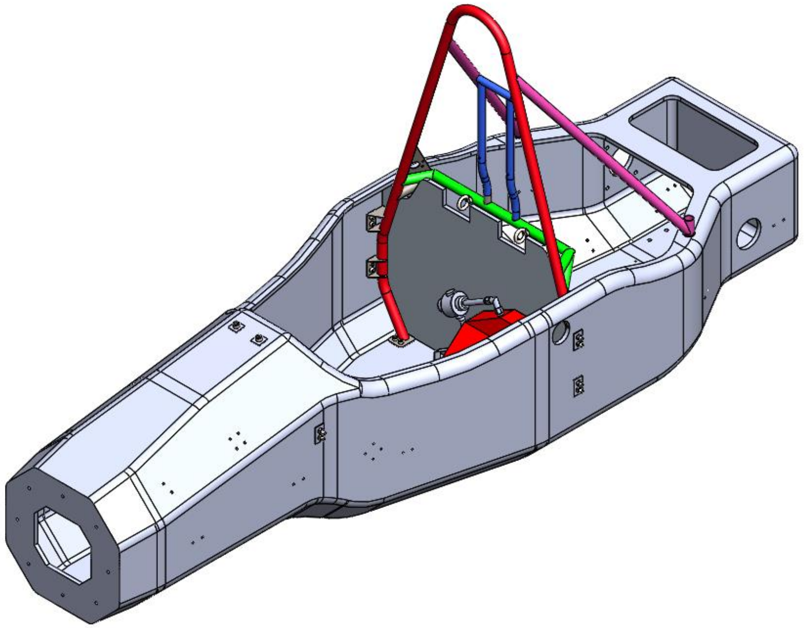
SES Guidance for FSAEJ

Monocoque

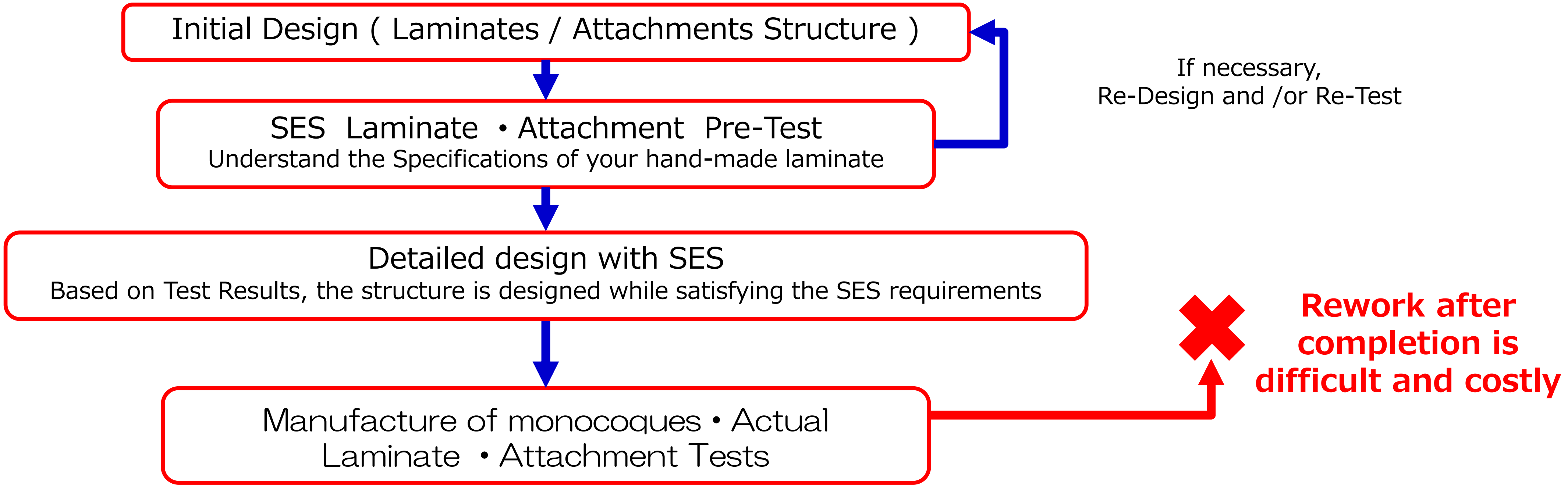


2025 v1.1 Compliant

How to describe Monocoque SES

- Design flow with SES / SESを用いた設計フロー

  SES requires proof tests (Laminate Test and Attachment Test) for equivalence proof
  ⇒ By making good use of SES,
  you can avoid the risk of fatal rework and non-compliance with rules.



If you test after manufacturing Monocoque and find that it lacks strength or does not comply with the rules,
Recovery is more difficult than Steel Tube Frame, so use SES well!

How to describe Monocoque SES

- Basic Procedure of SES input / SES入力手順

① F.3.1-5 Tube Chassis -> Basic Info & Select [Tube] or [Composite]
Define your Composite Portion in the Structure.

↓

② F.4.3 Composite
If necessary, duplicate [F.4.3 Composite] Sheet for Different or Additional Layup
It's strongly recommended to be completed before proceeding to the next step.

↓

③ Test section in F.7.9-10 Attachments & in F.8 Front Protection (& in F.10-11 EV Accumulator)
Sometime test results affect your Chassis design

↓

④ F.7 Composite Chassis, Remaining F.7.9-10 Attachments (and F.10-11 EV Accumulator)

↓

⑤ Remaining F.8 Front Protection
Front Bulkhead section requires to complete FBHS section in F.7 Composite Chassis

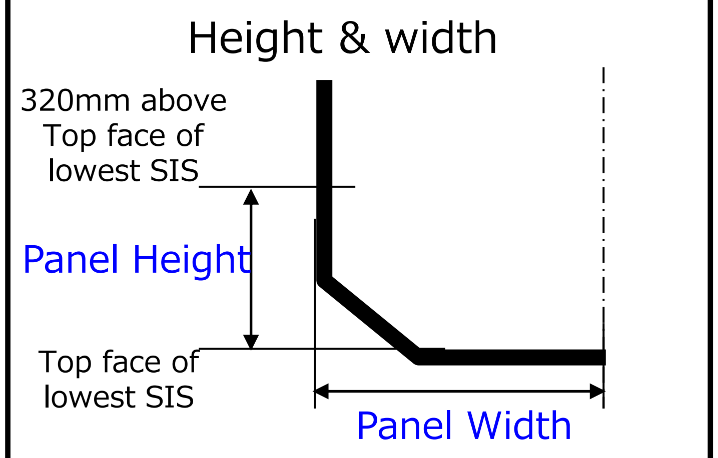
↓

⑥ Fill in remaining BLANKs

* Of course, BLANKs may be filled when possible.

- Equivalent Flat Panel Calculation (F.4.4) / フラットパネル換算

The EI of the monocoque is calculated as that of a flat panel with the same composition as the monocoque about the neutral axis of the laminate. The curvature of the panel and geometric cross section of the monocoque must be ignored for these calculations.



e.g. Side impact structure

Note : Comply with F.4.4 for the following calculations

・Front Bulkhead Support Structure
Vertical wall must have EI more than ONE Baseline steel tube.

・Side Impact Structure
Vertical wall must have EI more than TWO Baseline steel tube
Floor Panel must have EI more than ONE Baseline steel tube

see (F.7.3.2, F.7.5.3, F.7.5.4)

- Height/Width of Flat Panel cross-section

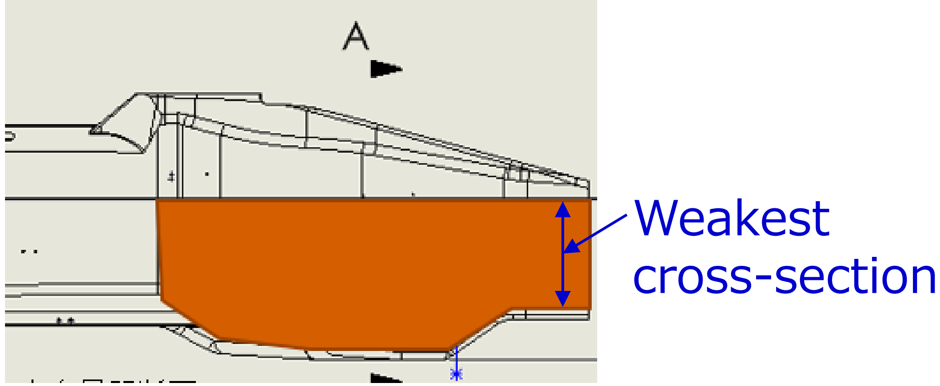
The SES specifies the cross-section as Minimum or average

Select the minimum or average cross section for the FBHS.
Access holes or single skins are not counted, and usually create the minimum cross section.
Treat sharp cross sectional discontinuities (example: damper cutouts) like holes.

FSAEJ strongly recommends to select MINIMUM

Reason

- If they are equivalent at the weakest cross section, the whole is more than equivalent.
- the average requires more complex calculations than select the minimum.
- When you select Average, the Minimum is not equivalent



If Average cross section is selected,

It must be determined from the integrated area value.

In the most case… **(Max.+Min.)/2≠Average**

Describe the calculation process in the SES.

Monocoque SES

F.4.3 Composite

Attention : Rule References in the SES are not reflected changes in 2025 Rules
This guidance is based on description of the SES

2025 v1.1 Compliant

- Derivation of Key Elements for Proof of Equivalence

  If it is a tube frame, it is possible to use common values for physical properties such as Young's modulus and yield strength, but for Monocoque, physical properties vary greatly depending on how it is made, so it is essential to derive physical properties through actual tests.

  Reuse of test results from different years is prohibited (F.4.2.1b).

Contents of F.4.3 Composite

① Use of Laminates

② 3-point Bending of Size-B Steel Tube(s) F.4.2.3, F.4.2.4

③Laminate Test (3-Point Bending) F.4.2.2, F.4.2.4

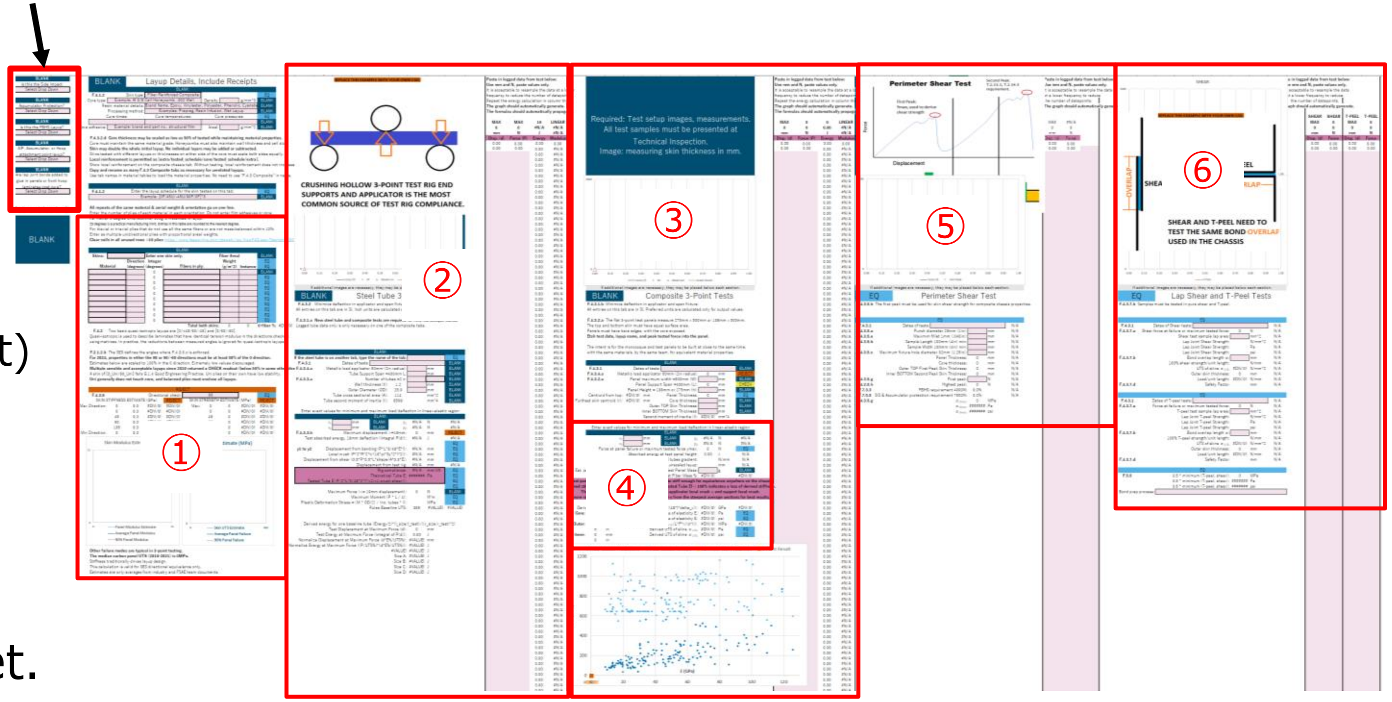
④Derived physical property value for F.7 (E・UTS)

⑤Shear strength(SIS/FBHS/Acc.Protection/Attachment) F.4.2.5

⑥Shear & Peel strength of adhesion F.4.2.6

If you have Different Layup, duplicate this sheet.

