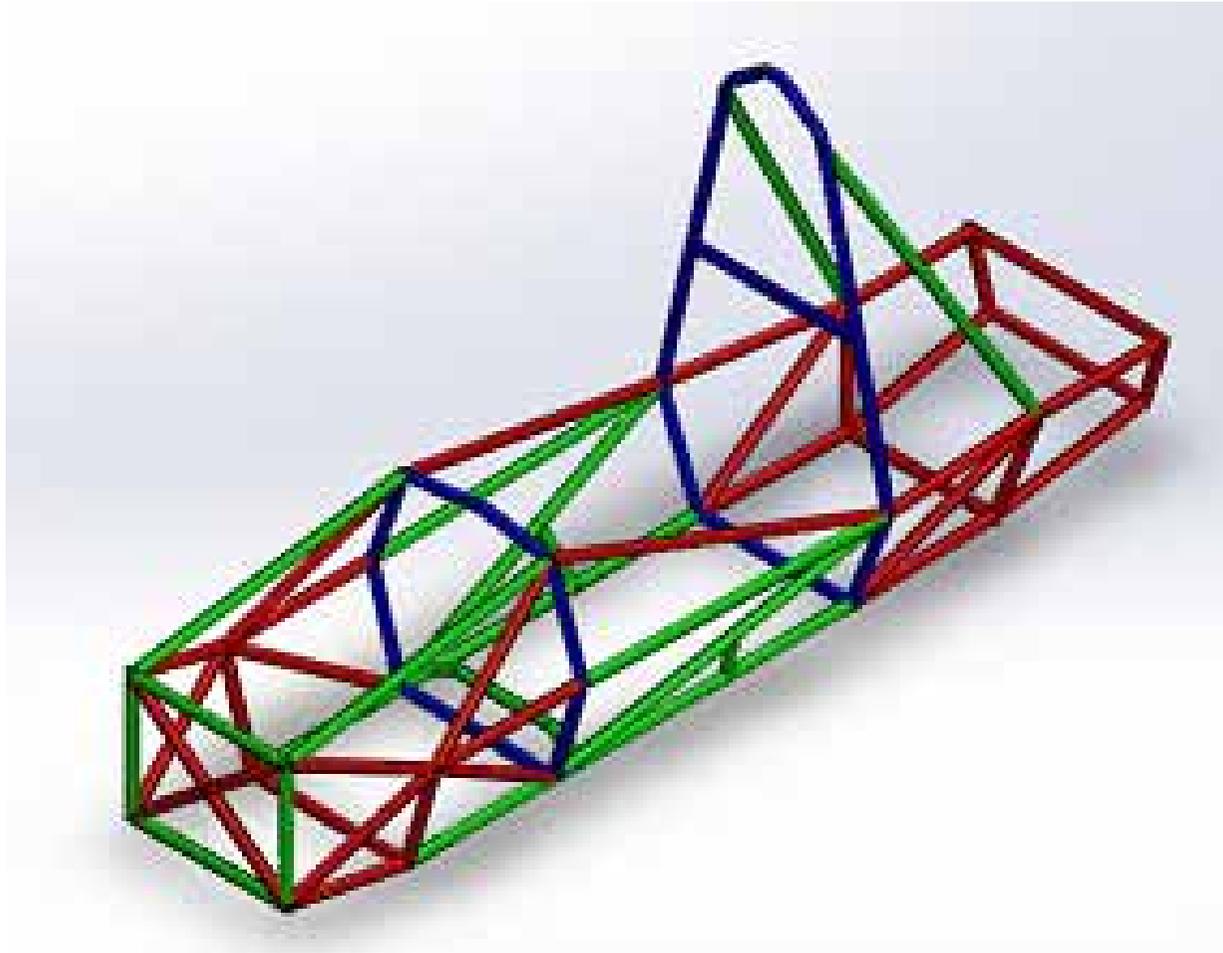


# SES Inspection

## - Steel Tube -



SES = **S**tructural **E**quivalency **S**preadsheet

# Contents

- 1. Basic Information for SES**
- 2. How to report SES**

2019-FSAE-Structural-Equivalency-Spreadsheet\_V1.4.xls

<http://www.fsaeonline.com>

**1. Basic Information for SES**

2. How to report SES

# Basic Information for SES

**Primary Structure should be properly designed to protect the driver.**  
**SES is the evidence to prove safety of your Primary Structure.**

**All teams MUST submit either SES or SCRF.**

We request additional information or calculations If submitted SES is incomplete.

SES	: Electronic data (Excel/15 MB)
Submission deadline	: 14:00, May 13 (Mon.) JST
Extended submission deadline	: 14:00, May 18 (Sat.) JST
Re-submission	: 14:00, Jul. 31 (Wed.) JST
Submission past deadline	: 10-point penalty for each day past the deadline
Non-submission	: 50-point penalty and may not participate in Technical Inspection

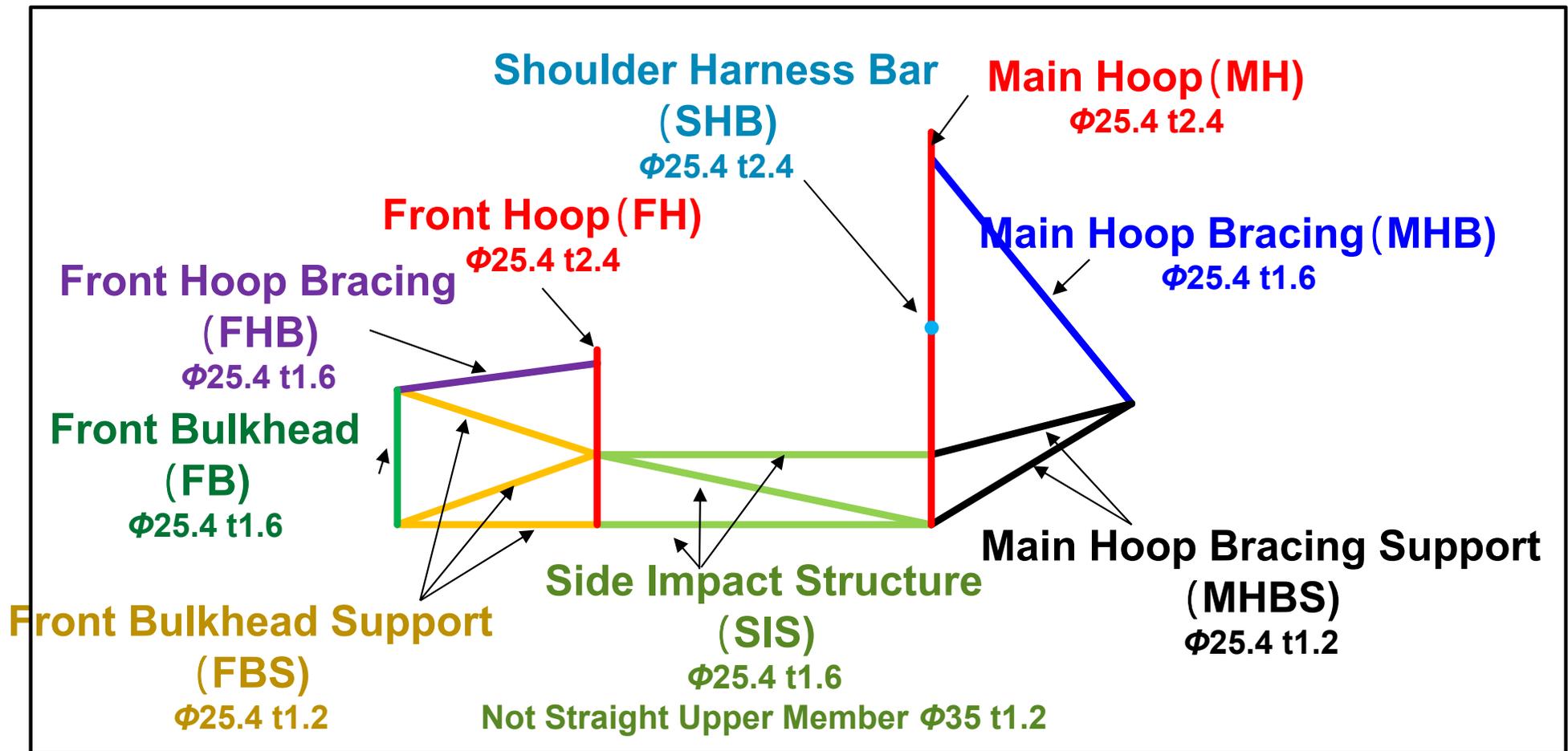
**When re-submission or additional data submission is required, a re-submission term is less than one week from a re-submission requirement.**

