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SAE REEV – TECHNICAL INSTRUCTION





Version Log

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0.0.0	17 May, 2018	Initial Version	Initial Version
1.0.0	31 May, 2018	Content Updated	
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Advice from Our Tech Inspectors

Range extended Electric vehicle (REEV) technical inspection team welcomes you to the most challenging of the SAE Collegiate Design Series competitions. Most of us are professionals in the automotive industry dealing with real competitive world. We have two goals: to have a safe competition and see every team on the track.

TOP Tips for Building Urban Mobility Vehicle

1. Safety is Paramount. Ensure you use the right protective equipment every time. You are working-on or using the vehicle.
2. Plan your work & work to your plan. Start work early & don't assume everything goes right the first time.
3. Get your fundamentals right. Take inputs from your mentors / seniors e.g. Lessons learnt seriously & work on them.
4. Today's Automobile requires all streams of Engineering. So, ensure you have diverse engineering streams represented in your team.
5. Read all rules carefully. If you don't understand, please ask!!
6. Use Project Management tools & techniques. They will make life easier & will help you as engineers. Most importantly, they will help you arrive at the competition with a finished car.
7. Start testing your car early!! Ensure safety aspects / systems are in place & tested (like brake test, engine integration and Electrical integration). Pay serious attention to “ ☠ ” symbol.
8. Take advantage of extra day of electrical tech inspection. That will give you extra time if you need to make modifications.
9. Watch out for the rules tagged with the “ ⚠ Attention ” symbol. These have a history of tripping up teams.



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General comment:

- a. The use of alternative materials is allowed, provided they have been judged by a technical review to have equal or superior properties to those specified (Backed up with data)
- b. Inspection Holes: To allow the verification of tubing wall thicknesses, 4.5 mm inspection holes must be drilled in a non-critical location of both the Main Hoop and the Front Hoop.

PART T - VEHICLE REQUIREMENTS AND RESTRICTIONS

ARTICLE T1 Technical Inspection

The following requirements and restrictions will be enforced through technical inspection. Noncompliance must be corrected and the car re-inspected before the car is allowed to operate under power.

Note: Teams are advised that cockpit template (see **T4.1**) and Percy (see **Figure 3**) compliance will be strictly enforced during mechanical technical inspection. Check the URBAN MOBILITY website for an instructional video on template and Percy inspection procedures.

T1.1 Modifications and Repairs

- T1.2.1 Once the vehicle has been presented for judging in the Design Events, or submitted for Technical Inspection, and until the vehicle is approved to compete in the dynamic events, i.e. all the inspection stickers are awarded, the only modifications permitted to the vehicle are those directed by the Inspector(s) and noted on the Inspection Form.
- T1.2.2 Once the vehicle is approved to compete in the dynamic events, the **ONLY** modifications permitted to the vehicle are:
- (a) Adjustment of belts, chains and clutches
 - (b) Adjustment of brake bias
 - (c) Adjustment of the driver restraint system, head restraint, seat and pedal assembly
 - (d) Substitution of the head restraint or seat inserts for different drivers
 - (e) Adjustment to engine operating parameters, e.g. fuel mixture and ignition timing and any software calibration changes
 - (f) Adjustment of mirrors
 - (g) Adjustment of the suspension where no part substitution is required, (except that springs, sway bars and shims may be changed)
 - (h) Adjustment of tire pressure
 - (i) Adjustment of wing angle (but not the location)
 - (j) Replenishment of fluids



- (k) Replacement of worn tires or brake pads - The replacement tires and/or brake pads must be identical in material, composition and size to those presented and approved at Technical Inspection.
- (l) The changing of wheels and tires for “wet” or “damp” conditions as allowed in **D3.1** of the URBAN MOBILITY Rules.
- (m) Recharging of Grounded Low Voltage (GLV) supplies.
- (n) Recharging of Accumulators. (see **EV10.2**)
- (o) Adjustment of motor controller operating parameters.

T1.2.3 The vehicle must maintain all required specifications, e.g. ride height, suspension travel, braking capacity, sound level and wing location throughout the competition.

T1.2.4 Once the vehicle is approved for competition, any damage to the vehicle that requires repair, e.g. crash damage, electrical or mechanical damage will void the Inspection Approval. Upon the completion of the repair and before re-entering into any dynamic competition, the vehicle **MUST** be re-submitted to Technical Inspection for reapproval.

ARTICLE T2 DRIVER’S SPACE

T2.1 General Requirements

T2.1.1 Among other requirements, the vehicle’s structure must include two roll hoops that are braced, a front bulkhead with support system and Impact Attenuator, and side impact structures.

Note: It is important to analyze the car-structure and strengthen it to handle the dynamic stresses.

Technical inspectors will pay close attention to mounting of accumulator systems. Being heavy, they must be adequately fastened to the main structure of the vehicle.

T2.2 Definitions

The following definitions apply throughout the Rules document:

- a. Main Hoop - A roll bar located alongside or just behind the driver’s torso.
- b. Front Hoop - A roll bar located above the driver’s legs, in proximity to the steering wheel.
- c. Roll Hoops – Both the Front Hoop and the Main Hoop are classified as “Roll Hoops”
- d. Roll Hoop Bracing Supports – The structure from the lower end of the Roll Hoop Bracing back to the Roll Hoop(s).
- e. Frame Member - A minimum representative single piece of uncut, continuous tubing.



- f. Frame - The “Frame” is the fabricated structural assembly that supports all functional vehicle systems. This assembly may be a single welded structure, multiple welded structures.
- g. Primary Structure – The Primary Structure is comprised of the following Frame components:
 - i. Main Hoop
 - ii. Front Hoop
 - iii. Roll Braces and Supports
 - iv. Side Impact Structure
 - v. Front Bulkhead
 - vi. Front Bulkhead Support System
 - vii. All Frame Members, guides and supports that transfer load from the Driver’s Restraint System into items (i) through (vi).
- h. Major Structure of the Frame – The portion of the Frame that lies within the envelope defined by the Primary Structure. The upper portion of the Main Hoop and the Main Hoop Bracing are not included in defining this envelope.
- i. Front Bulkhead – A planar structure that defines the forward plane of the Major Structure of the Frame and functions to provide protection for the driver’s feet.
- j. Impact Attenuator – A deformable, energy absorbing device located forward of the Front Bulkhead
- k. Side Impact Zone – The area of the side of the car extending from the top of the floor to 350 mm above the ground and from the Front Hoop back to the Main Hoop.
- l. Node-to-node triangulation – An arrangement of frame members projected onto a plane, where a co-planar load applied in any direction, at any node, results in only tensile or compressive forces in the frame members. This is also what is meant by “properly triangulated”.

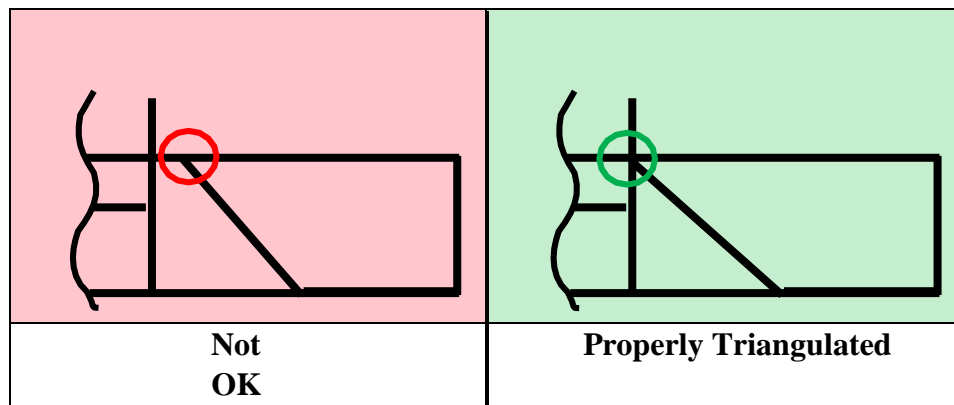


Figure 1 - Triangulation

T2.3 Minimum Material Requirements



T2.3.1 Baseline Steel Material

The Primary Structure of the car must be constructed of:

Either: Round, mild or alloy, steel tubing (minimum 0.1% carbon) of the minimum dimensions specified in **TABLE 1**. Or: Approved alternatives per Rules **T2.2**

ITEM or APPLICATION	OUTSIDE DIMENSION x WALL THICKNESS
	Metric
Main & Front Hoops, Shoulder Harness Mounting Bar	Round: 25.0 mm x 2.50 mm
Side Impact Structure	Round: 25.0 mm x 1.75 mm
Roll Hoop Bracing	Square: 25.0 mm x 25.0 mm x 1.25 mm
Front Bulkhead	Square: 26.0 mm x 26.0 mm x 1.2 mm
Driver's Restraint Harness Attachment (except for Shoulder Harness Mounting Bar)	
Main Hoop Bracing Supports	Round: 25.0 mm x 1.5 mm
Front Bulkhead Supports	Round: 26.0 mm x 1.2 mm
Protection of Tractive System Components	

Table 1 - Baseline Steel

Note 1: 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, are NOT rules deviations requiring approval.

Note 2: Except for inspection holes, any holes drilled in any regulated tubing require the submission of an SES.

Note 3: Baseline steel properties used for calculations to be submitted in an SES may not be lower than the following:

Bending and buckling strength calculations:

Young's Modulus (E) = 200 GPa
Yield Strength (Sy) = 305 MPa
Ultimate Strength (Su)= 365 MPa



- T2.3.2 When a cutout, or a hole greater in diameter than 3/16 inch (4 mm), is made in a regulated tube, e.g. to mount the safety harness or suspension and steering components, in order to regain the baseline, cold rolled strength of the original tubing, the tubing must be reinforced by the use of a welded insert or other reinforcement. The welded strength figures given above must be used for the additional material. And the details, including dimensioned drawings, must be included in the SES.

