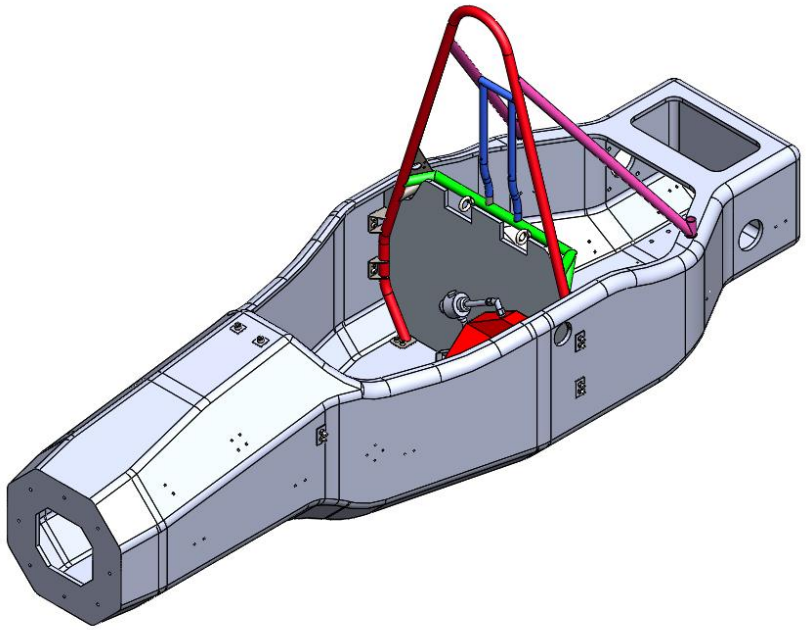
# 2024 Structural Equivalency Spreadsheet

Monocoque

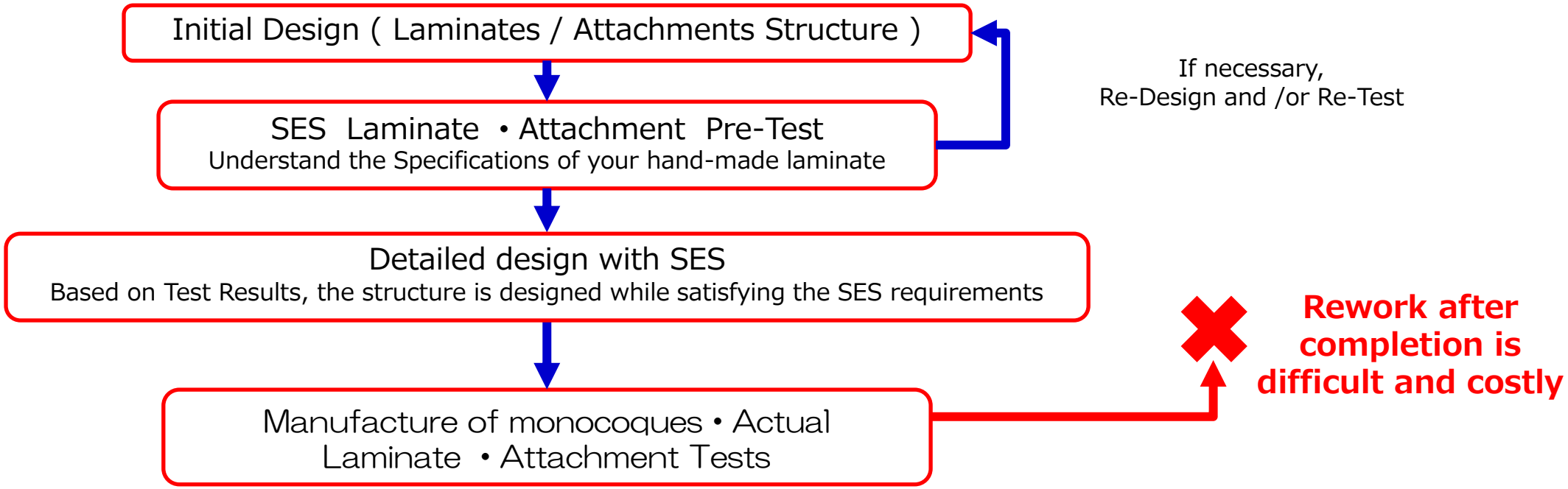


2024 v1.2 Compliant

# How to describe Monocoque SES

- Design flow with SES

  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

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

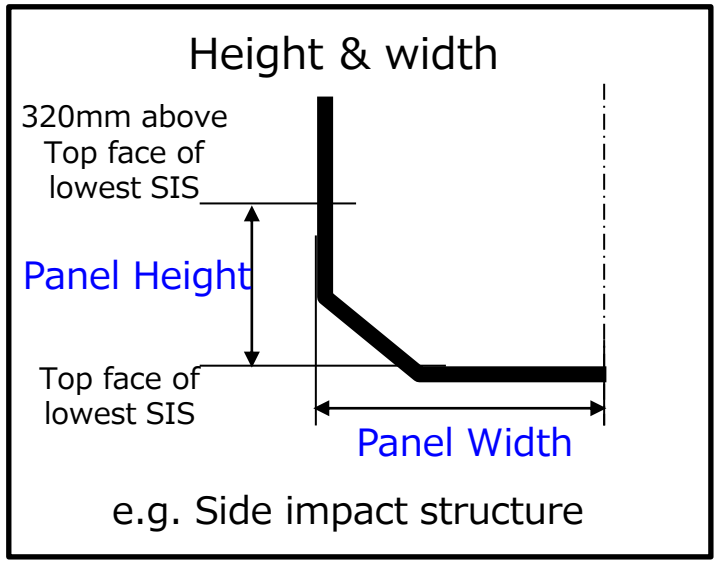
⑥ Fill in remaining BLANKs

* Of course, BLANKs may be filled when possible.

# Basic Calculations of Monocoque Equivalence

- Equivalent Flat Panel Calculation (F.4.4)

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)

# Basic Calculations of Monocoque Equivalence

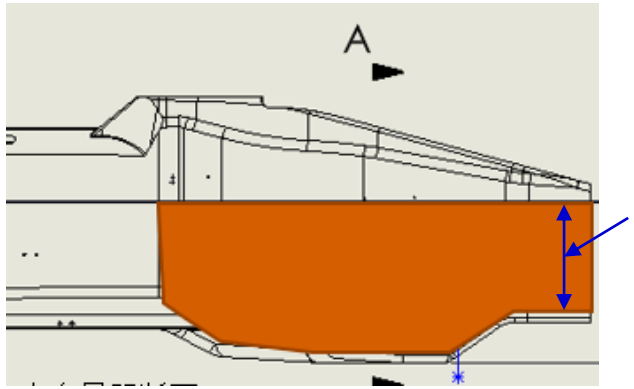
- Height/Width of Flat Panel cross-section

2024 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 most caces... **(Max.+Min.)/2≠Average**

Describe the calculation process in the SES.

2024 Monocoque SES

# F.4.3 Composite

2024 v1.2 Compliant

# F.4.3 Composite

- 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.4.3.1b ).

Contents of F.4.3 Composite

①Quasi-Isotropy F.4.2, F.4.3.6

② 3-point Bending of Size-B Steel Tube(s) F.4.3.3, F.4.3.4

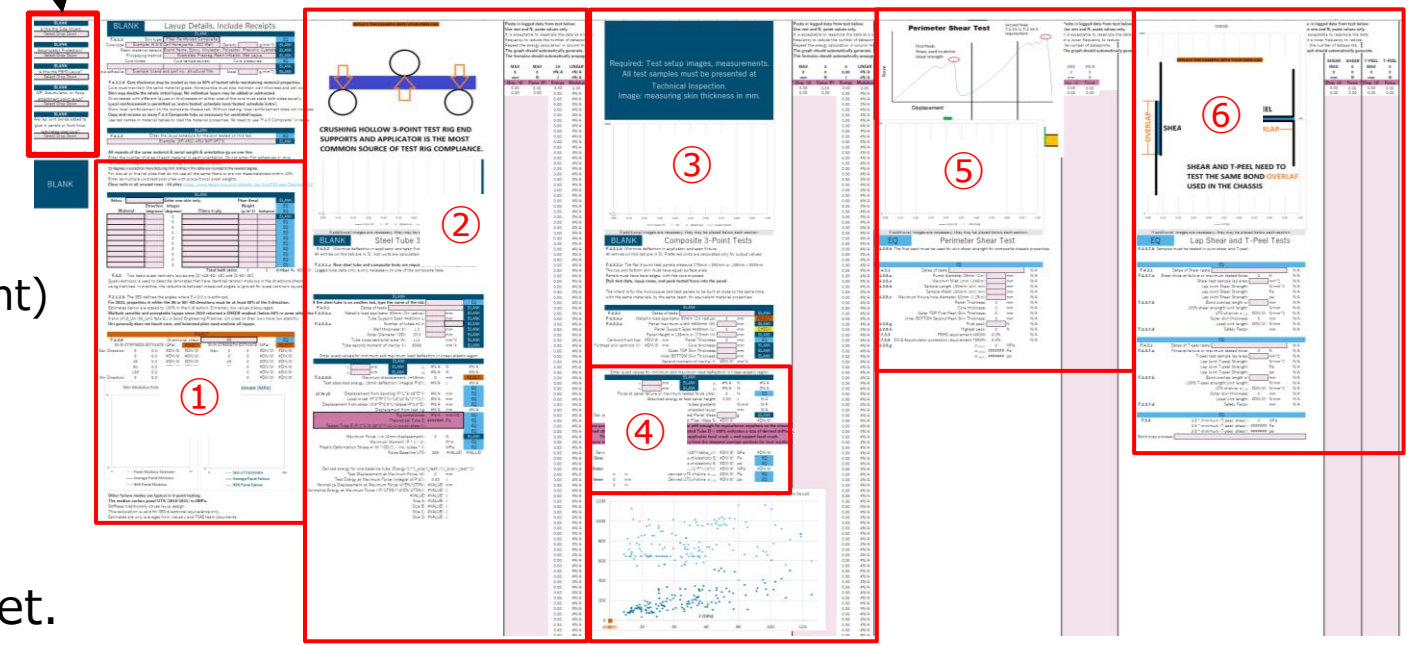
③Laminate Test (3-Point Bending) F.4.3.2, F.4.3.4

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

⑤Shear strength(SIS/FBHS/Acc.Protection/Attachment) F.4.3.5

⑥Shear & Peel strength of adhesion F.4.3.7

Select the Purpose of the Laminate correctly




If you have Different Layup, duplicate this sheet.