Select the Purpose of the Laminate correctly



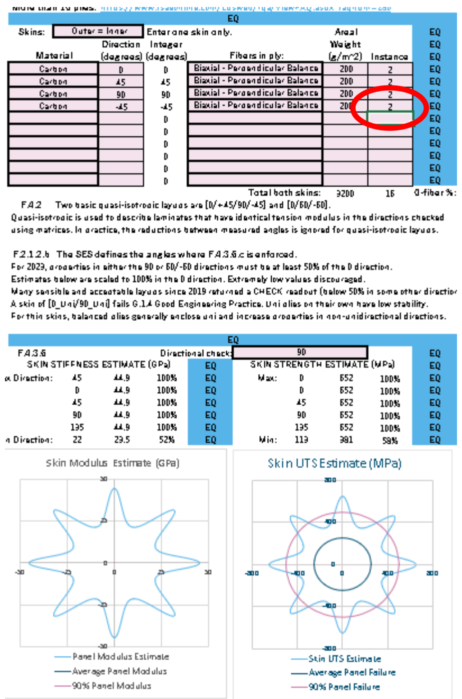
F.4.3 Composite

① Use of Laminates

Almost Skin thickness in SES must be described by Scaling option (Integer only)

		Layup Used:	SIS F.4.3 Composite		EQ
			Monocoque		EQ
		Core thickness:	12	mm	EQ
Scaling option, layup repeats:	1	Outer skin thickness:	3	mm	EQ
Scaling option, layup repeats:	1	Inner skin thickness:	3	mm	EQ
		Panel thickness:	18	mm	EQ

Must be an integral multiple of the Layup Schedule for Laminate Test
(Because thickness change of 1 ply unit may lose quasi-isotropy)

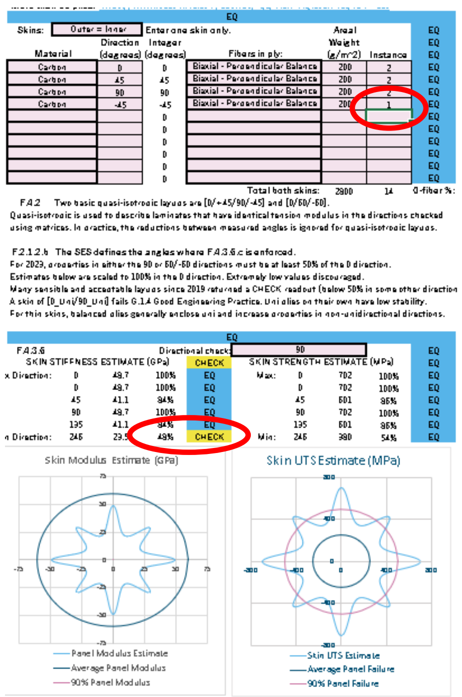


For example, if you subtract 1ply from [0/45/90/-45] evenly

Reduced stiffness in specific directions

±60deg or 90deg direction need 50% or more at 0deg (See Comment in SES)

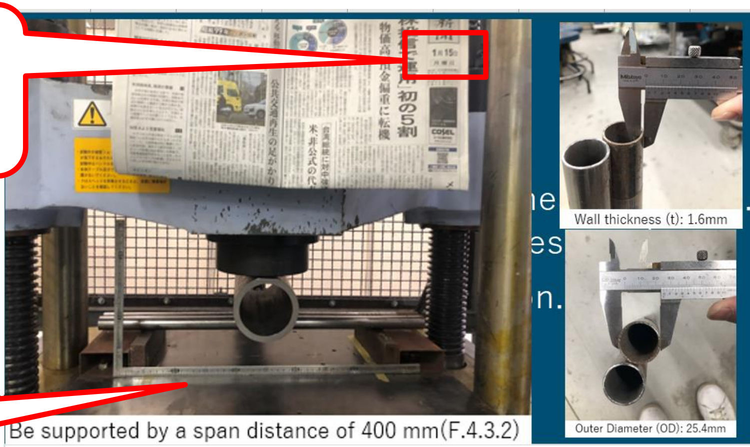
All thickness differences that are not integral multiples should be treated as Different Layups and their physical properties should be obtained using the Laminate Test.



② Steel Tube 3-Points Test - How to describe -

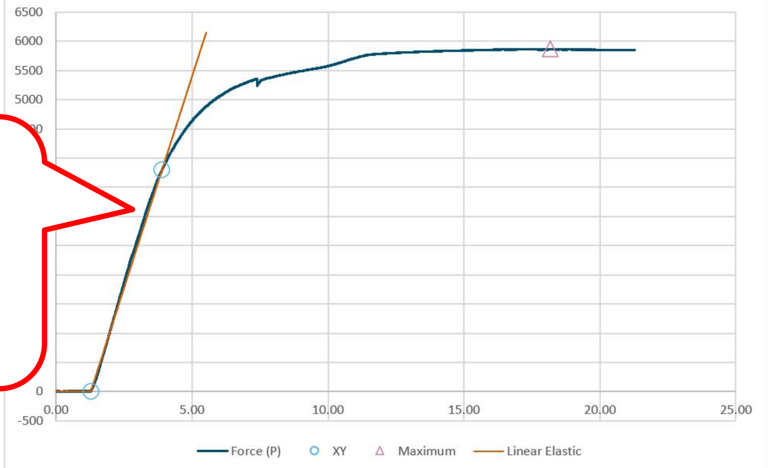
Take a photo with the date in the photo (News Paper is the BEST)

Simultaneous Shooting of the Rig and Scale



Be supported by a span distance of 400 mm(F.4.3.2)

The Chart is drawn automatically
Other Chart (your own made or custom) must be REJECT as Format mismatch



If additional images are necessary, they may be placed below each section.

EQ | Steel Tube 3-Point Test

Paste in logged data from test below:
Use mm and N, paste values only.
It is acceptable to resample the data at a lower frequency to reduce the number of datapoints.
Repeat the energy calculation in column three.
The graph should automatically generate.
The formulas should automatically propagate.

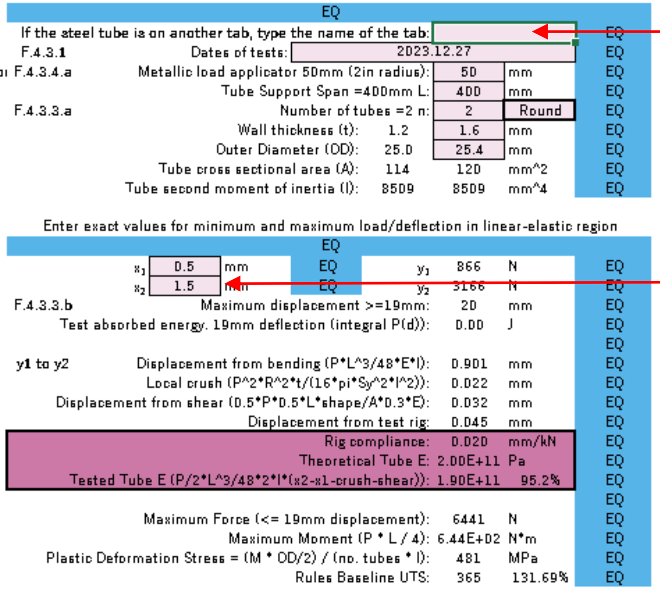
MAX	MAX	19	LINEAR
21.282	5865.313	88.50	1.45E+03
mm	N	J	-1.85E+03
Disp. (d)	**Force (P)**	**Energy**	**Modulus**
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
0.00	1.88	0.00	0.00
0.00	0.31	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.94	0.00	0.00
0.00	1.56	0.00	0.00
0.00	2.19	0.00	0.00
0.00	2.19	0.00	0.00
0.00	2.81	0.00	0.00
0.00	2.50	0.00	0.00
0.00	3.44	0.00	0.00
0.00	1.88	0.00	0.00
0.00	2.19	0.00	0.00
0.00	1.25	0.00	0.00
0.00	2.50	0.00	0.00
0.00	1.88	0.00	0.00
0.00	2.19	0.00	0.00
0.00	3.44	0.00	0.00
0.00	3.44	0.00	0.00
0.00	2.81	0.00	0.00
0.00	2.81	0.00	0.00
0.00	5.00	0.00	0.00
0.00	4.06	0.00	0.00
0.00	2.81	0.00	0.00
0.00	3.13	0.00	0.00
0.00	1.88	0.00	0.00
0.00	2.50	0.00	0.00
0.00	2.81	0.00	0.00
0.00	1.25	0.00	0.00

Input Test Data directly Displacement(mm) and Force[N]

The load Data must be zero when Actual is no load.

F.4.3 Composite

② Steel Tube 3-Points Test -Detail-



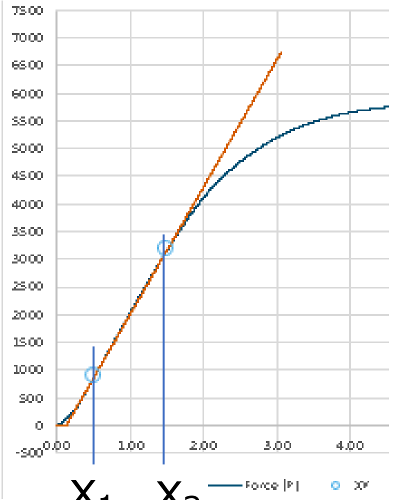
	EQ				
	If the steel tube is on another tab, type the name of the tab:				EQ
F.4.3.1	Dates of tests:		2023.12.27		EQ
F.4.3.4.a	Metallic load applicator 50mm (2in radius):		50	mm	EQ
	Tube Support Span =400mm L:		400	mm	EQ
F.4.3.3.a	Number of tubes =2 n:		2	Round	EQ
	Wall thickness (t):	1.2	1.6	mm	EQ
	Outer Diameter (OD):	25.0	25.4	mm	EQ
	Tube cross sectional area (A):	114	120	mm^2	EQ
	Tube second moment of inertia (I):	8509	8509	mm^4	EQ

Enter exact values for minimum and maximum load/deflection in linear-elastic region

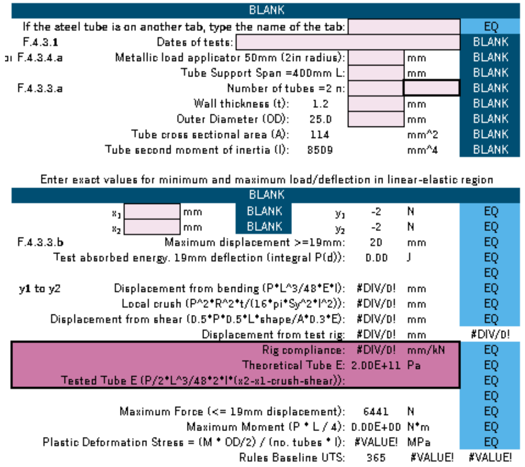
	EQ				
	x1 0.5 mm	EQ	y1	866 N	EQ
	x2 1.5 mm	EQ	y2	3166 N	EQ
F.4.3.3.b	Maximum displacement >=19mm:		20	mm	EQ
	Test absorbed energy. 19mm deflection (integral P(d)):		0.00	J	EQ
y1 to y2	Displacement from bending (P*L^3/48*E*I):		0.901	mm	EQ
	Local crush (P^2*R^2*t/(16*pi*Sy^2*I^2)):		0.022	mm	EQ
	Displacement from shear (0.5*P*0.5*L*shape/A*0.3*E):		0.032	mm	EQ
	Displacement from test rig:		0.045	mm	EQ
	Rig compliance:		0.020	mm/kN	EQ
	Theoretical Tube E:		2.00E+11	Pa	EQ
	Tested Tube E (P/2*L^3/48*2*I*(x2-x1-crush-shear)):		1.90E+11	95.2%	EQ
	Maximum Force (<= 19mm displacement):		6441	N	EQ
	Maximum Moment (P * L / 4):		6.44E+02	N*m	EQ
	Plastic Deformation Stress = (M * OD/2) / (no. tubes * I):		481	MPa	EQ
	Rules Baseline UTS:		365	131.69%	EQ

If you have multiple F.4.3 Composite Sheets, you only need to describe it on one sheet.
⇒For other sheets, just specify that sheet.

x_1 : Start displacement of Liner-Elastic Region
x_2 : End displacement of Liner-Elastic Region



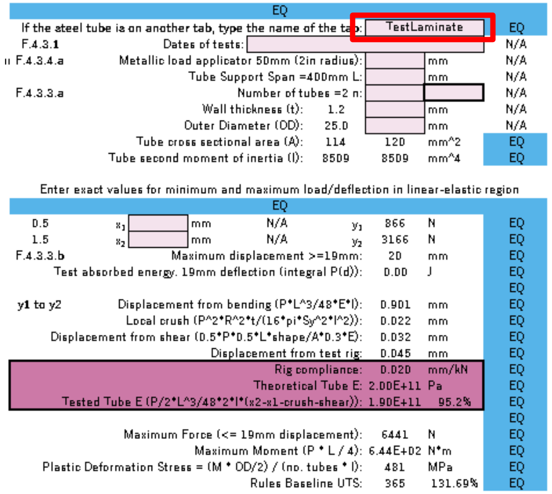
if you describe it in one sheet
For Different Layup, just refer to that sheet.



