal fibers of a fabric. The warp is the high strength direction due to the straightness of the fibers. A warp clock is used to describe direction of fibers on a diagram, spec sheet, or manufacturer's sheets.



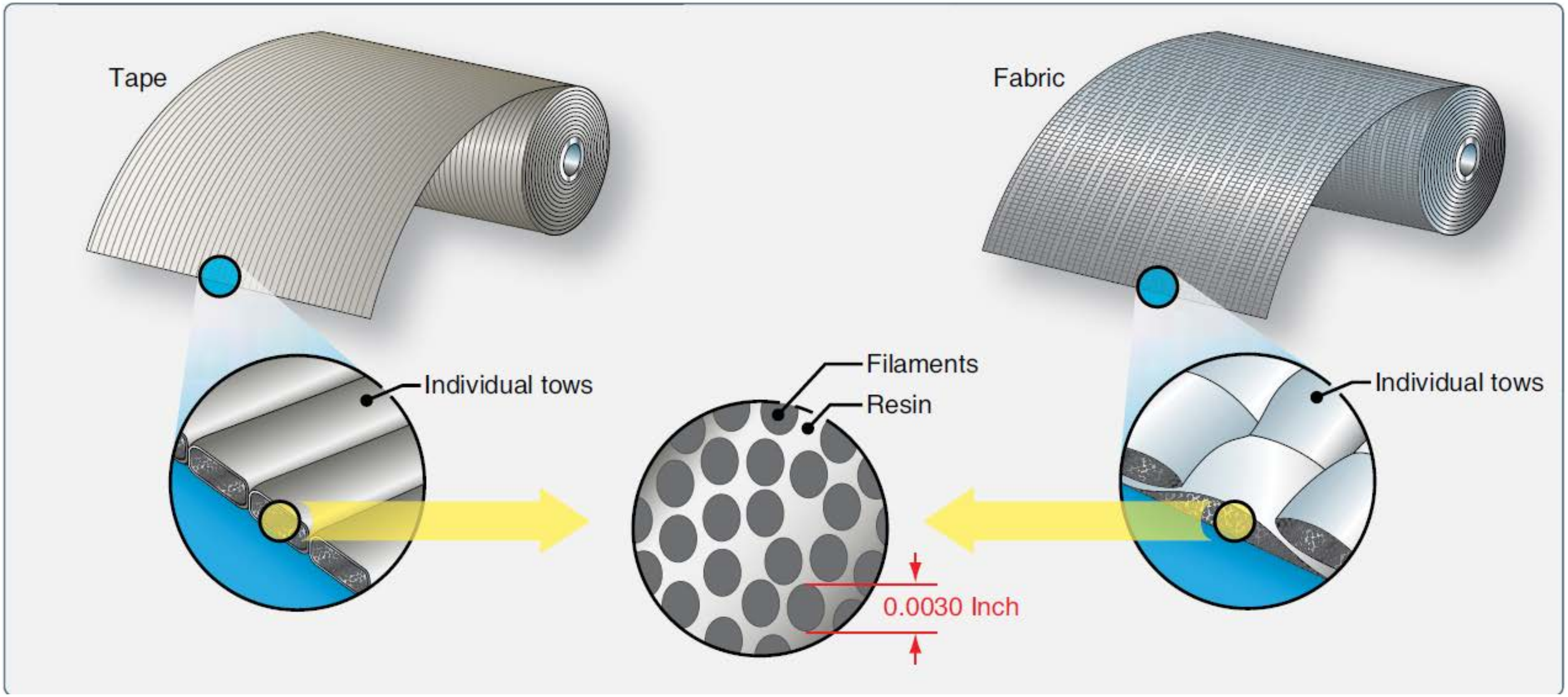
Bidirectional and unidirectional material properties.

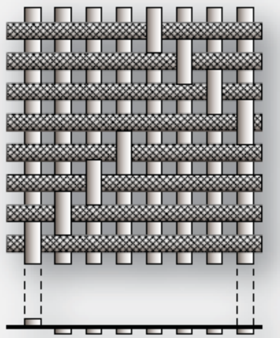




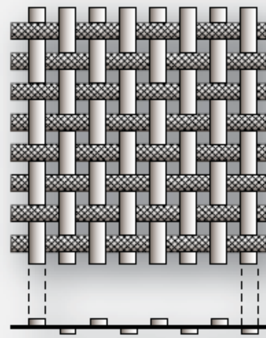
Quasi-isotropic material lay-up.