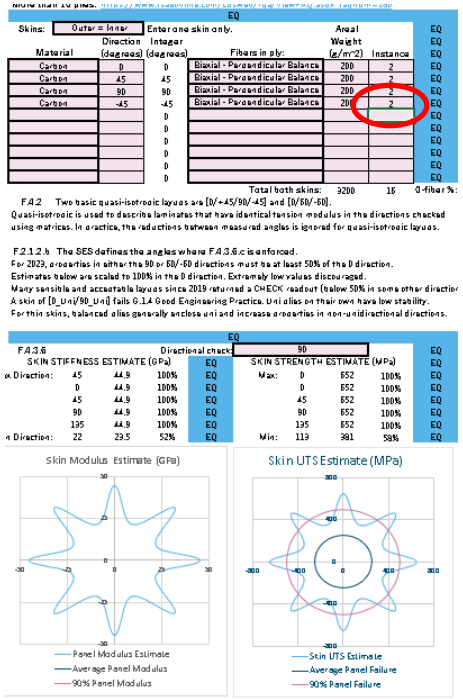
# F.4.3 Composite

## ① Quasi-Isotropy

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)

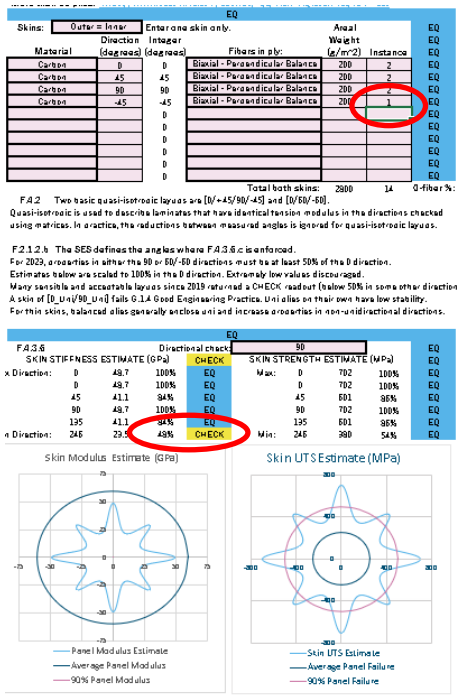



For example, if you subtract 1ply from [0/45/90/-45] evenly

Reduced stiffness in specific directions
⇒ Loss of quasi-isotropy

±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.

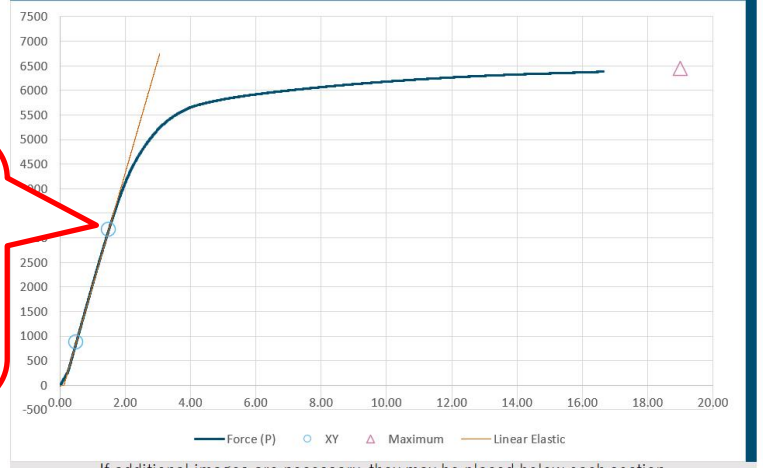


## ② Steel Tube 3-Points Test - How to describe -

**Take a photo with the date in the photo**

**Simultaneous Shooting of the Rig and Scale**

**In 2024 SES, 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

**F.4.3.2** Minimize deflection in applicator and span fixture.
All entries on this tab are in SI. Inch units are calculated only for output values.

**F.4.3.1.a New steel tube and composite tests are required for new monocoque builds.**
Logged tube data only is only necessary on one of the composite tabs.

**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 |
|---|---|---|---|
| 20.00001 | 6441.15527 | 0.00 | 2.30E+03 |
| mm | N | J | -2.84E+02 |
| Disp. (d) | Force (P) | Energy | Modulus |
| 0.00 | 0.00 | 0.00 | 0.00 |
| 0.00 | 0.00 | 0.00 | 0.00 |
| 0.00068 | -1.63908 | 0.00 | 0.00 |
| 0.00209 | -1.26859 | 0.00 | 0.00 |
| 0.00405 | -1.2299 | 0.00 | 0.00 |
| 0.00573 | -1.45987 | 0.00 | 0.00 |
| 0.00737 | -1.15977 | 0.00 | 0.00 |
| 0.00906 | -1.53145 | 0.00 | 0.00 |
| 0.01071 | -1.09855 | 0.00 | 0.00 |
| 0.01238 | 0.75603 | 0.00 | 0.00 |
| 0.01406 | 1.75787 | 0.00 | 0.00 |
| 0.0157 | 4.31078 | 0.00 | 0.00 |
| 0.0174 | 5.77078 | 0.00 | 0.00 |
| 0.01905 | 7.56844 | 0.00 | 0.00 |
| 0.0207 | 9.77582 | 0.00 | 0.00 |
| 0.02242 | 10.94664 | 0.00 | 0.00 |
| 0.02405 | 12.98738 | 0.00 | 0.00 |
| 0.02572 | 15.25291 | 0.00 | 0.00 |
| 0.02743 | 17.03223 | 0.00 | 0.00 |
| 0.02902 | 18.50953 | 0.00 | 0.00 |
| 0.03072 | 20.56926 | 0.00 | 0.00 |
| 0.03241 | 22.43157 | 0.00 | 0.00 |
| 0.03402 | 24.02636 | 0.00 | 0.00 |
| 0.03574 | 26.16495 | 0.00 | 0.00 |
| 0.0374 | 27.74346 | 0.00 | 0.00 |
| 0.03903 | 30.05233 | 0.00 | 0.00 |
| 0.04074 | 31.39499 | 0.00 | 0.00 |
| 0.04238 | 33.73969 | 0.00 | 0.00 |
| 0.04406 | 35.79788 | 0.00 | 0.00 |
| 0.04573 | 37.46491 | 0.00 | 0.00 |
| 0.04739 | 39.37881 | 0.00 | 0.00 |
| 0.04906 | 41.4975 | 0.00 | 0.00 |
| 0.05072 | 42.87376 | 0.00 | 0.00 |
| 0.0524 | 45.11401 | 0.00 | 0.00 |
| 0.05407 | 46.62231 | 0.00 | 0.00 |
| 0.05571 | 49.11248 | 0.00 | 0.00 |

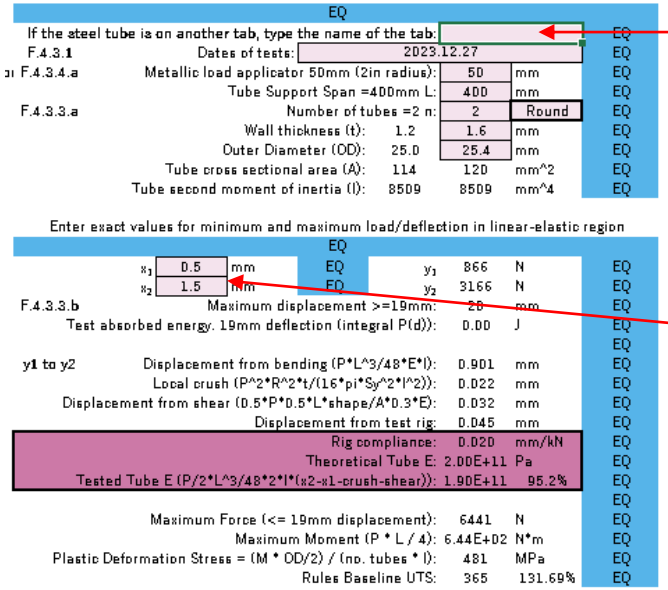
**Input Test Data directly Displacement(mm) and Force[N]**

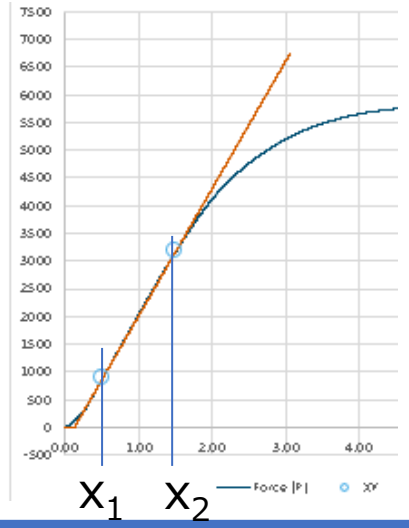
Absorbed Energy is calculated automatically. But the calculation is only halfway, so complete it yourself.