**By the defect of IAD, when changes of design, such as Front Bulkhead, are required, extension of a deadline is taken into consideration.**

**We recommend strongly that SES is recognized at an early stage as much as possible, and makes frame structure decide.**

# Basic Information for SES

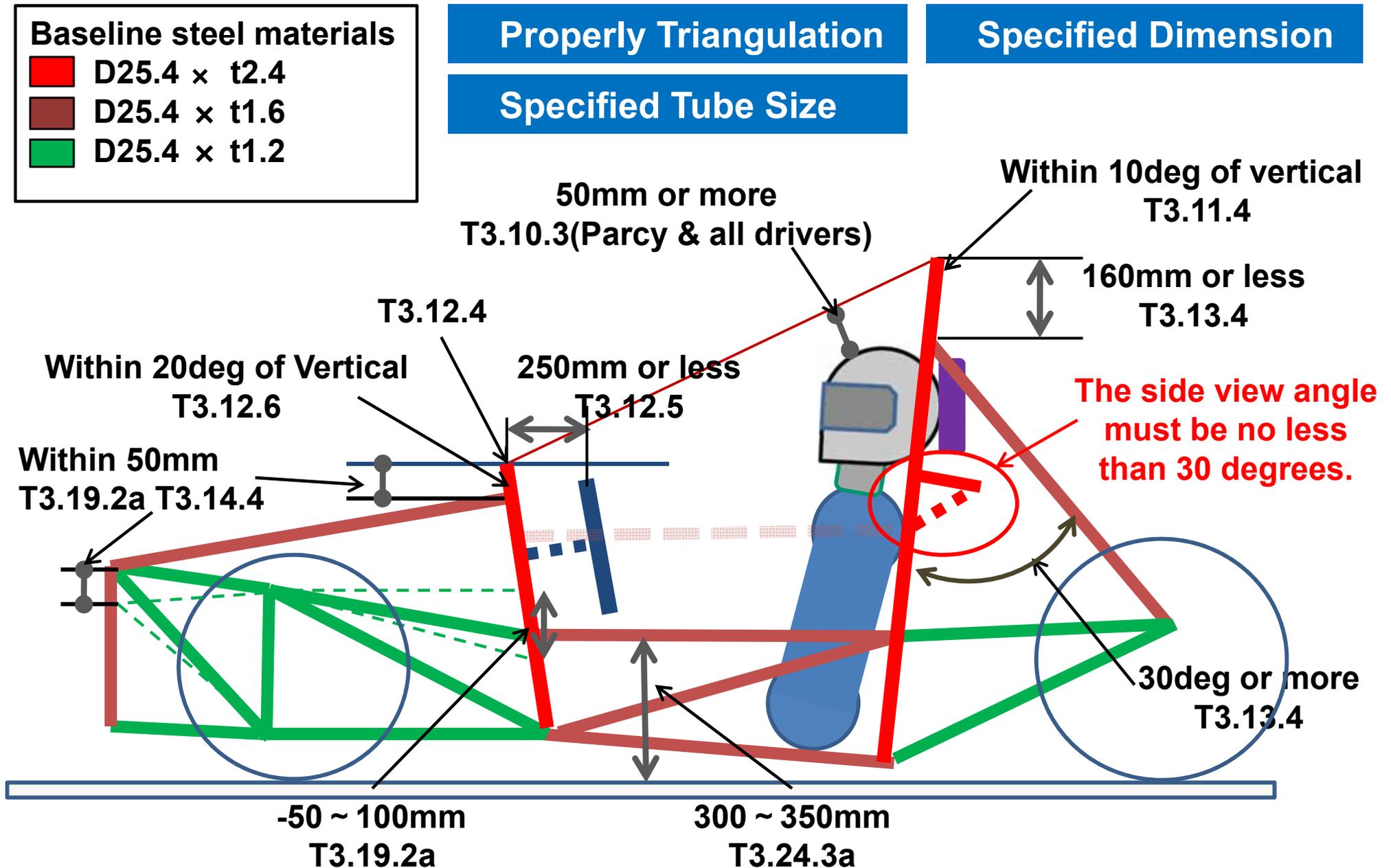
SES is a document to prove that your structure has more equivalent with standard structure shown in the figure below.



Each part name of standard structure is defined as the rule.  
Are careful to prevent mistakes.

# Basic Information for SES

## Excerpt of Rules about Primary Structure



# Basic Information for SES

Although entry form was changed in 2019, there is no change in a criterion of judgment.

## Judging standard

At all the basic structure, E I, a cross-section area, and intensity are more than standard material equivalent (more than 100%).

T.2.5 ~ T.2.7 A pipe is steel or aluminum, and they must be more than the specified size.

T.2.6.5 Any tubing with wall thickness less than 1.2 mm (0.047 inch) is not considered structural and will be ignored when assessing compliance to any rule.

EI	2.68E+03	4.02E+03	150.0
Area, mm <sup>2</sup>	182.5	273.0	150.0
Yield tensile strength, N	5.57E+04	8.35E+04	150.0
UTS, N	6.66E+04	9.99E+04	150.0
Yield tensile strength, N as welded	3.28E+04	4.93E+04	150.0
UTS, N as welded	5.47E+04	8.21E+04	150.0
Max load at mid span to give UTS for 1m long tube, N	1.54E+03	2.31E+03	150.0
Max deflection at baseline load for 1m long tube, m	1.20E-02	7.98E-02	66.7
Energy absorbed up to UTS, J	9.22E+00	1.38E+01	150.0

“Max deflection at baseline load for 1m long tube, m” Should be 100% or less

The 2018 SES calculation method is a base of a judgment.

# Basic Information for SES

## About use of steel tube STKM11A

The kind of steel tube <http://www.toishi.info/sozai/stkm/stkm11a.html>

### The ingredient of STKM11A

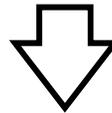
STKM11Aの成分 (%) : 11種A

鋼管の記号	C (炭素)	Si (シリコン)	Mn (マンガン)	P (リン)	S (硫黄)	Nb (ニオブ) もしくはV (バナジウム)
STKM11A	0.12以下	0.35以下	0.60以下	0.040以下	0.040以下	—

T.2.3.1 The Primary Structure :

**Expression of steel tubing (minimum 0.1% carbon) was deleted.**

T.2.5.3 Properties for ANY steel material for calculations submitted in an SES must be:



**Use of steel tube STKM11A is permitted based on these rules. J2019-02**

# Basic Information for SES

## (2018) T3.4.1 Baseline Steel Material

ITEM or APPLICATION	OUTSIDE DIMENSION X WALL THICKNESS
Main & Front Hoops, Shoulder Harness Mounting Bar	Round 1.0 inch (25.4 mm) x 0.095 inch (2.4 mm) or Round 25.0 mm x 2.50 mm metric
Side Impact Structure, Front Bulkhead, Roll Hoop Bracing, Driver's Restraint Harness Attachment (except as noted above) EV: Accumulator Protection Structure	Round 1.0 inch (25.4 mm) x 0.065 inch (1.65 mm) or Round 25.0 mm x 1.75 mm metric or Round 25.4 mm x 1.60 mm metric or Square 1.00 inch x 1.00 inch x 0.047 inch or Square 25.0 mm x 25.0 mm x 1.20 mm metric
Front Bulkhead Support, Main Hoop Bracing Supports, Shoulder Harness Mounting Bar Bracing EV: Tractive System Components Protection	Round 1.0 inch (25.4 mm) x 0.047 inch (1.20 mm) or Round 25.0 mm x 1.5 mm metric or Round 26.0 mm x 1.2 mm

It was deleted from the list.