T2.4 Composite Materials (Seat/Skin)

- T2.4.1 If any composite or other material is used, the team must present documentation of material type, e.g. purchase receipt, shipping document or letter of donation, and of the material properties. Details of the composite lay-up technique as well as the structural material used (cloth type, weight, and resin type, number of layers, core material, and skin material if metal) must also be submitted. The team must submit calculations demonstrating equivalence of their composite structure to one of similar geometry made to the minimum requirements found in Section **T2.2**. Equivalency calculations must be submitted for energy dissipation, yield and ultimate strengths in bending, buckling, and tension. Submit the completed “Structural Equivalency Spreadsheet” per Section T2.5.

Note: Some composite materials present unique electrical shock hazards, and may require additional engineering and fabrication effort to minimize those hazards. See: **ARTICLE EV8**.

T2.5 Structural Documentation – SES Submission

- T2.5.1 All equivalency calculations must prove equivalency relative to steel grade SAE/AISI 1010.
- T2.5.2 All teams must submit a Structural Equivalency Spreadsheet (SES) even if they are not planning to use alternative materials or tubing sizes to those specified in section **T2.1** Baseline Steel Materials.
- T2.5.3 Approval of alternative material or tubing sizes will be based upon the engineering judgment and experience of the chief technical inspector or his appointee.
- T2.5.4 The technical review is initiated by completing the “Structural Equivalency Spreadsheet” (SES) which can be downloaded from the REEV website.
- T2.5.5 Vehicles completed under an approved SES must be fabricated in accordance with the materials and processes described in the SES.
- T2.5.6 Teams must bring a copy of the approved SES with them to Technical Inspection.

T2.6 Main and Front Roll Hoops – General Requirements

- T2.6.1 The driver’s head and hands must not contact the ground in any rollover attitude.
- T2.6.2 The Frame must include both a Main Hoop and a Front Hoop as shown in Figure 4.



T2.6.3 When seated normally and restrained by the Driver's Restraint System, the helmet of a 95th percentile male (anthropometrical data; See **Table 2** and **Figure 3**) and all of the team's drivers must:

- Be a minimum of 50.8 mm from the straight line drawn from the top of the main hoop to the top of the front hoop. (**Figure 2a**)
- Be a minimum of 50.8 mm from the straight line drawn from the top of the main hoop to the lower end of the main hoop bracing if the bracing extends rearwards. (**Figure 2b**)
- Be no further rearwards than the rear surface of the main hoop if the main hoop bracing extends forwards. (**Figure 2c**)

A two dimensional template used to represent the 95th percentile male is made to the following dimensions:

- A circle of diameter 200 mm will represent the hips and buttocks.
- A circle of diameter 200 mm will represent the shoulder/cervical region.
- A circle of diameter 300 mm will represent the head (with helmet).
- A straight line measuring 490 mm will connect the centers of the two 200 mm circles.
- A straight line measuring 280 mm will connect the centers of the upper 200 mm circle and the 300 mm head circle.

Table 2 - 95th Percentile Male Template Dimensions

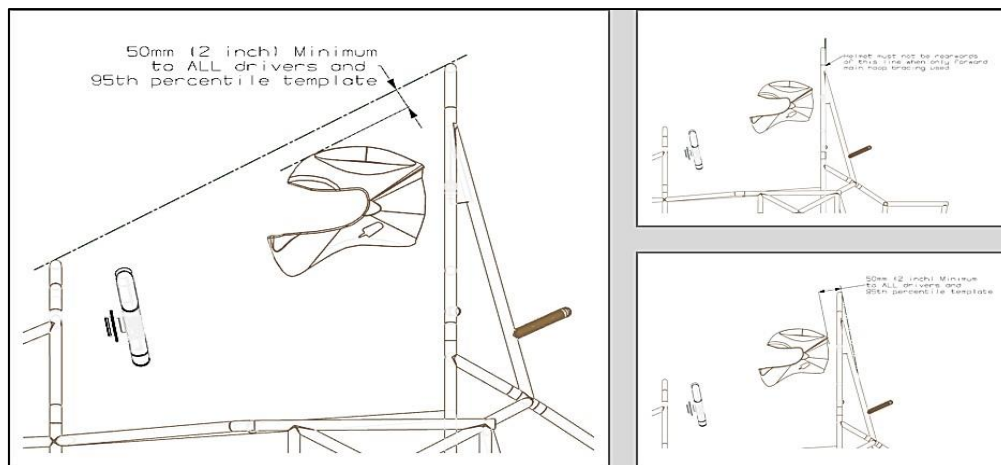




Figure 2 (a, b, c) - Roll Hoops and Helmet Clearance

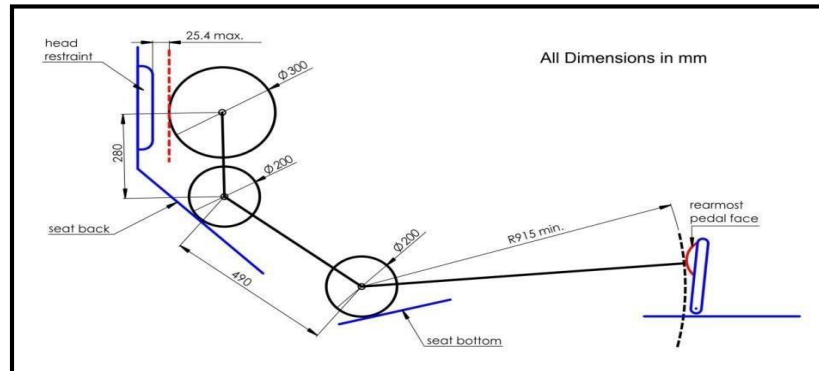


Figure 3 - Percy - 95th Percentile Male with Helmet

- T2.6.4 The 95th percentile male template (Percy) will be positioned as follows: (See **Figure 3**)
- The seat will be adjusted to the rearmost position,
 - The pedals will be placed in the most forward position.
 - The bottom 200 mm circle will be placed on the seat bottom such that the distance between the center of this circle and the rearmost face of the pedals is no less than 915 mm.
 - The middle 200 mm circle, representing the shoulders, will be positioned on the seat back.
 - The upper 300 mm circle will be positioned no more than 25.4 mm away from the head restraint (i.e. where the driver's helmet would normally be located while driving).

IMPORTANT: If the requirements of section **T2.6.4** are not met with the 95th percentile male template, the car will not receive a Technical Inspection Sticker and will not be allowed to compete in the dynamic events.

- T2.6.5 Drivers who do not meet the helmet clearance requirements of section **T2.6.3** will not be allowed to drive in the competition.
- T2.6.6 The minimum radius of any bend, measured at the tube centerline, must be at least three times the tube outside diameter. Bends must be smooth and continuous with no evidence of crimping or wall failure.
- T2.6.7 The Main Hoop and Front Hoop must be securely integrated into the Primary Structure using gussets and/or tube triangulation.



T2.7 Main Hoop

- T2.7.1 The Main Hoop must be constructed of a single piece of uncut, continuous, closed section steel tubing per section **T2.1**.
- T2.7.2 The Main Hoop must extend from the lowest Frame Member on one side of the Frame, up, over and down the lowest Frame Member on the other side of the Frame.
- T2.7.3 In the side view of the vehicle, the portion of the Main Roll Hoop that lies above its attachment point to the Major Structure of the Frame must be within ten degrees (10°) of the vertical.
- T2.7.4 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 section **T2.1**.
- T2.7.5 In the front view of the vehicle, the vertical members of the Main Hoop must be at least 380 mm apart (inside dimension) at the location where the Main Hoop is attached to the Major Structure of the Frame.

T2.8 Front Hoop

- T2.8.1 The Front Hoop must be constructed of closed section metal tubing section **T2.1**.
- T2.8.2 The Front Hoop must extend from the lowest Frame Member on one side of the Frame, up, over and down to the lowest Frame Member on the other side of the Frame.
- T2.8.3 With proper gusseting and/or triangulation, it is permissible to fabricate the Front Hoop from more than one piece of tubing.
- T2.8.4 The top-most surface of the Front Hoop must be no lower than the top of the steering wheel in any angular position.
- T2.8.5 The Front Hoop must be no more than 250 mm forward of the steering wheel. This distance shall be measured horizontally, on the vehicle centerline, from the rear surface of the Front Hoop to the forward most surface of the steering wheel rim with the steering in the straight- ahead position.
- T2.8.6 In side view, no part of the Front Hoop can be inclined at more than twenty degrees (20°) from the vertical. Steel Material

T2.9 Main Hoop Bracing

- T2.9.1 Main Hoop braces must be constructed of closed section steel tubing per section **T2.1**.
- T2.9.2 The Main Hoop must be supported by two braces extending in the forward or rearward direction on both the left and right sides of the Main Hoop.



- T2.9.3 In the side view of the Frame, the Main Hoop and the Main Hoop braces must not lie on the same side of the vertical line through the top of the Main Hoop, i.e. if the Main hoop leans forward, the braces must be forward of the Main Hoop, and if the Main Hoop leans rearward, the braces must be rearward of the Main Hoop.
- T2.9.4 The Main Hoop braces must be attached as near as possible to the top of the Main Hoop but not more than 160 mm 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 thirty degrees (30°). See: **Figure 4**.