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

# F.4.3 Composite

## ② Steel Tube 3-Points Test -Detail-




$x_1$ $x_2$

Changed in 2024

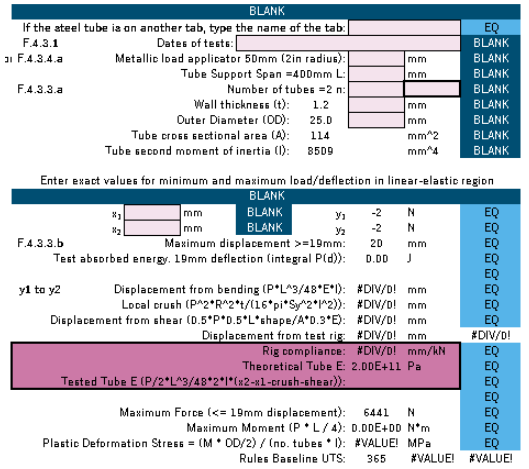
If you have multiple F.4.3 Composite Sheets, you only need to describe it on one sheet.

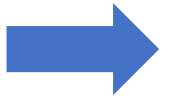
⇒For other sheets, just specify that sheet.

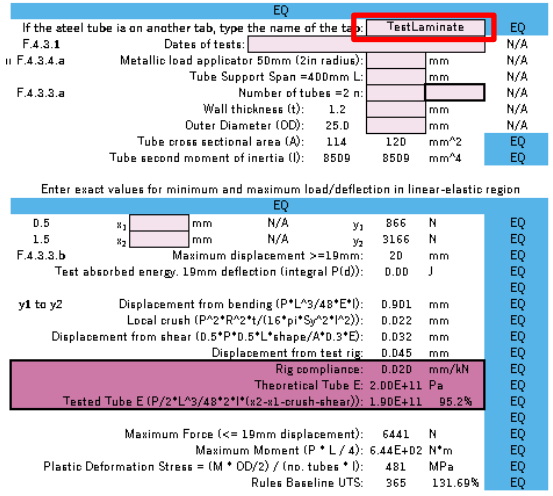
x1 : Start displacement of Liner-Elastic Region

x2 : End displacement of Liner-Elastic Region

In 2024SES, if you describe it in one sheet
For Different Layup, just refer to that sheet.





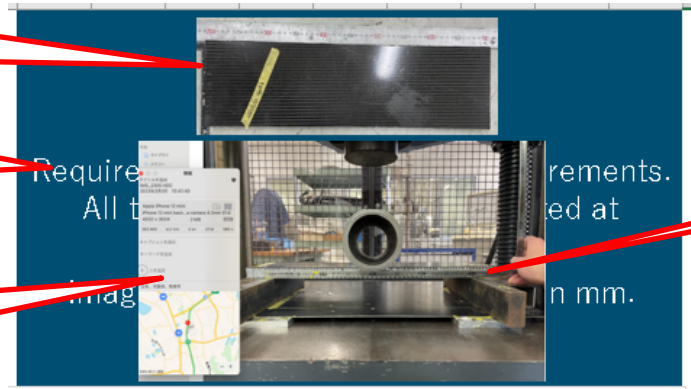
# F.4.3 Composite

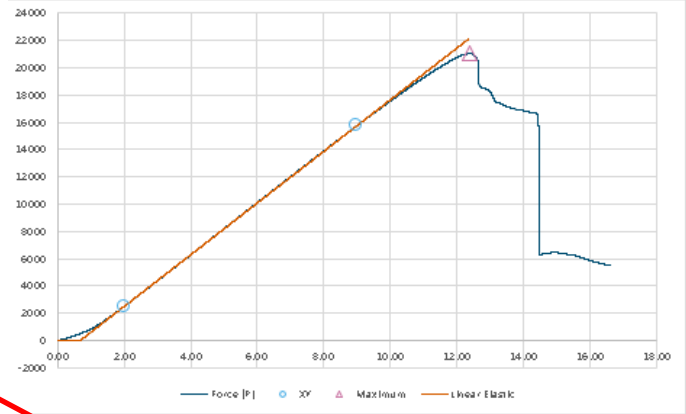
## ③ Composite 3-Point Tests - How to describe -

**attach a photo showing the dimensions of the Test Piece.**

**Take a photo with the date in the photo**

**Simultaneous Shooting of the Rig and Scale**





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

EQ Composite 3-Point Tests

F.4.3.1.b Minimize deflection in applicator and span fixture.
All entries on this tab are in SI. Preferred units are calculated only for output values.

F.4.3.2.a The flat 3-point test panels measure 275mm x 500mm or 138mm x 500mm.
The top and bottom skin must have equal surface area.
Panels must have bare edges. with the core exposed.
Etch test date, layup name, and peak tested force into the panel.

The intent is for the monocoque and test panels to be built at close to the same time. with the same materials. by the same team. for equivalent material properties.

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

| MAX | | 20 | LINEAR |
|---|---|---|---|
| | 21045.031 | 196.23 | 1.89E+03 |
| mm | N | J | ####### |
| Disp. (d) | Force (P) | Energy | Modulus |
| 0.00 | 0.00 | 0.00 | 0.00 |
| 0.00 | 0.00 | 0.00 | 0.00 |
| 0 | -0.6835 | 0.00 | 0.00 |
| 0.00067 | -0.76501 | 0.00 | 0.00 |
| 0.00233 | -0.77418 | 0.00 | 0.00 |
| 0.00415 | 0.52675 | 0.00 | 0.00 |
| 0.00583 | 0.52231 | 0.00 | 0.00 |
| 0.00752 | 1.47206 | 0.00 | 0.00 |
| 0.00916 | 1.79096 | 0.00 | 0.00 |
| 0.01085 | 2.04771 | 0.00 | 0.00 |
| 0.01252 | 2.76756 | 0.00 | 0.00 |
| 0.01417 | 2.83506 | 0.00 | 0.00 |
| 0.01587 | 4.38954 | 0.00 | 0.00 |
| 0.01749 | 5.03381 | 0.00 | 0.00 |
| 0.01917 | 5.819 | 0.00 | 0.00 |
| 0.02083 | 6.1736 | 0.00 | 0.00 |
| 0.02248 | 7.41094 | 0.00 | 0.00 |
| 0.02418 | 8.22864 | 0.00 | 0.00 |
| 0.02582 | 8.80476 | 0.00 | 0.00 |
| 0.02748 | 9.67263 | 0.00 | 0.00 |
| 0.0292 | 10.56119 | 0.00 | 0.00 |
| 0.03081 | 11.48161 | 0.00 | 0.00 |
| 0.0325 | 12.18751 | 0.00 | 0.00 |
| 0.03421 | 13.47253 | 0.00 | 0.00 |
| 0.03581 | 14.02057 | 0.00 | 0.00 |
| 0.03753 | 14.95142 | 0.00 | 0.00 |
| 0.03919 | 16.18604 | 0.00 | 0.00 |
| 0.04081 | 16.59914 | 0.00 | 0.00 |
| 0.04253 | 17.6814 | 0.00 | 0.00 |
| 0.04417 | 18.75738 | 0.00 | 0.00 |
| 0.04583 | 20.05048 | 0.00 | 0.00 |
| 0.04752 | 20.3838 | 0.00 | 0.00 |
| 0.04916 | 21.88537 | 0.00 | 0.00 |
| 0.05084 | 22.56861 | 0.00 | 0.00 |
| 0.05251 | 23.63621 | 0.00 | 0.00 |
| 0.05417 | 24.62138 | 0.00 | 0.00 |
| 0.05585 | 25.09245 | 0.00 | 0.00 |
| 0.0575 | 26.96531 | 0.00 | 0.00 |
| 0.05919 | 27.44976 | 0.00 | 0.00 |
| 0.06087 | 28.38279 | 0.00 | 0.00 |

**Same Rig must be set with Steel Tube Test F.4.3.4**

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

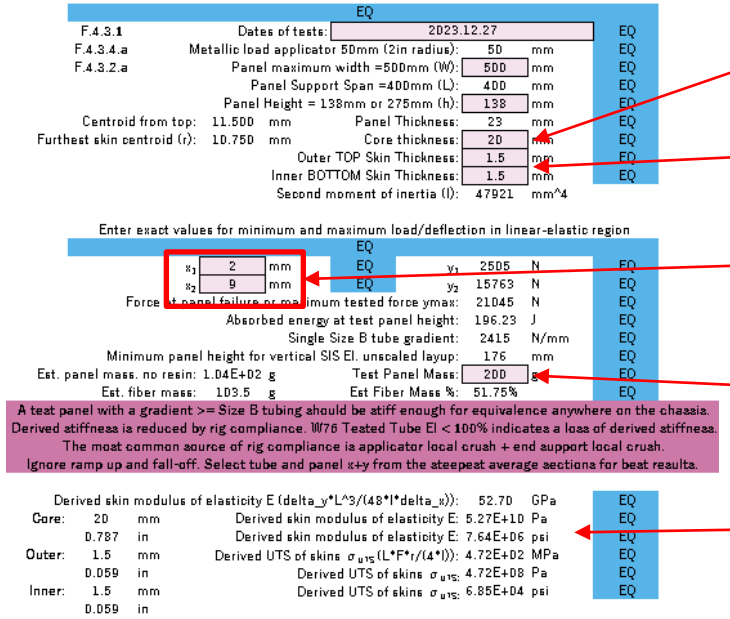
Absorbed Energy is calculated automatically. But the calculation is only halfway, so complete it yourself.