Unidirectional (Tape) and Bidirectional (Fabric)

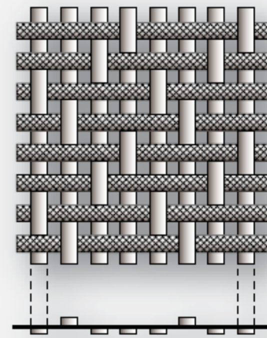




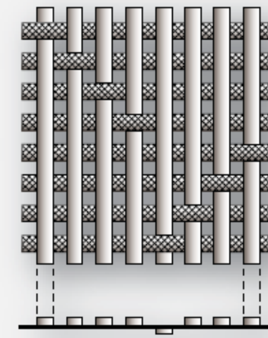
8 harness satin weave
Example:
Style 3K-135-8H carbon



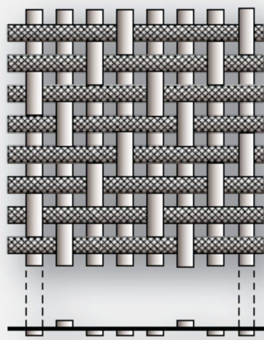
Plain weave
Example:
Style 3K-70-P carbon



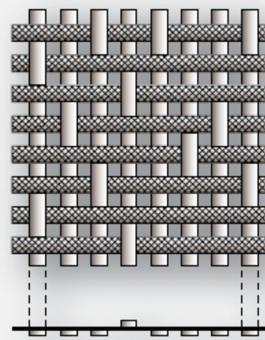
4 shaft satin weave
Example:
Style 120 fiberglass



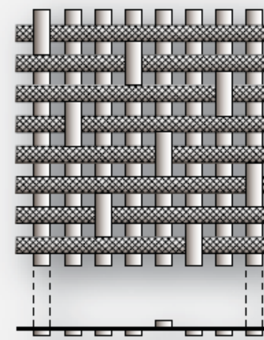
8 shaft satin weave
Example:
Style 1581 fiberglass



Crowfoot satin weave
Example:
Style 285 Kevlar®



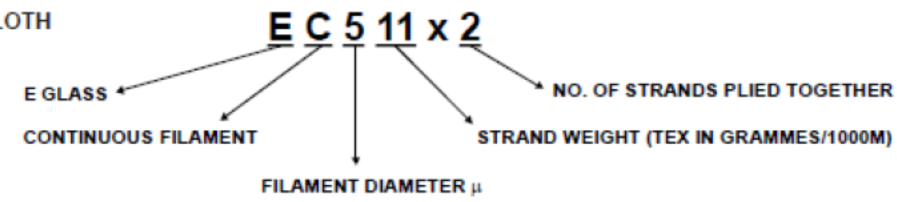
5 harness satin weave
Example:
Style 1K-50-5H carbon



8 shaft satin weave
Example:
Style 181 fiberglass

Fabric Identification

120 STYLE CLOTH



1

Product Description	Style	AMS Style	Weave	Warp Count	Fill Count	Warp Yarn	Fill Yarn	Fabric Weight (oz/yd2)	Fabric Weight (g/m2)	Fabric Thickness (mils)	Fabric Thickness (mm)	Warp Breaking Strength (lbf/in)	Fill Breaking Strength (lbf/in)
Glass	120		4H Satin	60	58	EDC 450-1/2	ECD 450-1/2	3.16	107	3.5	0.09	160	160

1

Style 120 E-Glass

DRY FABRIC REINFORCEMENT <1>			RESIN/ADHESIVE HARDENER WEIGHT/AREA <2>	
TYPE	STYLE	WEIGHT $g/m^2 (oz/ft.^2)$	g/m^2	$oz/ft.^2$
Glass fabric	120	105 (0.34)	126	0.41
	181-1581-7781	295 (0.97)	354	1.16
Carbon fabric	Plain weave	135 (0.44)	162	0.53
	Plain weave	193 (0.63)	232	0.76
Carbon fabric	5H satin	285 (0.93)	342	1.12
	8H satin	370 (1.21)	444	1.45
Dry fabric reinforcement ceramic fab-ric (XC568)	5 Harness satin	254 (0.83)	305	1.0

CAUTION: AFTER MIXING THE RESIN, THE POT LIFE (WORKING LIFE) IS TIME LIMITED (REFER TO PARAGRAPH 6.B.(2)). THE TEMPERATURE OF THE MIXTURE INFLUENCES THE VISCOSITY AND THE POT LIFE.

2 Mixing small quantities of resin/adhesive and hardener carries the risk of errors unless accurate weighing devices are used. The risk is minimized if at least 50g (2.0 oz.), but preferably 100g (4.0 oz.) of resin/adhesive and the corresponding amount of hardener is mixed. On very small repairs this may lead to some wastage.