	BLANK				
	If the steel tube is on another tab, type the name of the tab:				EQ
F.4.3.1	Dates of tests:				BLANK
F.4.3.4.a	Metallic load applicator 50mm (2in radius):			mm	BLANK
	Tube Support Span =400mm L:			mm	BLANK
F.4.3.3.a	Number of tubes =2 n:				BLANK
	Wall thickness (t):	1.2		mm	BLANK
	Outer Diameter (OD):	25.0		mm	BLANK
	Tube cross sectional area (A):	114		mm^2	BLANK
	Tube second moment of inertia (I):	8509		mm^4	BLANK

Enter exact values for minimum and maximum load/deflection in linear-elastic region

	BLANK				
	x1 mm	BLANK	y1	-2 N	EQ
	x2 mm	BLANK	y2	-2 N	EQ
F.4.3.3.b	Maximum displacement >=19mm:		20	mm	EQ
	Test absorbed energy. 19mm deflection (integral P(d)):		0.00	J	EQ
y1 to y2	Displacement from bending (P*L^3/48*E*I):		#DIV/0!	mm	EQ
	Local crush (P^2*R^2*t/(16*pi*Sy^2*I^2)):		#DIV/0!	mm	EQ
	Displacement from shear (0.5*P*0.5*L*shape/A*0.3*E):		#DIV/0!	mm	EQ
	Displacement from test rig:		#DIV/0!	mm	#DIV/0!
	Rig compliance:		#DIV/0!	mm/kN	EQ
	Theoretical Tube E:		2.00E+11	Pa	EQ
	Tested Tube E (P/2*L^3/48*2*I*(x2-x1-crush-shear)):				EQ
	Maximum Force (<= 19mm displacement):		6441	N	EQ
	Maximum Moment (P * L / 4):		0.00E+00	N*m	EQ
	Plastic Deformation Stress = (M * OD/2) / (no. tubes * I):		#VALUE!	MPa	EQ
	Rules Baseline UTS:		365	#VALUE!	#VALUE!



	EQ				
	If the steel tube is on another tab, type the name of the tab:		TestLaminate		EQ
F.4.3.1	Dates of tests:				N/A
F.4.3.4.a	Metallic load applicator 50mm (2in radius):			mm	N/A
	Tube Support Span =400mm L:			mm	N/A
F.4.3.3.a	Number of tubes =2 n:				N/A
	Wall thickness (t):	1.2		mm	N/A
	Outer Diameter (OD):	25.0		mm	N/A
	Tube cross sectional area (A):	114	120	mm^2	EQ
	Tube second moment of inertia (I):	8509	8509	mm^4	EQ

Enter exact values for minimum and maximum load/deflection in linear-elastic region

	EQ				
0.5	x1 mm	N/A	y1	866 N	EQ
1.5	x2 mm	N/A	y2	3166 N	EQ
F.4.3.3.b	Maximum displacement >=19mm:		20	mm	EQ
	Test absorbed energy. 19mm deflection (integral P(d)):		0.00	J	EQ
y1 to y2	Displacement from bending (P*L^3/48*E*I):		0.901	mm	EQ
	Local crush (P^2*R^2*t/(16*pi*Sy^2*I^2)):		0.022	mm	EQ
	Displacement from shear (0.5*P*0.5*L*shape/A*0.3*E):		0.032	mm	EQ
	Displacement from test rig:		0.045	mm	EQ
	Rig compliance:		0.020	mm/kN	EQ
	Theoretical Tube E:		2.00E+11	Pa	EQ
	Tested Tube E (P/2*L^3/48*2*I*(x2-x1-crush-shear)):		1.90E+11	95.2%	EQ
	Maximum Force (<= 19mm displacement):		6441	N	EQ
	Maximum Moment (P * L / 4):		6.44E+02	N*m	EQ
	Plastic Deformation Stress = (M * OD/2) / (no. tubes * I):		481	MPa	EQ
	Rules Baseline UTS:		365	131.69%	EQ

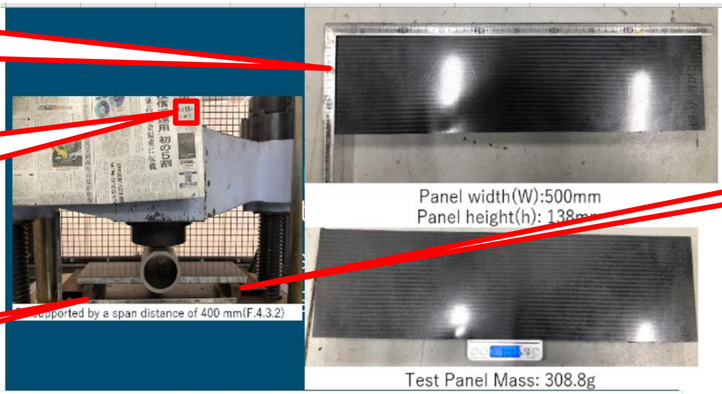
F.4.3 Composite

③ Composite 3-Point Tests - How to describe -

attach a photo showing the dimensions of the Test Piece.

Take a photo with the date in the photo (News Paper is the BEST)

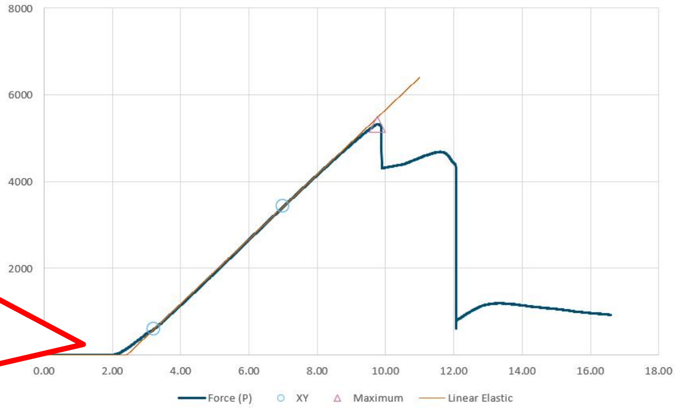
Simultaneous Shooting of the Rig and Scale



Same Rig must be set with Steel Tube Test F.4.2.4

Input Test Data directly Displacement(mm) and Force[N]

The Chart is drawn automatically
Other Chart (your own made or custom) must be REJECT as Format mismatch



If additional images are necessary, they may be placed below each section.

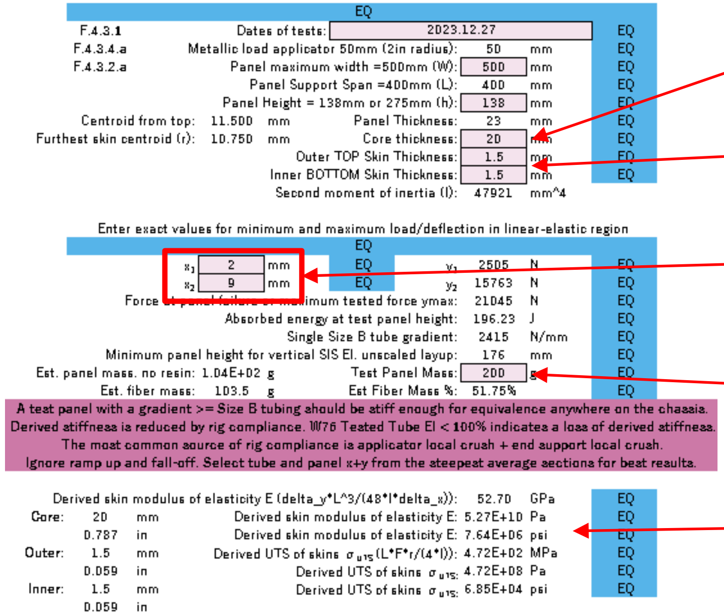
EQ | Composite 3-Point Tests

Paste in logged data from test below:
Use mm and N, paste values only.
It is acceptable to resample the data at a lower frequency to reduce the number of datapoints.
Repeat the energy calculation in column three.
The graph should automatically generate.
The formulas should autom... ...gate.

	9.76	22.148	LINEAR
22.148	5321.563	39.79	7.46E+02
mm	N	J	-1.80E+03
Disp. (d)	**Force (P)**	**Energy**	**Modulus**
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
0.00	6.25	0.00	0.00
0.00	4.69	0.00	0.00
0.00	5.00	0.00	0.00
0.00	5.00	0.00	0.00
0.00	5.31	0.00	0.00
0.00	5.63	0.00	0.00
0.00	6.88	0.00	0.00
0.00	5.94	0.00	0.00
0.00	4.69	0.00	0.00
0.00	4.69	0.00	0.00
0.00	4.06	0.00	0.00
0.00	5.00	0.00	0.00
0.00	3.75	0.00	0.00
0.00	3.75	0.00	0.00
0.00	6.25	0.00	0.00
0.00	6.25	0.00	0.00
0.00	5.63	0.00	0.00
0.00	5.31	0.00	0.00
0.00	4.06	0.00	0.00
0.00	4.69	0.00	0.00
0.00	5.31	0.00	0.00
0.00	5.00	0.00	0.00
0.00	5.94	0.00	0.00
0.00	6.56	0.00	0.00
0.00	6.88	0.00	0.00
0.00	6.88	0.00	0.00
0.00	6.25	0.00	0.00
0.00	6.56	0.00	0.00

The load Data must be zero when Actual is no load.

③ Composite 3-Point Tests -Detail-



				EQ		
F.4.3.1			Dates of tests:	2023.12.27		EQ
F.4.3.4.a			Metallic load applicator 50mm (2in radius):	50	mm	EQ
F.4.3.2.a			Panel maximum width =500mm (W):	500	mm	EQ
			Panel Support Span =400mm (L):	400	mm	EQ
			Panel Height = 138mm or 275mm (h):	138	mm	EQ
Centroid from top:	11.500	mm	Panel Thickness:	23	mm	EQ
Furthest skin centroid (r):	10.750	mm	Core thickness:	20	mm	EQ
			Outer TOP Skin Thickness:	1.5	mm	EQ
			Inner BOTTOM Skin Thickness:	1.5	mm	EQ
			Second moment of inertia (I):	47921	mm^4	

Enter exact values for minimum and maximum load/deflection in linear-elastic region

		EQ				
x_1	2 mm	EQ	y_1	2505	N	EQ
x_2	9 mm	EQ	y_2	15763	N	EQ
			Force at panel failure or maximum tested force ymax:	21045	N	EQ
			Absorbed energy at test panel height:	196.23	J	EQ
			Single Size B tube gradient:	2415	N/mm	EQ
			Minimum panel height for vertical SIS EI. unscaled layup:	176	mm	EQ
Est. panel mass. no resin:	1.04E+02 g		Test Panel Mass:	200	g	EQ
Est. fiber mass:	103.5 g		Est Fiber Mass %:	51.75%		EQ

A test panel with a gradient >= Size B tubing should be stiff enough for equivalence anywhere on the chassis.
Derived stiffness is reduced by rig compliance. W76 Tested Tube EI < 100% indicates a loss of derived stiffness.
The most common source of rig compliance is applicator local crush + end support local crush.
Ignore ramp up and fall-off. Select tube and panel x+y from the steepest average sections for best results.