## (2019) T.2.5.1 Minimum Dimensions – Steel

### T.2.5 Baseline Tubing and Material T.2.5.1 Minimum Dimensions – Steel Tubing

Application	Outside Diameter and Wall Thickness Options
Main Hoop, Front Hoop, Shoulder Harness Mounting Bar	Round 1.0 inch x 0.095 inch, Round 25.0 mm x 2.50 mm
Side Impact Structure, Front Bulkhead, Roll Hoop Bracing, Driver Restraint Harness Attachment (other than Shoulder Harness Mounting Bar), (EV) Accumulator Protection Structure	Round 1.0 inch x 0.065 inch, Round 25.0 mm x 1.75 mm, Square 1.0 inch x 1.0 inch x 0.047 inch, Square 25.0 mm x 25.0 mm x 1.20 mm
Front Bulkhead Support, Main Hoop Bracing Supports, Shoulder Harness Mounting Bar Bracing, (EV) Tractive System Component Protection	Round 1.0 inch x 0.047 inch, Round 25.0 mm x 1.5 mm
Bent Upper Side Impact Member	Round 1.375 inch x 0.047 inch Round 35.0 mm x 1.2 mm

**φ25.4 t1.6 is OK.  
It has been issued at J2019-04.**

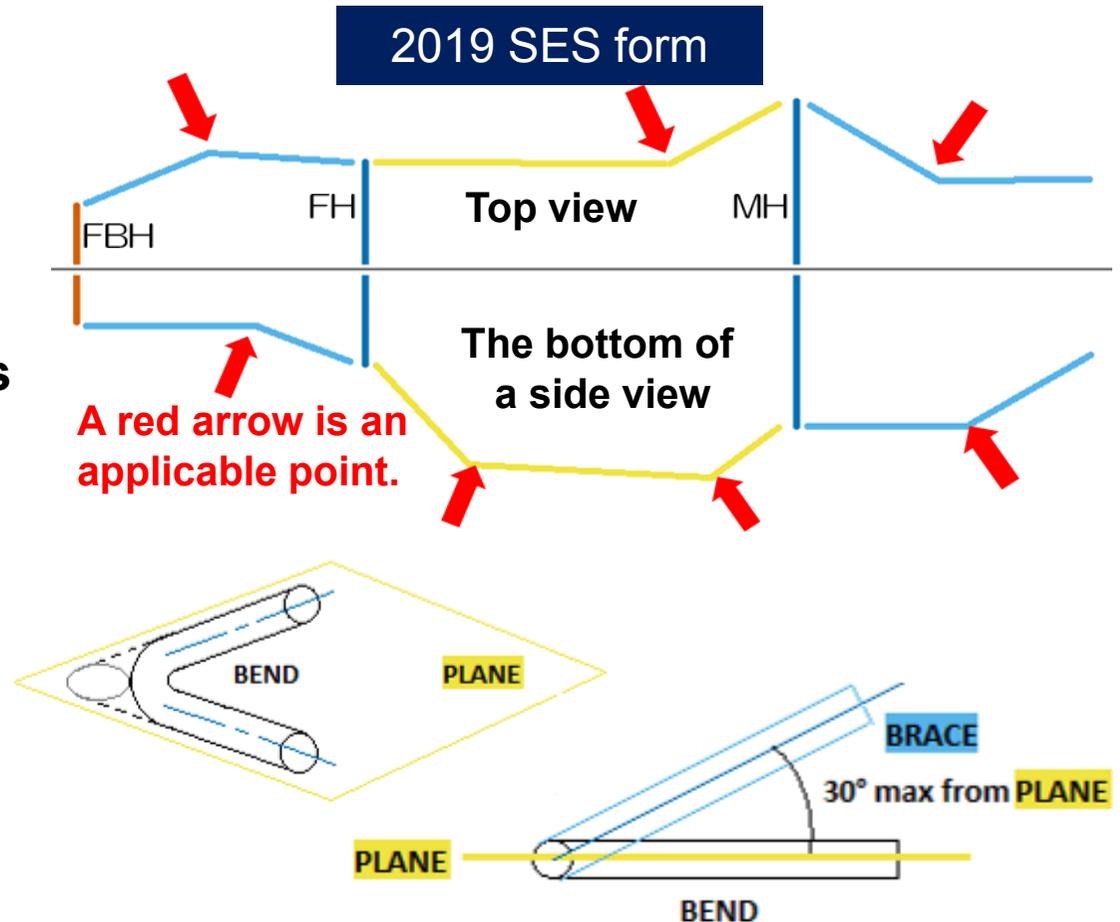
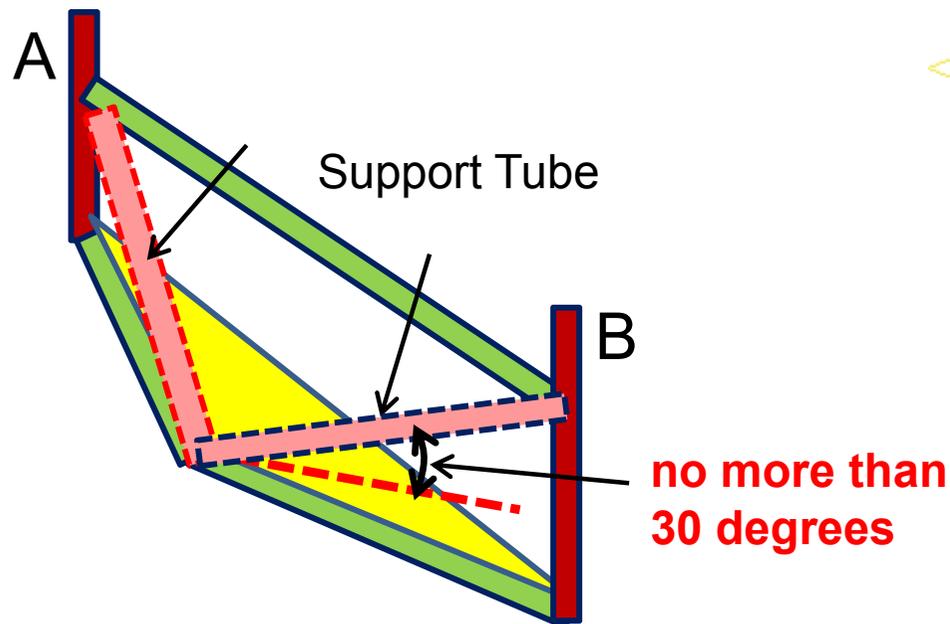
# Basic Information for SES

The support tube addition to a bend tube is the same as 2018.

If pipe has bent to pipe A-B, support tube or is required.

The meaning of attaching a support tube to no more than 30 degrees to a node to the yellow field which consists of and .

It is not an angle of and



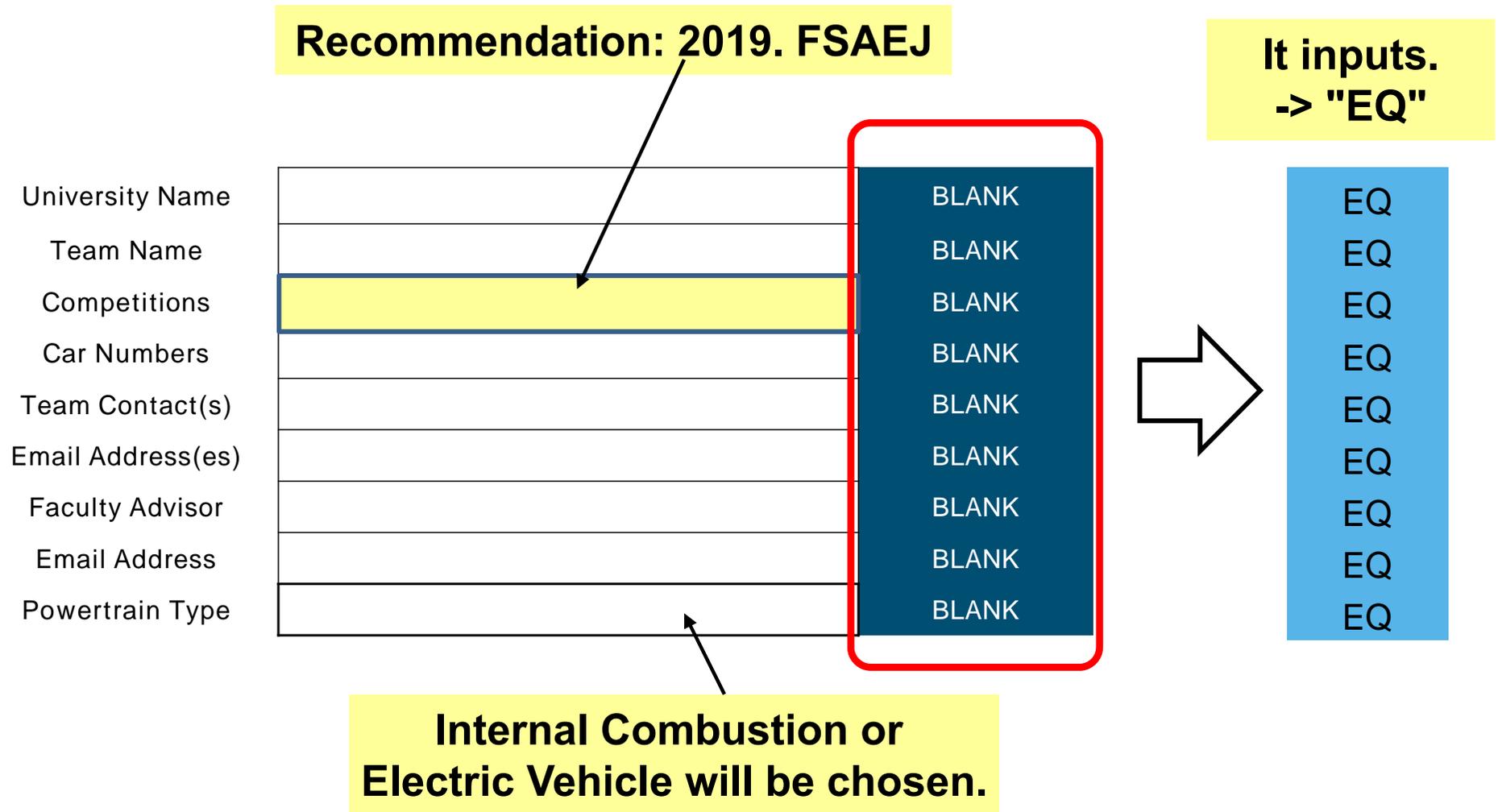
Please add the Excel sheet, if the CAD drawing showing the angle of a bend pipe and a support tube has not gone into the space specified by SES.