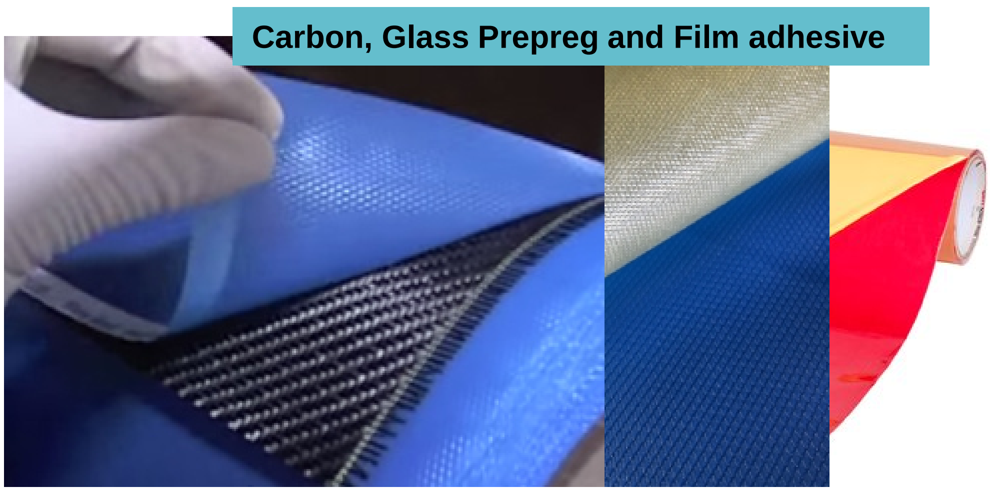
DRY FABRIC REINFORCEMENT <1>			RESIN/ADHESIVE HARDENER WEIGHT/AREA <2>	
TYPE	STYLE	WEIGHT g/m²(oz/ft.²)	g/m ²	oz/ft. ²
Glass fabric	120	105 (0.34)	126	0.41
	181-1581-7781	295 (0.97)	295	0.97
	Plain weave	135 (O.44)	175	0.57
Carbon fabric	Plain weave	193 (0.63)	251	0.82
Carbon fabric	5H satin	285 (0.93)	370	1.21
	5H or 8H satin	370 (1.21)	481	1.58
Dry fabric reinforcement ceramic fabric (XC568)	5 H satin	254 (0.83)	330	1.08

<1> Refer to Paragraph 4.H for the process to be followed for dry fabric impregnation.
<2> 30 % added for contingency purposes.

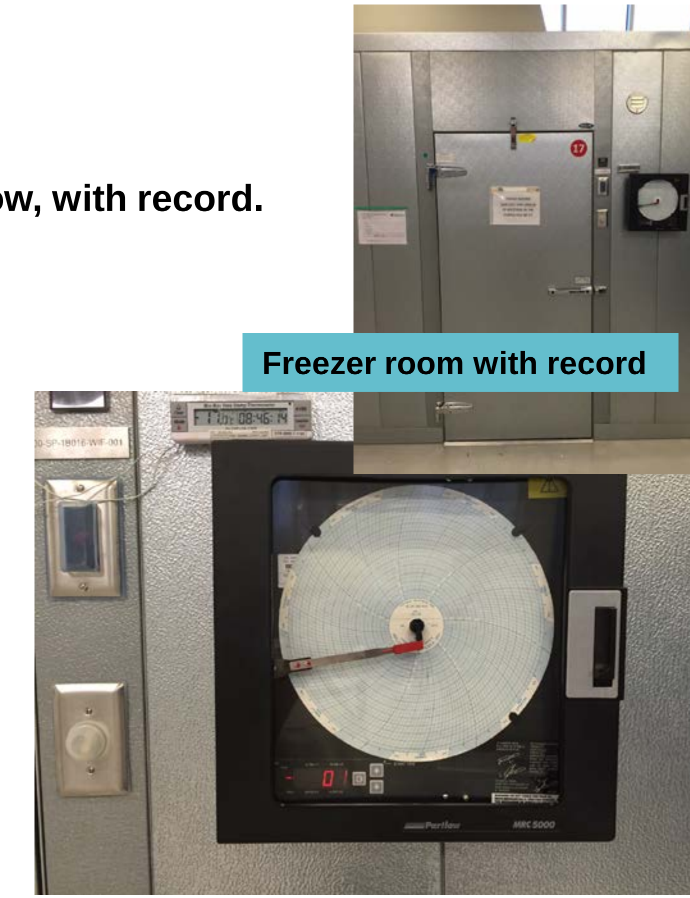
Glass fiber 1 : 1.2
Carbon Fiber 1 : 1.3

PREPREG MATERIAL

- **A prepreg is a sheet of fiber reinforcement impregnated with the resin/hardener system.**
- **Only enough Resin to cure its own fiber.**
- **Shelf life expire.**
- **Transported and Stored in sealed bags at -18°C or below, with record.**
- **Film Adhesive are used combined with Prepreg.**
- **Fiber/Glass Laminate. (GLARE)**