			Derived skin modulus of elasticity E (delta_y*L^3/(48*I*delta_x)):	52.70	GPa	EQ
Core:	20	mm	Derived skin modulus of elasticity E:	5.27E+10	Pa	EQ
	0.787	in	Derived skin modulus of elasticity E:	7.64E+06	psi	EQ
Outer:	1.5	mm	Derived UTS of skins σ_{u1S} (L*F*r/(4*I)):	4.72E+02	MPa	EQ
	0.059	in	Derived UTS of skins σ_{u1S}:	4.72E+08	Pa	EQ
Inner:	1.5	mm	Derived UTS of skins σ_{u1S}:	6.85E+04	psi	EQ
	0.059	in				

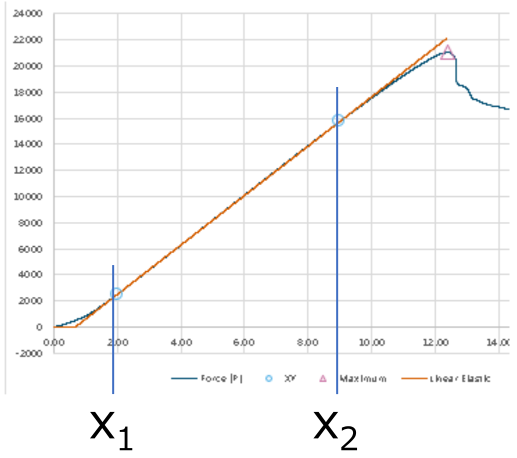
FSAE Rules specify Core Thickness of Test Panel
It must use the thickest core associated with each skin layup(F.4.2.2d)

Outer side must be upside (Also Actual Test Setup)

x1 : Start displacement of Liner-Elastic Region
x2 : End displacement of Liner-Elastic Region

Measure and record Panel weight before the test
Consistency with the Ply Schedule is checked

④ Young modulus E and UTS are calculated automatically



If Young's modulus/UTS is determined to be inappropriate due to mistake in this sheet, all items that refer to these on other sheets will be "unconditionally" REJECTED as unreviewable.

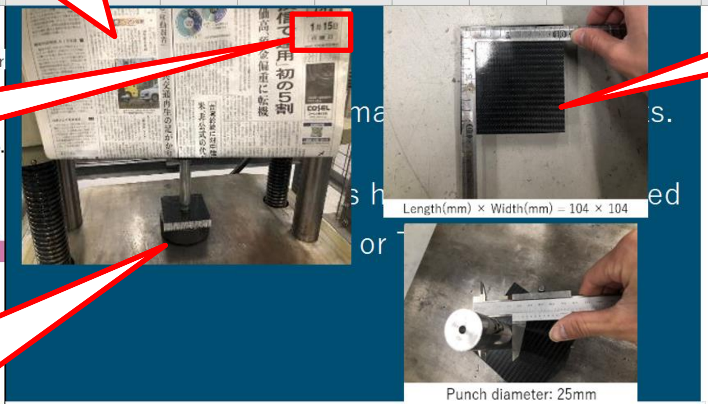
"Unconditionally" means that there is no content review

⑤ Perimeter Sheer Test

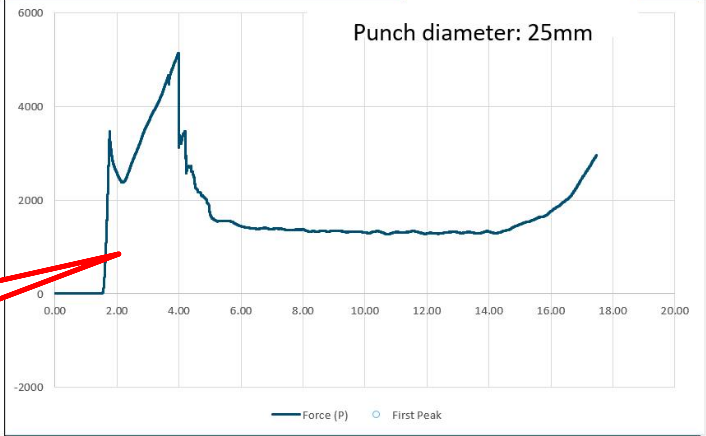
Test Setup

Take a photo with the date in the photo (News Paper is the BEST)

Prepare the die with sufficient thickness
Correct measurement will not be possible if the Bottom Skin touches during the test
Thin die may be REJECTED



attach a photo showing the dimensions of the Test Piece.



The Chart is drawn automatically
Other Chart (your own made or custom) must be REJECT as Format mismatch

If additional images are necessary, they may be placed below each section.

EQ Perimeter Shear Test

F.4.3.5.b The first peak must be used for skin shear strength for composite chassis properties.

..., paste values onl
It is acceptable to resample the d
at a lower frequency to reduce
the number of datapoints.
The graph should automatically

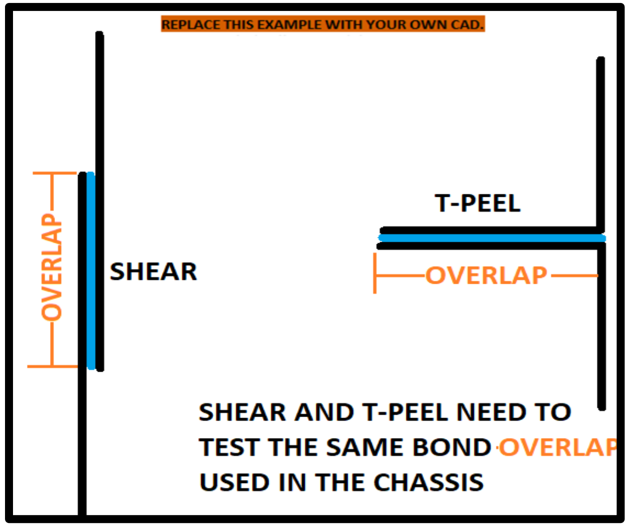
MAX	#N/A
17.46275	5131.658
mm	N
Disp. (d)	Force (P)
0.00	0.00
0.00	0.00
0.00	0.29
0	0.317891
0	0.190735
0	0.095367
0	0.095367
0	0.063578
0	0
0	0.031789
0	0.206629
0	0.333786
0	0.349681
0	0.349681
0	0.429153
0	0.445048
0	0.270208
0	-0.03179
0	-0.22252
0	-0.20663
0	-0.07947
0	0
0.000125	-0.04768
0.000125	-0.14305
0.000125	-0.15895
0.00025	-0.06358
0.00025	-0.01589
0.000375	-0.19073
0.0005	-0.47684
0.000625	-0.68347
0.00075	-0.65168

Input Test Data directly Displacement(mm) and Force[N]

The load Data must be zero when Actual is no load.

⑥ Lap-Joint Test

Enter test results for both Shear Test and T-Peel Test



EQ Lap Shear and T-Peel Tests

F.4.3.7.b Samples must be tested in pure shear and T-peel.

EQ				
F.4.3.1	Dates of Shear tests:			N/A
F.4.3.7.a	Shear force at failure or maximum tested force:	0	N	N/A
	Shear test sample lap area:		mm^2	N/A
	Lap Joint Shear Strength:		N/mm^2	N/A
	Lap Joint Shear Strength:		Pa	N/A
	Lap Joint Shear Strength:		psi	N/A
F.4.3.7.b	Bond overlap length w:		mm	N/A
	100% shear strength/unit length:		N/mm	N/A
	UTS of skins σ_{UTS}:	4.72E+02	N/mm^2	N/A
	Outer skin thickness:	1.5	mm	N/A
	Load/unit length:	708.154	N/mm	N/A
F.4.3.7.d	Safety Factor		mm	N/A

EQ				
F.4.3.1	Dates of T-peel tests:			N/A
F.4.3.7.a	Force at failure or maximum tested force:	0	N	N/A
	T-peel test sample lap area:		mm^2	N/A
	Lap Joint T-peel Strength:		N/mm^2	N/A
	Lap Joint T-peel Strength:		Pa	N/A
	Lap Joint T-peel Strength:		psi	N/A
F.4.3.7.b	Bond overlap length w:		mm	N/A
	100% T-peel strength/unit length:		N/mm	N/A
	UTS of skins σ_{UTS}:	4.72E+02	N/mm^2	N/A
	Outer skin thickness:	1.5	mm	N/A
	Load/unit length:	708.154	N/mm	N/A
F.4.3.7.d	Safety Factor		mm	N/A

EQ			
F.5.5	0.5 * minimum (T-peel. shear):	0	MPa
	0.5 * minimum (T-peel. shear):	0.00E+00	Pa
	0.5 * minimum (T-peel. shear):	0.00E+00	psi
Bond prep process:			

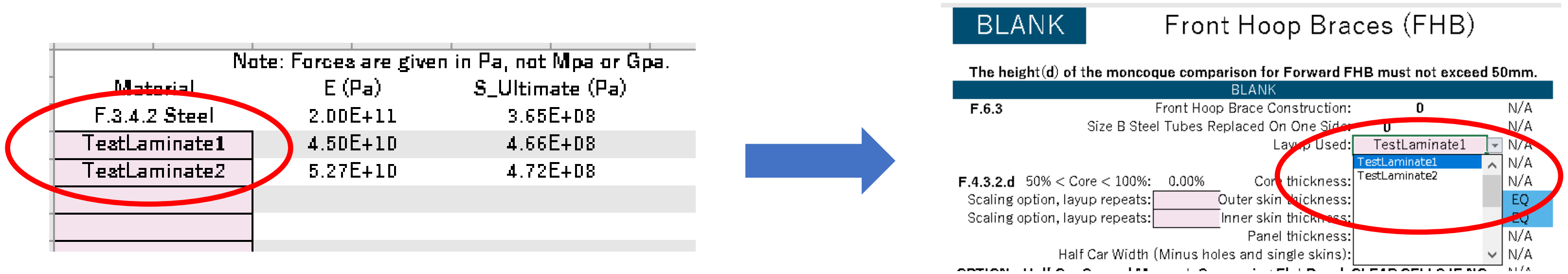
Enter pretreatment for adhesion in "Bond prep Process"
(e.g. polishing / degreasing)

F.4.3 Composite

- Different or Additional Layup
  If there are multiple types of layups, duplicate the SES F.4.3 Composite sheet and enter the test results each time

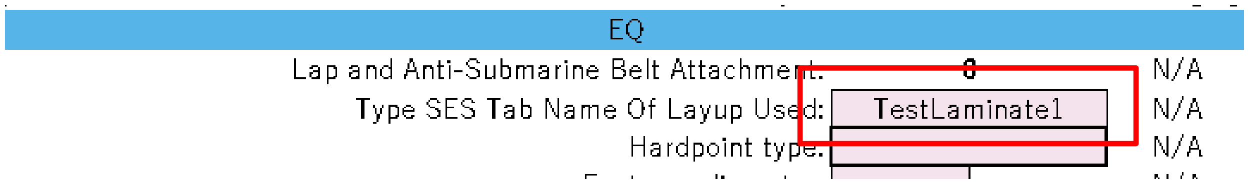
How to refer
F.7 Composite Chassis

Enter each sheet name in A4:B20 and select from the pull-down menu of each [Layup Used:]



F.7.9-10 Attachments / F.8 Front Protection

Enter the sheet name directly in each [Type SES Tab Name Of Layup Used]