1. Basic Information for SES

**2. How to report SES**

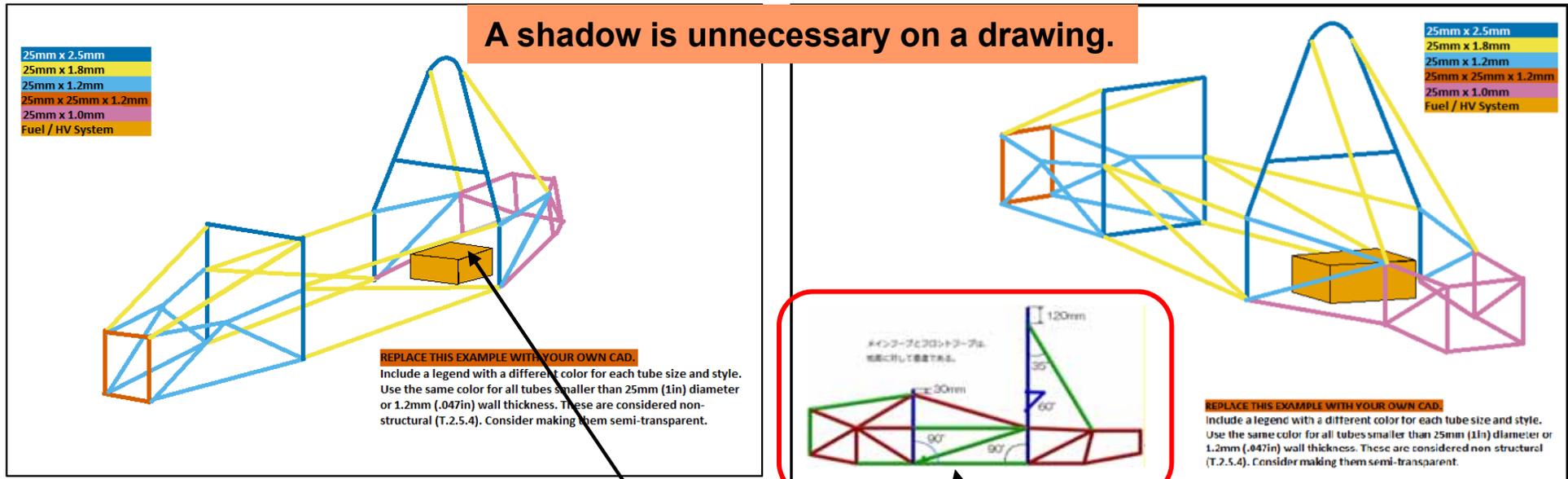
# The Input of Team Information

Although there is no restriction in expression, you should input correctly.

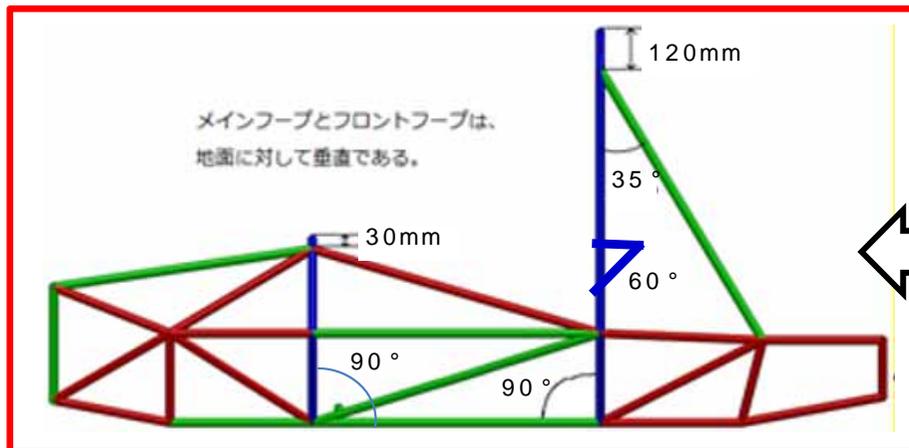


# Clarification and Drawing of Pipes

An isometric drawing inserts the front and back, as shown below.



1. Three views drawing is unnecessary.
2. Illustrate a **Fuel Tank** in ICV and illustrate **Accumulator Container** in EV.
3. Please write pipe classification by color like a sample.
4. All pipes smaller than  $\phi 25\text{mm}$  or  $t1.2\text{mm}$  are the same colors.

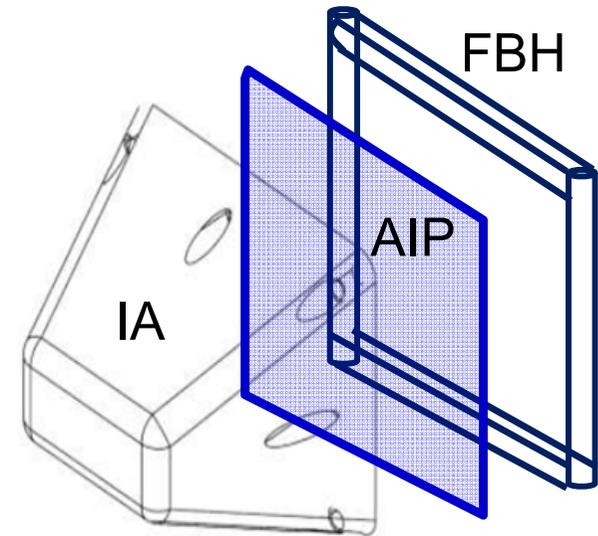


**Please add the side view showing each part size to either. (In order to make a technical inspection smooth)**

# Drawing : Fixation of AIP and FBH

## T.2.22.3

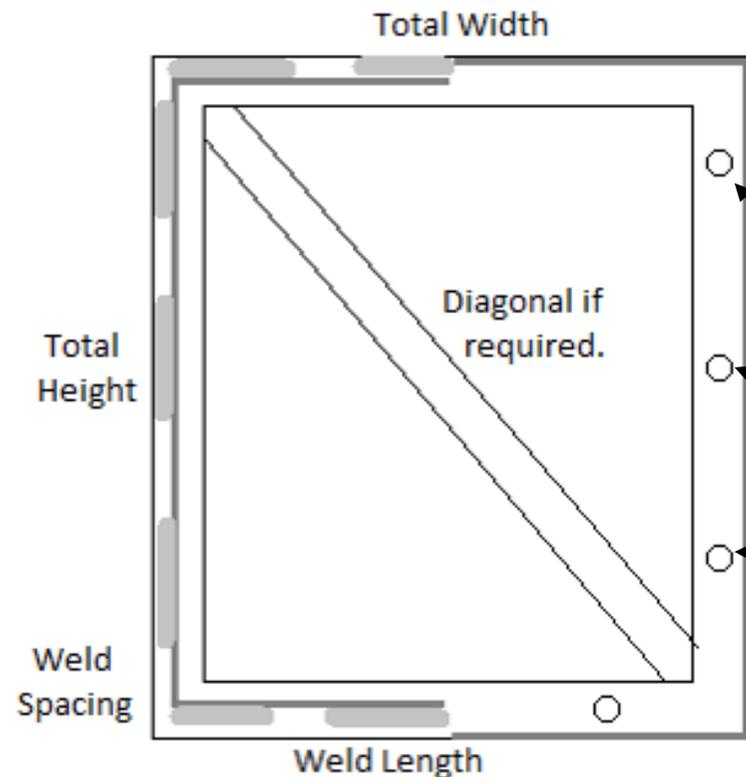
- Welding**, where the welds are either continuous or interrupted. If interrupted, the weld/space ratio must be at least 1:1. All weld lengths must be greater than 25 mm.
- Bolted joints**, using no less than eight 8 mm or 5/16" minimum diameter **Critical Fasteners**, see T.10.2 and T.10.3. The distance between any two bolt centers must be at least 50 mm.



