T3 Driver’s Cell

Vehicle Structure - 2 Options

- Teams may, at their option, design their vehicle to comply with either of two (2) separate, but related, sets of requirements and restrictions. Specifically, teams may elect to comply with either:
  a. Part B Article 3 “Drivers Cell” as defined below or
  b. Part AF “Alternate Frame Rules” as found in Appendix AF and on the FSAE website.

- Notice Requirement – Teams planning to use the Part AF “Alternate Frame Rules” must notify the Rules Committee of their intent by November 1, 2011. Alternate Frame Rules use requires the submission of the “Structural Requirements Certification Form (SRCF)” which supersedes the “Structural Equivalency Spreadsheet”.

- Teams submitting a Structural Requirements Certification Form (SRCF) do not have to submit a Structural Equivalency Spreadsheet (SEC)

Presenter’s Note: Competitions outside the USA typically do not accept the AFR option unless the design has been accepted by another recognized (official) competition, e.g. FSAE USA.
T3.9 Structural Equivalency

Structural Documentation – SES or SRCF Submission

- All teams MUST submit either a STRUCTURAL EQUIVALENCY SPREADSHEET (SES) or a STRUCTURAL REQUIREMENTS CERTIFICATION FORM (SCRF).

- Teams complying with the Part Article 3 “Drivers Cell” rules MUST submit a Structural Equivalence Spreadsheet (SES), even if they are NOT planning to use alternative materials or tubing sizes to those specified in T3.4.1 Baseline Steel Materials.

- Teams following the Part AF “Alternate Frame Rules” MUST submit a Structural Requirements Certification Form (SRCF). See Rule AF2.

- The use of alternative materials or tubing sizes to those specified in T3.4.1 “Baseline Steel Material,” is allowed, provided they have been judged by a technical review to have equal or superior properties to those specified in T3.4.1.

- Vehicles completed under an approved SES must be fabricated in accordance with the materials and processes described in the SES.

- Teams must bring a copy of the approved SES with them to Technical Inspection.
T3.3 Driver’s Cell - Definitions

Definitions

• The following definitions apply throughout the Rules document:
  – Main Hoop - A roll bar located alongside or just behind the driver’s torso.
  – Front Hoop - A roll bar located above the driver’s legs, in proximity to the steering wheel.
  – Roll Hoops – Both the Front Hoop and the Main Hoop are classified as “Roll Hoops”
  – Roll Hoop Bracing Supports – The structure from the lower end of the Roll Hoop Bracing back to the Roll Hoop(s).

Then there are some carryover definitions, e.g. Frame, Primary Structure.

– Side Impact Zone – The area of the side of the car extending from the top of the floor to 350 mm (13.8 inches) above the ground and from the Front Hoop back to the Main Hoop.
Frame Member Names

- Front Hoop
- Front Roll Hoop
- Main Roll Hoop
- Main Hoop Bracing
- Harness Mounting Bar
- Front Bulkhead
- Front Bulkhead Supports (3+)
- Side Impact Structure (3)
- Main Hoop Bracing Supports (2)
T3.4.1 Steel Tube Wall Thickness
(for 1” OD, most common)

The task at Tech Inspection is to check that the car has been built to the (approved) SES. Check the configuration of the tubes against the SES, and if possible, check the OD and wall thickness of major tubes (MRH, FRH, MHBr, SHBar) and others at random.
T3.4 1 Baseline Steel Material – Cont’d

• Side Impact Structure, Front Bulkhead Support, Roll Hoop Bracing, Driver’s Restraint Harness Attachment (except Shoulder Harness Mounting Bar)
  – Options of:
    • or Square 1.00 inch x 1.00 inch x 0.049 inch
    • or Square 25.0 mm x 25.0 mm x 1.25 mm metric
    • or Square 26.0 mm x 26.0 mm x 1.2 mm metric
    Added without having to submit the change on the SES

• Main Hoop Bracing Supports
  – Added tubes are required to be 1.00” x 0.049” wall minimum.

• Note 2: For a specific application:
  - Using tubing of the specified outside diameter but with greater wall thickness,
  - OR of the specified wall thickness and a greater outside diameter,
  - Or replacing round tubing with square tubing of the same or larger size to those listed above,
    IS NOT a rules deviation requiring approval.