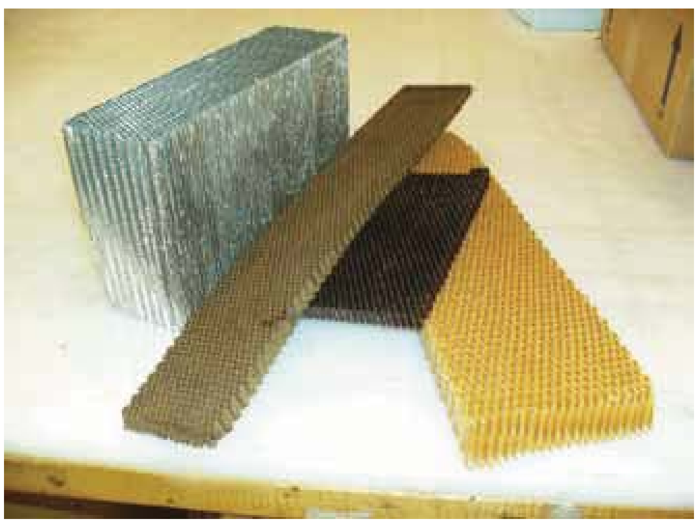
Carbon, Glass Prepreg and Film adhesive

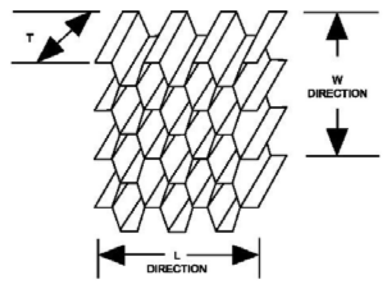


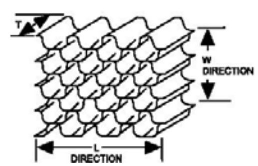
Freezer room with record

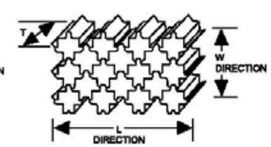
CORE, SANDWICH STRUKTURER HERUNDER KERNEMATERIALE

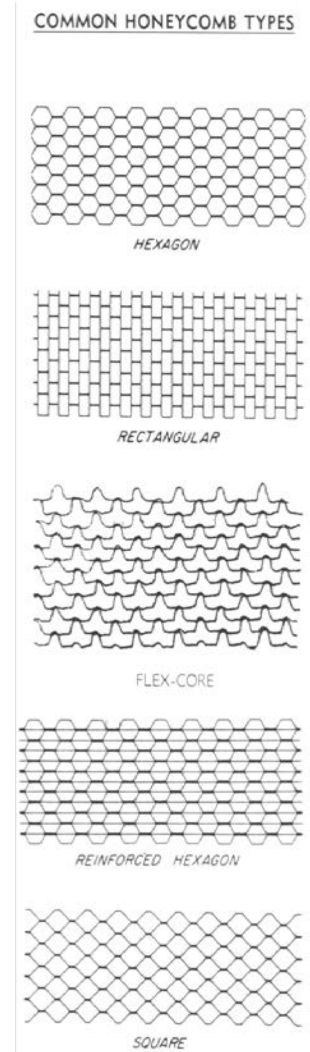
- **Core Materials:**
    - **Aramid Paper Honeycomb.**
    - **Aluminum Honeycomb.**
    - **Glass Fiber.**
- **Hexagonal Honeycomb Core.**
- **Over expanded Core.**
- **Flexi Core.**
- **Rectangular Core.**
- **Reinforced Hexagonal Core.**



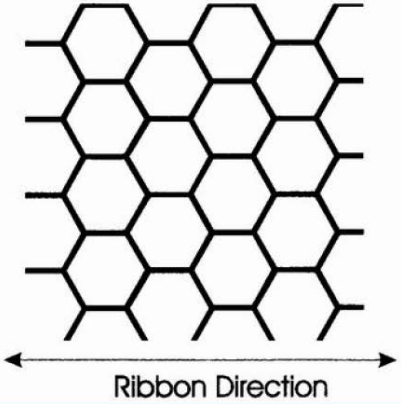








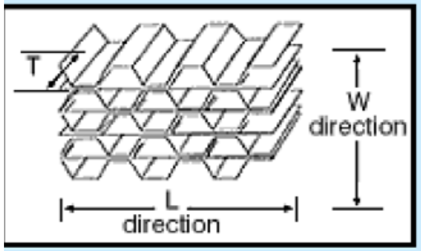
- Honeycomb
  - Form most commonly used in aerospace
    - Made from Nomex (aramid paper), fiberglass, or aluminum
    - Fire retardant, flexible and lightweight
    - Offers best strength-to-weight ratio
- Cell shape
  - Most common is hexagon, known as Hex Core
    - Suitable for flat panels
    - Difficult to curve

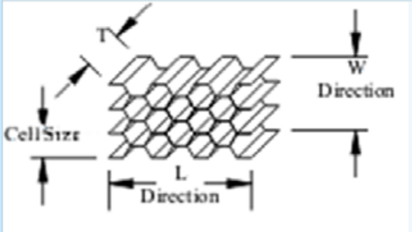


Hexagonal Core

Most common cellular configuration

- **Manufactured honeycomb core:**
  - **Core direction is important:**
    - »**"L" is ribbon, "strong" direction**
    - »**"W" is "weak" direction**