**REPLACE THIS EXAMPLE WITH YOUR OWN CAD.**

Include all required dimensions.

The Front Bulkhead shape may be more complex than this example.



**Indicate the size of each part on a drawing.**

A bolted Anti Intrusion plate reaches the perimeter of the bulkhead. At least 8 x 8mm (5/16in) T.10.2-3 bolts are used. Minimum spacing 50mm (2in).

**A spacer etc. are required, when making a hole in a Bulk Head and bolted.**

**(For bending prevention)**

# Judgment : Fixation of AIP and FBH

A blank is inputted correctly -> A result is judged automatically.

**BLANK**

## Anti-Intrusion and Front Bulkhead

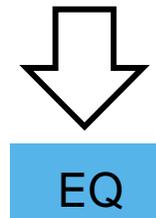
BLANK			
T.2.22.1	Anti-Intrusion Plate (AI) material:	Steel	EQ
	Steel: 1.5mm (0.060in), Aluminum: 4.0mm (.157in):		BLANK

T.2.39 - For AI plates made of any material besides steel or aluminum, either the IA test or 3-Point and Shear tests are required. In the latter case, the 3-Point and Shear tabs in the Monocoque / Hybrid / Non-Ferrous SES must be copied into this file and completed.

All will be set to EQ if it is O.K.

BLANK			
T.2.22.2	AI Attachment:	Welded	EQ
	AI plate must at least reach the centerline of Front Bulkhead tubes.		EQ
	At least half the perimeter must be welded:		BLANK
	Shortest weld >= 25mm (1in):		BLANK

**Cautions:**  
In a bolt and welding, the contents of an input are different.



BLANK			
T.2.19	Front Bulkhead (FB) thinnest wall tube used:	Round	EQ
	Wall thickness:		BLANK
	Outer Diameter (OD):		BLANK

**Cautions:**  
In a circle pipe and a square pipe, the contents of an input are different.

T.2.5.1 - minimum Front Bulkhead tube size:

Round: 25mm x 1.75mm (1in x .065in)

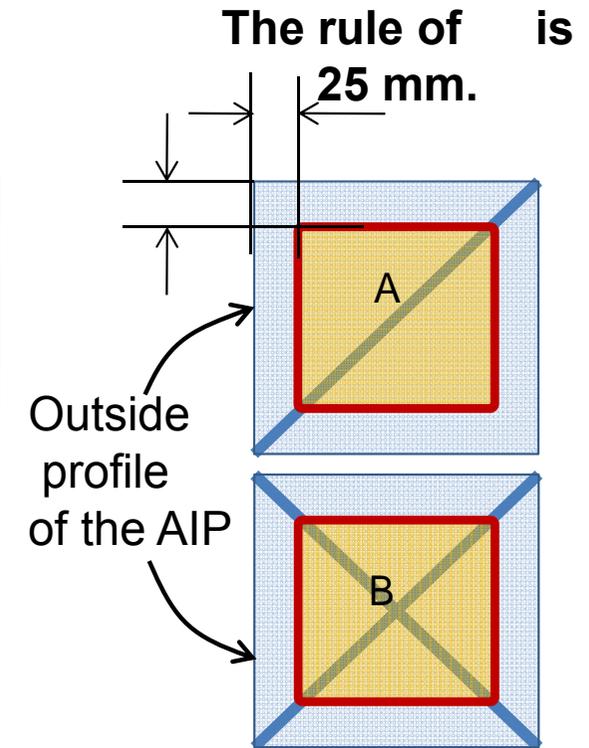
Square: 25mm x 25mm x 1.2mm (1in x 1in x .047in)

T.2.6.3 - For alternate T.2.6 Front Bulkhead wall thicknesses as low as 1.2mm (.047in), the outer diameter must be increased to maintain the cross sectional area.

# Judgment : Fixation of AIP and FBH

**A blank is inputted correctly  
-> A result is judged automatically.**

BLANK			
T.2.23.4	Impact Attenuator (IA) used:	Standard	EQ
	Longest FB dimension (Height or Width)	<input type="text"/>	BLANK
	Shortest FB dimension (Height or Width)	<input type="text"/>	BLANK
	Optional Front Bulkhead Diagonal:	Round	EQ
	Diagonal wall thickness:	<input type="text"/>	N/A
	Outer Diameter (OD):	<input type="text"/>	N/A
No diagonal or X-brace required.			



**In the case of the standard IA, the necessity or the needlessness of X-brace is judged with the size of FBH.**

## T.2.23.4

**If a team uses the Standard Impact Attenuator, and the outside profile of the Anti Intrusion Plate extends beyond the Standard Impact Attenuator by more than 25 mm on any side, then one of the following must be met:**

- The Front Bulkhead must include a diagonal or X-brace meeting the requirements for a Front Bulkhead Support tube per **T.2.5**, or an approved equivalent per **T.2.6** OR **T.2.7**, must be included in the Front Bulkhead.
- Physical testing must be performed to prove that the Anti Intrusion Plate does not permanently deflect more than 25 mm.

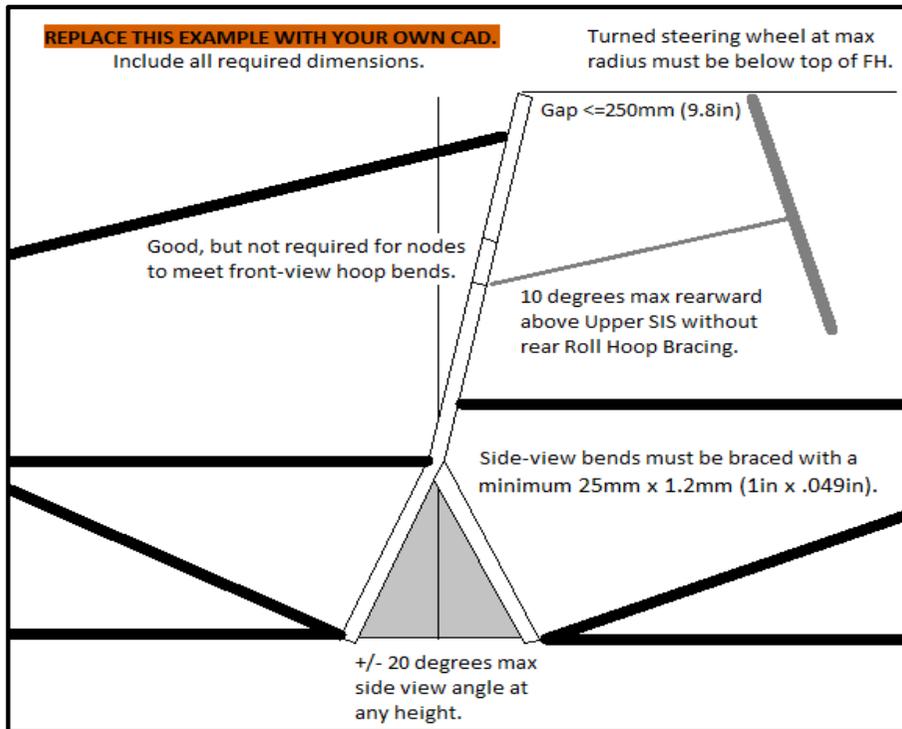
**No more than 25mm  
-> it is NG.**



**Be careful of size change by deterioration.**

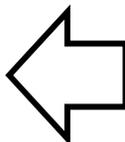
# Drawing and Judgment : Front Hoop

The size of the following relevance is indicated with a side view.  
A blank is inputted correctly -> A result is judged automatically.



All will be set to EQ if it is O.K.

EQ



## BLANK

## Front Hoop (FH)

T.2.12.2 - The FH runs from the lowest frame member on each side.

T.2.12.3 - The FH may be multiple pieces. Side view bends must be braced per T.2.8.

BLANK			
T.2.12	Front Hoop thinnest wall tube used:	Round	EQ
	Wall thickness:	<input type="text"/> in	BLANK
	Outer Diameter (OD):	<input type="text"/> in	BLANK

T.2.5.1 - minimum Front Hoop tube size:

Round:  $25\text{mm} \times 2.5\text{mm}$  (1in  $\times$  .095in)

T.2.6.3 - For alternate T.2.6 Front Hoop wall thicknesses as low as  $2.0\text{mm}$  (.079in), the outer diameter must be increased to maintain the cross sectional area.