• Note 3: Except for any inspection holes, any holes drilled in any regulated tubing require the submission of an SES.
T3.6 Alternative Steel Tubing

• Steel Tubing for Front & Main Roll Hoops and Shoulder Harness Mounting Bar
  – Minimum Thickness of 2.0 mm (0.079 inches)

• Steel Tubing for Roll Hoop Bracing, Roll Hoop Bracing Supports, Side Impact Structure, Front Bulkhead, Front Bulkhead Support, and Driver’s Harness Attachment (except Shoulder Harness Mounting Bar)
  – Minimum Thickness 1.2 mm (0.047 inches)

However:

Note 3: To maintain the equivalent yield and ultimate tensile strength the same cross-sectional area of steel as the baseline tubing specified T3.4.1 **MUST** be maintained.

Presenter’s Comment:
If the wall thickness goes down to these values, the OD **MUST** go up!
Alternative “Frame” Tubing

Alternative Tubing and Material – General

• T3.5.2 Titanium or magnesium on which welding has been utilized may not be used for any part of the Primary Structure. This includes the attachment of brackets to the tubing or the attachment of the tubing to other components.
Frame tube triangulation
Basics

Multilateral > 3 sides

“Bay”

Trilateral

(Combination)
Frame tube triangulation

All bays triangulated
Frame tube triangulation
Frame tube triangulation

OK
Frame tube triangulation
Frame tube triangulation

Fully triangulated again
Frame tube triangulation
Frame tube triangulation

Bottom bays are triangulated. Upper bay is not. (This is OK)
This is the same frame!
A real frame has “other” links, on top of the minimum structures. Be sure to confirm which links are the required materials, and which are thinner (weaker.)
T3.5.5 “Bent” Tubes

T3.5.5 If a bent tube (or member consisting of multiple tubes that are not in a line) is used anywhere in the primary structure, other than the front and main roll hoops, an additional tube must be attached to support it. The attachment point must be the position along the tube where it deviates farthest from a straight line connecting both ends. The support tube must have the same diameter and thickness as the bent tube, terminate at a node of the chassis, and be angled no more than 45 degrees from the plane of the bent tube.

Braces attached to the upper side impact member are not required to meet the 45 degree from the plane of the bent tube requirement.
T3.25 Inspection Holes

Inspection Holes

- The Technical Inspectors may check the compliance of all tubes. This may be done by the use of ultra sonic testing or by the drilling of inspection holes at the inspector’s request.

Presenter’s comment:
Teams have been recommended that they drill inspection holes in non-critical locations in the Main and Front Hoops to the requirements of the 2010 Rules, in case the ultra sonic equipment is not available or is malfunctioning.
T3.11 Main Hoop

- Must be a single piece of uncut, continuous, closed section steel tubing, (1.00 inch OD x 0.095 inch wall or approved alternative).
- No aluminum alloys, titanium alloys or composite materials.
- From the lowest Frame Member on one side down the lowest Frame Member on the other side.
- In the front view of the vehicle, the vertical members of the Main Hoop must be at least 380 mm (15 inch) apart (inside dimension) at the location where the Main Hoop is attached to the bottom tubes of the Major Structure of the Frame.
T3.11 Main Hoop – Cont’d

- In the side view, above the Major Structure, must be within 10 degrees of the vertical.
- In the side view of the vehicle, any bends in the Main Roll Hoop above its attachment point to the Major Structure of the Frame must be braced to a node of the Main Hoop Bracing Support structure with tubing meeting the requirements of Roll Hoop Bracing as per Rule T3.4.1.
- In the side view of the vehicle, the portion of the Main Roll Hoop that lies below the upper side impact member attachment point may be inclined at any angle to the vertical in the forward direction but, it must be inclined rearward no more than ten degrees ($10^\circ$) of the vertical.

Note: Special attention must be given to the attachment of Main Hoops to monocoques. (Review the team’s SES for approved details. See later in the presentation.)
T3.13 Main Hoop Bracing

- Must be closed section steel tubing 1.00” OD x 0.065” wall or approved equivalent.

- No aluminum alloys, titanium alloys or composite materials

- Two braces, forward or rearward direction, one on each side.

- In the side view, the Main Hoop and the Main Hoop Braces must not lie on the same side of the vertical.

- Attached no more than 160 mm (6.3 in) below the top-most surface of the Main Hoop. The included angle formed by the Main Hoop and the Main Hoop Braces must be at least 30 degrees.