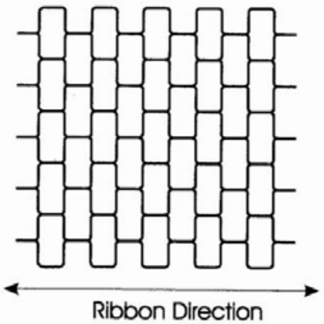




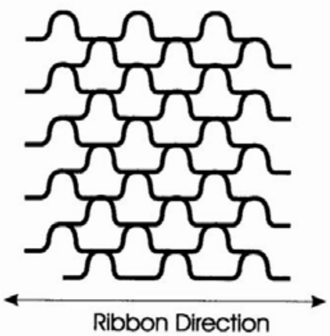
Ox-Core ®

Over-expanded in height direction.

Form facilitates curving or forming in ribbon direction.



- **Over-expanded during manufacture**
- **A "flattened" hexagon**
- **Easily curved in ribbon ("L") direction**



Flex-Core ®

Exceptional formability.

Compound curvature without buckling of cell walls.

Retains mechanical properties in curved condition.

- **Capable of compound curves**
- **Used for radomes and nose cones**
- **More expensive than Hex or Ox-Core**

- Foam Core
  - Offers higher density than honeycomb
  - Greater crush resistance
  - Bonds to skin are less strong
  - Must be cut and shaped to fit
  - Common types
    - Polystyrene
    - Polyurethane
    - Polyvinyl chloride (PVC)

- **Balsa Wood**
  - Excellent structural core material
  - Low cost, easy to use
  - Can have moisture problems
  - Can burn in a fire
    - Used less in aviation due to FAA flammability requirements
  - Used primarily in marine construction
    - Inherent floatability

Sandwich Structures

- Sandwich structures:
  - Combination of strong, thin skins and a relatively light “core” material
  - Very efficient structures with high stiffness-to-weight ratios
  - Also called “honeycomb”
- Chief purpose of core:
  - Passes shear forces between the skin surfaces
  - Allows substantially improved structural properties in thicker sections with only slight increase in weight

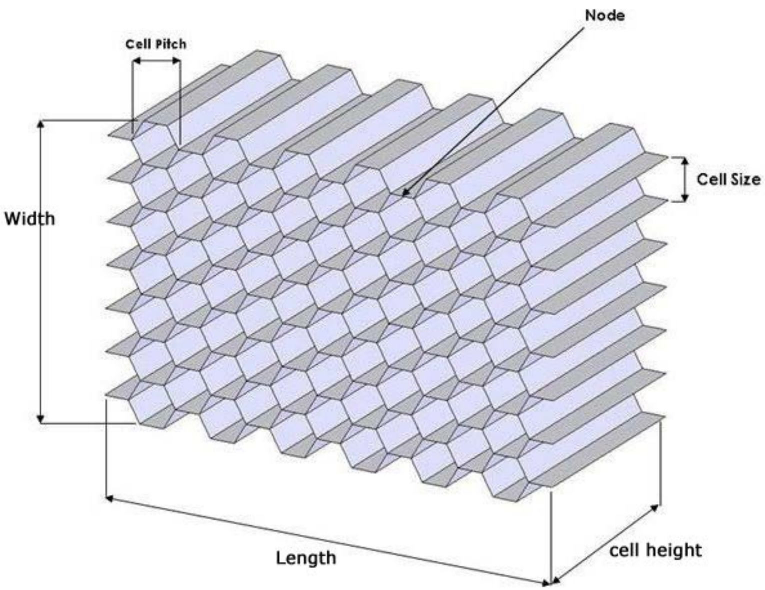
Sandwich Structures

- Typical sandwich structures:

Sandwich Structures

- Disadvantages of sandwich construction:
  - Sandwich structures have thin skins that can be easily damaged by even minor impacts.
  - Susceptible to moisture intrusion:
    - Can cause unintentional weight gain
    - Freezing may cause disbonds (if subjected to lower temperatures of higher altitudes)
    - If core becomes contaminated with oil, fuel or hydraulic fluid, it is virtually impossible to remove completely and must be replaced