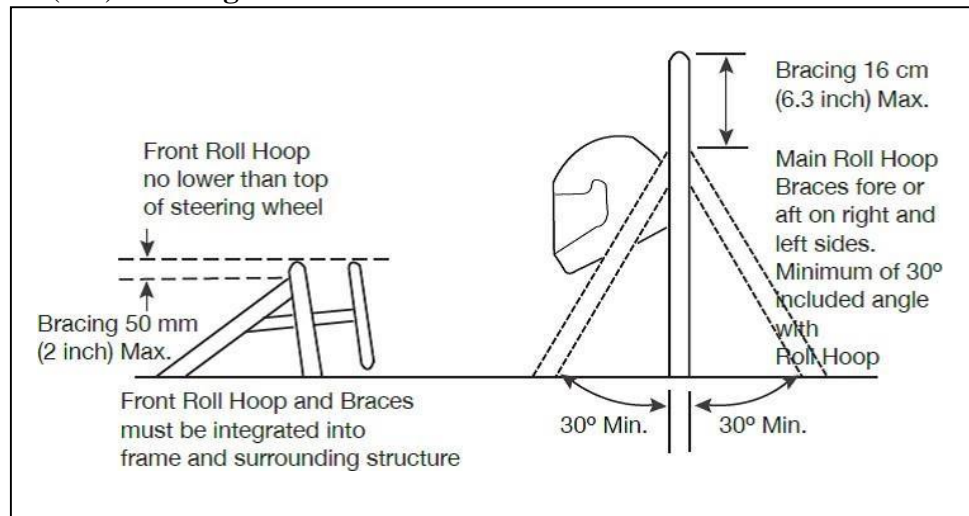


Figure 4 - Main and Front Hoop Bracing

- T2.9.5 The Main Hoop braces must be straight, i.e. without any bends.
- T2.9.6 The attachment of the Main Hoop braces must be capable of transmitting all loads from the Main Hoop into the Major Structure of the Frame without failing. 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 (section **T2.2**) or an SES approved alternative. Bracing loads must not be fed solely into the engine, transmission or differential, or through suspension components.
- T2.9.7 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.

T2.10 Front Hoop Bracing

- T2.10.1 Front Hoop braces must be constructed of material per section **T2.3.1**



- T2.10.2 The Front Hoop must be supported by two braces extending in the forward direction on both the left and right sides of the Front Hoop.
- T2.10.3 The Front Hoop braces must be constructed such that they protect the driver's legs and should extend to the structure in front of the driver's feet.
- T2.10.4 The Front Hoop braces must be attached as near as possible to the top of the Front Hoop but not more than 50.8 mm below the top-most surface of the Front Hoop. See: **FIGURE 4.**
- T2.10.5 If the Front Hoop leans rearwards by more than ten degrees (10°) from the vertical, it must be supported by additional bracing to the rear. This bracing must be constructed of material per section **T2.3.1.**

T2.11 Other Bracing Requirements

- T2.11.1 Where the braces are not welded to steel Frame Members, the braces must be securely attached to the Frame using 8 mm Metric Grade 8.8 (5/16 in SAE Grade 5), or stronger, bolts. Mounting plates welded to the Roll Hoop braces must be at least 2.0 mm thick steel.

T2.12 Other Side Tube Requirements

- T2.12.1 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.
- T2.12.2 The threaded fasteners used to secure non-permanent joints are considered critical fasteners and must comply with **ARTICLE T9.**
- T2.12.3 In a double-lug joint the pin or bolt must be 10 mm Grade 9.8 or 3/8 inch 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.
- T2.12.4 For sleeved butt joints the sleeve must have a minimum length of 76 mm (38 mm on either side of the joint) and be a close-fit around the base tubes. The wall thickness of the sleeve must be at least that of the base tubes. The bolts must be 6 mm Grade 9.8 or 1/4 inch SAE Grade 8 minimum. The holes in the sleeves and tubes must be a close-fit with the bolts.

T2.13 Frontal Impact Structure



T2.13.1 The driver's feet and legs must be completely contained within the Major Structure of the Frame. While the driver's feet are touching the pedals, in side and front views no part of the driver's feet or legs can extend above or outside of the Major Structure of the Frame.

T2.13.2 Forward of the Front Bulkhead must be an energy-absorbing Impact Attenuator.

T2.14 Bulkhead

T2.14.1 The Front Bulkhead must be constructed of closed section tubing per section **T2.3.1**.

T2.14.2 Except as allowed by section **T2.14.3**, the Front Bulkhead must be located forward of all non-crushable objects, e.g. batteries, master cylinders, hydraulic reservoirs.

T2.14.3 The Front Bulkhead must be located such that the soles of the driver's feet, when touching but not applying the pedals, are rearward of the bulkhead plane. (This plane is defined by the forward-most surface of the tubing.) Adjustable pedals must be in the forward most position.

T2.15 Front Bulkhead Support

T2.15.1 The Front Bulkhead must be securely integrated into the Frame.

T2.15.2 The Front Bulkhead must be supported back to the Front Roll Hoop by a minimum of three (3) Frame Members on each side of the vehicle with one at the top (within 50.8mm of its top-most surface), one (1) at the bottom, and one (1) as a diagonal brace to provide triangulation.

T2.15.3 The triangulation must be node-to-node, with triangles being formed by the Front Bulkhead, the diagonal and one of the other two required Front Bulkhead Support Frame Members.

T2.15.4 All the Frame Members of the Front Bulkhead Support system listed above must be constructed of closed section tubing per section **T2.3.1**.

T2.16 Impact Attenuator (IA)

T2.16.1 On all cars there must be an Impact Attenuator and an Anti-Intrusion Plate forward of the Front Bulkhead, with the Anti-Intrusion Plate between the Impact Attenuator and the Front Bulkhead.

T2.16.2 All methods of attachment of the IA to the Anti-Intrusion Plate and of the Anti-Intrusion Plate to the Front Bulkhead must provide adequate load paths for transverse and vertical loads in the event of off-axis impacts.



- T2.16.3 The Anti-Intrusion Plate must:
- a) Be a 1.5 mm (0.060 in) thick solid steel or 4.0 mm (0.157 in) thick solid aluminum plate.
 - b) Be attached securely and directly to the Front Bulkhead.
 - c) Have an outer profile that meets the requirements of section **T2.16.4**.
- T2.16.4 The requirements for the outside profile of the Anti-Intrusion Plate are dependent on the method of attachment to the Front Bulkhead:
- a) For welded joints the profile must extend at least to the centerline of the Front Bulkhead tubes on all sides.
 - b) For bolted joints the profile must match the outside dimensions of the Front Bulkhead around the entire periphery.
- T2.16.5 For tube frame cars, the accepted methods of attaching the 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").
- NOTE:** Holes in mandated tubes will require appropriate measures to ensure compliance with **T2.3.1 (Note 3: Baseline steel properties used for calculations to be submitted in an SES may not be lower than the following:)** and **T2.3.2**.
- T2.16.6 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.
 - d) Segmented foam attenuators must have all segments bonded together to prevent sliding.



- T2.16.7 The accepted methods of attaching the Impact Attenuator to the Anti-Intrusion Plate are:
- a) Bolted joints, using a minimum of four (4) 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").
 - b) By the use of a structural adhesive. The adhesive must be appropriate for use with both substrate types. Appropriate adhesive choice, substrate preparation, and equivalency of this bonded joint to the bolted joint in section **T2.16.7 (a)** must be documented in the team's IAD Report.

Note: Foam IA's cannot be attached solely by the bolted method.

- T2.16.8 If a team uses the "standard" FSAE Impact Attenuator², 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.

T2.17 Impact Attenuator Test Data Report Requirement

- T2.17.1 Impact Attenuator Test Data Report Requirement.
- T2.17.2 All teams, whether they are using their own design of Impact Attenuator (IA) or the "standard" FSAE Impact Attenuator, must submit an Impact Attenuator Data Report using the Impact Attenuator Data (IAD) Template found on the download page at: <https://saeindia.org/bangaluru-section/reev/>
- T2.17.3 All teams must submit calculations and/or test data to show that their Impact Attenuator, when mounted on the front of their vehicle and run into a solid, non-yielding impact barrier with a velocity of impact of 7.0 meters/second, would give an average deceleration of the vehicle not to exceed 20 g, with a peak deceleration less than or equal to 40 g's.
- NOTE 1:** Quasi-static testing is allowed.
- NOTE 2:** The calculations of how the reported absorbed energy, average deceleration and peak deceleration figures have been derived from the test data **MUST** be included in the report and appended to the report template.
- T2.17.4 Calculations must be based on the actual vehicle mass with a 175 lb. driver, full fluids, and rounded up to the nearest 100 lb.
- T2.17.5 A schematic of the test method must be supplied along with photos of the attenuator before and after testing.



- T2.17.6 The test piece must be presented at technical inspection for comparison to the photographs and the attenuator fitted to the vehicle.
- T2.17.7 The report must be submitted electronically in Adobe Acrobat ® format (*.pdf file) to the address and by the date provided in the Action Deadlines provided on the Formula Hybrid website. This material must be a single file (text, drawings, data or whatever you are including).
- T2.17.8 The Impact Attenuator Data Report must be named as follows: carnumber_Collegename_competitioncode_IAD.pdf using the assigned car number, the complete collage name and competition code
- T2.17.9 Impact Attenuator Reports will be evaluated by the organizers and the evaluations will be passed to the Design Event Captain for consideration in that event.
- T2.17.10 During the test, the attenuator must be attached to the Anti-Intrusion Plate using the intended vehicle attachment method. The Anti-Intrusion Plate must be spaced at least 50 mm from any rigid surface. No part of the Anti-Intrusion Plate may permanently deflect more than 25.4 mm beyond the position of the Anti-Intrusion Plate before the test.