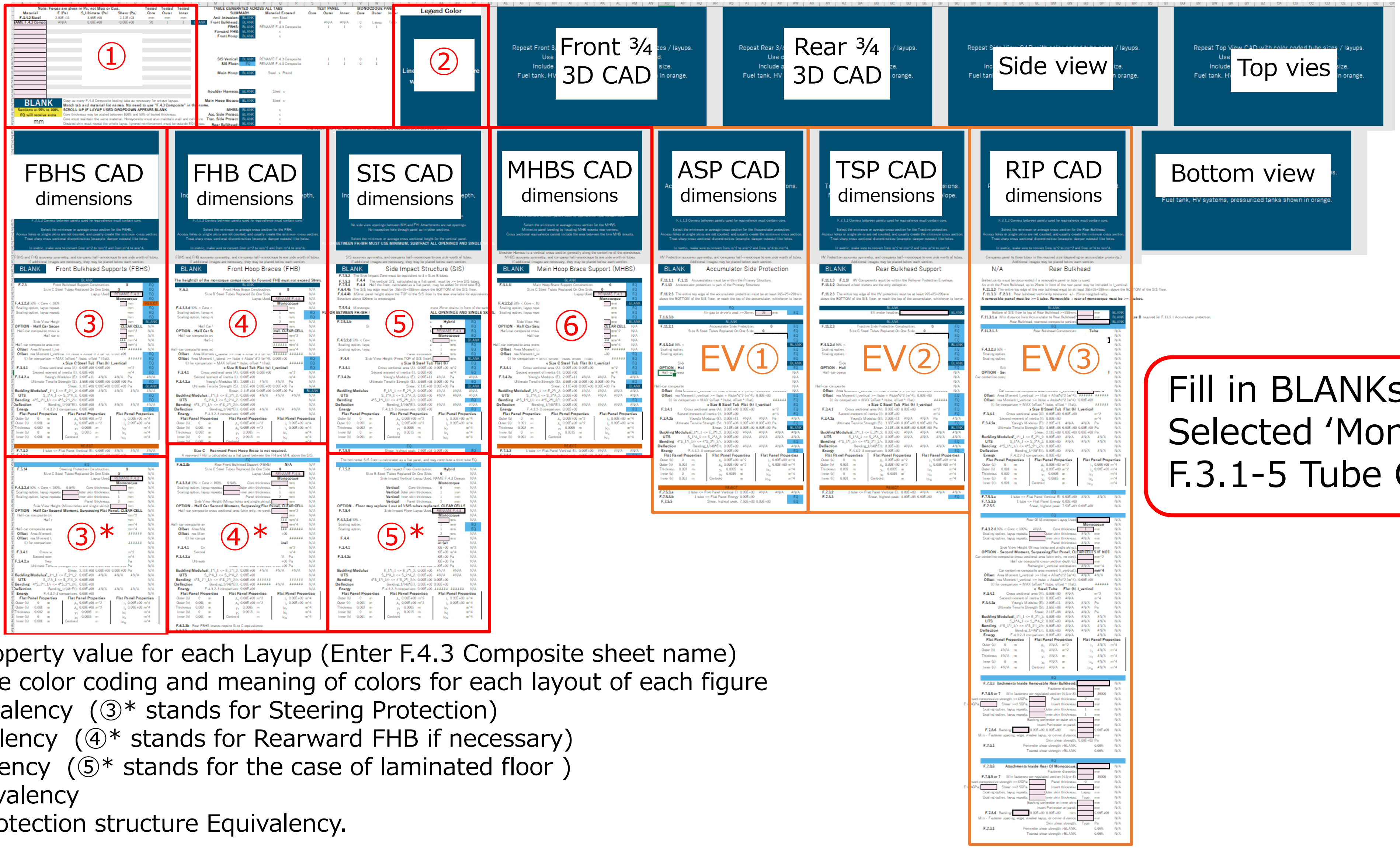
Monocoque SES

F.7 Composite Chassis

2025 v1.1 Compliant

F.7 Composite Chassis

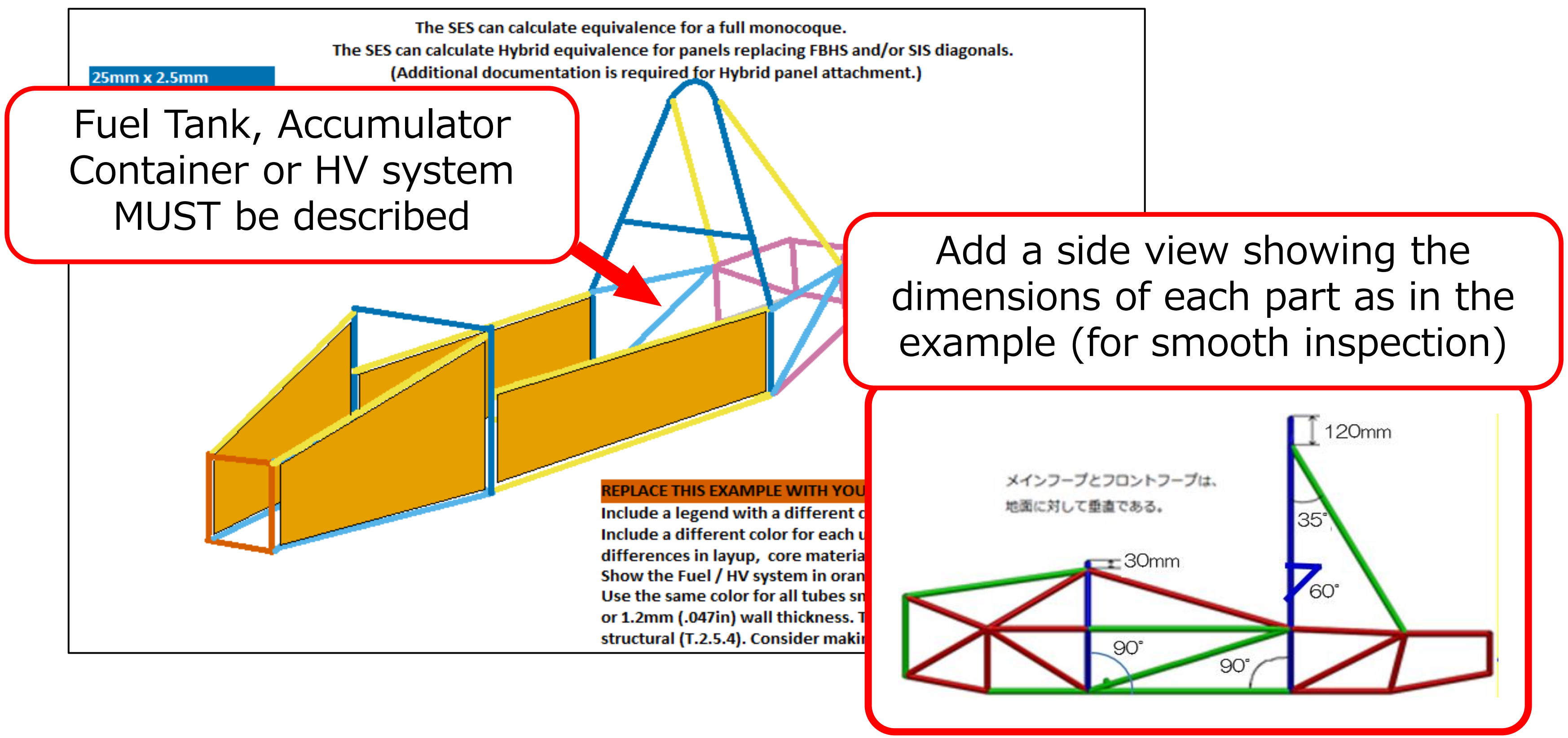
- Summary of F.7 Composite Chassis sheet



Fill in BLANKs where Selected ‘Monocoque’ in F.3.1-5 Tube Chassis

① Physical property value for each Layup (Enter F.4.3 Composite sheet name)
② Describe the color coding and meaning of colors for each layout of each figure
③ FBHS Equivalency (③* stands for Steering Protection)
④ FHB Equivalency (④* stands for Rearward FHB if necessary)
⑤ SIS Equivalency (⑤* stands for the case of laminated floor)
⑥ MHBS Equivalency
EV①-③ EV Protection structure Equivalency.

- Entry Example of 3/4 CAD



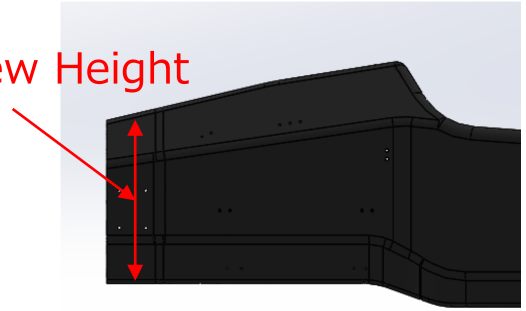
1. Show the requested CAD
2. Fuel Tank or Accumulator Container be described
3. It is recommended that the color coding of the pipe is the same as the sample.
4. All pipes with an outer diameter of <25 mm or a wall thickness of <1.2 mm Should be of the same color.

- Front Bulkhead Supports (FBHS)

(1) Flat panel calculation

⇒ Equivalence to 3 Size-B steel tubes is evaluated based on Side View Height
Indicate that the entered Panel Height should be the weakest dimension
(If there is an opening, subtract its dimension)

Side View Height



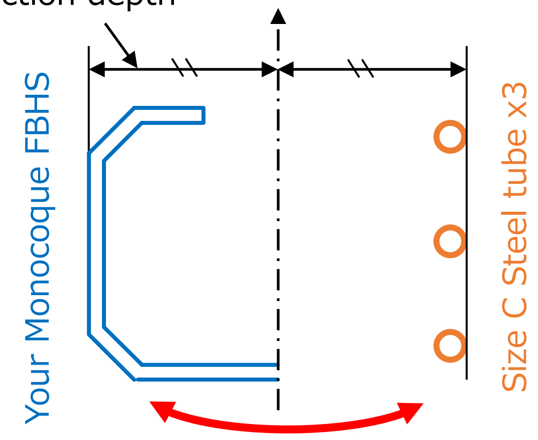
All Dimensions entered to SES must be shown by CAD Images

(2) If equivalence is less than 100% in (1), use OPTION – Half Car ~

Enter the Cross-sectional area of **skin only** to "Half-car composite cross sectional area"

Enter the Outer Width from car center axis to "Half-car composite cross-section depth" (refer to right fig.)

Enter the area moment of inertia Izz for **only the skin** around the vehicle center axis (Z axis) to "Half-car composite second moment about car centerline"



The actual calculation is to calculate the magnification of the moment of inertia around the Z-Axis when the flat panel is at half-car width, and then multiplying the flat panel by that magnification and comparing it with 3 Tubes. Since it is only about 130% at most, it is desirable to design it so that it can be achieved with a flat panel.

- Supplement of OPTIONAL Calculation

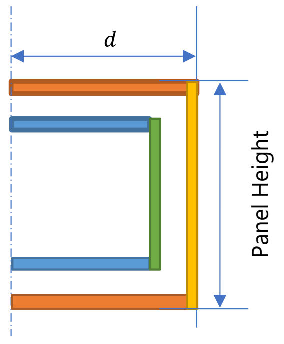
Rectangle I_vertical estimation: mm^4

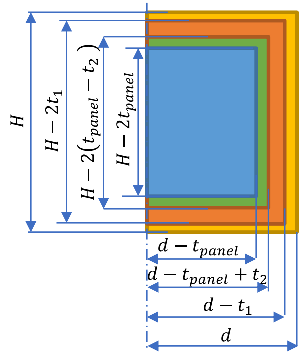
Rectangle I_* estimation

Maximum rectangular MOI estimation

based on panel specifications, panel height, and Half car width

MOI : second Moment of Inertia

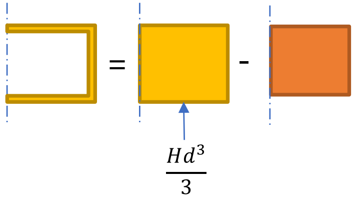




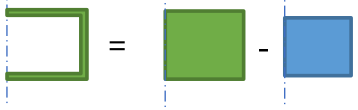
I_{ZZ} estimation

$$= \frac{Hd^3-(H-2t_1)(d-t_1)^3}{3} + \frac{\{H-2(t_{panel}-t_2)\}(d-t_{panel}+t_2)^3-(H-2t_{panel})(d-t_{panel})^3}{3}$$

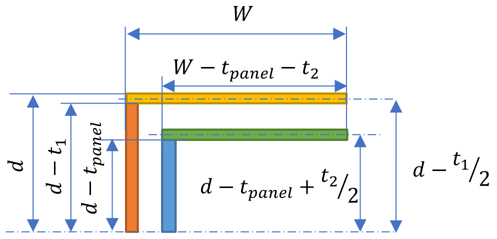
Moment of inertia of outer skin cross-section



Moment of inertia of Inner skin cross-section



For FHB



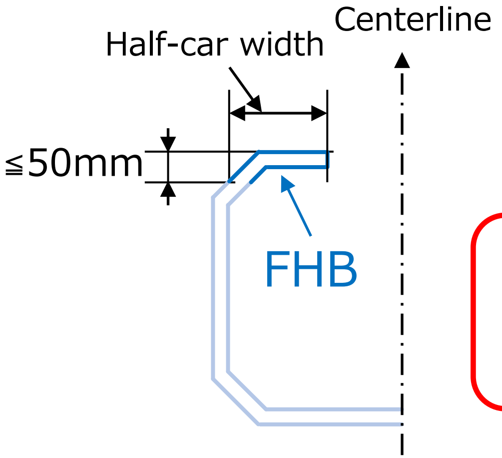
$$I_{ZZ} \text{ estimation} = \frac{Wd^3-(W-t_1)(d-t_1)^3}{3} + \frac{(W-t_{panel}+t_2)(d-t_{panel}+t_2)^3-(W-t_{panel})(d-t_{panel})^3}{3}$$

The actual MOI cannot be greater than the rectangle estimation

- Front Hoop Brace (FHB)

(1) Flat panel calculation

⇒ Equivalence to 1 Size-B steel tube is evaluated based on Panel Width
Indicate that the entered Panel Width should be the weakest dimension
(If there is an opening, subtract its dimension)