CORE HONEYCOMB FABRICATION AND DIMENSION



Duxford A1/A10

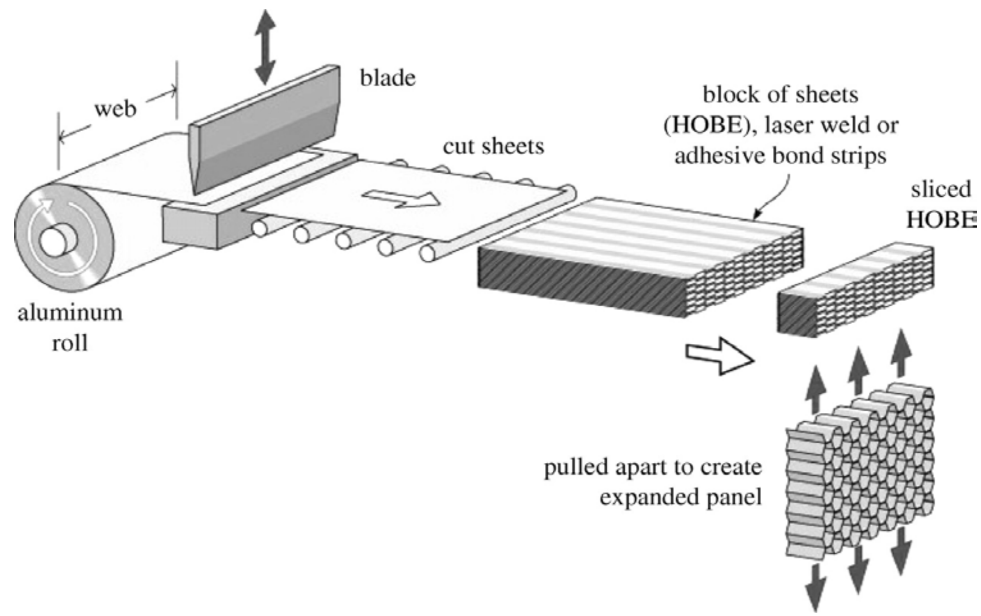
A1 — 48 — 5 — OX

- A1: Paper Type — A1 Aerospace Nomex, A10 Industrial Nomex
- 48: Density kg/m³
- 5: Cell size (mm) Nominal
- OX: Added for rectangular cell shape (over-expanded)

Casa Grande

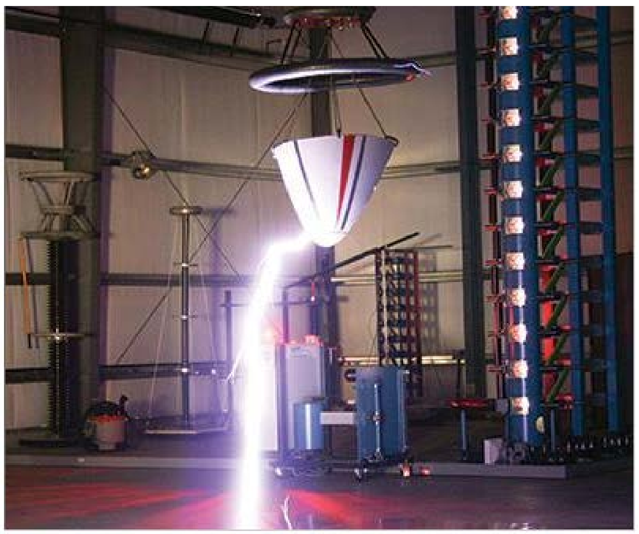
HRH-10 / OX — 3/16 — 3.0

- HRH-10: Paper Type — HRH10 Aerospace Nomex, HRH78 Industrial Nomex, HRH-36 Kevlar
- OX: Added for rectangular cell shape (over-expanded)
- 3/16: Cell size inches
- 3.0: Density lb/ft³



COBBER AND ALUMINUM MESH

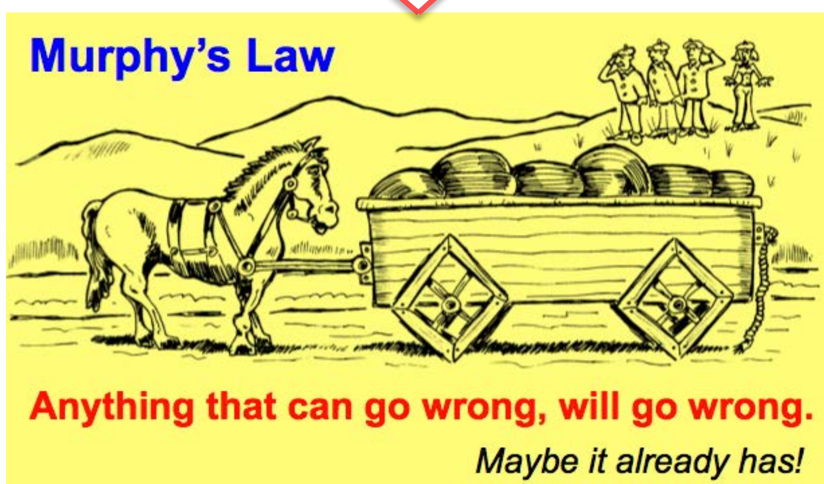
- **Shields from Electromagnetic Interference and Electrostatic Fields**



An aircraft radome undergoes lightning testing at National Technical Systems' (Calabasas, Calif.) lightning test laboratory. A 2.4-megavolt generator produces a strike to test the lightning strike protection (LSP) system on the part. Radomes are particularly susceptible to Zone 1A lightning, which can produce 200,000 amps. Source: National Technical Systems (formerly Lightning Technologies)

Human Factors

INCIDENT → ACCIDENT



PERSONLIG SIKKERHED VED REPARATIONER.