Note: The 25.4 mm spacing represents the front bulkhead support and insures that the plate does not intrude excessively into the cockpit.

T2.18 Non-Crushable Objects

- T2.18.1 Except as allowed by 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.
- T2.18.2 The front wing and wing supports may be forward of the Front Bulkhead, but may NOT be located in or pass through the Impact Attenuator. If the wing supports are in front of the Front Bulkhead, the supports must be included in the test of the Impact Attenuator. See section **T2.17**.

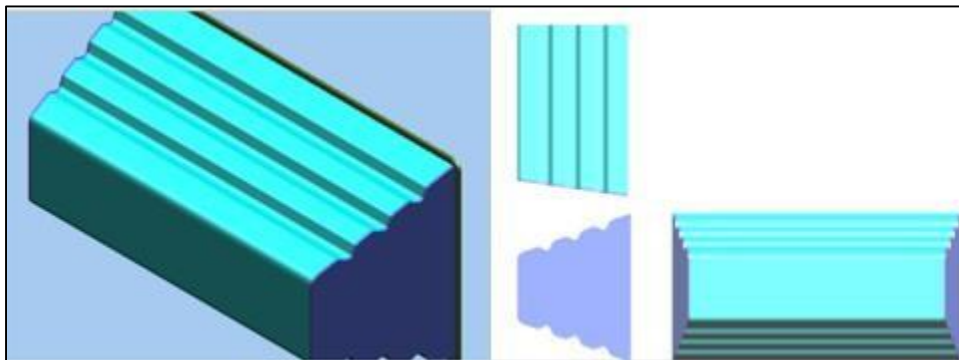


Figure 5



T2.19 Front Bodywork

- T2.19.1 All forward facing edges on the bodywork that could impact people, e.g. the nose, must have forward facing radii of at least 38 mm. This minimum radius must extend to at least forty-five degrees (45°) relative to the forward direction, along the top, sides and bottom of all affected edges.

T2.20 Side Impact Structure for Tube Frame Cars

- T2.20.1 The Side Impact Structure must meet the requirements listed below.
- T2.20.2 The Side Impact Structure for tube frame cars 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 6**.

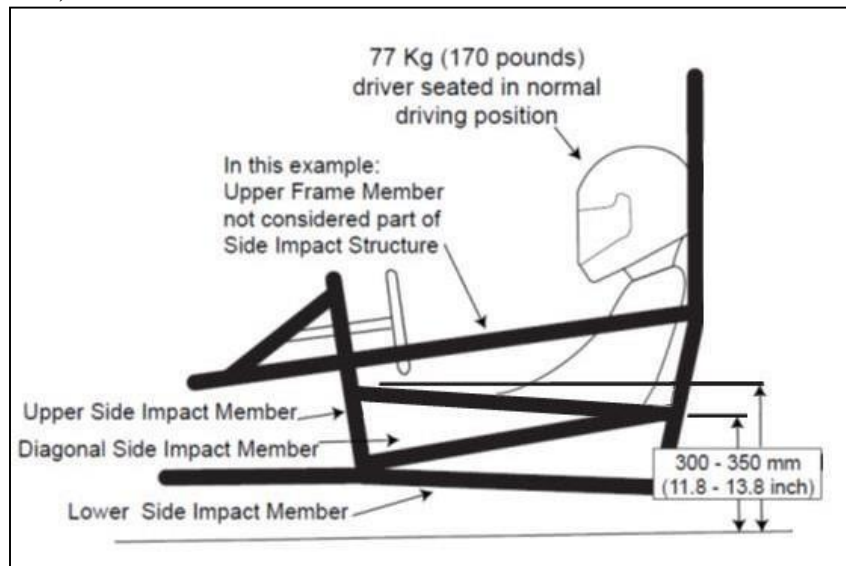


Figure 6 - Side Impact Structure

- T2.20.3 The three (3) required tubular members must be constructed of material per section **T2.3.1**



- T2.20.4 The locations for the three (3) required tubular members are as follows:
- a) The upper Side Impact Structural member must connect the Main Hoop and the Front Hoop. With a 77 kg driver seated in the normal driving position all of the member must be at a height between 300 mm and 350 mm above the ground. The upper frame rail may be used as this member if it meets the height, diameter and thickness requirements.
 - b) The lower Side Impact Structural member must connect the bottom of the Main Hoop and the bottom of the Front Hoop. The lower frame rail/frame member may be this member if it meets the diameter and wall thickness requirements.
 - c) The diagonal Side Impact Structural member must connect the upper and lower Side Impact Structural members forward of the Main Hoop and rearward of the Front Hoop.
- T2.20.5 With proper gusseting and/or triangulation, it is permissible to fabricate the Side Impact Structural members from more than one piece of tubing.

ARTICLE T3 Vehicle details

T3.1 Driver's Seat

- T3.1.1 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.



T3.1.2 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 sixty degrees C (60°C). The insulation may be external to the cockpit or incorporated with the driver's seat or firewall. 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 between the heat source and the panel.
- b) Convection Isolation by a minimum air gap of 25 mm 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 or
 - (ii) Reflective foil or tape when combined with section **T3.1.2 a) (ii)** above.

T3.2 Floor Close-out

T3.2.1 All vehicles must have a floor closeout made of one or more panels, which separate the driver from the pavement. If multiple panels are used, gaps between panels are not to exceed 3 mm. The closeout must extend from the foot area to the firewall and prevent track debris from entering the car. The panels must be made of a solid, non-brittle material.

T3.3 Firewall

T3.3.1 Firewall(s) must separate the driver compartment from the following components:

- a) Fuel Tanks.
- b) Accumulators.
- c) All components of the fuel supply.
- d) External engine oil systems including hoses, oil coolers, tanks, etc.
- e) Liquid cooling systems including those for I.C. engine and electrical components.



- f) Lithium-based GLV batteries.
- g) All tractive systems (TS) components
- h) All conductors carrying tractive system voltages (TSV) (Whether contained within conduit or not.)
- T3.3.2 The firewall(s) must be a rigid, non-permeable surface made from 1.5 mm or thicker aluminium or proven equivalent.
- T3.3.3 The firewall(s) must seal completely against the passage of fluids and hot gases, including at the sides and the floor of the cockpit, e.g. there can be no holes in a firewall through which seat belts pass.
- T3.3.4 Pass-throughs for GLV wiring, cables, etc. are allowable if grommets are used to seal the pass-throughs.
- T3.3.5 Multiple panels may be used to form the firewall but must be mechanically fastened in place and sealed at the joints.
- T3.3.6 For those components listed in section **T3.1.1** positioned under the driver, the firewall must extend:
 - a) Continuously rearwards the full width of the cockpit from the Front Bulkhead, under and up behind the driver to a point where the helmet of the 95th percentile male template touches the head restraint, and
 - b) Alongside the driver, from the top of the Side Impact Structure down to the lower portion of the firewall required by and from the rearmost front suspension mounting point to connect (without holes or gaps) behind the driver with the firewall required. See **FIGURE 7**.
- T3.3.7 For the components listed in section T3.3.1 that are mounted in ways that do not fall clearly under any of sections T3.3.5, T3.3.6, the firewall must be configured to provide equivalent protection to the driver, and the firewall configuration must be approved by the Rules Committee.
- T3.3.8 **Note:** To ensure adequate time for consideration and possible re-designs, applications should be submitted at least 1 month in advance of the event.

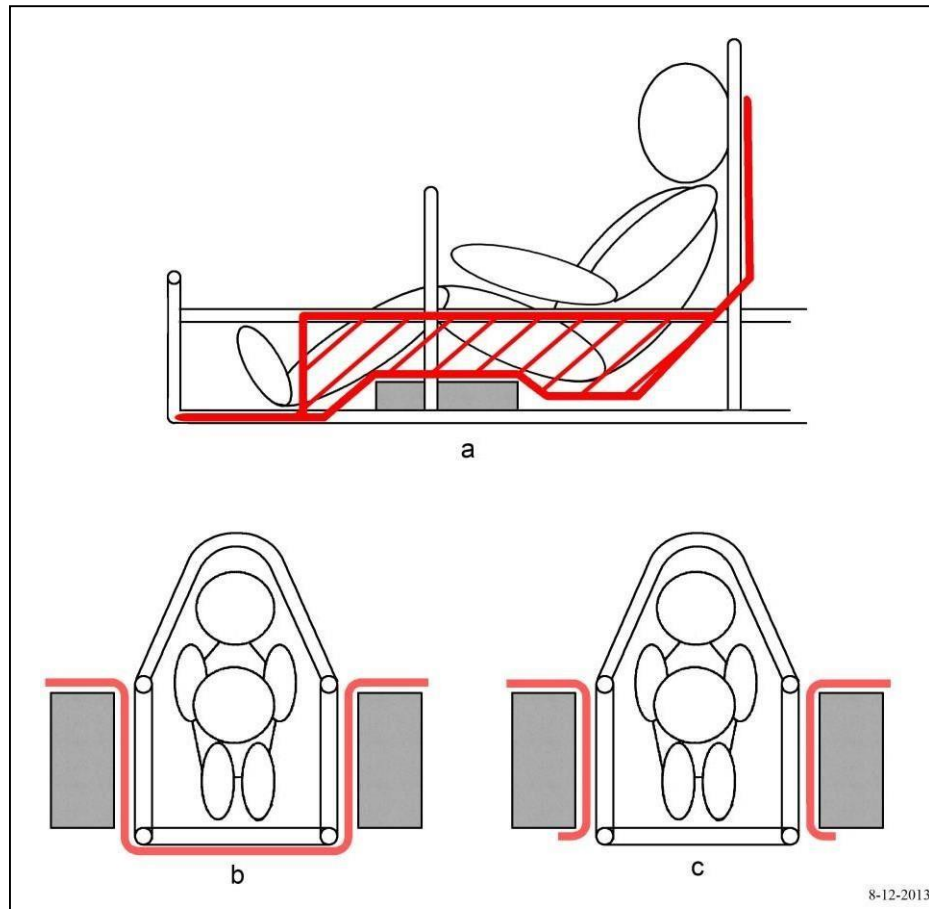


Figure 7 - Examples of firewall configurations

T3.4 Accessibility of Controls

- T3.4.1 All vehicle controls, including the shifter, must be operated from inside the cockpit without any part of the driver, e.g. hands, arms or elbows, being outside the planes of the Side Impact Structure defined in section **T2.20**.