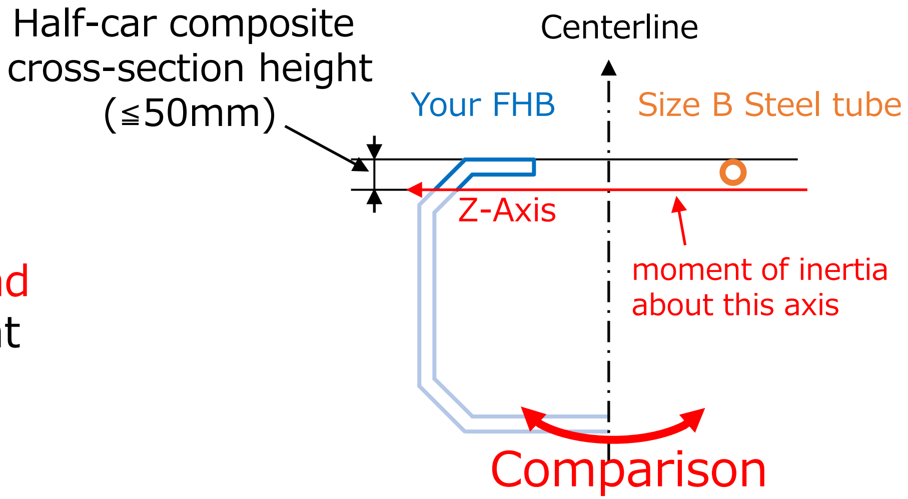
All Dimensions entered to SES must be shown by CAD Images

(2) If equivalence is less than 100% in (1), use OPTION – Half Car ~

Enter **the Cross-sectional area of skin only** to "Half-car composite cross sectional area"

Enter FHB height from top (≦ 50mm) to "Half-car composite cross-section height"

Enter the area moment of inertia Izz for **only the skin** around **Z axis in right figure** to "Half-car composite second moment about car centerline"



- Side Impact Structure (SIS)

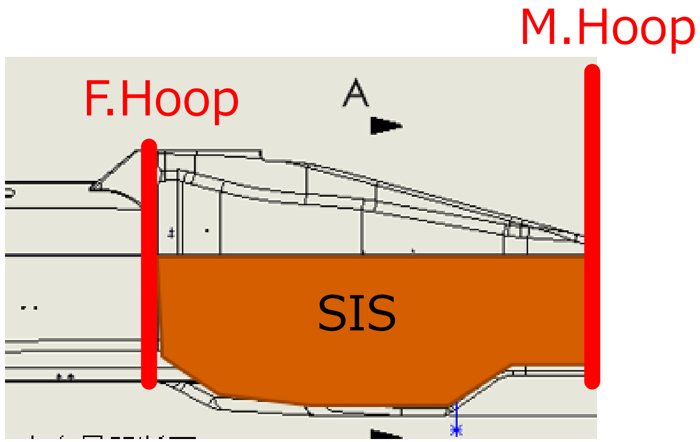
(1) Flat panel calculation

No allowance for geometric form calculation.(F.4.4)

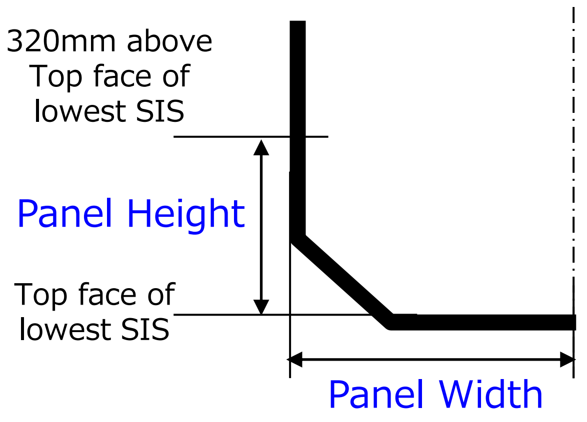
The following equivalence is evaluated:

- Vertical Wall (Side view height) vs 2 Size-B Steel tubes
- Horizontal Wall (Floor width) vs 1 Size-B Steel tube

If there is an opening, subtract its dimension



Geometric form is ignored



Side impact structure

Notice : Floor width must be the minimum between FH and MH

FLOOR BETWEEN FH/MH MUST USE MINIMUM, SUBTRACT ALL OPENINGS AND SINGLE SKINS.

SIS is the most important Driver Protection same as Roll Hoop among Primary Structures, so be sure to prove equivalence based on The Rules!

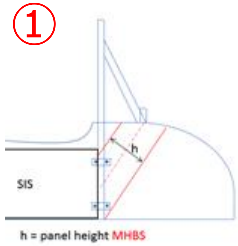
All Dimensions entered to SES must be shown by CAD Images

- Main Hoop Brace Support(MHBS)

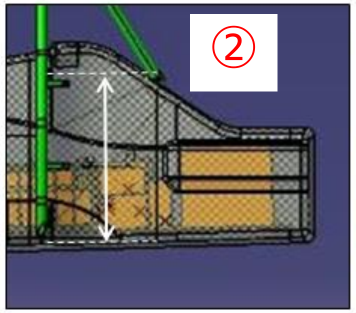
(1) Flat panel calculation

⇒ Equivalence to 1 Size-B steel tube is evaluated based on Panel Width
Indicate that the entered Panel Width should be the weakest dimension
(If there is an opening, subtract its dimension)

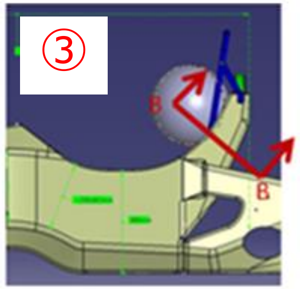
①



Ideally, monocoques orient their strength from midway between the MH mounts to the MHB.



Monocoques that extend below the MHB to a flat floor may use this flat panel height.



Monocoques with a limited path must use the minimum section, and are strongly encouraged to monitor laminate directional strength.

Usually use the dimension h of ①

Monocoque that extend below the MHB
to flat floor may use Panel Height of ②

③ refer to (2) OPTION calculation

All Dimensions entered to SES must be shown by CAD Images

(2) If equivalence is less than 100% in (1), use OPTION – Half Car ~
Same as FBHS

F.7 Composite Chassis

- Accumulator Side Protection
- Tractive Side Protection
- Rear Impact Protection

(1) Flat panel calculation

⇒ Equivalence to Specified condition is evaluated based on input dimension
Indicate that the entered dimensions should be the weakest dimension
(If there is an opening, subtract its dimension)

(2) If equivalence is less than 100% in (1), use OPTION – Half Car ~
Same as FBHS

For Detachable Rear Impact Protection
Enter the structure description in the field. Refer to the Attachment section for How to describe

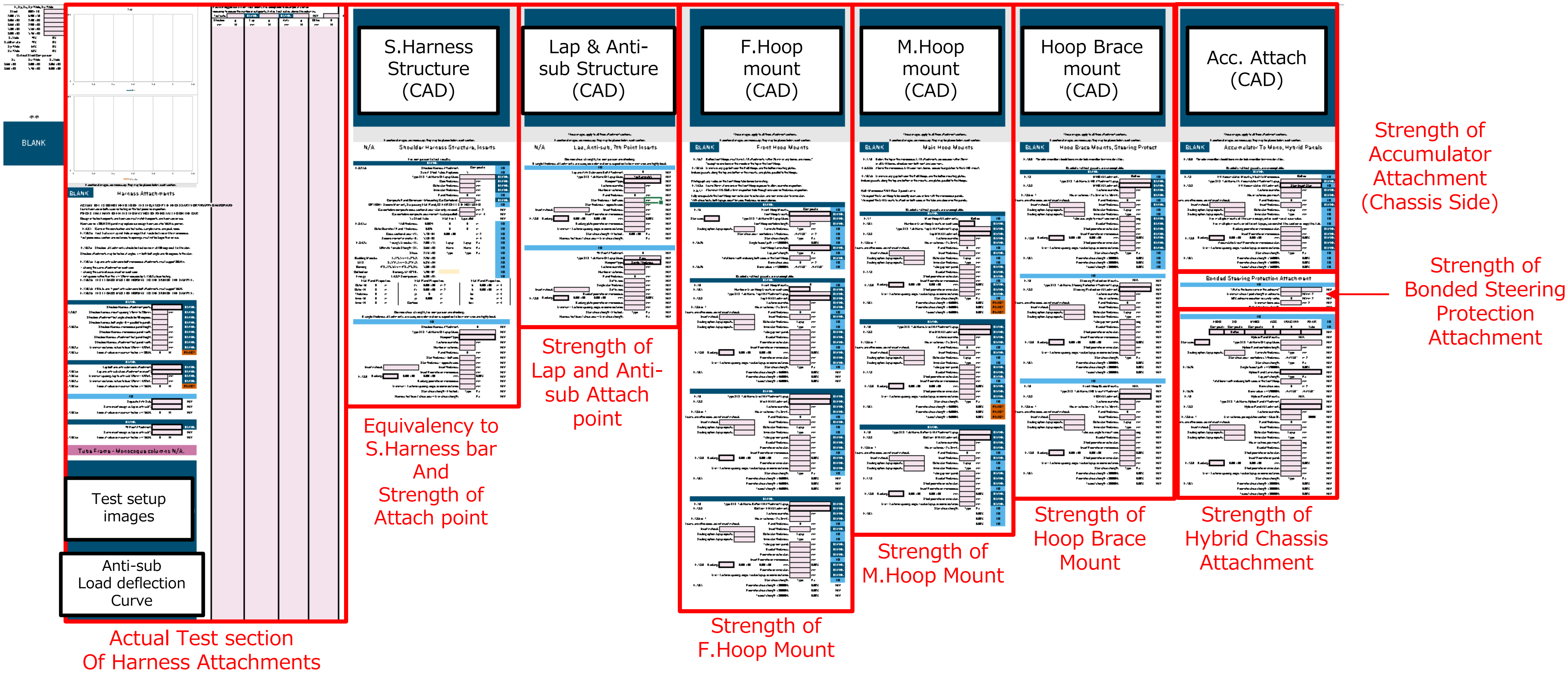
Monocoque SES

F.7.8-9 Attachments

2025 v1.1 Compliant

F.7.8-9 Attachments

- Summary of F.7.8-9 Attachments sheet



Select Structure and fill in BLANKs

F.7.8-9 Attachments

- Harness Attachments

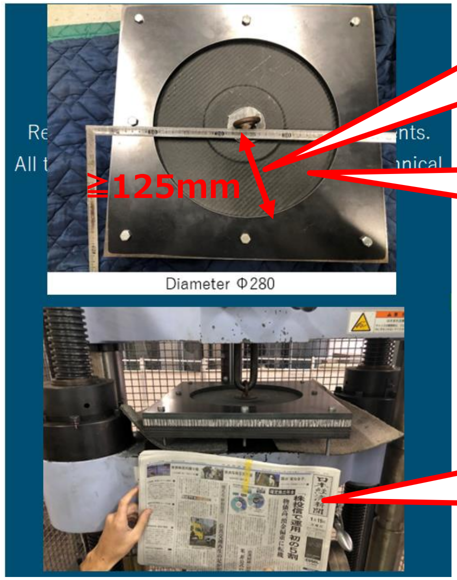
	EQ			
	Shoulder Harness attachment points:	Monocoque		EQ
T.2.6.2	Shoulder harness mount spacing 175mm to 235mm:	200	mm	EQ
	Shoulder attachment test angle should be 90 degrees:	90		EQ
	Shoulder harness belt angle (0 = parallel to panel):			N/A
F.7.10.2.c	Shoulder Harness monocoque panel height:	400	mm	EQ
	Shoulder Harness monocoque panel width:	400	mm	EQ
	Shoulder Harness attachment test panel height:	400	mm	EQ
	Shoulder Harness attachment test panel width:	400	mm	EQ
F.7.10.2.a	Minimum distance, fixture to load 125mm (4.92in):	130	mm	EQ
F.7.10.1.a	Force at failure or maximum tested >= 30kN:	31776.525	N	EQ
	EQ			
	Lap belt and anti-submarine attachment:	Monocoque		EQ
F.7.10.1.d	Lap and anti-sub share attachment or insert?:	Yes		
F.7.10.1.d	Minimum spacing, lap to anti-sub 125mm (4.92in):		mm	N/A
F.7.10.2.a	Minimum distance, fixture to load 125mm (4.92in):	130	mm	EQ
F.7.10.1.d	Force at failure or maximum tested >= 30kN:	31776.525	N	EQ
	EQ			
	Separate Anti-Sub:	Monocoque		N/A
	Same insert design as lap or anti-sub?:	Yes		
F.7.10.1.c	Force at failure or maximum tested >= 15kN:	0	N	N/A
	EQ			
	7th Point Attachment:	Six Point Harness		EQ
	Same insert design as lap or anti-sub?:			N/A
F.7.10.1.c	Force at failure or maximum tested >= 15kN:	0	N	N/A

Tube Frame - Monocoque columns N/A.