**In 2024 SES, The Chart is drawn automatically**
**Other Chart (your own made or custom) must be REJECT as Format mismatch**

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

# F.4.3 Composite

## ③ Composite 3-Point Tests -Detail-



| | | | | | |
|---|---|---|---|---|---|
| | EQ | | | | 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 | | | | | 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 |
| Core: | 20 mm | Derived skin modulus of elasticity E: | | 5.27E+10 | Pa |
| | 0.787 in | Derived skin modulus of elasticity E: | | 7.64E+06 | psi |
| Outer: | 1.5 mm | Derived UTS of skins $\sigma_{uts}$ (L*F*r/(4*I)): | | 4.72E+02 | MPa |
| | 0.059 in | Derived UTS of skins $\sigma_{uts}$: | | 4.72E+08 | Pa |
| Inner: | 1.5 mm | Derived UTS of skins $\sigma_{uts}$: | | 6.85E+04 | psi |
| | 0.059 in | | | | |

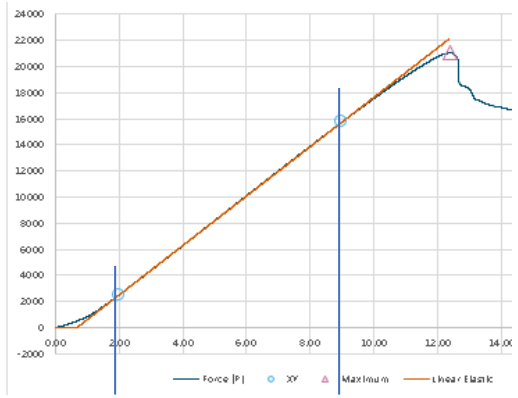
2024Rules specify Core Thickness of Test Panel
It must use the thickest core associated with each skin layup(F.4.3.2d)

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




$x_1$ $x_2$

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

# F.4.3 Composite

## ⑤ Perimeter Sheer Test

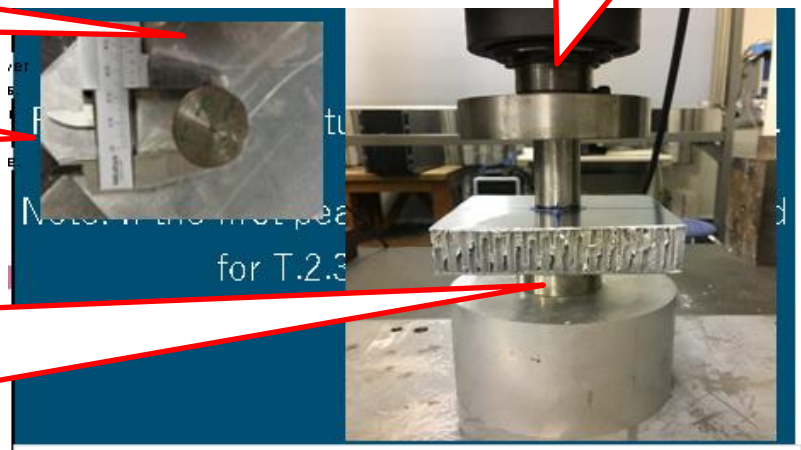
**attach a photo showing the dimensions of the Test Piece.**

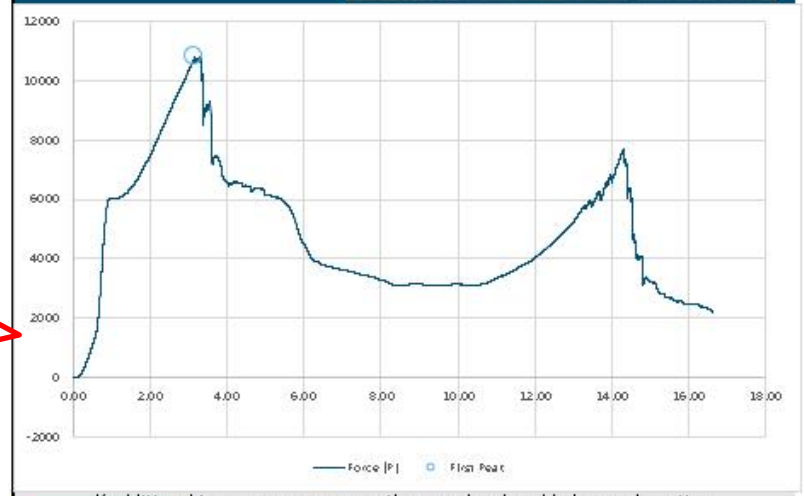
**Take a photo with the date in the photo**

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

**In 2024 SES, The Chart is drawn automatically**
**Other Chart (your own made or custom) must be REJECT as Format mismatch**

**Test Setup**






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 in logged data from test t
Use mm and N, paste values onl
It is acceptable to resample the
at a lower frequency to reduce
the number of datapoints.
The graph should automatically

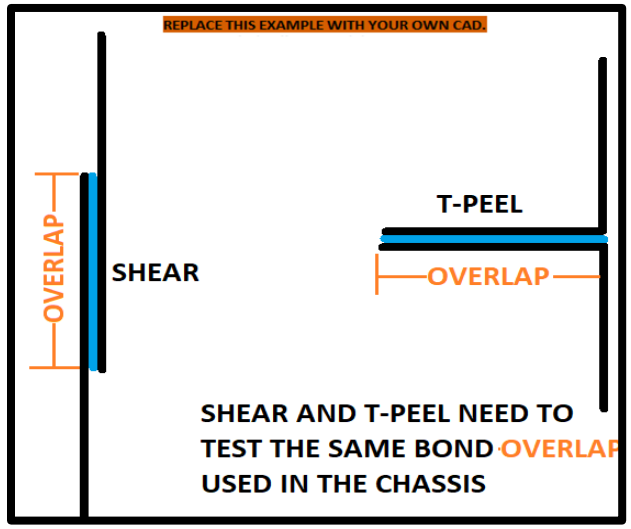
| | |
|---|---|
| MAX | 3.16245 |
| 22.1338 | 10763.8 |
| mm | N |
| Disp. (d) | Force (P) |
| 0.00 | 0.00 |
| 0.00 | 0.00 |
| 0 | 0.15152 |
| 0.00068 | 0.35986 |
| 0.00211 | 0.22205 |
| 0.00412 | 0.44783 |
| 0.0057 | 0.71346 |
| 0.00742 | 0.18248 |
| 0.0091 | 0.81529 |
| 0.0107 | 0.32301 |
| 0.01243 | 0.06762 |
| 0.01407 | 0.32271 |
| 0.0157 | 0.40386 |
| 0.01743 | -0.30244 |
| 0.01907 | -0.22822 |
| 0.02074 | 0.02858 |
| 0.02242 | 0.0673 |
| 0.02408 | -0.02959 |
| 0.02574 | 0.18953 |
| 0.02741 | 0.09645 |
| 0.0291 | 0.51378 |
| 0.03075 | 0.10381 |
| 0.0324 | 0.2789 |
| 0.03411 | 0.20709 |
| 0.03573 | 0.0746 |
| 0.0374 | 0.11034 |
| 0.03912 | -0.07252 |
| 0.04071 | 0.29979 |
| 0.04241 | -0.27286 |
| 0.04412 | 0.56767 |
| 0.04571 | 0.22647 |

**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




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

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 $\sigma_{uts}$: | 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 $\sigma_{uts}$: | 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: | | |

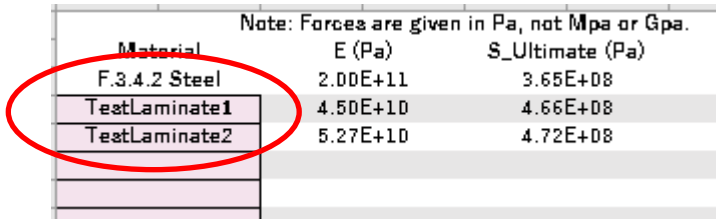
# F.4.3 Composite

- 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

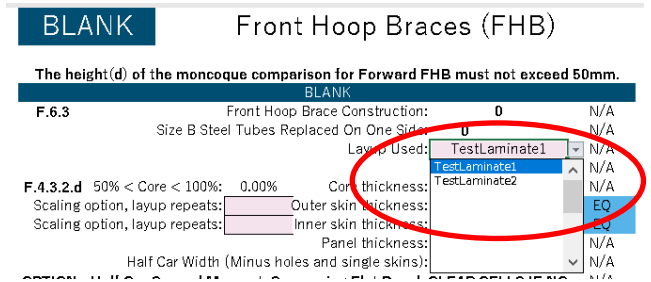
How to refer

F.7 Composite Chassis

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



| Note: Forces are given in Pa, not Mpa or Gpa. | | |
|---|---|---|
| Material | E (Pa) | S_Ultimate (Pa) |
| F.3.4.2 Steel | 2.00E+11 | 3.65E+08 |
| TestLaminate1 | 4.50E+10 | 4.66E+08 |
| TestLaminate2 | 5.27E+10 | 4.72E+08 |



BLANK Front Hoop Braces (FHB)

The height(d) of the moncoque comparison for Forward FHB must not exceed 50mm.