T3.5 Driver Visibility

- T3.5.1 The driver must have adequate visibility to the front and sides of the car. With the driver seated in a normal driving position he/she must have a minimum field of vision of two hundred degrees (200°) (a minimum one hundred degrees (100°) to either side of the driver). The required visibility may be obtained by the driver turning his/her head and/or the use of mirrors.
- T3.5.2 If mirrors are required to meet section **T3.5.1**, they must remain in place and adjusted to enable the required visibility throughout all dynamic events.



T3.6 Driver Egress

- T3.6.1 All drivers must be able to exit to the side of the vehicle in no more than 5 seconds. Egress time begins with the driver in the fully seated position, hands in driving position on the connected steering wheel and wearing the required driver equipment. Egress time will stop when the driver has both feet on the pavement.

T3.7 Main Hoop

- T3.7.1 With their vision obscured, all drivers must be able to operate the cockpit Big Red Button (BRB) in less than one second.
- T3.7.2 Time begins with the driver in the fully seated position, hands in driving position on the connected steering wheel, and wearing the required driver equipment.

ARTICLE T4 Vehicle safety

T4.1 Full Vehicle Safety Criteria

- T4.1.1 While running CAE analysis simulations for dynamic load case care must be taken to ensure the vehicle structure meets the following safety criteria.
- T4.1.2 **Full Frontal Crash** - The vehicle needs to be run at impact velocity of 25kmph and hit a non-deformable barrier such that the average acceleration is 20g and peak acceleration 40g. Velocity and targets set by SAE are based on Human acceleration tolerance limits.
- T4.1.3 **Offset Crash (Offset Crash on tire area)**
- a) Assuming scenario with Crash during cornering, drifting off track into barrier or vehicle in Highway zone and average impact velocity 25kmph. The condition assumed is Offset crash involving vehicle tire area (front structure bypassed)
 - b) Tire rotates and intrudes into battery pod
 - c) Intrusion into tire and battery compartment will be monitored.
- T4.1.4 **Side Impact (Vehicle to Vehicle)**
Highway cornering scenario with average cornering velocity (post braking):20kmph
- a) Possible crash Scenarios
 - b) Into Soft Barrier (like tires)
 - c) Vehicle to Vehicle crash into battery pod – Considered



- d) Maximum intrusion allowed into occupant compartment < 25mm

T4.1.5 Rear Crash (Vehicle rear-ending another Vehicle):

- a) Assuming 50% drop in average velocity during braking and energy absorbed by Impacting Vehicle Impact attenuator (7350 J - SAE Target)
- b) Maximum intrusion allowed into occupant compartment < 25mm

Crash scenarios formulated based on race track and driving conditions – The below pictures are for representation purpose only.

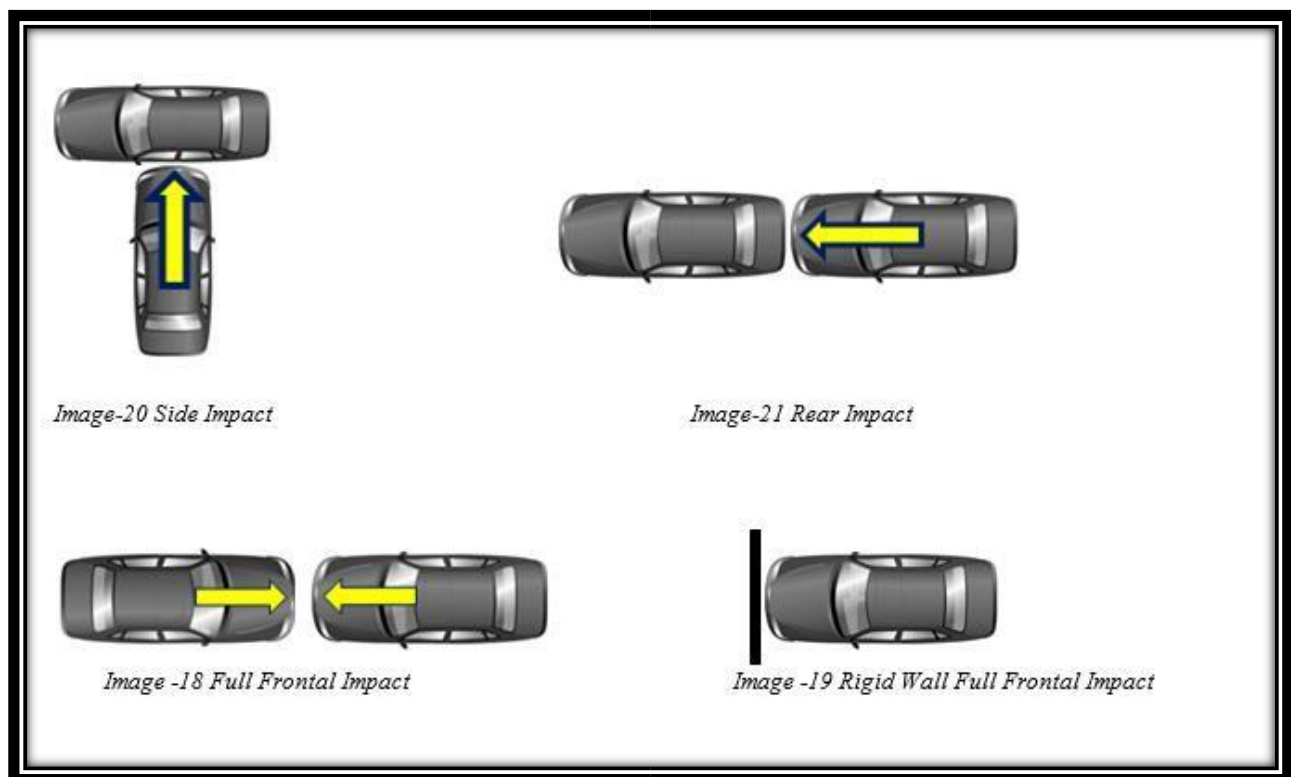


Figure 8 - Crash scenarios

ARTICLE T5 DRIVER'S EQUIPMENT (BELTS AND COCKPIT PADDING)

T5.1 Belts - General

T5.1.1 Definitions (Note: Belt dimensions listed are nominal widths.)



- a) 5-point system – consists of a 3 inch lap belt, 3 inch shoulder straps and a single 2 inch anti-submarine strap. The single anti-submarine strap must have a metal-to-metal connection with the single release common to the lap belt and shoulder harness.
- b) 6-point system – consists of a 3 inch lap belt, 3 inch shoulder straps and two (2) 2 inch leg or anti-submarine straps.
- c) 7-point system – system is the same as the 6-point except it has three (3) antisubmarine straps, two (2) from the 6-point system and one (1) from the 5-point system. (Not Required)
- d) Note: 6 point harnesses to FIA specification 8853/98 and SFI Specification 16.5 with 2 inch lap belts are acceptable.
- e) Chest-groin line - is the straight line that in side view follows the line of the shoulder belts from the chest to the release buckle.

T5.1.2 Harness Requirements - All drivers must use a 5 or 6 point restraint harness meeting the following specifications

- a) All driver restraint systems must meet SFI Specification 16.1, SFI Specification 16.5, or FIA specification 8853/98.
- b) The belts must bear the appropriate dated labels.
- c) The material of all straps must be in perfect condition.
- d) There must be a single release common to the lap belt and shoulder harness using a metal to-metal quick release type latch.
- e) To accommodate drivers of differing builds, all lap belts must have a “tilt-lock adjuster” feature.

Note: Lap belts with “pull-up” adjusters are recommended over “pull-down” adjusters, and a tilt lock adjuster in each portion of the lap belt is highly recommended.





Figure 9 - Lap Belts



Figure 10 - Shoulder Harness

- f) The shoulder harness must be the over-the-shoulder type. Only separate shoulder straps are permitted (i.e. “Y”-type shoulder straps are not allowed). The “H”-type configuration is allowed.
- g) It is mandatory that the shoulder harness, where it passes over the shoulders, be 3 inch, except as noted below. The shoulder harness straps must be threaded through the three bar adjusters in accordance with manufacturer’s instructions.
- h) When the HANS device is used by the driver, FIA certified 2 inch shoulder harnesses are allowed. Should a driver, at any time not utilize the HANS device, then 3 inch shoulder harnesses are required.



Figure 11 - HANS device

- T5.1.3 **Harness Replacement** - SFI spec harnesses must be replaced following December 31st of the 2nd year after the date of manufacture as indicated by the label. FIA spec harnesses must be replaced following December 31st of the year marked on the label. (Note: FIA belts are normally certified for five (5) years from the date of manufacture.)
- T5.1.4 The restraint system must be worn tightly at all times.
- T5.2 Belt, Strap and Harness Installation - General**
- T5.2.1 The lap belt, shoulder harness and anti-submarine strap(s) must be securely mounted to the Primary Structure. Such structure and any guide or support for the belts must meet the minimum requirements of section **T2.3.1**.