BLANK			
T.2.12.4	Turned Steering Wheel minimum below FH top:	<input type="text"/> in	BLANK

BLANK			
T.2.12.5	FH to Steering Wheel gap $\leq 250\text{mm}$ (9.8in)	<input type="text"/> in	BLANK

BLANK			
T.2.12.6	Maximum Front Hoop side angle $\leq 20$ degrees:	<input type="text"/> degrees	BLANK

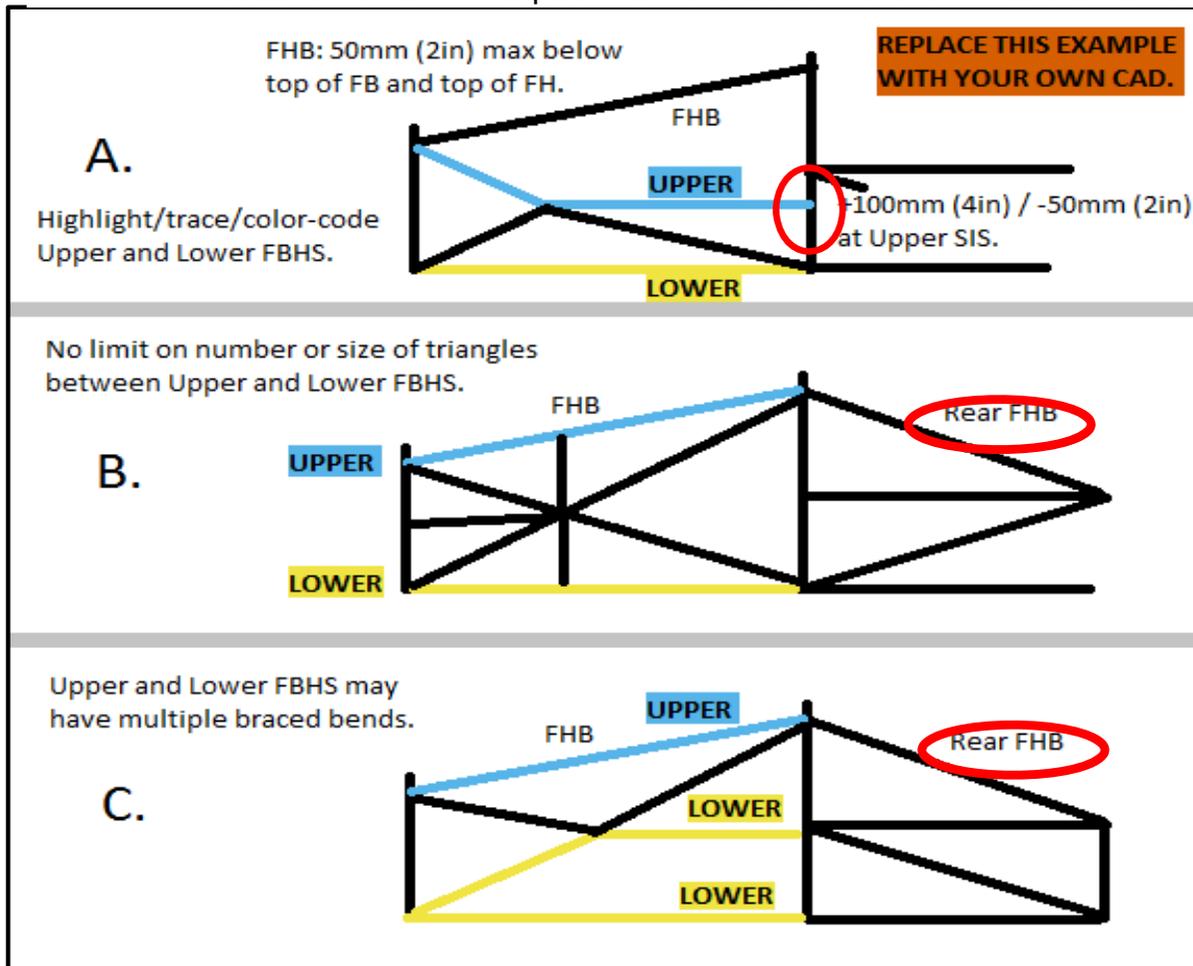
BLANK			
T.2.14.5	FH rearward lean above Upper SIS $\leq 10$ , or braced:	<input type="text"/> degrees	BLANK
	Rearward Front Hoop Brace is not required.		

# Special Attention : FBHS and FHB

About FBHS and FHB, you have to clarify to any of "A-B-C" of the following illustration it corresponds.

There are three basic configurations for the FBHS:

- A. Upper FBHS from the top of the FB to the Upper SIS, with a tolerance.  
Lower FBHS from the bottom of the FB to the Lower SIS.
- B. Upper FBHS from the top of FB to above the Upper SIS, braced rearward.  
Lower FBHS from the bottom of the FB to the Lower SIS.
- C. Upper FBHS from the top of FB to above the Upper SIS, braced rearward.  
Lower FBHS from the bottom of the FB to the Upper SIS, with a tolerance.  
A second Lower FBHS path from the bottom of the FB to the Lower SIS.



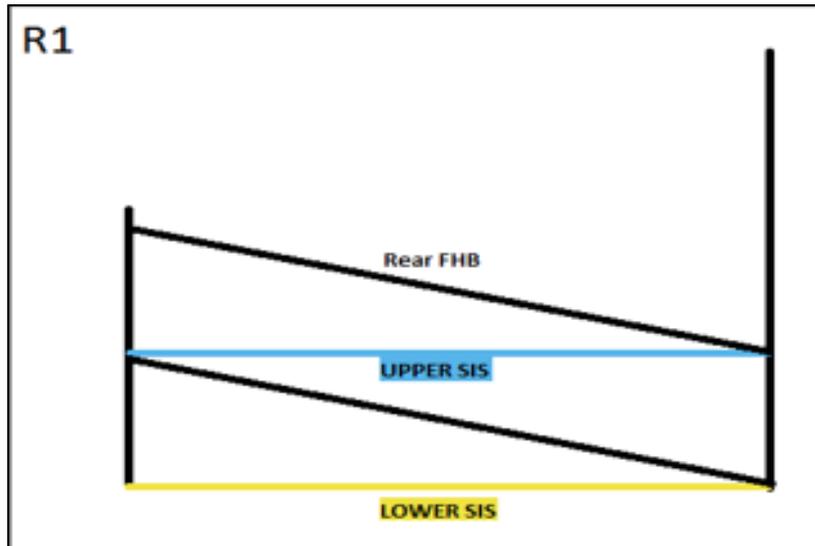
If FHB and Upper FBHS are independent,  
According to the distance of Upper FBHS and Upper SIS, you need Rear FHB.

If FHB and Upper FBHS are common,  
According to the distance of Upper FBHS and Upper SIS, you need Rear FHB.

FHB and Upper FBHS are common,  
Regardless of the distance of Upper FBHS and Upper SIS, you need Rear FHB.

# Special Attention : Rear FHB

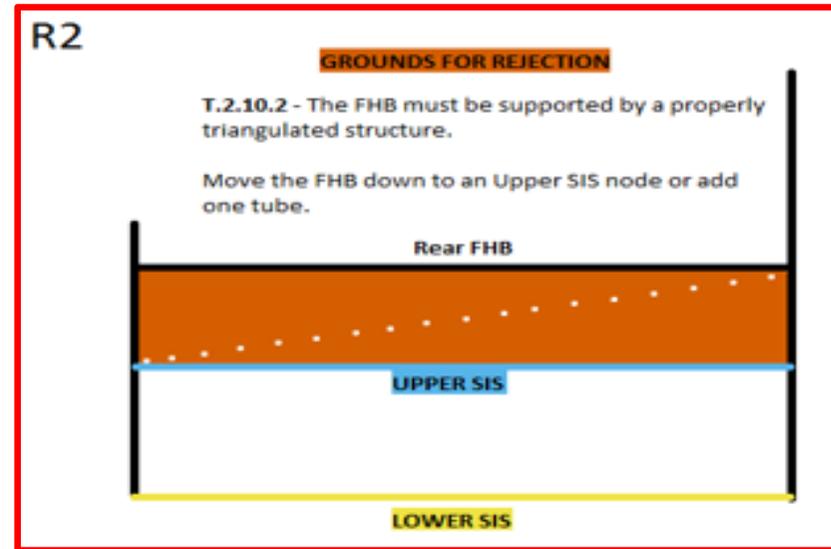
If "Rear FHB" is required by the spatial relationship of FBHS and FHB, You must be cautious of the following figure "R1" and "R2."



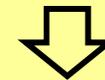
Rear FHB is connected to the node.



**An additional brace is unnecessary.**



Rear FHB is not connected to the node.



**An additional brace is required.**

- ✓ As for Rear FHB, the same standard pipe as FHB is required.
- ✓ The same standard pipe is required also about an additional brace.

# Judgment: FBHS and FHB

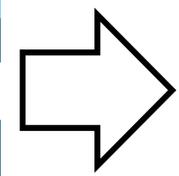
A blank is inputted correctly -> A result is judged automatically.