BLANK

F.6.3 Front Hoop Brace Construction: 0 N/A

Size B Steel Tubes Replaced On One Side: 0 N/A

Layup Used: TestLaminate1 N/A

TestLaminate1 N/A

TestLaminate2 N/A

F.4.3.2.d 50% < Core < 100%: 0.00% Core thickness: N/A

Scaling option, layup repeats: Outer skin thickness: EQ

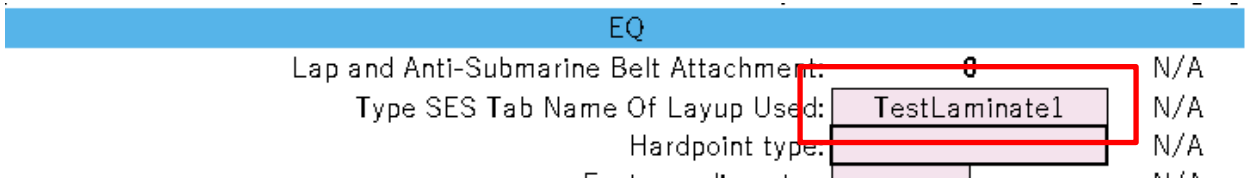
Scaling option, layup repeats: Inner skin thickness: EQ

Panel thickness: N/A

Half Car Width (Minus holes and single skins): N/A

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

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



EQ

Lap and Anti-Submarine Belt Attachment: 0 N/A

Type SES Tab Name Of Layup Used: TestLaminate1 N/A

Hardpoint type: N/A

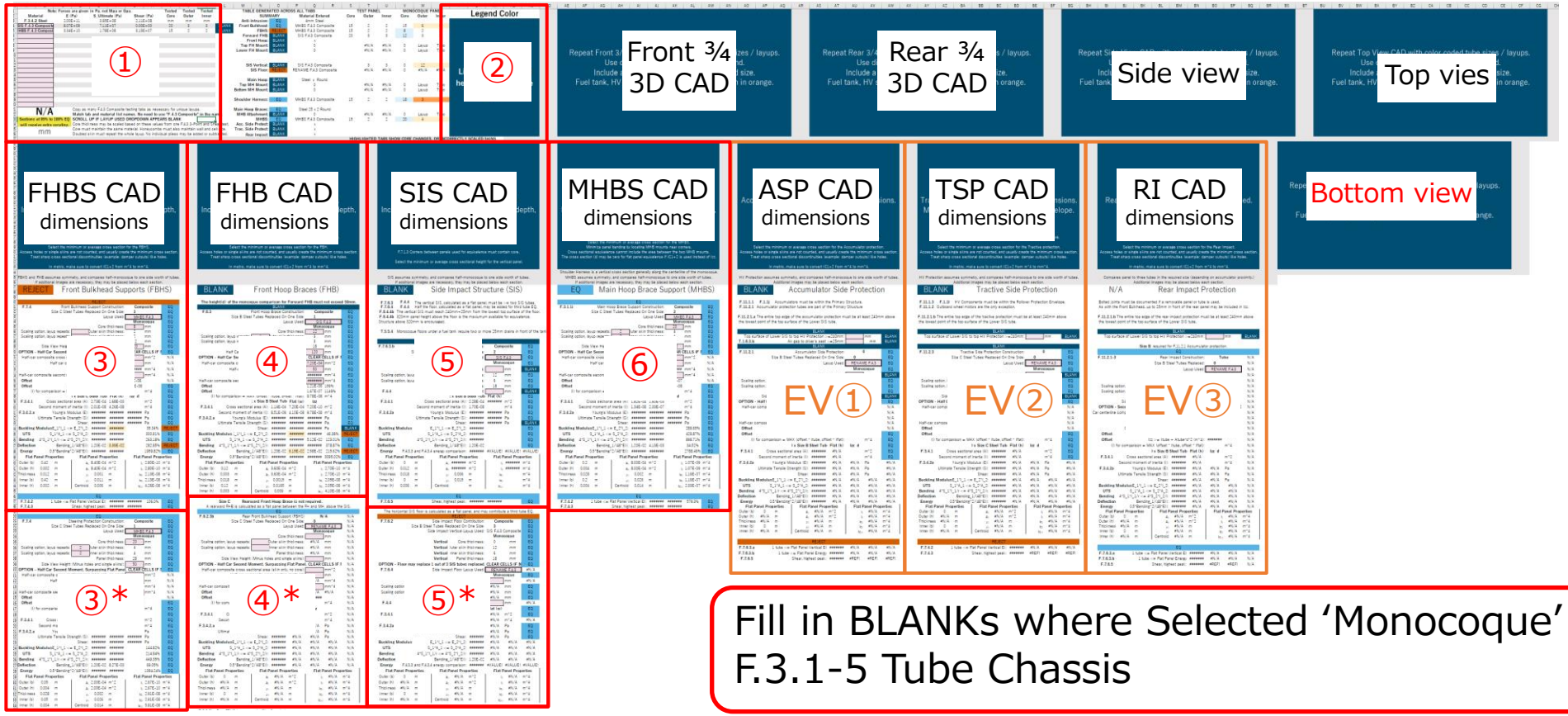
2024 Monocoque SES

# F.7 Composite Chassis

2024 v1.2 Compliant

# F.7 Composite Chassis

- Summary of F.7 Composite Chassis sheet

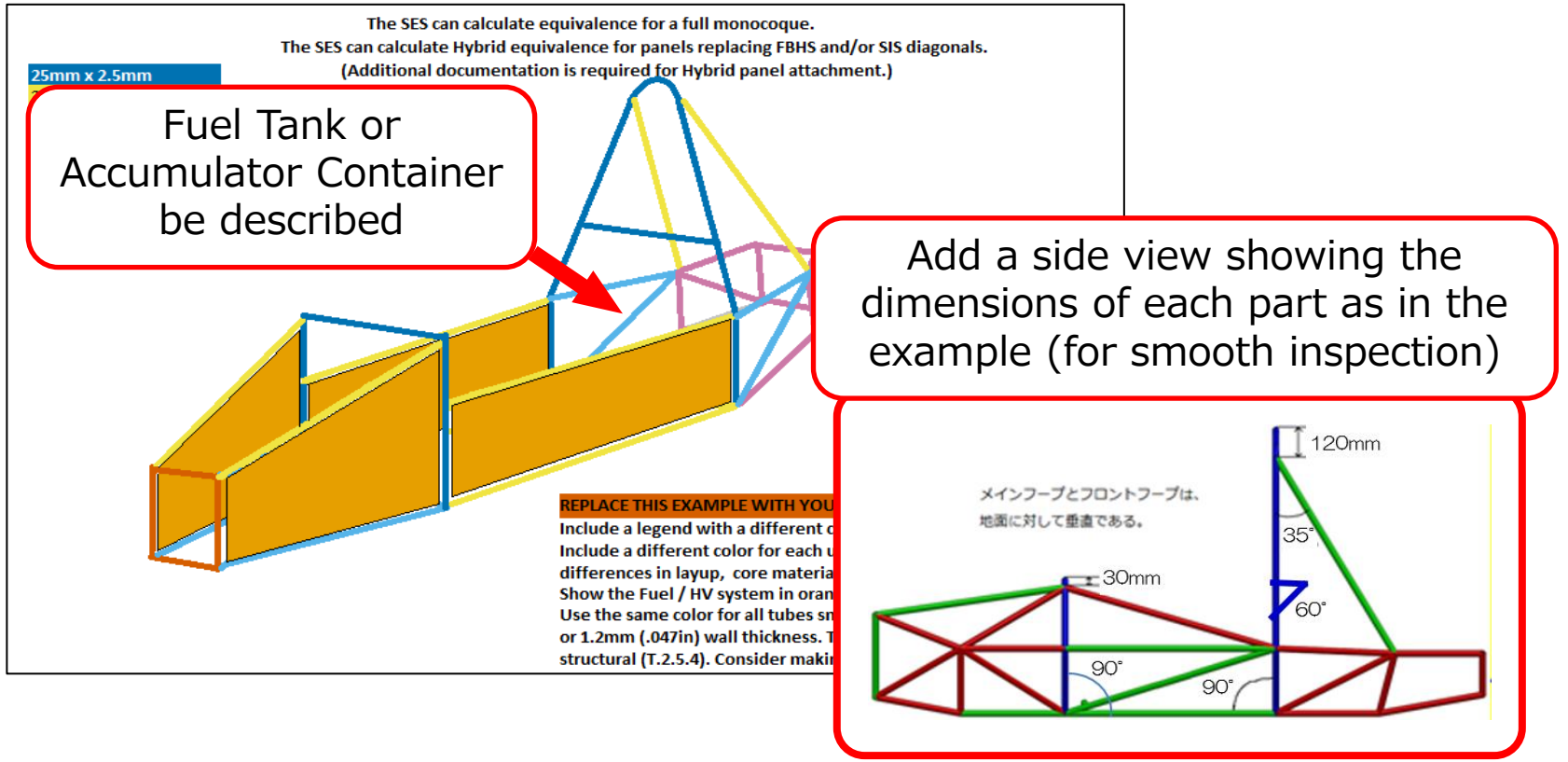



Fill in BLANKs where Selected ‘Monocoque’ in F.3.1-5 Tube Chassis

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 FHBS 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 )
EV①-③ EV Protection structure Equivalency.

# F.7 Composite Chassis

- Entry Example of 3/4 CAD



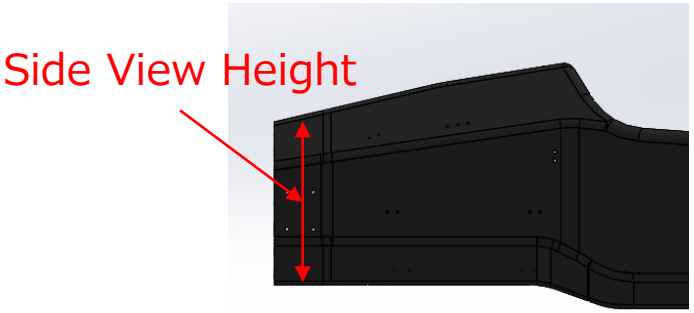

1. Show the requested CAD
2. Fuel Tank or Accumulator Container be described
3. It is recommended that the color coding of the pipe is the same as the sample.
4. All pipes with an outer diameter of <25 mm or a wall thickness of <1.2 mm Should be of the same color.