- T5.2.2 The tab or bracket to which any harness is attached must fulfill the following requirements:
- a) Have a minimum cross sectional area of 60 sq. mm (0.093 sq. in) of steel to be sheared or failed in tension at any point of the tab, and
 - b) Have a minimum thickness of 1.6 mm (0.063 inch).
 - c) Where lap belts and anti-submarine belts use the same attachment point, there must be a minimum cross sectional area of 90 sq. mm (0.140 sq. in) of steel to be sheared or failed in tension at any point of the tab.
 - d) Where brackets are fastened to the chassis, two 6mm Metric Grade 8.8 (1/4 inch SAE Grade 5) fasteners or stronger must be used to attach the bracket to the chassis.
 - e) Where a single shear tab is welded to the chassis, the tab to tube welding must be on both sides of the base of the tab.
 - f) The bracket or tab should be aligned such that it is not put in bending when that portion of the harness is put under load.

NOTE: Double shear attachments are preferred. Where possible, the tabs and brackets for double shear mounts should also be welded on both sides.

- T5.2.3 Harnesses, belts and straps must not pass through a firewall, i.e. all harness attachment points must be on the driver's side of any firewall.
- T5.2.4 The attachment of the Driver's Restraint System to a monocoque structure requires an approved Structural Equivalency Spreadsheet per section **T2.5**.
- T5.2.5 The restraint system installation is subject to approval of the Chief Technical Inspector.

T5.3 Lap Belt Mounting

- T5.3.1 The lap belt must pass around the pelvic area below the Anterior Superior Iliac Spines (the hip bones).
- T5.3.2 The lap belts must not be routed over the sides of the seat. The lap belts must come through the seat at the bottom of the sides of the seat to maximize the wrap of the pelvic surface and continue in a straight line to the anchorage point.
- T5.3.3 Where the belts or harness pass through a hole in the seat, the seat must be rolled or grommited to prevent chafing of the belts.



- T5.3.4 To fit drivers of differing statures correctly, in side view, the lap belt must be capable of pivoting freely by using either a shouldered bolt or an eye bolt attachment, i.e. mounting lap belts by wrapping them around frame tubes is no longer acceptable.
- T5.3.5 With an “upright driving position”, in side view the lap belt must be at an angle of between forty-five degrees (45°) and sixty-five degrees (65°) to the horizontal. This means that the centerline of the lap belt at the seat bottom should be between 0 – 76 mm forward of the seat back to seat bottom junction. (See Figure 17).

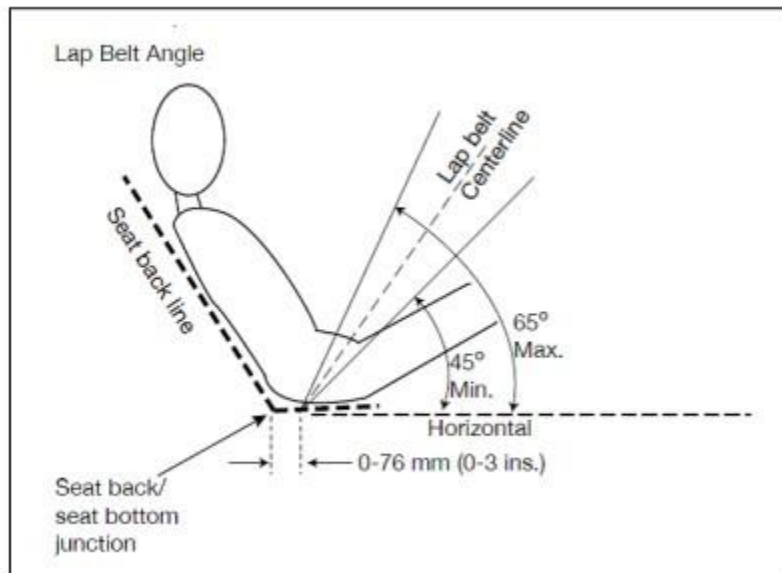


Figure 12 - Lap Belt Angles with Upright Driver

- T5.3.6 With a “reclined driving position”, in side view the lap belt must be between an angle of sixty degrees (60°) and eighty degrees (80°) to the horizontal.
- T5.3.7 Any bolt used to attach a lap belt, either directly to the chassis or to an intermediate bracket, must be a minimum of 10mm Metric Grade 8.8 (3/8 inch SAE Grade 5).

T5.4 Shoulder Harness

- T5.4.1 The shoulder harness must be mounted behind the driver to structure that meets the requirements of section **T3.1.1**. However, it cannot be mounted to the Main Roll Hoop Bracing or attendant structure without additional bracing to prevent loads being transferred into the Main Hoop Bracing.
- T5.4.2 If the harness is mounted to a tube that is not straight, the joints between this tube and the structure to which it is mounted must be reinforced in side view by gussets or triangulation tubes to prevent torsional rotation of the harness mounting tube.



- T5.4.3 The shoulder harness mounting points must be between 178 mm and 229 mm apart. (see **Figure 13**)

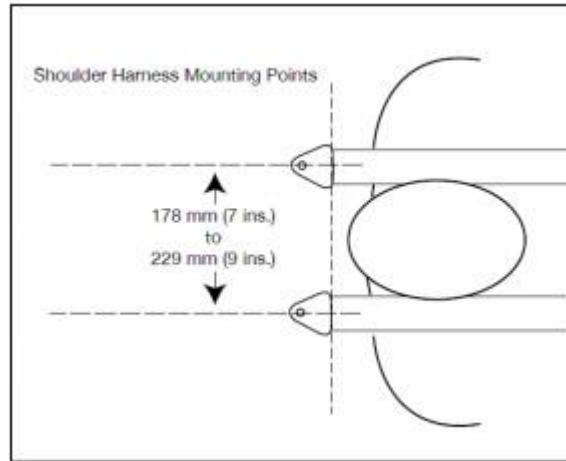


Figure 13 - Shoulder Harness Mounting Points

- T5.4.4 From the driver's shoulders rearwards to the mounting point or structural guide, the shoulder harness must be between ten degrees (10°) above the horizontal and twenty degrees (20°) below the horizontal. (see **Figure 14**).

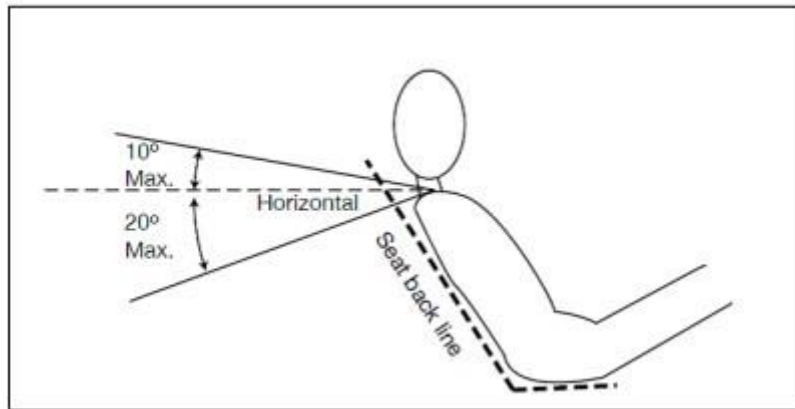


Figure 14 - Shoulder Harness Mounting – Side View

- T5.4.5 Any bolt used to attach a shoulder harness belt, either directly to the chassis or to an intermediate bracket, must be a minimum of 10mm Metric Grade 8.8 (3/8 inch SAE Grade 5).

T5.5 Anti-Submarine Belt Mounting

- T5.5.1 The anti-submarine belt of a 5-point harness must be mounted so that the mounting point is in line with, or angled slightly forward (up to twenty degrees (20°)) of, the driver's chest-groin line.

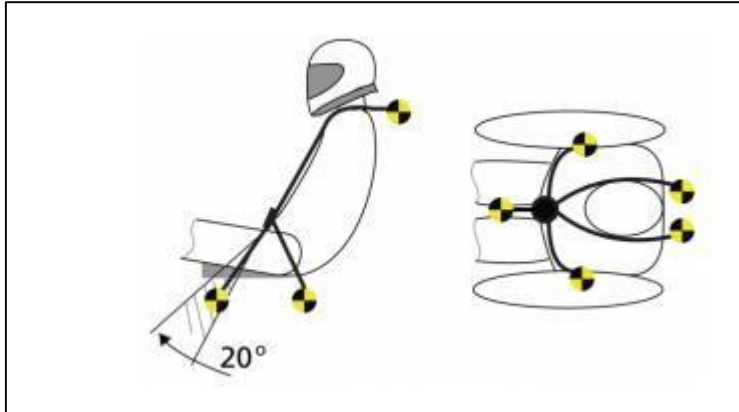


Figure 15 - Seat belt mounting - 5-point harness

T5.5.2 The anti-submarine belts of a 6-point harness must be mounted either:

- a) With the belts going vertically down from the groin, or angled up to twenty degrees (20°) rearwards. The anchorage points should be approximately 100 mm apart. Or

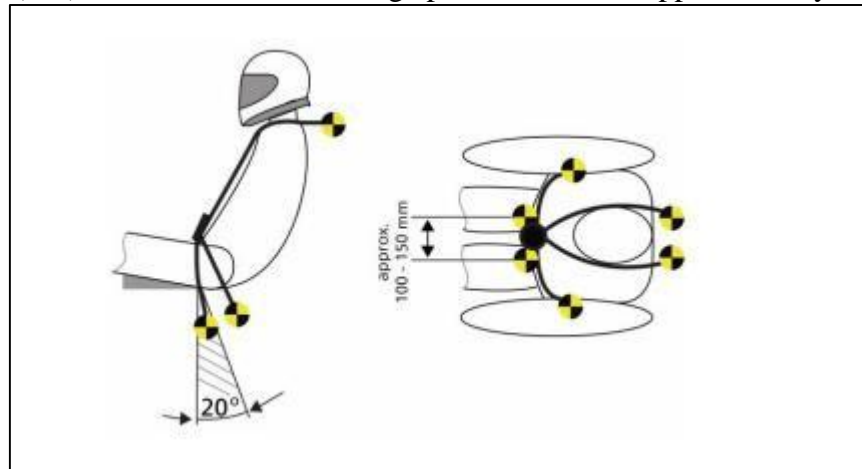


Figure 16 - Seat belt mounting - 6-point harness

- b) With the anchorage points on the Primary Structure at or near the lap belt anchorages, the driver sitting on the anti-submarine belts, and the belts coming up around the groin to the release buckle.