- Must be straight, i.e. without any bends.
T3.13 Main Hoop Bracing – Cont’d

50 mm (2 inch) Minimum to ALL drivers and 95th percentile template

Front Roll Hoop
no lower than top of steering wheel

Bracing 50 mm (2 inch) Max.

Front Roll Hoop and Braces
must be integrated into frame and surrounding structure

30° Min. | 30° Min.

Bracing 16 cm (6.3 inch) Max.

Main Roll Hoop
Braces fore or aft on right and left sides.
Minimum of 30° included angle with Roll Hoop

FIGURE 1
T3.13.6-7 Main Hoop Bracing Supports

• The Main Hoop Braces must be securely integrated into the Frame and be capable of transmitting all loads from the Main Hoop into the Major Structure of the Frame without failing.

• The lower end of the Main Hoop Braces must be supported back to the Main Hoop by a minimum of two Frame Members on each side of the vehicle; an upper member and a lower member in a properly triangulated configuration.
  a. The upper support member must attach to the node where the upper Side Impact Member attaches to the Main Hoop.
  b. The lower support member must attach to the node where the lower Side Impact Member attaches to the Main Hoop.

• Each of the above members may be multiple or bent tubes provided the requirements of T3.5.5 are met.

Note: What we are looking for here are 2 load paths. Each load path can be made of multiple tubes, but must be properly triangulated.
Main Hoop Bracing Supports - cont’d

• From the lower end of the braces there must be a properly triangulated structure back to the lowest part of the Main Hoop and the node at which the upper side impact tube meets the Main Hoop.

• This structure must meet the minimum requirements for Main Hoop Bracing Supports (see Rule T.3.4.1) or an SES approved alternative.
Main Hoop Bracing Supports - cont’ d

- From the lower end of the braces there must be a properly triangulated structure back to the lowest part of the Main Hoop and the node at which the upper side impact tube meets the Main Hoop.
- This structure must meet the minimum requirements for Main Hoop Bracing Supports or an SES approved alternative.
Main Hoop Bracing - cont’d

Not OK

• The lower end of the Main Hoop Braces must be supported back to the Main Hoop by a minimum of two Frame Members on each side of the vehicle; an upper member and a lower member in a properly triangulated configuration.
  a. The upper support member must attach to the node where the upper Side Impact Member attaches to the Main Hoop.
  b. The lower support member must attach to the node where the lower Side Impact Member attaches to the Main Hoop.

OK if Tube Sizes are OK

• Bracing loads must not be fed solely into the engine, transmission or differential, or through suspension components.
Main Hoop Bracing - cont’d

Bracing loads must **not** be fed solely into the engine, transmission or differential, or through suspension components.
Main Hoop Bracing - cont’d

Not OK - Goes through Suspension Components
Main Hoop Bracing - cont’d

- T3.13.9 If any item which is outside the envelope of the Primary Structure is attached to the Main Hoop braces, then additional bracing must be added to prevent bending loads in the braces in any rollover attitude.

Presenter’s Comment: Typically, this is applies to rear wings and radiators that are mounted to or have struts to the Main Hoop Bracing.
T3.13.9 Items Mounted to Main Hoop Bracing

Suspension mount puts bending into required structure.

T3.13.9 If any item which is outside the envelope of the Primary Structure is attached to the Main Hoop braces, then additional bracing must be added to prevent bending loads in the braces in any rollover attitude.
T3.13.9 Items Mounted to Main Hoop Bracing-
Cont’d

Additional link provides triangulation, OK now.

T3.13.9 If any item which is outside the envelope of the Primary Structure is attached to the Main Hoop braces, then additional bracing must be added to prevent bending loads in the braces in any rollover attitude.
T3.17 Main Hoop Bracing - Mechanically Attached

Figure 2

Capping Plate

3/8 Pin

3/8 I.D. Tubing welded into ends of stay

Figure 3

Capping Plate

25 mm (1 inch) Minimum

Axis of bracing

Figure 4

6 mm (1/4 in)
For double-lug joints, each lug must be at least 4.5 mm (0.177 in) thick steel, measure 25 mm (1.0 in) minimum perpendicular to the axis of the bracing and be as short as practical along the axis of the bracing.