# F.7 Composite Chassis

- 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)



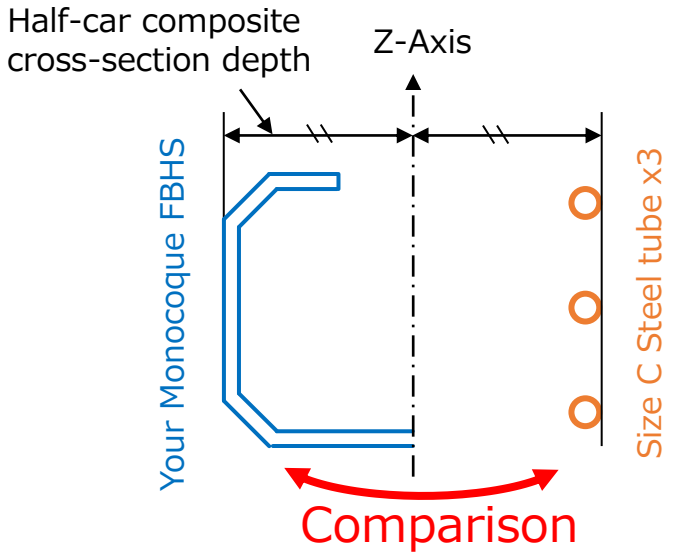

All Dimensions entered to SES must be shown by CAD Images

**(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"

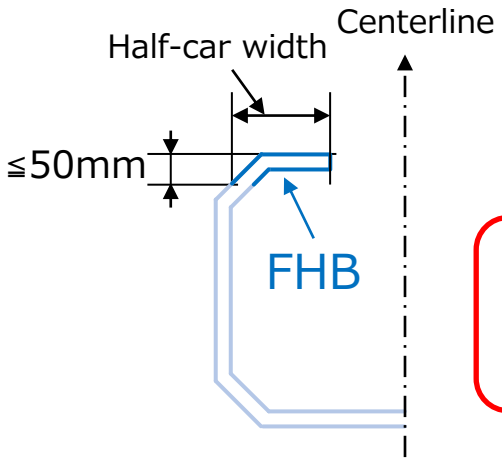



The actual calculation is to calculate the magnification of the moment of inertia around the Z-Axis when the flat panel is at half-car width, and then multiplying the flat panel by that magnification and comparing it with 3 Tubes. Since it is only about 130% at most, it is desirable to design it so that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

- 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)



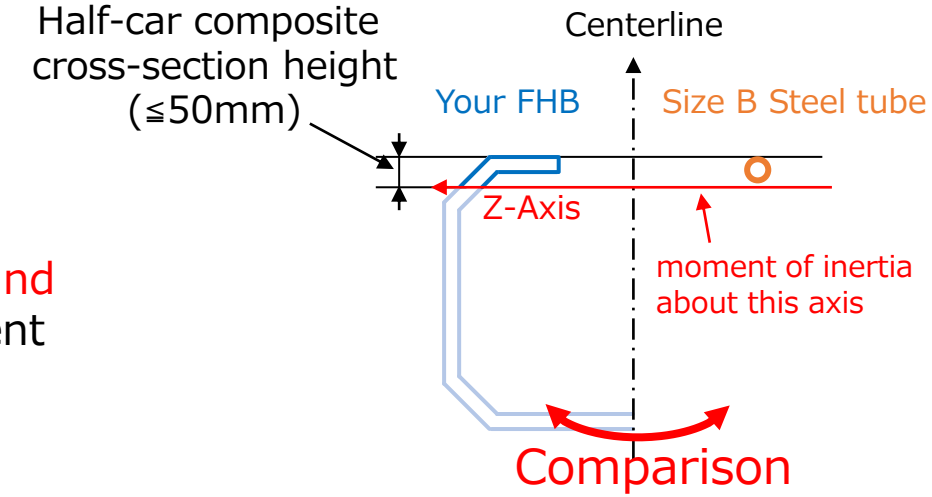

All Dimensions entered to SES must be shown by CAD Images

**(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"



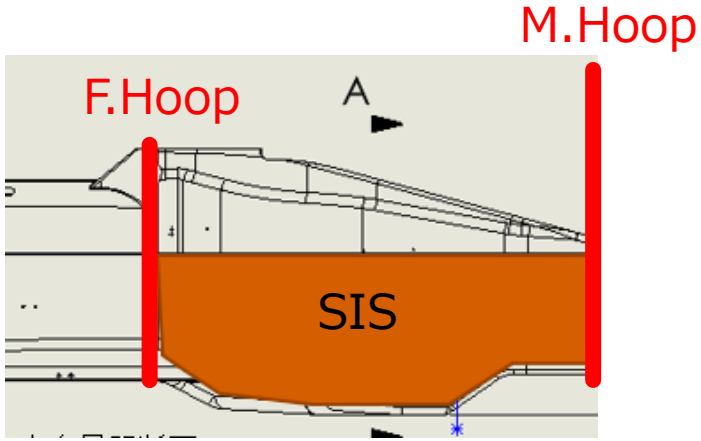
- Side Impact Structure (SIS)

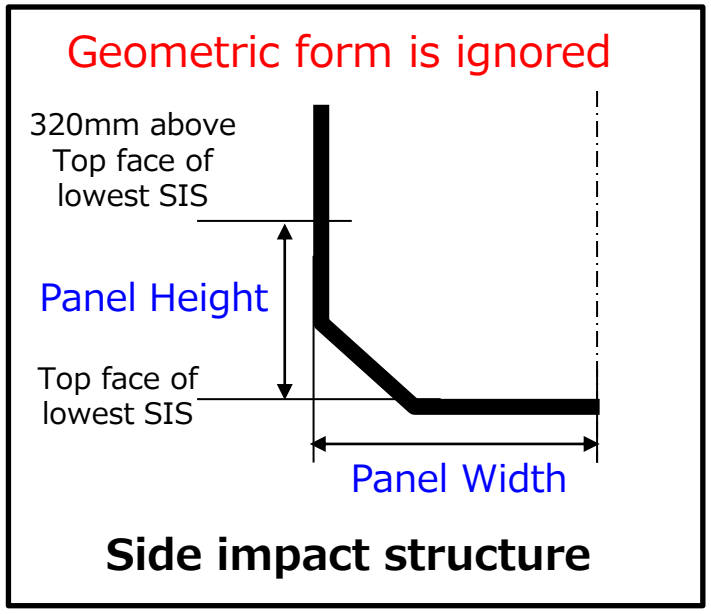
**(1) Flat panel calculation**

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




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

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

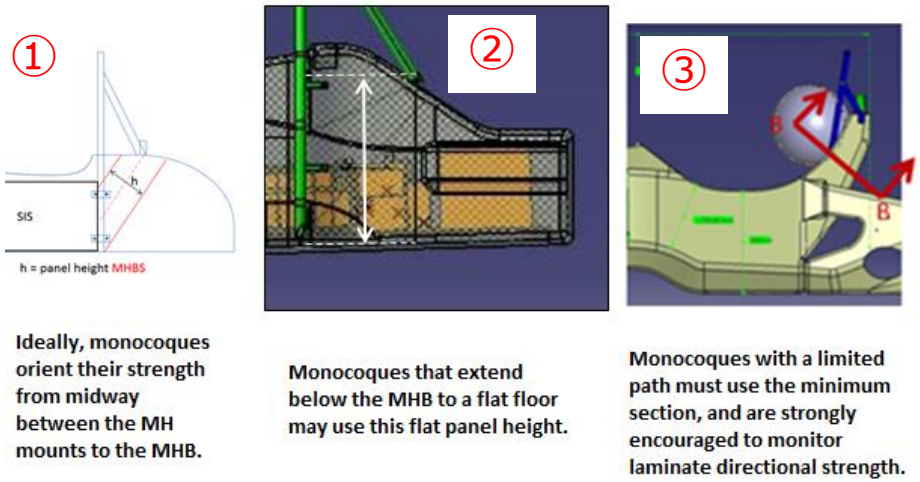
**SIS is the most important Driver Protection same as Roll Hoop among Primary Structures, so be sure to prove equivalence based on The Rules!**

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)