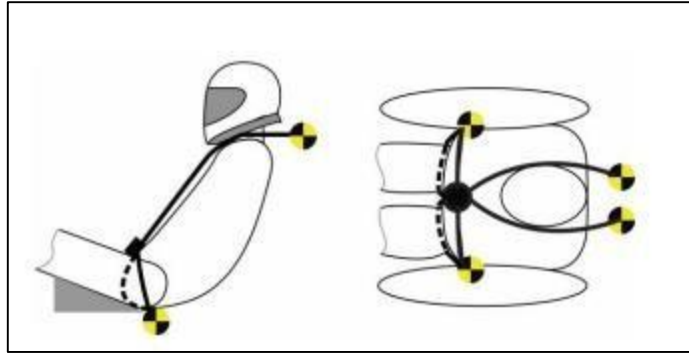


Figure 17 - Seat belt mounting - Anchorage Points

T5.5.3 All anti-submarine belts must be installed so that they go in a straight line from the anchorage point(s) to:

- a) Either the harness release buckle for the 5-point mounting per section **T5.5.1**,
- b) Or the first point where the belts touch the driver's body for the 6-point mounting per section **T5.5.2 a)** or **T5.5.2 b)**. without touching any hole in the seat or any other intermediate structure.

T5.5.4 Any bolt used to attach an anti-submarine belt, either directly to the chassis or to an intermediate bracket, must be a minimum of 8mm Metric Grade 8.8 (5/16 inch SAE Grade 5).

T5.6 Head Restraint

T5.6.1 A head restraint must be provided on the car to limit the rearward motion of the driver's head.

T5.6.2 The restraint must:

- a) Be vertical or near vertical in side view.
- b) Be padded with a minimum thickness of 38 mm (1.5 inches) of an energy absorbing material that meets either SFI Standard 45.2, or is listed on the FIA Technical List No.17 as a "Type B Material for single seater cars", i.e. CONFOR™ foam CF-42 (pink) or CF-42M (pink).
- c) Have a minimum width of 15 cm (6 inches).
- d) Have a minimum area of 235 sq. cms (36 sq. inches) AND have a minimum height adjustment of 17.5 cm (7 inches), OR have a minimum height of 28 cm (11 inches).
- e) Be located so that for each driver:
 - (i) The restraint is no more than 25 mm (1 inch) away from the back of the driver's helmet, with the driver in their normal driving position.



- (ii) The contact point of the back of the driver's helmet on the head restraint is no less than 50 mm (2 inches) from any edge of the head restraint.

Note 1: Head restraints may be changed to accommodate different drivers (see section [T1.2.2\(d\)](#)).

Note 2: The above requirements must be met for all drivers.

Note 3: Approximately 100 mm (4 inches) longitudinal adjustment is required to accommodate 5th to 95th Percentile drivers. This is not a specific rules requirement, but teams must have sufficient longitudinal adjustment and/or alternative thickness head restraints available, such that the above requirements are met by all their drivers.

- T5.6.3 The restraint, its attachment and mounting must be strong enough to withstand a force of 890 Newton's applied in a rearward direction.

T5.7 Roll Bar Padding

- T5.7.1 Any portion of the roll bar, roll bar bracing or frame which might be contacted by the driver's helmet must be covered with a minimum thickness of 12 mm (0.5 inches) of padding which meets SFI spec 45.1 or FIA 8857-2001.

T5.8 Driver's Leg Protection

- T5.8.1 To keep the driver's legs away from moving or sharp components, all moving suspension and steering components, and other sharp edges inside the cockpit between the front-roll hoop and a vertical plane 100 mm rearward of the pedals, must be shielded with a shield made of a solid material. Moving components include, but are not limited to springs, shock absorbers, rocker arms, anti-roll/sway bars, steering racks and steering column CV joints.
- T5.8.2 Covers over suspension and steering components must be removable to allow inspection of the mounting points.

ARTICLE T6 GENERAL CHASSIS RULES

T6.1 Suspension

- T6.1.1 The car must be equipped with a fully operational suspension system with shock absorbers, front and rear, with usable wheel travel of at least 80 mm, 40mm jounce and 40mm rebound, with driver seated. The judges reserve the right to disqualify cars which do not represent a serious attempt at an operational suspension system or which demonstrate handling inappropriate for an autocross circuit.



- T6.1.2 All suspension mounting points must be visible at Technical Inspection, either by direct view or by removing any covers.

T6.2 Ground Clearance

- T6.2.1 The ground clearance must be sufficient to prevent any portion of the car (other than tires) from touching the ground during track events, and with the driver aboard there must be a minimum of 120 mm of static ground clearance under the complete car at all times.

T6.3 Wheels

- T6.3.1 The wheels of the car must be 10 inches (245mm) or more in diameter.
- T6.3.2 Any wheel mounting system that uses a single retaining nut must incorporate a device to retain the nut and the wheel in the event that the nut loosens. A second nut (“jam nut”) does not meet these requirements.
- T6.3.3 Standard wheel lug bolts are considered engineering fasteners and any modification will be subject to extra scrutiny during technical inspection. Teams using modified lug bolts or custom designs will be required to provide proof that good engineering practices have been followed in their design.
- T6.3.4 Aluminum wheel nuts may be used, but they must be hard anodized and in pristine condition.

T6.4 Tires

- T6.4.1 Vehicles may have tires which are treaded with a minimum tread depth of 3.0mm.
- Note:** Hand cutting, grooving or modification of the tires by the teams is specifically prohibited.
- T6.4.2 Within each tire set, the tire compound or size, or wheel type or size may not be changed after static judging has begun. Tire warmers are not allowed. No traction enhancers may be applied to the tires after the static judging has begun.
- T6.4.3 Tire and wheel assembly should have minimum clearance with wheel arch and other chassis parts by 50mm during worst case dynamic condition.

T6.5 Steering

- T6.5.1 The steering wheel must be mechanically connected to the wheels



- T6.5.2 The steering system must have internal steering stops. The stops may be placed on the uprights or on the rack and must prevent the tires from contacting suspension, body, or frame members during the track events.
- T6.5.3 Allowable steering system free play is limited to ten degrees (10°) total measured at the steering wheel.
- T6.5.4 The steering wheel must be attached to the column with a quick disconnect. The driver must be able to operate the quick disconnect while in the normal driving position with gloves on.
- T6.5.5 The steering wheel must have a continuous perimeter that is near circular or near oval, i.e. the outer perimeter profile can have some straight sections, but no concave sections. “H”, “Figure 8”, or cutout wheels are not allowed.
- T6.5.6 In any angular position, the top of the steering wheel must be no higher than the topmost surface of the Front Hoop. See Figure 7.
- T6.5.7 Steering systems using cables for actuation are prohibited.
- T6.5.8 The steering rack must be mechanically attached to the frame. If fasteners are used, they must be compliant with **ARTICLE T9**.
- T6.5.9 Joints between all components attaching the steering wheel to the steering rack must be mechanical and be visible at Technical Inspection. Bonded joints without a mechanical backup are not permitted.

T6.6 Jacking Point

- T6.6.1 A jacking point, which is capable of supporting the car’s weight and of engaging the organizers’ “quick jacks”, must be provided at the rear of the car.
- T6.6.2 The jacking point is required to be:
- a) Painted orange.
 - b) Oriented horizontally and perpendicular to the centerline of the car
 - c) Made from round, 25–29 mm O.D. aluminum or steel tube
 - d) A minimum of 300 mm long
 - e) Exposed around the lower 180 degrees (180°) of its circumference over a minimum length of 280 mm
 - f) The height of the tube is required to be such that:



(i) There is a minimum of 120 mm clearance from the bottom of the tube to the ground measured at tech inspection.

(ii) With the bottom of the tube 200 mm above ground, the wheels do not touch the ground when they are in full rebound.

T6.6.3 Comment on Disabled Cars – The organizers and the Rules Committee remind teams that cars disabled on course must be removed as quickly as possible. A variety of tools may be used to move disabled cars including quick jacks, dollies of different types, tow ropes and occasionally even boards. We expect cars to be strong enough to be easily moved without damage. Speed is important in clearing the course and although the course crew exercises due care, parts of a vehicle can be damaged during removal. The organizers are not responsible for damage that occurs when moving disabled vehicles. Removal/recovery workers will jack, lift, carry or tow the car at whatever points they find easiest to access. Accordingly, we advise teams to consider the strength and location of all obvious jacking, lifting and towing points during the design process.