All double-lug joints, whether fitted at the top or bottom of the tube, must include a capping arrangement (Figures 2 & 3 on previous slide).

In a double-lug joint the pin or bolt must be 10 mm Metric Grade 9.8 (3/8 in. SAE Grade 8) minimum. The attachment holes in the lugs and in the attached bracing must be a close fit with the pin or bolt.
Bolted joints in frame must have > 1.5 dia. from edge of hole to edge of material. (But not suspension pickups; frame only.)

AKA “edge distance ratio “e/D” of 2 or greater”

Bolted joint in primary structure

This tab is too small
T5.4.1 Shoulder Harness Mounting Bar

- Minimum size must be 1.00” OD x 0.095” wall thickness steel, or approved equivalent.

- The shoulder harness must be mounted behind the driver to a single piece of uncut, continuous, closed section steel tubing that meets the requirements of T3.4.1. This Shoulder Harness Mounting Bar must attach to the Main Hoop on both sides of the chassis. Bends in the Shoulder Harness Mounting Bar, if present, must be smooth and continuous with no evidence of crimping or wall failure.

- Bent Shoulder Harness Mounting Bars are required to have bracing members attached at the bends and to the Main Hoop. Material for this bracing must meet the requirements of T3.4.1 “Shoulder Harness Mounting Bar Bracing.” The included angle in side view between the Shoulder Harness Bar and the braces must be no less than 30 degrees.
T5.4.1 Shoulder Harness Bar - cont’d

If the harness is mounted to a tube that is not straight, in side view there must be triangulation tubes going forward to the Main Hoop to prevent torsional rotation of the harness mounting tube.
T3.12 Front Hoop

- Closed section metal tubing 1.00” OD x 0.095” wall steel or approved equivalent
- No composite materials.
- From the lowest Frame Member on one side, up, over and down to the lowest Frame Member on the other side. With proper gusseting and/or triangulation, it is permissible to be from more than one piece of tubing.
- The top-most surface of the Front Hoop must be no lower than the top of the steering wheel in any angular position.
- The Front Roll Hoop must be no more than 250 mms (9.8 inches) forward of the steering wheel. This distance shall be measured horizontally, on the vehicle centerline, from the rear surface of the Front Roll Hoop to the front surface of the steering wheel rim with the steering in the straight-ahead position.
- In side view, no part of the Front Hoop can be inclined at more than twenty (20) degrees from the vertical.
T3.12 Front Hoop

Front Roll Hoop and Braces must be integrated into frame and surrounding structure

50 mm (2 inch) Minimum to ALL drivers and 95th percentile template

Bracing 16 cm (6.3 inch) Max.

Main Roll Hoop Braces fore or aft on right and left sides. Minimum of 30° included angle with Roll Hoop

Front Roll Hoop no lower than top of steering wheel

Bracing 50 mm (2 inch) Max.

FIGURE 1
T3.14 Front Hoop Bracing

50 mm (2 inch) Minimum to ALL drivers and 95th percentile template

Front Roll Hoop no lower than top of steering wheel

Bracing 50 mm (2 inch) Max.

Main Roll Hoop Braces fore or aft on right and left sides. Minimum of 30° included angle with Roll Hoop

Front Roll Hoop and Braces must be integrated into frame and surrounding structure

Bracing 16 cm (6.3 inch) Max.

30° Min. 30° Min.

FIGURE 1
• Two braces extending forward on both the left and right sides, 1.00” OD x 0.065” wall steel tubing or approved equivalent.

• Constructed such that they protect the driver’s legs and should extend to the structure in front of the driver’s feet. (Note: Not “must extend”. They can be “long”, top left, or “short “top right.)

• Attached no more than 50.8 mm (2 in) below the top-most surface of the Front Hoop.

• If the front hoop leans rearwards by more than 10 degrees from the vertical, it must be supported by additional bracing to the rear. This bracing must be constructed of material per Section T3.4.1.
T3.16 Other Side Tubes

If there is a roll hoop brace or other frame tube alongside the driver, at the height of the neck of any of the team’s drivers, a metal tube or piece of sheet metal must be firmly attached to the Frame to prevent the drivers’ shoulders from passing under the roll hoop brace or frame tube, and his/her neck contacting this brace or tube.
T3.24 Side Impact Requirements

Tube Frames

The Side Impact Structure must be comprised of at least three (3) tubular members located on each side of the driver while seated in the normal driving position, as shown in Figure 7. The three (3) required tubular members must be constructed of material per Section T3.4. The locations for the three (3) required tubular members are as follows:
Minimum of three (3) 1.00” OD x 0.065” wall steel tubes or approved equivalent:

- Upper, connecting the Main Hoop and the Front Hoop. With a 77kg (170 pound) driver seated in the normal driving position all of the member must be between 300 mm (11.8 inch) and 350 mm (13.8 inch) above the ground.