Load Direction is specified in the Rules

If Lap and Anti-sub share Attachment ⇒ Yes

If the design of Anti-sub attachment is same as Lap ⇒ Yes

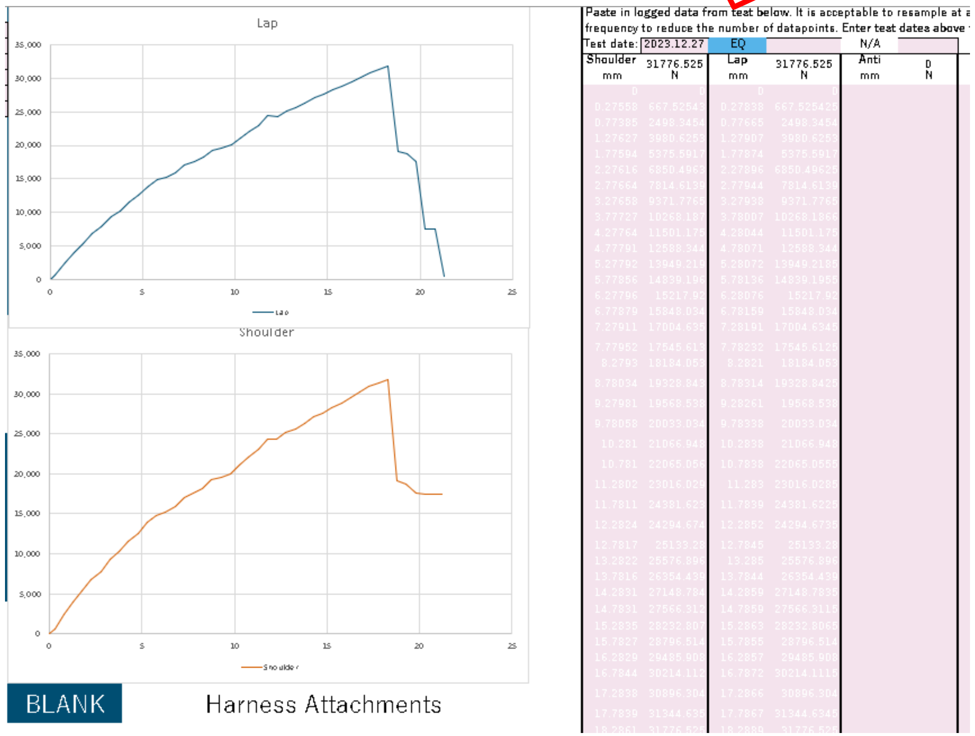


The load point must be **no less than 125mm** away from the fixture

Test panel must NOT be larger than actual size

Test Setup photo should show also test date

Input Test Data directly Displacement(mm) and Force[N]



The load Data must be zero when Actual is no load.

Chart for Shoulder and Lap are automatically created. However, not for Anti-sub, so you must create the Chart yourself if it’s necessary

F.7.8-9 Attachments

- Shoulder Harness Structure,Inserts (Lap, Anti-sub, 7th Point Inserts)

  At Upper part of Shoulder Harness Structure Section,

  the equivalence to Shoulder Harness Bar(Size-B Steel tube) is evaluated.
  At Other Section, Pull-out and Tear-out strength of each attachment are evaluated.

EQ Shoulder Harness Structure, Inserts

For comparison to test results.

			EQ				
F.3.2.1.k	Shoulder Harness Attachment:	Composite					
	Size A Steel Tubes Replaced:	1					
	Type SES Tab Name Of Layup Used:	TestLaminat					
	Core thickness:	20	mm				
	Outer skin thickness:	1.5	mm				EQ
	Inner skin thickness:	1.5	mm				EQ
	Panel thickness:	23	mm				EQ
	Composite Panel Dimension (Intersecting Car Centerline):	200	mm				
	OPTION - Second Moment, Surpassing Flat Panel, CLEAR CELLS IF NOT USE						
	r centerline composite cross sectional area (skin only. no core):		mm^2				
	Car centerline composite area moment (I_skinparallel):		mm^4				
		1 x Steel Tube	Flat h or L	I_parallel			
F.3.4.1.a	Wall thickness:	0.0024	0.0015	0.0015	m		EQ
	Outer Diameter / Panel Thickness:	0.025	0.0015	0.0015	m		EQ
	Cross sectional area (A):	1.73E-04	6.00E-04		m^2		EQ
	Second moment of inertia (I):	1.13E-08	6.95E-08		m^4		EQ
F.3.4.2a	Young's Modulus (E):	2.00E+11	5.27E+10	5.27E+10	Pa		EQ
	Ultimate Tensile Strength (S):	3.65E+08	4.72E+08	4.72E+08	Pa		EQ
	Shear:	2.11E+08	9.14E+07	9.14E+07	Pa		EQ
Buckling Modulus	E_1*I_1 <= E_2*I_2:	2.26E+03	3.66E+03			161.66%	EQ
UTS	S_1*A_1 <= S_2*A_2:	6.31E+04	2.83E+05			448.59%	EQ
Bending	4*S_1*I_1/r <= 4*S_2*I_2/r:	1.30E+03	1.75E+05			#######	EQ
Deflection	Bending_1/(48*EI):	1.20E-02	7.41E-03			61.86%	EQ
Energy	F.4.3.2-3 comparison:	5.80E+01	2.84E+02			490.25%	EQ

Flat Panel Properties			Flat Panel Properties			Flat Panel Properties		
Outer (b)	0.2	m	A_1	3.00E-04	m^2	I_1	5.63E-11	m^4
Outer (h)	0.0015	m	A_2	3.00E-04	m^2	I_2	5.63E-11	m^4
Thickness	0.023	m	y_1	0.00075	m	Ic_1	3.47E-08	m^4
Inner (b)	0.2	m	y_2	0.022	m	Ic_2	3.47E-08	m^4
Inner (h)	0.0015	m	Centroid	0.012	m	Ic_{12}	6.95E-08	m^4

Enter the applicable Laminate sheet name

The length of the short side of the panel should be entered

Show each dimension entered to cells

Derived shear strength, for comparison and checking.
If single thickness attachments are used, core elimination is expected to be minimized and highly local.

			EQ			
		Shoulder Harness Attachment:	Monocoque			EQ
		Type SES Tab Name Of Layup Used:	TestLaminate2			EQ
		Hardpoint type:	Skin-Insert-Skin			EQ
		Fastener diameter:	8	mm		EQ
		Number of fasteners:	2			EQ
		Panel thickness:	1.5	mm		EQ
		Skin thickness - belt side:	0	mm		EQ
		Skin thickness - opposite side:	1.5	mm		EQ
Insert material:	Aluminium	Insert thickness:	0	mm		EQ
		Insert Perimeter on monocoque:	150	mm		EQ
F.7.8.6	Backing: Steel	2.00E+11 1.76E+08 mm:	2	200.00%		EQ
		Backing perimeter on monocoque:	86	mm		EQ
		Minimum - Fastener spacing. edge. or corner distance:	90	mm		EQ
		Skin shear strength (If tested):	9.14E+07	Pa		EQ
		Harness test load / shear area = Min shear strength:	2.46E+08	Pa		EQ

Structure must follow the Rules
For Harness Attachments, equivalence should be proven through actual tests, so if it is filled in, it will be EQ

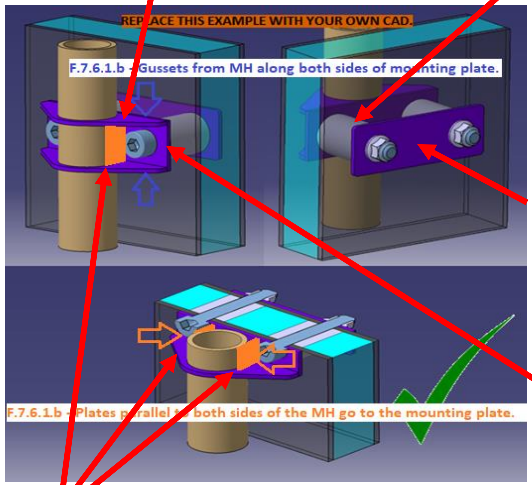
F.7.8-9 Attachments

- Attachment Calculation

Gusset

Insert

F7.8.8 a or b



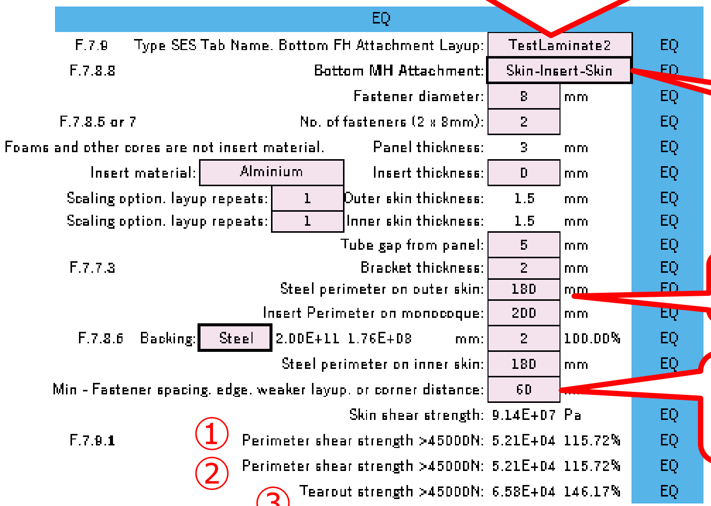
Backing Plate

Mount Plate

Parallel Plate (Steel t2 or thicker)
M.Hoop & F.Hoop Attachment
MUST satisfy F.7.6.1

All Dimensions entered to SES must be shown by CAD Images

Enter the applicable Laminate sheet name



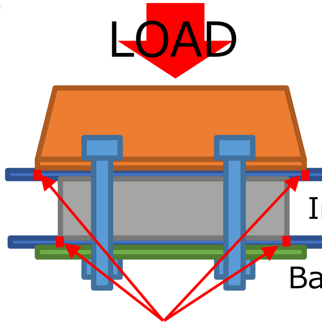
				EQ		
F.7.9			Type SES Tab Name. Bottom FH Attachment Layup:	TestLaminate2		EQ
F.7.8.8			Bottom MH Attachment:	Skin-Insert-Skin		EQ
			Fastener diameter:	8	mm	EQ
F.7.8.5 or 7			No. of fasteners (2 x 8mm):	2		EQ
Foams and other cores are not insert material.			Panel thickness:	3	mm	EQ
	Insert material:	Alminium	Insert thickness:	0	mm	EQ
	Scaling option. layup repeats:	1	Outer skin thickness:	1.5	mm	EQ
	Scaling option. layup repeats:	1	Inner skin thickness:	1.5	mm	EQ
			Tube gap from panel:	5	mm	EQ
F.7.7.3			Bracket thickness:	2	mm	EQ
			Steel perimeter on outer skin:	180	mm	EQ
			Insert Perimeter on monocoque:	200	mm	EQ
F.7.8.6	Backing:	Steel	2.00E+11 1.76E+08 mm:	2	100.00%	EQ
			Steel perimeter on inner skin:	180	mm	EQ
			Min - Fastener spacing. edge. weaker layup. or corner distance:	60	mm	
			Skin shear strength:	9.14E+07	Pa	EQ
F.7.9.1	①		Perimeter shear strength >45000N:	5.21E+04	115.72%	EQ
	②		Perimeter shear strength >45000N:	5.21E+04	115.72%	EQ
	③		Tearout strength >45000N:	6.58E+04	146.17%	EQ

Laminate Type(F.7.8.8a or b)