MSDS EA 9396

HEALTH AND SAFETY:

- Handling of Resins, cleaning and curing agency.
- MSDS - Material safety data sheet (Identification).
- Fume and dust extraction.
- Skin protection.
- Disposal of uncured resin and contaminated material and tool.
- Flammability risk.
- Glass, Carbon and aramid fibers awareness.

MAL KODE

HENKEL EA 9396 Part A/B

Point 8

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Employers should complete an assessment of all workplaces to determine the need for, and selection of, proper exposure controls and protective equipment for each task performed.

Hazardous Component(s)	ACGIH TLV	OSHA PEL	AIHA WEEL	OTHER
Tetraethylene pentamine	None	None	(SKIN) Aerosol. 1 ppm (5 mg/m3) TWA Aerosol. (Skin sensitizer)	None
N,N'-Bis(3-aminopropyl)piperazine	None	None	None	None
3,6,9,12-tetraazatetradecamethylenediamine	None	None	None	None

Engineering controls: Provide local and general exhaust ventilation to effectively remove and prevent buildup of any vapors or mists generated from the handling of this product.

Respiratory protection: If ventilation is not sufficient to effectively prevent buildup of aerosols, mists or vapors, appropriate NIOSH/MSHA respiratory protection must be provided.

Eye/face protection: Safety goggles or safety glasses with side shields.

Skin protection: Wear impervious gloves for prolonged contact. Use of impervious apron and boots are recommended.

PUNKT 8: Eksponeringskontrol/personlige værnemidler

8.1. Kontrolparametre

Grænseværdier for erhvervsmæssig eksponering

Gælder for
DK

ingen

Biologisk grænseværdi:
ingen

8.2. Eksponeringskontrol:

Åndedrætsværn:
Egnet ansiktmaske (åndedræt) ved utilstrækkelig ventilation.
Egnet åndedrætsværn:
Filtertype: A

Håndbeskyttelse:
Kemikaliebestandige beskyttelseshandsker (EN 374)
.Egnede materialer ved kort kontakt eller stænk (Anbefalet: Mindst beskyt telsesindeks 2, svarende til > 30 minutter permeationstid iht. EN 374): Nitrilgummi (NBR; >= 0,4 mm lagtykkelse).Egnede materialer også ved længere, direkte kontakt (Anbefalet: Mindst beskyttelsesindeks 6, svarende til > 480 minutter permeationstid iht. EN 374): Nitrilgummi (NBR; >= 0,4 mm lagtykkelse). Angivelserne baserer på litteraturangivelser og informationer fra handskeproducenter eller er afledt ved analogikonklusioner fra lignende stoffer. Man skal være opmærksom på, at en kemikaliebeskyttelseshandskes anvendelsesvarighed i praksis kan være betydeligt kortere end den permeationstid, som er beregnet iht. EN 374, på grund af de mange påvirkende faktorer (f.eks. temperatur). Ved tegn på slitage skal handsken udskiftes.

Øjenbeskyttelse:
Tætsluttende beskyttelsesbriller.
og/eller
Ansigtsbeskyttelse

Kropsbeskyttelse:
Beskyttelsesudstyr skal bæres.
Beskyttelsestøj, som dækker arme og ben.
Forklæde

Rådet for personlig beskyttelse udrustning:
Forurening af huden skal vaskes grundigt af med vand og sæbe, hudpleje.
Indænd ikke støv og dampe.

MAL Kode.

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EPOXYBASEREDE CEMENT/INJEKTIONSMIDLER

Kode nr.	Arbejde:	Påføringsmidler:	
00-5 0-5			1. Ingen tilsmudsning: Handsker kan udelades
1-5			2. Brug åndedrætsværn i stillestående luft
			3. Indeholder produktet lavt-kogende væsker: Brug altid luftforsynet åndedrætsværn
4-5 5-5			4. Ved arbejde med limtube: Handsker kan udelades
			5. Brug helmaske hvis halvmaske og øjenværn ikke kan bæres samtidig
			6. Ved risiko for tilsmudsning: Brug dragt og øjenværn
			7. Ved arbejde på små emner: Åndedrætsværn kan udelades

Gruppe 2

Epoxybaserede cement/injektionsmidler

Workshop Task 1:

Composite Wet Lay-up Fabrication:

Make 1 ea. 4 ply monolithic laminate by Carbon Prepreg 200 G and 1 ea. Layer of cobber wire mesh.

Caution: USE SANDING ROOM AND PROTECTIVE BREATING MASK WHEN SANDING.

Caution: FOLLOW **MSDS** FOR CORRECTIVE PROTECTION. (Hand protection, etc……..)