- Lower, connecting the bottom of the Main Hoop and the bottom of the Front Hoop.

- A diagonal connecting the upper and lower SIS members between the Main & Front Hoops.

- With proper gusseting and/or triangulation, it is permissible to fabricate the Side Impact Structural members from more than one piece of tubing.
T3.18 Front Bulkhead, T3.22 Crush Zone

• T3.18.2 Except as allowed by T3.22.2, the Front Bulkhead must be located forward of all non-crushable objects, e.g. batteries, master cylinders, hydraulic reservoirs.

• T3.22.1 All non-crushable objects (e.g. batteries, master cylinders, hydraulic reservoirs) inside the primary structure must have 25 mm (1”) clearance to the rear face of the Impact Attenuator Anti-Intrusion Plate.

• T3.22.2 All non-crushable objects outside the primary structure must be either:
  a. Included in the Impact Attenuator physical test
  b. Subject to an analysis approach as per T3.21.6.b or T3.21.6.c
  c. Mounted rearwards of an imaginary transverse vertical plane, offset forwards from the Impact Attenuator Anti-Intrusion Plate by a distance equal to the height of the crushed impact attenuator.
T3.19 Front Bulkhead Support

• The Front Bulkhead must be supported back to the Front Roll Hoop by a minimum of three Frame Members on each side of the vehicle:
  a. An upper member
  b. A lower member
  c. And a diagonal brace to provide triangulation.
T3.19 Front Bulkhead Support

a. The **upper support member** must be attached:

- Within 50mm (2") of the top surface of the Front Bulkhead,

- And attach to the Front Roll Hoop within a zone extending 100mm (4") above and 50mm (2") below the Upper Side Impact member.

If the upper support member is further than 100mm (4") above the Upper Side Impact member, then properly triangulated bracing is required to transfer load to the Main Hoop, either via the Upper Side Impact member, or an additional member that meets the size requirements of T3.4, transmitting load from the junction of the Upper Support Member with the Front Hoop.
Bulkhead support must:
“attach to the Front Roll Hoop within a zone extending (4”) above and (2”) below the Upper Side Impact member.”
T3.19.2: Front Bulkhead Support – Cont’d

Bulkhead support must:
“attach to the Front Roll Hoop within a zone extending (4”) above and (2”) below the Upper Side Impact member.”
T3.19.2: Front Bulkhead Support – Cont’d

Bulkhead support must:
“attach to the Front Roll Hoop within a zone extending (4”) above and (2”) below the Upper Side Impact member.”
b. The lower support member must be attached to the base of the Front Bulkhead and the base of the Front Roll Hoop.

c. **The diagonal brace must properly triangulate the upper and lower support members**

- Each of the above members may be multiple or bent tubes provided the requirements of T3.5.5 are met.
T3.20 Impact Attenuator & Mounting

• The Impact Attenuator must be:
  a. At least 200 mm (7.8 in) long, with its length oriented along the fore/aft axis of the Frame.
  b. At least 100 mm (3.9 in) high and 200 mm (7.8 in) wide for a minimum distance of 200 mm (7.8 in) forward of the Front Bulkhead.
  c. Attached securely to the Anti-Intrusion Plate.

• The attachment of the Impact Attenuator and Anti-Intrusion Plate must be constructed to provide an adequate load path for transverse and vertical loads in the event of off-center and off-axis impacts.