Structural Dimensions

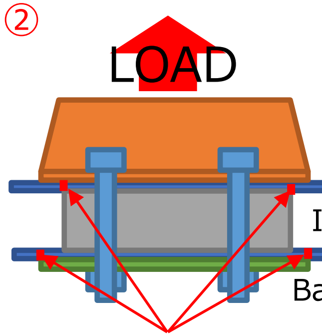
Distance to the nearest Panel Edge

①



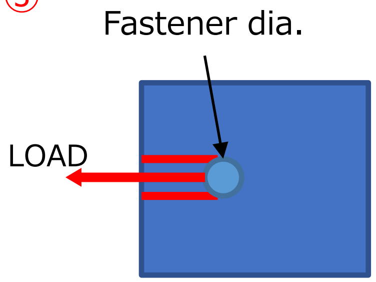
Perimeter Shear

②



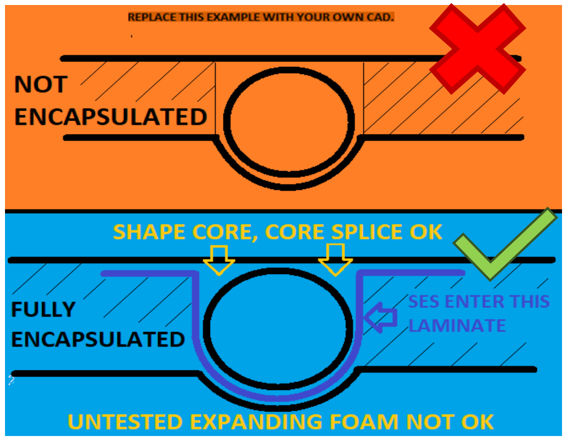
Perimeter Shear

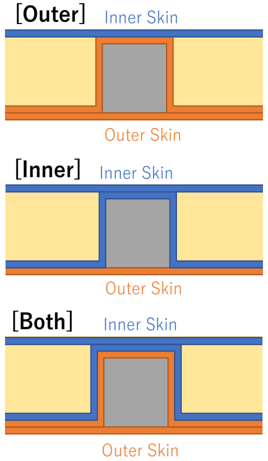
③

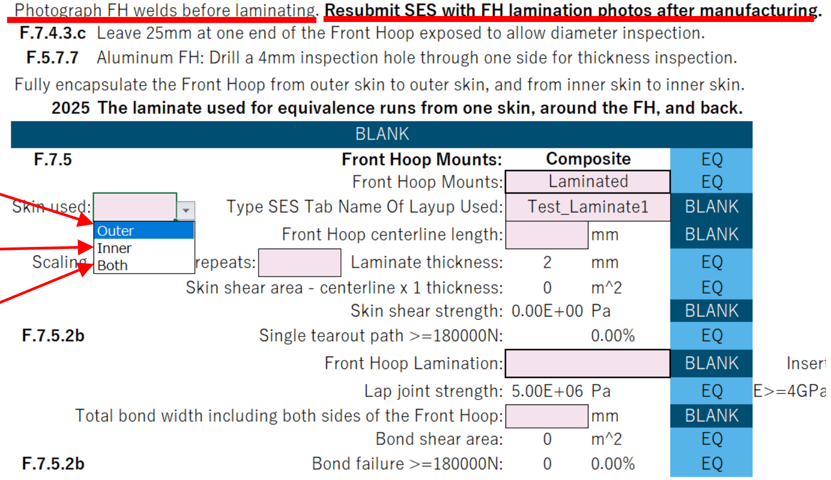


Tearout

- Full-Laminated Front Hoop






Photograph FH welds before laminating. **Resubmit SES with FH lamination photos after manufacturing.**

F.7.4.3.c Leave 25mm at one end of the Front Hoop exposed to allow diameter inspection.

F.5.7.7 Aluminum FH: Drill a 4mm inspection hole through one side for thickness inspection.

Fully encapsulate the Front Hoop from outer skin to outer skin, and from inner skin to inner skin.

2025 The laminate used for equivalence runs from one skin, around the FH, and back.

	BLANK			
F.7.5	**Front Hoop Mounts:**	**Composite**		EQ
	Front Hoop Mounts:	Laminated		EQ
Skin used: [Outer / Inner / Both]	Type SES Tab Name Of Layup Used:	Test_Laminate1		BLANK
	Front Hoop centerline length:		mm	BLANK
Scaling repeats:	Laminate thickness:	2	mm	EQ
	Skin shear area - centerline x 1 thickness:	0	m^2	EQ
	Skin shear strength:	0.00E+00	Pa	BLANK
F.7.5.2b	Single tearout path >=180000N:		0.00%	EQ
	Front Hoop Lamination:			BLANK
	Lap joint strength:	5.00E+06	Pa	EQ
	Total bond width including both sides of the Front Hoop:		mm	BLANK
	Bond shear area:	0	m^2	EQ
F.7.5.2b	Bond failure >=180000N:	0	0.00%	EQ

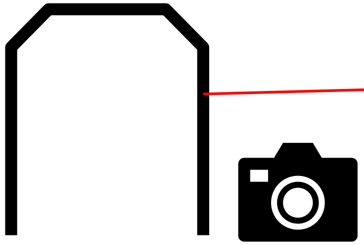
Inser E>=4GPa

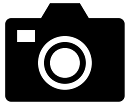
Not Encapsulated laminated Front Hoop is NOT considered "Full-Laminated"

Attach a CAD image of the cross-section as the evidence

Two Photographic Evidences are required
They must be attached to resubmit before the submission of shakedown certification

Before Laminated





Lamination Photo
Photos of the production process are better

F.7.8-9 Attachments

- Insert Material

"MPa" Typo

Insert compressive strength >=12GPa:

E>=4GPa:　　　Shear >=2.5GPa:

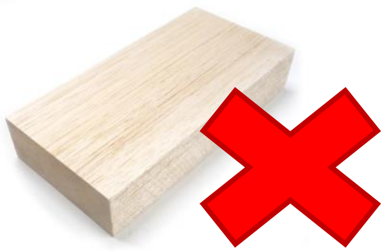
Assessing the Insert Material property

They will be ignored 2025 FSAEJ, so enter larger number.
However, describe Insert Material in additional info.

[Guide To 2025 FSAE Frame Rule Changes — DesignJudges.com]

Per F.7.8.8, bolted attachment points with test loads (roll hoops, accumulator, AIP, removable rear impact, etc.) require either solid inserts or single thickness layup hardpoints with no core. Inserts provide extra local stiffness as a load path to prevent core crush and engage both skins in the pullout load. You can see that if you work through the SES math. Core material alone does not serve this function. Core alone could allow one skin to be loaded and failed in shear before loading the other skin, basically cutting the load rating of the attachment in half. We have done an initial review of materials. We expect all monocoque teams this year to work toward using inserts that are at least 4GPa modulus, 2.5MPa shear, and 12MPa compression strength. These minimums are effectively End Grain Balsa, but not the engineered balsas whose properties are half as much. We will work with teams and assess the information that comes in this year to write a proper rule for 2026.

End Grain Balsa



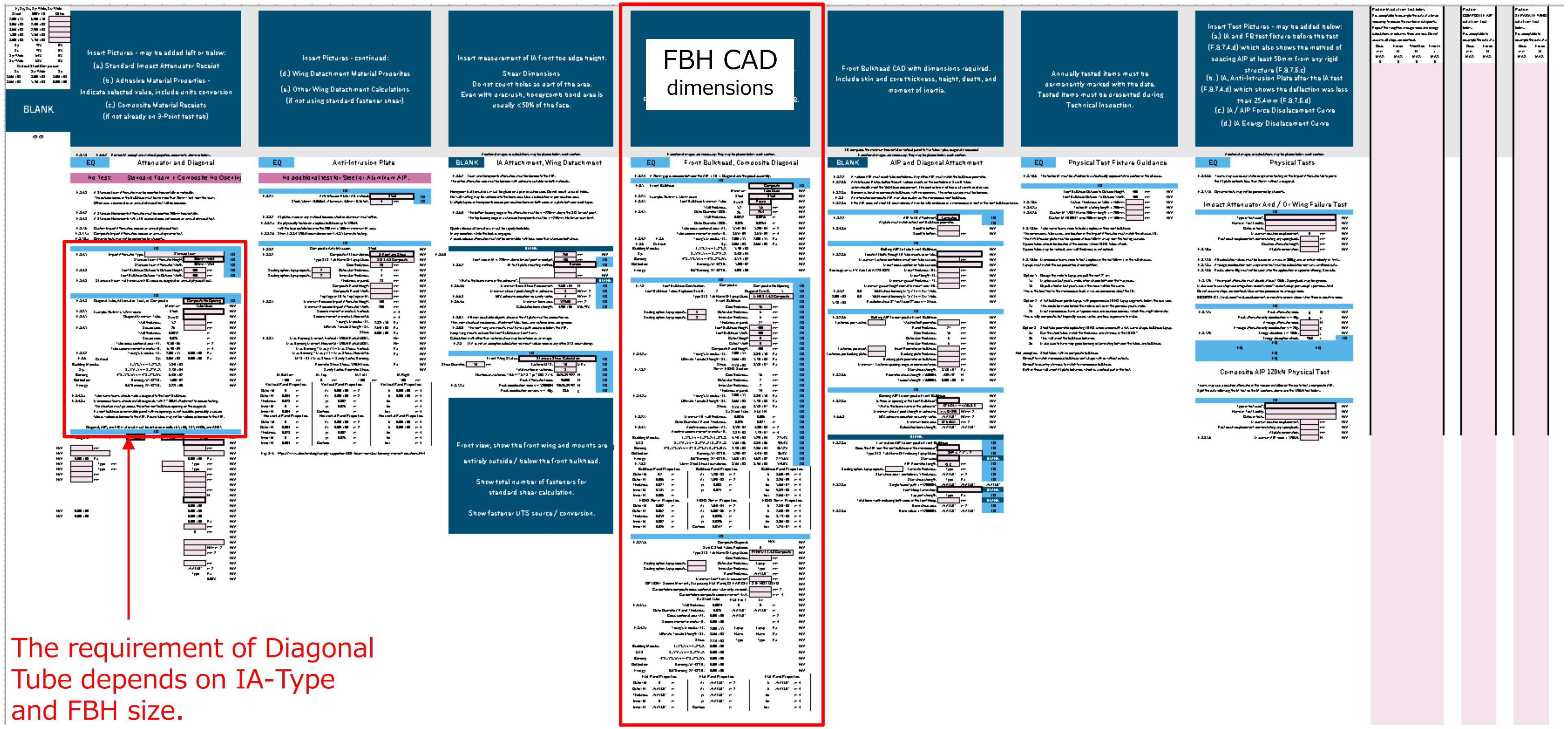
Common Balsa
(Engineered Balsa)

Monocoque SES

F.8 Front Protection

2025 v1.1 Compliant

- Focus on Monocoque (other items are referenced the guidance for F.8)



The requirement of Diagonal Tube depends on IA-Type and FBH size.

↓

If Diagonal is required, choose a conformance certification F.8.4.3 method

Equivalency of FBH

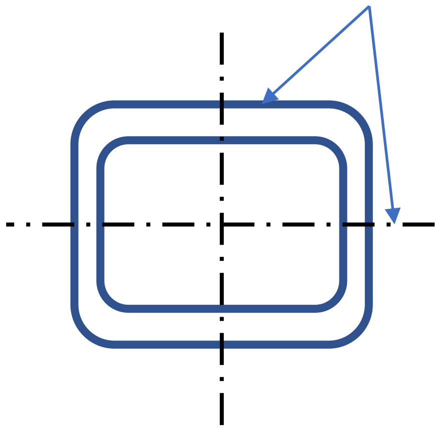
Select Structure and fill in BLANKs

- Front Bulkhead, Composite Diagonal

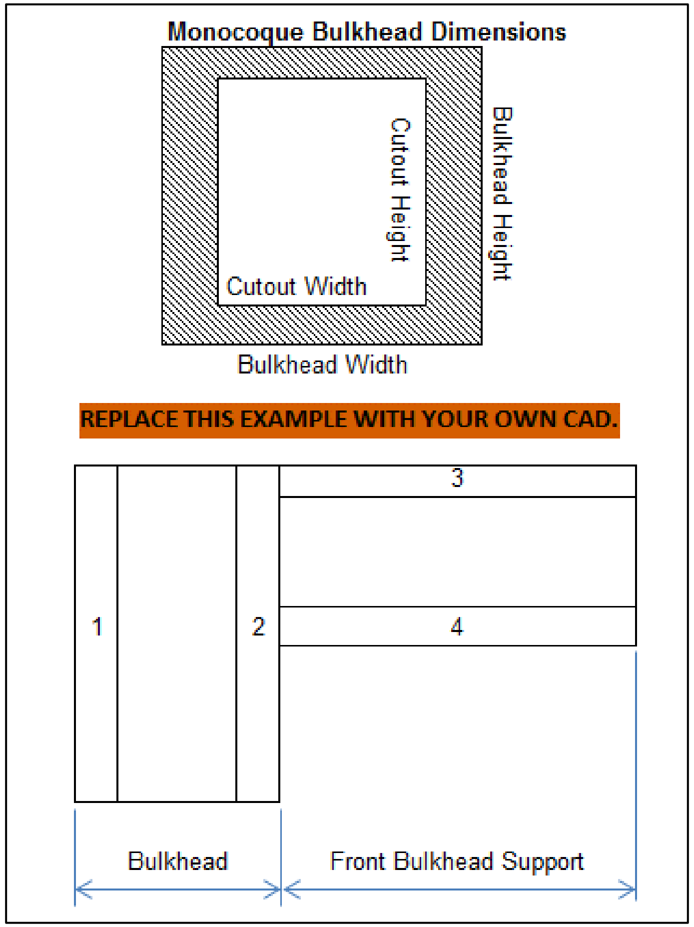
(1)Flat Panel Calculation

⇒ Equivalence to 2 Size-B steel Tubes is evaluated based on L shape Model

Weaker cross-section is used for calculation



Since the input value of F.7 Composite Chassis is used for the FBHS part, enter them first



F.7.2.1 L shaped Model