**BLANK**

**FBHS and FHB**

BLANK			
T.2.20	Front Bulkhead Support (FBHS) thinnest wall tube:	Round	EQ
	Wall thickness:		BLANK
	Outer Diameter (OD):		BLANK
T.2.5.1 - minimum FBHS tube size: Round: 25mm x 1.5mm -or- 26mm x 1.2mm (1in x .047in) Square: 25mm x 25mm x 1.2mm (1in x 1in x .047in)			
BLANK			
T.2.20.2a	Top of FB to Upper FBHS tube, 2in vertical limit:		BLANK
BLANK			
T.2.20.2at	FBHS configuration:	A	EQ
	Top of Upper FBHS tube relative to top of Upper SIS tube:	Above	EQ
	Without Rear FHB, vertical limit 4in above:		BLANK
Rearward Front Hoop Brace is not required.			
BLANK			
T.2.14.4	Top of FH to top of FHB tube, 2in vertical limit:		BLANK
BLANK			
T.2.14	Forward Front Hoop Brace thinnest wall tube:	Round	EQ
	Wall thickness:		BLANK
	Outer Diameter (OD):		BLANK
Rearward Front Hoop Brace is not required.			
EQ			
T.2.20.2b	Rear Front Bulkhead Support thinnest wall tube:	Round	N/A
	Wall thickness:		N/A
	Outer Diameter (OD):		N/A

**All will be set to EQ if it is O.K.**



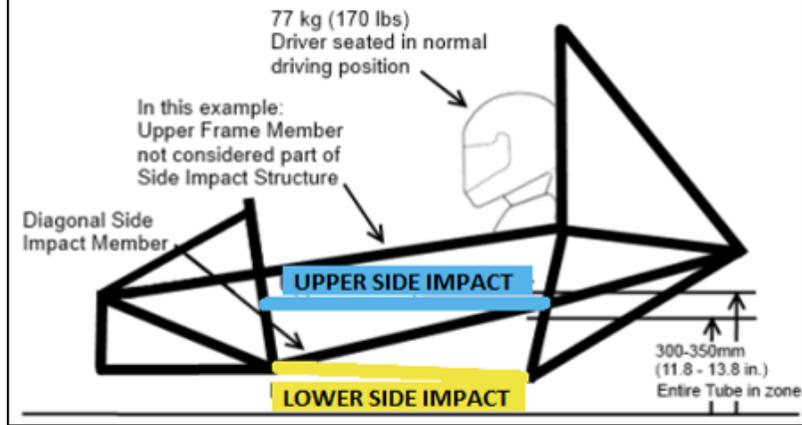
**EQ**

# Drawing and Judgment : SIS

A blank is inputted correctly -> A result is judged automatically.

**OK-NG of Frame composition looks at S1-S5, and R1-R5.**

**REPLACE THIS EXAMPLE WITH YOUR OWN CAD.**  
 Include all required dimensions.  
 Highlight/trace/color code Upper and Lower SIS.  
 Bent Upper SIS must use larger tube whether bent in top or side



**All will be set to EQ if it is O.K.**



S1		R1	
S2	<b>REJECTION</b> 	R2	<b>REJECTION</b> T.2.10.2 - The FHB must be supported by a properly triangulated structure. Move the FHB down to an Upper SIS node or add one tube. 
S3		R3	<b>REJECTION</b> T.2.10.2, T.2.8 - The FHB must be supported by a properly triangulated structure, and multi-segments must be braced. Add another triangulating tube (example R5) or reconfigure the triangulating tubes (example R4). 
S4		R4	
S5		R5	

**BLANK**

**Side Impact Structure (SIS)**

BLANK

T.2.26.4	Lowest point of Upper SIS at ride height $\geq 11.8$ in:	<input type="text"/>	in	BLANK
	Highest point of Upper SIS at ride height $\leq 13.8$ in:	<input type="text"/>	in	BLANK

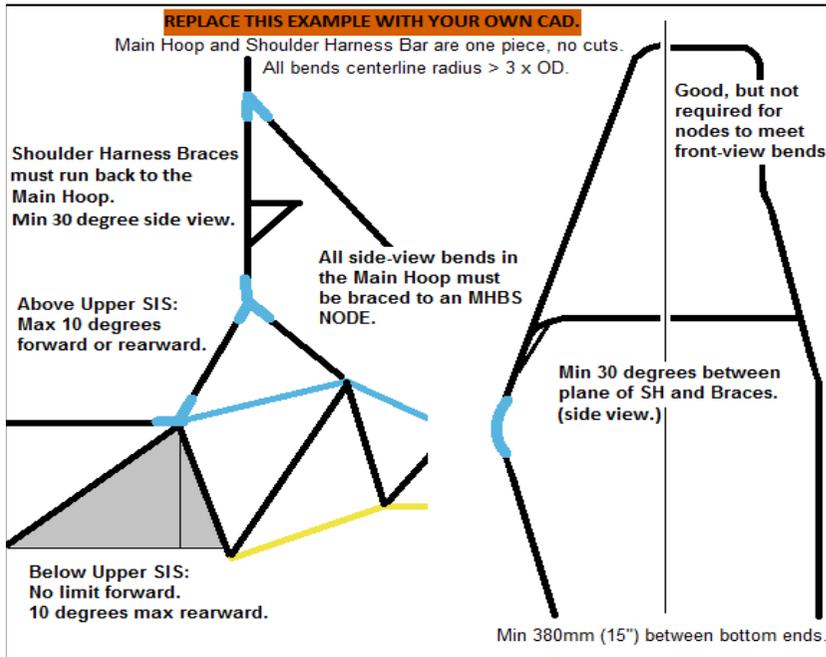
BLANK

T.2.26	Upper SIS geometry:	Straight		EQ
	Upper SIS thinnest wall tube used:	Round		EQ
	Wall thickness:	<input type="text"/>	in	BLANK
	Outer Diameter (OD):	<input type="text"/>	in	BLANK

BLANK

T.2.26	Lower and Diagonal SIS thinnest wall tube used:	Round		EQ
	Wall thickness:	<input type="text"/>	in	BLANK
	Outer Diameter (OD):	<input type="text"/>	in	BLANK

# Drawing and Judgment : M/H & S/H Bar



**A blank is inputted correctly  
-> A result is judged automatically.**

**All will be set to EQ if it is O.K.**

**EQ** ←

**BLANK**

M/Hoop and S/H Bar

**BLANK**

T.2.11	Main Hoop thinnest wall tube used:	Round	EQ
	Wall thickness:	<input type="text"/> in	BLANK
	Outer Diameter (OD):	<input type="text"/> in	BLANK

**BLANK**

T.4.5	Shoulder Harness Bar Geometry:	Straight	EQ
	Shoulder Harness Bar thinnest wall tube used:	Round	EQ
	Wall thickness:	<input type="text"/> in	BLANK
	Outer Diameter (OD):	<input type="text"/> in	BLANK

Shoulder Harness Bar does not require braces.

**EQ**

T.4.5.3b	Brace angle to plane of SH side view >= 30:	<input type="text"/> degrees	N/A
----------	---	------------------------------	-----

T.2.8.1 - The plane of a bent tube is defined by the straight axes on either side of the bend.

Shoulder Harness Bar does not require braces.

**EQ**

T.4.5	Shoulder Harness Brace:	Round	N/A
	Wall thickness:	<input type="text"/> in	N/A
	Outer Diameter (OD):	<input type="text"/> in	N/A

**BLANK**

T.2.11.3a	Main Hoop direction in side view above Upper SIS:	Rearward	EQ
	Main Hoop side angle above Upper SIS <=10:	<input type="text"/> degrees	BLANK

T.2.13.3 Main Hoop Braces may run forward or rearward.

**BLANK**

T.2.11.3c	Main Hoop direction in side view below Upper SIS:	Rearward	EQ
	Main Hoop <=10 degrees in the rearward direction:	<input type="text"/> degrees	BLANK

**BLANK**

T.2.11.4	Distance between Main Hoop ends >=380mm(15")	<input type="text"/> in	BLANK
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T.2.8.1 - Enter the tightest bend on any T.5-6 tube in the chassis (usually in the MH or SH.)