• If the team is NOT using the “Standard” FSAE Impact Attenuator, they are required to bring the IA that was tested to scrutineering to compare it to the one mounted to the car.
T3.20.3 & T3.20.5 Impact Attenuator Anti-Intrusion Plate

- On all cars, a 1.5 mm (0.060 in) solid steel or 4.0 mm (0.157 in) solid aluminum “Anti-Intrusion Plate” must be mounted between the Front Bulkhead and the IA.
  - If the IA plate is bolted to the Front Bulkhead, it must be the same size as the outside dimensions of the Front Bulkhead.
  - If it is welded to the Front Bulkhead, it must extend at least to the centerline of the Front Bulkhead tubing.
- Alternative designs of the anti-intrusion plate allowed by T3.38 that do not comply with the minimum specifications given above require testing and an approved “Structural Equivalency Spreadsheet”.
- The IA Plate will be listed on the SES.
**T3.20.4 Impact Attenuator and Anti-Intrusion Plate Mounting**

- The accepted methods of attaching the IA to the Anti-Intrusion Plate, and Anti-Intrusion Plate to the Front Bulkhead are:
  a. 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 (1”).
  b. Bolted joints, using a minimum of eight (8) 8 mm Metric Grade 8.8 (5/16” SAE Grade 5) bolts with positive locking. The distance between any two bolt centers must be at least 50 mm (2”).

- The Impact Attenuator may also be attached to the Anti-Intrusion Plate using a structural adhesive.

- The adhesive must be appropriate for use with both substrate types. Equivalency of this bonded joint to a welded or bolted joint must be documented in the team’s SES submission.
Front Wing Supports

• T3.22.2 All non-crushable objects outside the primary structure must be either:
  a. Included in the Impact Attenuator physical test
  b. Subject to an analysis approach as per T3.21.6.b or T3.21.6.c
  c. Mounted rearwards of an imaginary transverse vertical plane, offset forwards from the Impact Attenuator Anti-Intrusion Plate by a distance equal to the height of the crushed impact attenuator.

• T3.21.6 Teams with any non-crushable object(s) that do not meet the requirements of T3.22.2 c) must prove the combination of their Impact Attenuator Assembly and non-crushable object(s) do not exceed the peak deceleration of rule T3.21.2. Any of the following methods may be used to prove the design does not exceed 120kN:
  a. Physical testing of the Impact Attenuator Assembly including any required non-crushable object(s). See fsaeonline.com FAQs for an example of the structure to be included in the test for wings and wing mounts.
  b. Combining the peak force from physical testing of the Impact Attenuator Assembly with the failure load for the mounting of the non-crushable object(s), calculated from fastener shear and/or link buckling.
  c. Combining the “standard” Impact Attenuator peak load of 95kN with the failure load for the mounting of the non-crushable object(s), calculated from fastener shear and/or link buckling.

These proofs must be in an approved Impact Attenuator Data Report.
Impact Attenuator

“Standard Attenuator” must be **glued** together if made up of multiple sheets of foam.

If the attenuator is made of more than one piece of foam those pieces must be glued together using a structural adhesive that is compatible with the Impax foam. Segments may not be stacked without glue.

- Requirements found at www.fsaeonline.com
T3.20.6 Standard Impact Attenuator

Standard Attenuator
• Teams may choose to use that style of impact attenuator and need not submit test data with their IAD Report……

However,
• If a team uses the “standard” FSAE Impact Attenuator, and the outside profile of the Anti-Intrusion Plate extends beyond the “standard” Impact Attenuator by more than 25 mm (1”) on any side, a diagonal or X-brace made from 1.00” x 0.049” steel tube, or an approved equivalent per T3.5, must be included in the Front Bulkhead.
• Teams may choose to not brace the bulkhead, but physical testing must then be carried out to prove that the Anti-Intrusion Plate does not permanently deflect more than 25 mm (1”).
T4.3 Seat Mounting

Any rigid structures used to mount the driver’s seat must be designed to avoid piercing the seat in a collision.

For example, go-kart style seat shells should not be mounted with steel tubes, especially if the tube centerlines point in the direction of the driver’s torso.
T4.3.1 Seat - Not OK

Seat

The lowest point of the driver’s seat must be no lower than the bottom surface of the lower frame rails or by having a longitudinal tube (or tubes) that meets the requirements for Side Impact tubing, passing underneath the lowest point of the seat.