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

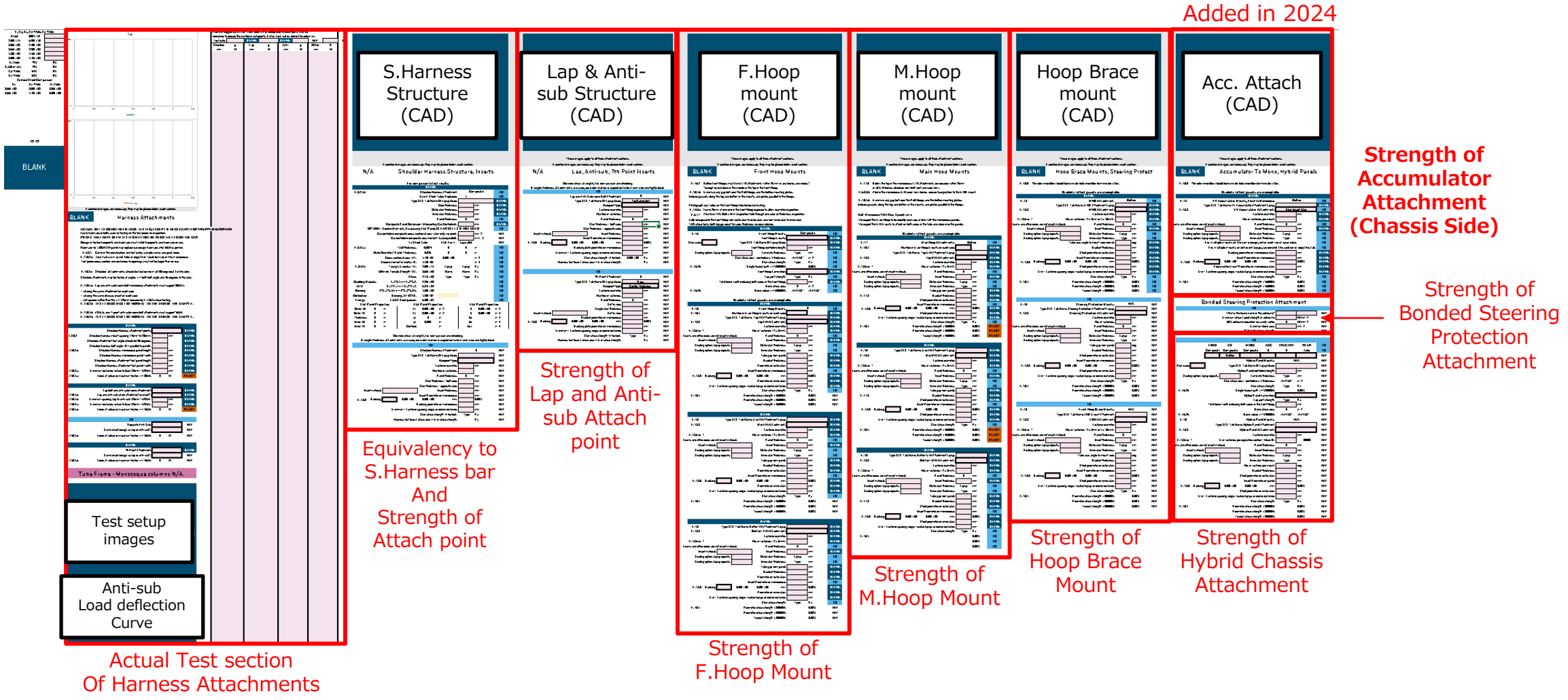
# 2024 Monocoque SES

# F.7.8-9 Attachments

2024 v1.2 Compliant

# F.7.8-9 Attachments

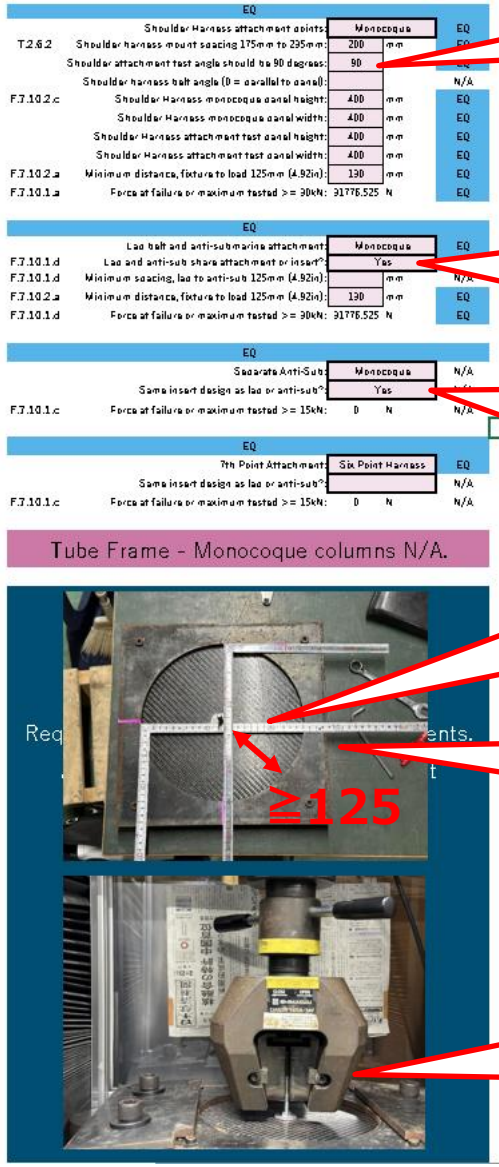
- Summary of F.7.8-9 Attachments sheet




**Select Structure and fill in BLANKs**

# F.7.8-9 Attachments

- Harness Attachments




Load Direction is specified in the Rules

If Lap and Anti-sub share Attachment ⇒ Yes

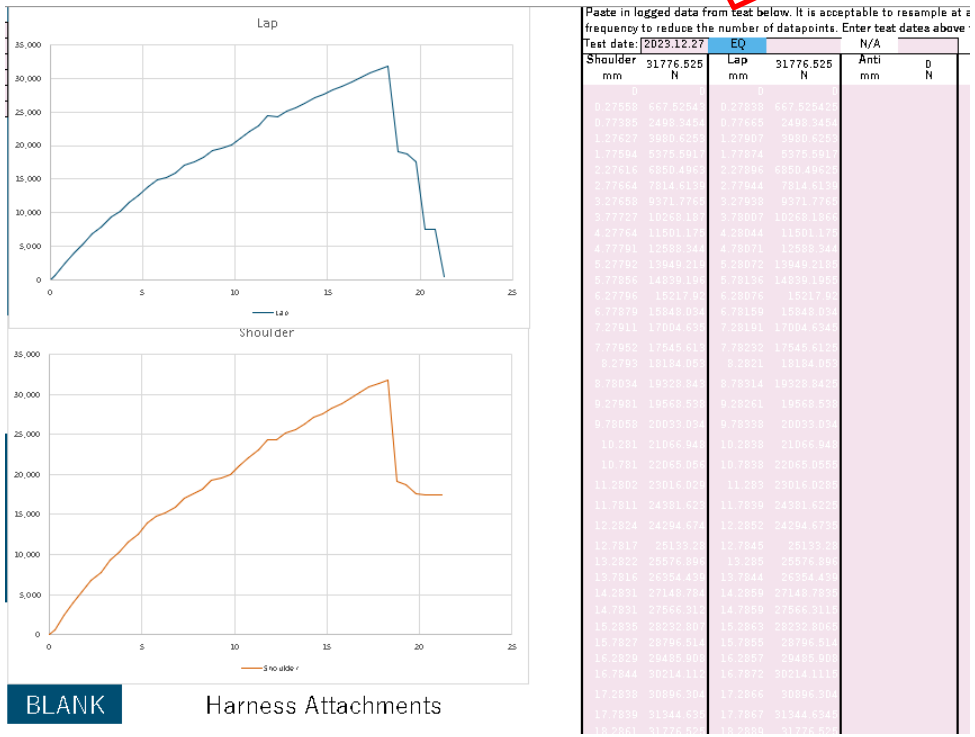
If the design of Anti-sub attachment is same as Lap ⇒ Yes

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.

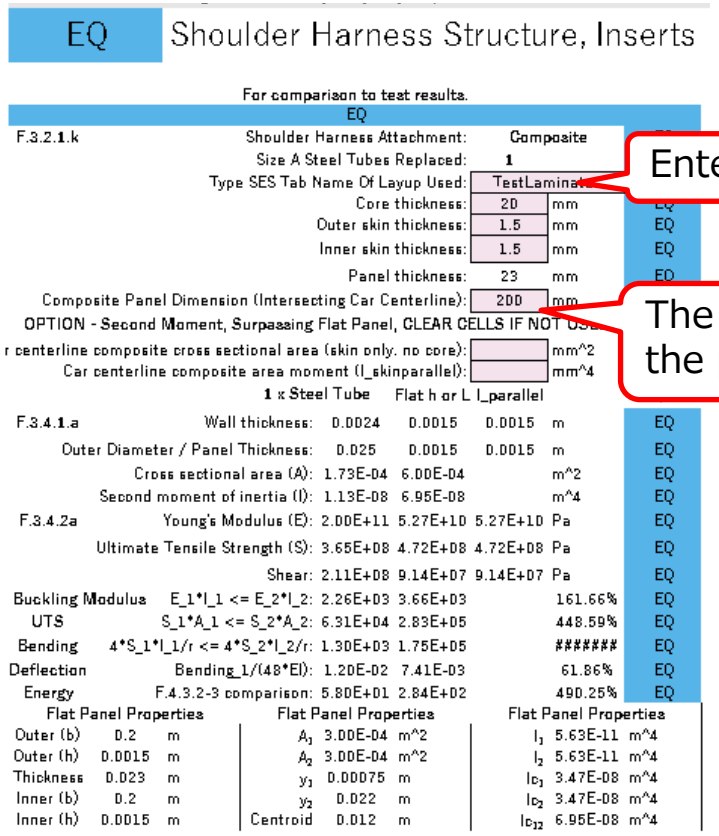
Chart for Shoulder and Lap are automatically created. However, not for Anti-sub, so you must create the Chart yourself if it's necessary

# 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: | TestLaminate | | | | |
| | Core thickness: | 20 | | | mm | EQ |
| | 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 | EQ |
| | 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