Caution: OBSERVE BEFORE WORKING WHERE PROTECTION IS STORED.

Material:	Tool:
EWT 300g, Twill weave Fabric	Peel Ply
PRO SET LAM 125/226 Resin 100/35	Breather
Carbon Prepreg 200 g	Flash breaker tape
	Black backing tape
	Backing Film
	Hot bonder

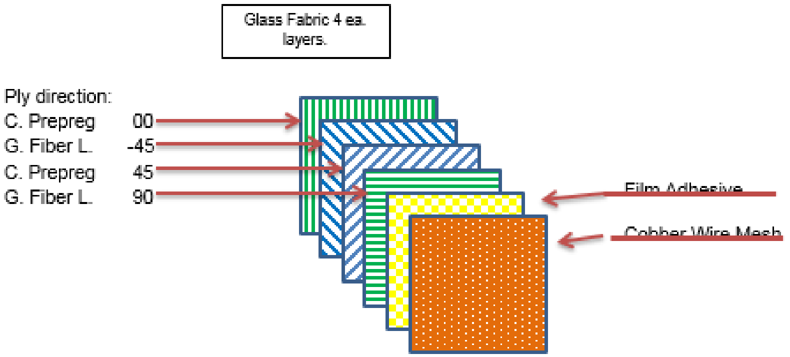
1) Prepare The Carbon Prepreg Fiber Layers with Cobber wire mesh, for fabrication of 1 ea. monolithic laminate 250 * 250 mm.

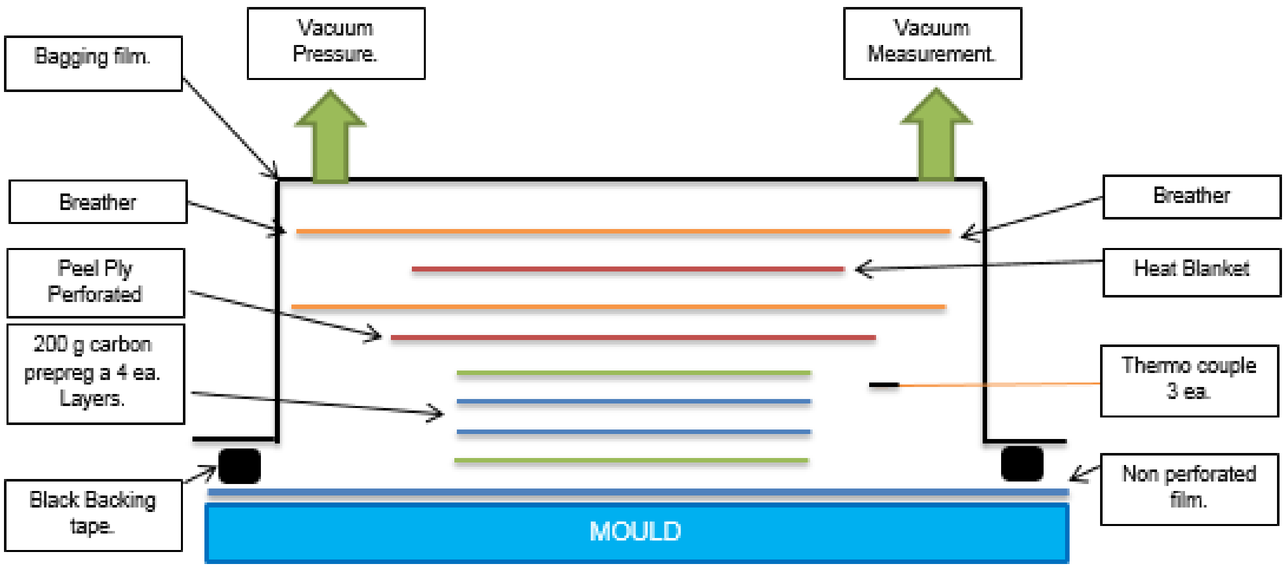
2) Use a mould plate covered non perforated film as a resin barrier.

   a. Layup the Prepreg fabric as same direction as pr. Drawing.

3) Perform the Vacuum bagging with heat blanket and thermo couplers 3 ea.

4) Cure the laminate for 8 hours/ 80°C, with ramp up and down +3°C.


Glass Fabric 4 ea. layers.
Ply direction:
C. Prepreg 00
G. Fiber L. -45
C. Prepreg 45
G. Fiber L. 90
Film Adhesive
Cobber Wire Mesh


Bagging film.
Vacuum Pressure.
Vacuum Measurement.
Breather
Breather
Heat Blanket
Peel Ply Perforated
200 g carbon prepreg a 4 ea. Layers.
Thermo couple 3 ea.
Black Backing tape.
Non perforated film.
MOULD

MSDS
Instruction

PP
Instruction

SHOP Regulation

- ✓ **House Keeping.**
- ✓ **No Resin on floor.**
- ✓ **Meet in class after daily task.**