Note: The smallest tube would be 1.00” OD X 0.065” wall)
T4.3.2 Driver’s Seat

- When seated in the normal driving position, adequate heat insulation must be provided to ensure that the driver will not contact any metal or other materials which may become heated to a surface temperature above 60 degrees C.
- The insulation may be external to the cockpit or incorporated with the driver’s seat or firewall.
T4.3.2 Driver’s Seat - cont’d

- The design must show evidence of addressing all three (3) types of heat transfer, namely conduction, convection and radiation, with the following between the heat source, e.g. an exhaust pipe or coolant hose/tube and the panel that the driver could contact, e.g. the seat or floor:

  a. Conduction Isolation by:
     i. No direct contact between the heat source and the panel, or
     ii. A heat resistant, conduction isolation material with a minimum thickness of 8 mm (0.3 ins) between the heat source and the panel.

  b. Convection Isolation by a minimum air gap of 25 mm (1 inch) between the heat source and the panel

  c. Radiation Isolation by:
     i. A solid metal heat shield with a minimum thickness of 0.4 mm (0.015 ins) or
     ii. Reflective foil or tape when combined with T4.3.2.a.ii above.
T3.27-T3.39 Monocoque Inspections

• The design and build of a monocoque is a complex business.
• Therefore the prior review and approval of the team’s SES or SRF is critical.
• Hence, inspections at the competition should focus on whether the monocoque has been constructed to the approved SES or SRF.
• Pay particular attention that the following are to the SES/SRF:
  – The tubing sizes of the Main Hoop, and Main Hoop Bracing.
  – The mounting of the Main Hoop
  – The mounting of, or lamination in, of the Front Hoop. Measuring the tube size may be difficult, but its presence should be checked.
  – The mounting of the Main Hoop Braces.
  – The safety harness mountings.
  – That the SIS material given in the SES covers the full Side Impact Zone, Main Hoop to Front Hoop, and from floor to 350 mms above the ground.
• More information on T3.27-T3.39 follow. Particular attention should be given to T3.39 Monocoque Attachments.
T3.27 Monocoques - General Requirements

Monocoque General Requirements

- All equivalency calculations must prove equivalency relative to steel grade SAE/AISI 1010.

- All sections of the rules apply to monocoque structures except for the following sections which supplement or supersede other rule sections.

- Monocoque construction requires an approved Structural Equivalency Spreadsheet, per Section B.3.8. The form must demonstrate that the design is equivalent to a welded frame in terms of energy dissipation, yield and ultimate strengths in bending, buckling and tension.

- Composite and metallic monocoques have the same requirements.
T3.29 Monocoque Buckling Modulus – Equivalent Flat Panel Calculation

• When specified in the rules, the EI of the monocoque must be calculated as the EI 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.

Note: Calculations of EI that do not reference <above> may take into account the actual geometry of the monocoque.
T3.30 Monocoque Laminate Testing

Monocoque Laminate Testing

• Teams must build a representative section of the monocoque side impact zone (defined in T3.3.k) side as a flat panel and perform a 3 point bending test on this panel.

• They must prove by physical test that a section 275 mm (10.8 inches) x 500 mm (19.7 inches) has at least the same properties as a baseline steel side impact tube (See T3.4.1 “Baseline Steel Materials”) for buckling modulus, yield strength, ultimate strength and absorbed energy.

• The data from these tests and pictures of the test samples must be included in the SES. The test specimen must be presented at technical inspection.

• If the test specimen does not meet these requirements then the monocoque side impact zone must be strengthened appropriately.

Note: Teams are advised to make an equivalent test with the base line steel tubes such that any compliance in the test rig can be accounted for, if necessary.
T3.31 Monocoque Front Bulkhead

Monocoque Front Bulkhead

• See Rule T3.27 for general requirements that apply to all aspects of the monocoque.

• In addition when modeled as a flat plate the EI of the front bulkhead about both vertical and lateral axis must be equivalent to that of the tubes specified for the front bulkhead under T3.18. The length of the section perpendicular to the bulkhead may be a maximum of 25.4mm (1”) measured from the rearmost face of the bulkhead.

• Furthermore any front bulkhead which supports the IA plate must have a perimeter shear strength equivalent to a 1.5 mm thick steel plate.
T3.32 Monocoque Bulkhead Support

Monocoque Front Bulkhead Support

- In addition to proving that the strength of the monocoque is adequate, the monocoque must have equivalent El to the sum of the El of the six (6) baseline steel tubes that it replaces.

- The El of the vertical side of the front bulkhead support structure must be equivalent to at least the El of one baseline steel tube that it replaces when calculated as per rule <> Monocoque Buckling Modulus.