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

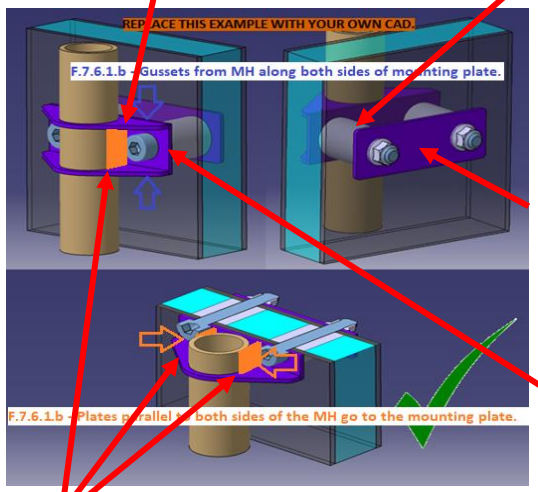
Show each dimension entered to cells

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 |

# F.7.8-9 Attachments

- Attachment Calculation




Parallel Plate (Steel t2or thicker)
M.Hoop & F.Hoop Attachment
MUST satisfy F.7.6.1

All Dimensions entered to SES must be shown by CAD Images

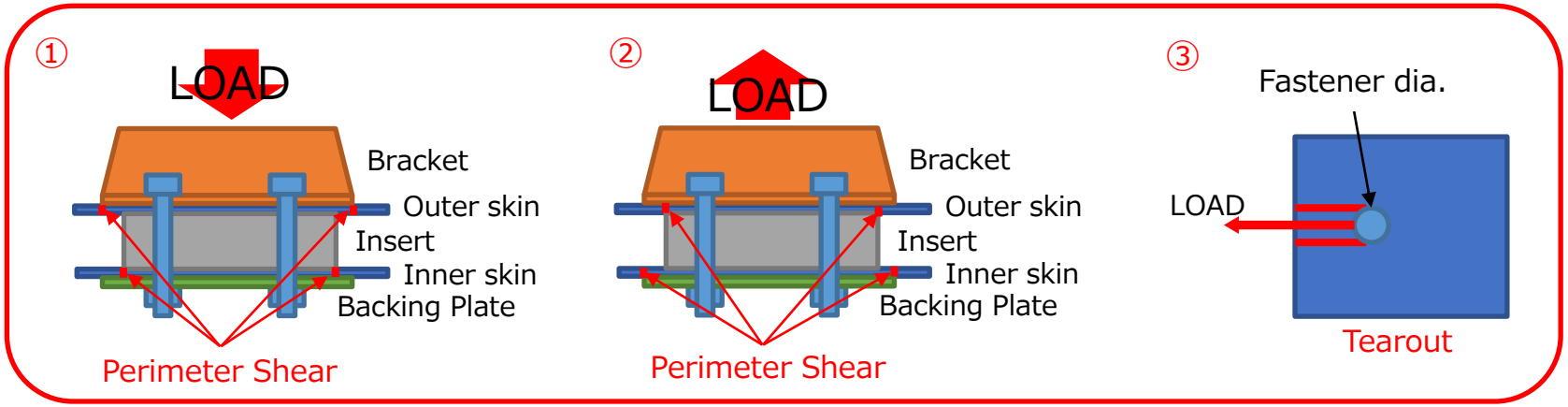
Enter the applicable Laminate sheet name

Laminate Type(F.7.8.8a or b)

Structural Dimensions

Distance to the nearest Panel Edge

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 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 | | | | |
| | 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 |



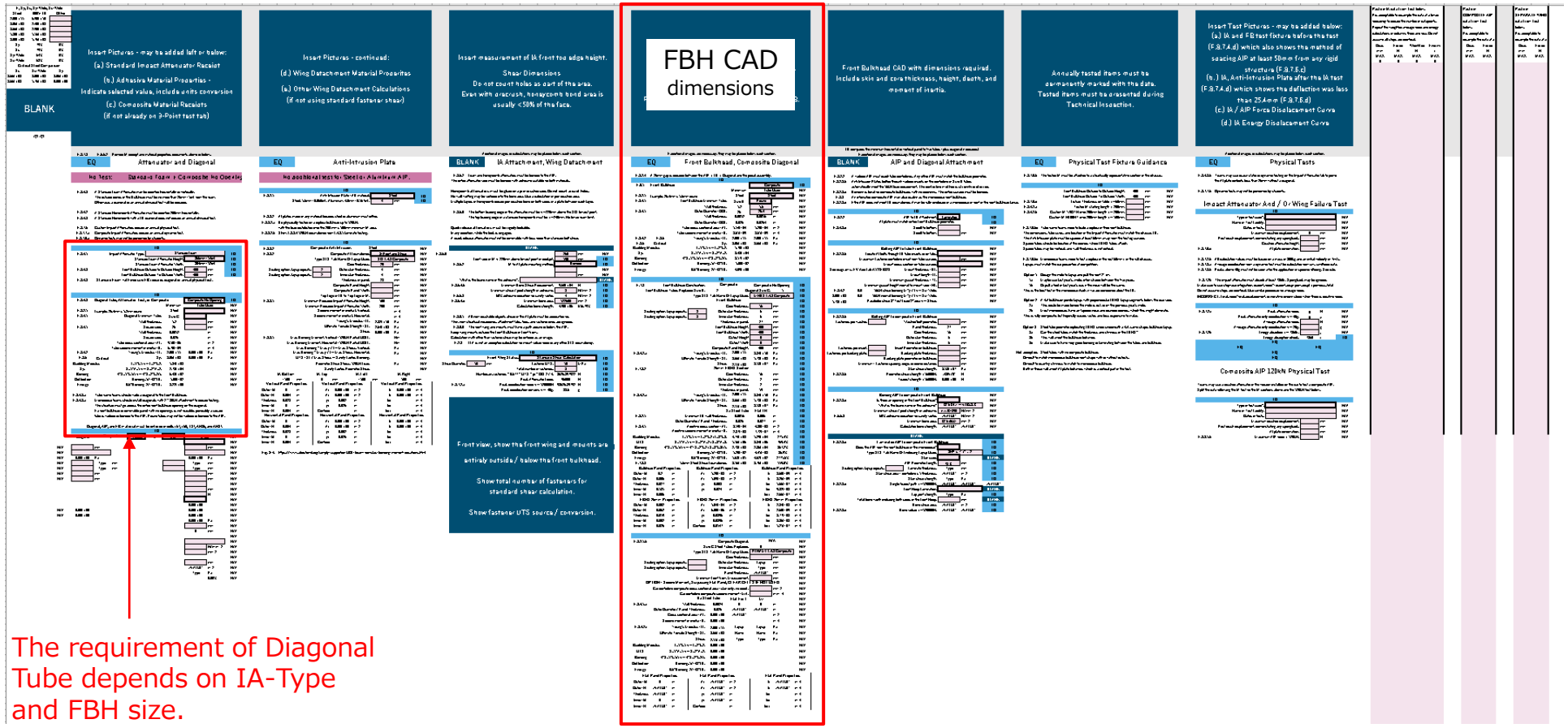
2024 Monocoque SES

# F.8 Front Protection

2024 v1.2 Compliant

# F.8 Front Protection

- Monocoque特有部分のPick Up (それ以外はFront Protectionのガイダンスと同じ)




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

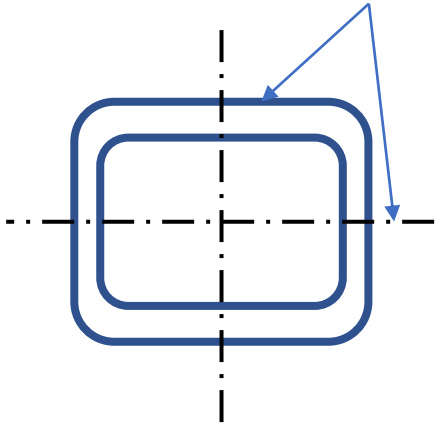
**Select Structure and fill in BLANKs**

- Front Bulkhead, Composite Diagonal

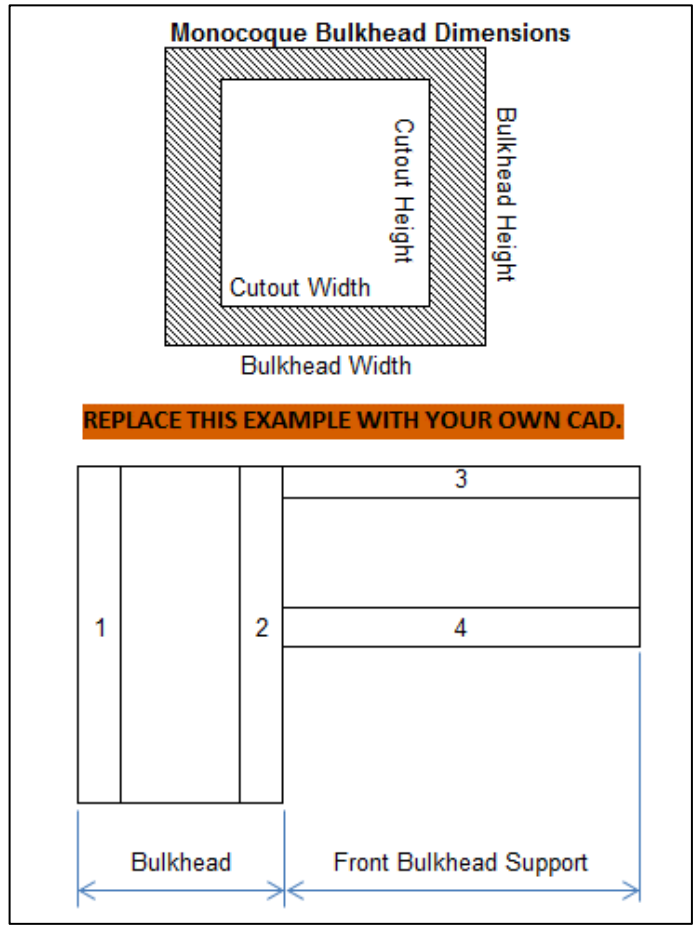
**(1)Flat Panel Calculation**

⇒ 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