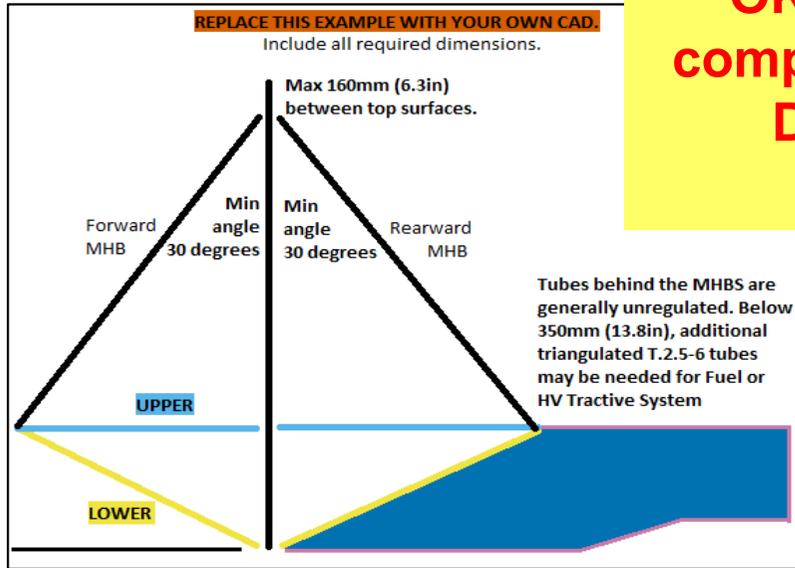
**BLANK**

T.2.8.1	Minimum tube centerline radius:	<input type="text"/> in	BLANK
	Outer Diameter (OD):	<input type="text"/> in	BLANK

# Drawing and Judgment : MH Brace & MHB Support

A blank is inputted correctly -> A result is judged automatically.

**OK-NG of Frame composition looks at D1-D5, E1-E5 and F1-F5.**



**All will be set to EQ if it is O.K.**



Main Hoop Braces may run forward or rearward.

<b>BLANK</b>			
T.2.13.3	Main Hoop brace direction:	Rearward	EQ
T.2.13.4	Angle between MH and MHB $\geq 30$ degrees:		degrees
<b>BLANK</b>			
T.2.13.4	Top of MH to top of MHB tube, 6.3in vertical limit:		in
<b>BLANK</b>			
T.2.13	Main Hoop Braces thinnest wall tube:	Round	EQ
	Wall thickness:		in
	Outer Diameter (OD):		in
<b>BLANK</b>			
T.2.13	Main Hoop Brace Support (MBHS) thinnest wall:	Round	EQ
	Wall thickness:		in
	Outer Diameter (OD):		in

**REASONS FOR REJECTION**

- D1:** Unregulated except for Fuel and HV protection below 30mm.
- E1:** Unregulated except for Fuel and HV protection below 30mm.
- F1:** Unregulated except for Fuel and HV protection below 30mm.
- D2:** Unregulated except for Fuel and HV.
- E2:** REASONS FOR REJECTION: T.2.13.2, T.2.10.2 - The area between the Upper and Lower MHBs must be completely triangulated with tubes meeting T.2.5-6 MHBs. Add 1 tube or move the top of the vertical tube to the Upper SIS.
- F2:** Unregulated except for Fuel and HV.
- D3:** Unregulated except for Fuel and HV.
- E3:** REASONS FOR REJECTION: T.2.13.7 - MHB must be supported by a minimum of two frame members. One member or point cannot carry the load. T.2.13.7b - Lower MHBs needs to run from the MHB to the Lower SIS.
- F3:** Unregulated except for Fuel and HV.
- D4:** Unregulated except for Fuel and HV.
- E4:** REASONS FOR REJECTION: T.2.13.8, T.2.10.2 - Any tube connecting to the MHB will be considered the start of the Upper and Lower MHBs. SH needs to be separated and braced. Examples F2-5 show how to use SH & Braces as MHBs.
- F4:** REASONS FOR REJECTION: T.2.13.7 - MHB must be supported by a minimum of two frame members. One member or point cannot carry the load. Move the Upper MHBs to match example F3 above. Except for the bottom end of the Main Hoop Brace, the Upper and Lower MHBs cannot share a load path.
- D5:** Unregulated except for Fuel and HV.
- E5:** REASONS FOR REJECTION: T.2.13.7, T.2.10.2, T.2.8 - The MHB must be supported by a properly triangulated structure, and multi-segments must be braced. Add 1 tube, which becomes the Lower MHBs.
- F5:** Unregulated except for Fuel and HV.

# Drawing and Judgment :

## Helmet Clearance, Head Restraint and Rear Wing Mounting

REPLACE THIS EXAMPLE WITH YOUR OWN CAD.

50 mm

50 mm

Helmet must be forward of this Line

**T.2.13.5,9 - Unbraced Main Hoop and Brace spans illegal for wing mounting.**

Mounts permitted at nodes.

Ideally, the entire head restraint structure will meet the helmet requirements.

Single braces under a wing mount are strongly discouraged. Teams are required to include an additional calculation to the SES: wing mount failure < unbraced mhb bending failure

Below 350mm in this area, Fuel and HV systems require a complete triangulated structure with minimum 25mm x 1.5mm, 26mm x 1.2mm, or 1in x .047in tubing.

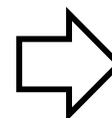
A blank is inputted correctly  
 -> A result is judged automatically.

T.2.13.9 -  
 Wing mounts cannot be added to the middle of the MHB without bracing.

BLANK

Helmet Clearance, Head Restraint, and Rear Wing Mounting

BLANK				
T.2.10.3a	Helmet $\geq 50$ mm (2in) below Roll Hoop plane:	<input type="text"/>	in	BLANK
BLANK				
T.2.10.3bc	Main Hoop Braces protecting Helmet:	Rear	<input type="text"/>	EQ
T.2.10.3bc	Helmet $\geq 50$ mm (2in) below Hoop/Brace plane:	<input type="text"/>	in	BLANK
BLANK				
T.2.2.1	Head Restraint $\geq 0$ from ground in any rollover:	<input type="text"/>	in	BLANK
EQ				
T.2.13.9	Rear Wing chassis mounting locations:	<input type="text"/>		EQ
				EQ



All will be set to EQ if it is O.K.

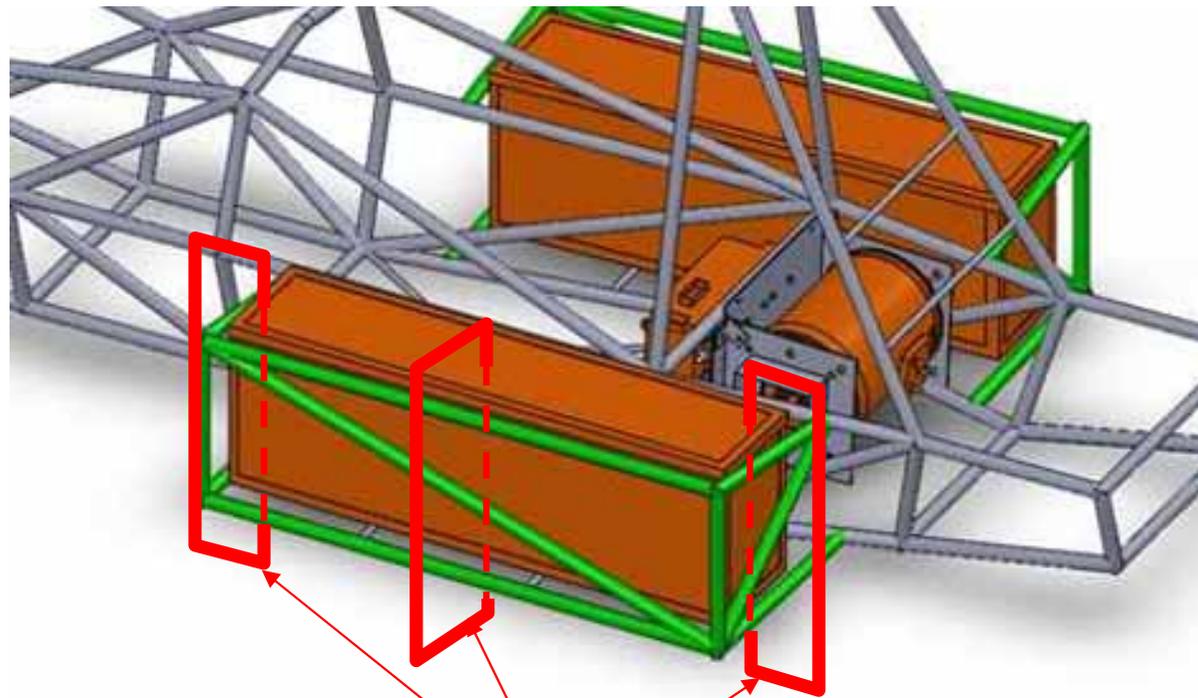
EQ

# EV

## ✓ EV: Accumulator & Tractive System Protection

Protections should be considered as Side Impact Structure equivalent.

You calculate in the composition pipe of the weakest perpendicular section.



Tube number should be counted in the  
weakest cross-section