- The perimeter shear strength of the monocoque laminate in the front bulkhead support structure should be at least 4 kN (880 pounds) for a section with a diameter of 25 mm (1 inch). This must be proven by a physical test by measuring the force required to pull or push a 25mm (1 inch) diameter object through a sample of laminate and the results include in the SES.
• In addition to proving that the strength of the monocoque is adequate, the side of the monocoque between the Main Hoop and the Front Hoop must have equivalent EI to the sum of the EI of the three (3) baseline steel tubes that it replaces.

• The side of the monocoque between the upper surface of the floor and 350 mm above the ground (the Side Impact Zone) must have an absorbed energy equivalent to two baseline steel tubes.
T3.33 Monocoque Side Impact - cont’d

• The perimeter shear strength of the monocoque laminate should be at least 7.5 kN (1700 pounds) for a section with a diameter of 25 mm (1 inch).

• This must be **proven by physical test** by measuring the force required to pull or push a 25 mm (1 inch) diameter object through a sample of laminate and the results included in the SES.
T3.34 Monocoque Main Hoop

• The Main Hoop must be constructed of a single piece of uncut, continuous, closed section steel tubing per T3.4.1 and extend down to the bottom of the monocoque.

• The Main Hoop must be mechanically attached at the top and bottom of the monocoque and at intermediate locations as needed to show equivalency.

• Mounting places welded to the Roll Hoop shall be at least 2.0 mm (0.080 inch) thick steel.

• Attachment of the Main Hoop to the monocoque must comply with T3.39.
T3.34 Monocoque Main Hoop

Not OK

- The Main Hoop must be constructed of a single piece of uncut, continuous, closed section steel tubing and extend down to the bottom of the monocoque.
- The Main Hoop must be mechanically attached at the top and bottom of the monocoque and at intermediate locations as needed to show equivalency.
- Mounting places welded to the Roll Hoop shall be at least 2.0 mm (0.080 inch) thick steel.
T3.35 Monocoque Front Hoop

- Composite materials are not allowed for the front hoop. See Rule T3.27 for general requirements that apply to all aspects of the monocoque.

- Attachment of the Front Hoop to the monocoque must comply with Rule T3.39.

- Fully laminating the front hoop into the monocoque is acceptable. Equivalence to at least four mounts compliant with Rule T3.40 must be shown in the SES.

- Evidence as per T3.28 must be shown to pass technical inspection.

- The use of adhesive as the sole method of attaching the front hoop to the monocoque is not acceptable. Fully laminating means encapsulating the hoop with an appropriate number and arrangement of plies.
T3.37 Monocoque IA Attachment & T3.38 IA Anti-Intrusion Plate

Monocoque Impact Attenuator Attachment

• The attachment of the Impact Attenuator to a monocoque structure requires an approved “Structural Equivalency Spreadsheet” per Rule T3.9 that shows the equivalency to a minimum of eight (8) 8 mm Grade 8.8 (5/16 inch Grade 5) bolts.

Monocoque Impact Attenuator Anti-intrusion Plate

• See Rule T3.38 for details. This part is covered in the SES, and must have been approved. Check the Al Plate against the SES.
T3.39 Monocoque Attachments

Monocoque Attachments

• In any direction, each attachment point between the monocoque and the other primary structure must be able to carry a load of 30kN (6740 lbs. f)

• The laminate, mounting plates, backing plates and inserts must have sufficient shear area, weld area and strength to carry the specified 30kN load in any direction. Data obtained from the laminate perimeter shear strength test (T3.30.5) should be used to prove adequate shear area is provided.

• Each attachment point requires a minimum of two (2) M8 grade 8.8 (or 5/16 inch Grade 5) bolts.

• Each attachment point requires steel backing plates with a minimum thickness of 2 mm. Alternate materials may be used for backing plates if equivalency is approved.
T3.39 Monocoque Attachments - cont’d

- The *Front Hoop Bracing*, Main Hoop Bracing and Main Hoop Bracing Supports *only* may use one (1) 10 mm Grade 8.8 (3/8 inch Grade 5) bolt as an alternative to T3.39 if the bolt is on the centerline of tube similar to the figure below.

- No crushing of the core is permitted.

- Main Hoop bracing attached to a monocoque (i.e. not welded to a rear space frame) is always considered “mechanically attached” and must comply with Rule T3.17.
Copyright © 2017 Albion Associates, LLC

All rights reserved.