T6.7 Rollover Stability

T6.7.1 The track and center of gravity of the car must combine to provide adequate rollover stability.

T6.7.2 Rollover stability will be evaluated on a tilt table using a pass/fail test. The vehicle must not roll when tilted at an angle of forty-five degrees (45°) to the horizontal in either direction, corresponding to 1G. The tilt test will be conducted with the tallest driver in the normal driving position.

ARTICLE T7 BRAKE SYSTEM

T7.1 Brake System - General

T7.1.1 The car must be equipped with a braking system that acts on all four wheels and is operated by a single control.

T7.1.2 It must have two (2) independent hydraulic circuits such that in the case of a leak or failure at any point in the system, effective braking power is maintained on at least two (2) wheels. Each hydraulic circuit must have its own fluid reserve, either by the use of separate reservoirs or by the use of a dammed, OEM-style reservoir.

T7.1.3 A single brake acting on a limited-slip differential is acceptable.

T7.1.4 The brake system must be capable of locking all four (4) wheels during the test specified in section **T7.2**.

T7.1.5 “Brake-by-wire” systems are prohibited for primary braking.

T7.1.6 Unarmored plastic brake lines are prohibited.



- T7.1.7 The braking systems must be protected with scatter shields from failure of the drive train (see section **T8.2**) or from minor collisions.
- T7.1.8 In side view no portion of the brake system that is mounted on the sprung part of the car can project below the lower surface of the frame or the skin (shell), whichever is applicable.
- T7.1.9 The brake pedal shall be designed to withstand a force of 2000 N without any failure of the brake system or pedal box. This may be tested by pressing the pedal with the maximum force that can be exerted by any official when seated normally.
- T7.1.10 The brake pedal must be fabricated from steel or aluminum or machined from steel, aluminum or titanium.
- T7.1.11 The first 25% of the brake pedal travel may be used to control regeneration without necessarily actuating the hydraulic brake system which is the primary means of braking
- T7.1.12 The remaining brake pedal travel must directly actuate the hydraulic brake system, but brake energy regeneration may remain active.

Note: Any strategy to regenerate energy while coasting or braking must be covered by the FMEA / ESF.

T7.2 Brake Test

- T7.2.1 The brake system will be dynamically tested and must demonstrate the capability of locking all four (4) wheels and stopping the vehicle in a straight line at the end of an acceleration run specified by the brake inspectors.
- T7.2.2 After accelerating, the tractive system must be switched off by the driver and the driver has to lock all four wheels of the vehicle by braking. The brake test is passed if all four wheels simultaneously lock while the tractive system is shut down.

Note: It is acceptable if the Tractive System Active Light switches off shortly after the vehicle has come to a complete stop as the reduction of the system voltage may take up to 5 seconds.

T7.3 Brake Over-Travel Switch

- T7.3.1 A brake pedal over-travel switch must be installed on the car as part of the shutdown system and wired in series with the shutdown buttons (EV6.1). This switch must be installed so that in the event of brake system failure such that the brake pedal over travels it will result in the shutdown system being activated.





- T7.3.2 Repeated actuation of the switch must not restore power to these components, and it must be designed so that the driver cannot reset it.
- T7.3.3 The brake over-travel switch must not be used as a mechanical stop for the brake pedal and must be installed in such a way that it and its mounting will remain intact and operational when actuated.
- T7.3.4 The switch must be implemented directly. i.e. It may not operate through programmable logic controllers, engine control units, or digital controllers
- T7.3.5 The Brake Over-Travel switch must be a mechanical single pole, single throw (commonly known as a two-position) switch (push-pull or flip type) as shown below.

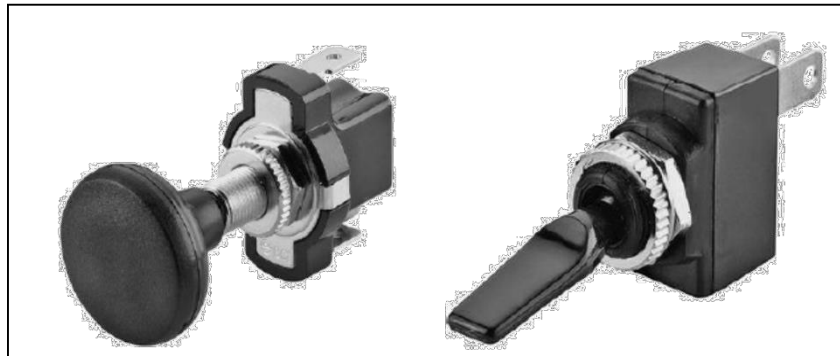


Figure 18 - Over-travel Switches

T7.4 Brake Light

- T7.4.1 The car must be equipped with a red brake light.
- T7.4.2 The brake light itself must have a black background and a rectangular shape with a minimum shining surface of at least 10 cm².
- T7.4.3 The brake light must be clearly visible from the rear in bright sunlight.
- T7.4.4 When LED lights are used without an optical diffuser, they may not be more than 20 mm apart.
- T7.4.5 If a single line of LEDs is used, the minimum length is 150 mm.
- T7.4.6 The light must be mounted between the wheel centerline and driver's shoulder level vertically and approximately on vehicle centerline laterally..



ARTICLE T8 Powertrain

T8.1 Transmission and Drive

T8.1.1 Any transmission may be used.

T8.2 Drive Train Shields and Guards

T8.2.1 Exposed high-speed final drivetrain equipment such as Continuously Variable Transmissions (CVTs), sprockets, gears, pulleys, torque converters, clutches, belt drives and clutch drives, must be fitted with scatter shields in case of failure. The final drivetrain shield must cover the chain or belt from the drive sprocket to the driven sprocket/chain wheel/belt or pulley. The final drivetrain shield must start and end parallel to the lowest point of the chain wheel/belt/pulley. (See **FIGURE 19**) Body panels or other existing covers are not acceptable unless constructed from approved materials.

Note: If equipped, the engine drive sprocket cover may be used as part of the scatter shield system.

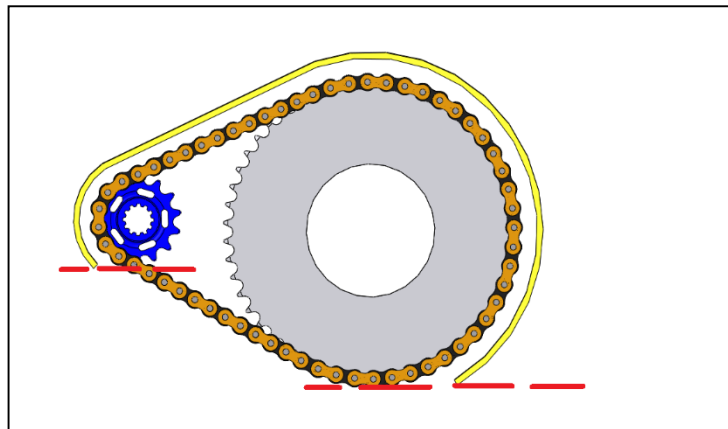


Figure 19 - Final Drive Scatter Shield Example

Comment: Scatter shields are intended to contain drivetrain parts which might separate from the car.

T8.2.2 Perforated material may not be used for the construction of scatter shields.

T8.2.3 Chain Drive - Scatter shields for chains must be made of at least 2.6 mm steel or stainless steel (no alternatives are allowed), and have a minimum width equal to three (3) times the width of the chain. The guard must be centered on the center line of the chain and remain aligned with the chain under all conditions.



- T8.2.4 Non-metallic Belt Drive - Scatter shields for belts must be made from at least 3.0 mm Aluminum Alloy 6061-T6, and have a minimum width that is equal to 1.7 times the width of the belt.
- T8.2.5 The guard must be centered on the center line of the belt and remain aligned with the belt under all conditions.
- T8.2.6 Attachment Fasteners - All fasteners attaching scatter shields and guards must be a minimum 6mm Metric Grade 8.8 or 1/4 inch SAE Grade 5 or stronger.
- T8.2.7 Finger Guards – Finger guards are required to cover any drivetrain parts that spin while the car is stationary with the engine running. Finger guards may be made of lighter material, sufficient to resist finger forces. Mesh or perforated material may be used but must prevent the passage of a 12 mm diameter object through the guard.

Comment: Finger guards are intended to prevent finger intrusion into rotating equipment while the vehicle is at rest.

ARTICLE T9 Fasteners

T9.1 Fastener Grade Requirements

- T9.1.1 All threaded fasteners utilized in the driver's cell structure, plus the steering, braking, driver's harness and suspension systems must meet or exceed, SAE Grade 5, Metric Grade 8.8 and/or AN/MS specifications.





- T9.1.2 The use of button head cap, pan head, flat head, round head or countersunk screws or bolts in ANY location in the following systems is prohibited: a) Driver's space structure,
b) Impact attenuator attachment
c) Driver's harness attachment
d) Steering system
e) Brake system
f) Suspension system.

Note: Hexagonal recessed drive screws or bolts (sometimes called Socket head cap screws or Allen screws/bolts) are permitted.

T9.2 Securing

- T9.2.1 All critical bolt, nuts, and other fasteners on the steering, braking, driver's harness, and suspension must be secured from unintentional loosening by the use of positive locking mechanisms.

- T9.2.2 Positive locking mechanisms are defined as those that:

- The Technical Inspectors (and the team members) are able to see that the device / system is in place, i.e. it is visible, and
- The "positive locking mechanism" does not rely on the clamping force to apply the "locking" or anti-vibration feature. In other words, if it loosens a bit, it still prevents the nut or bolt from coming completely loose. See **FIGURE 20**.

Positive locking mechanisms include:

- Correctly installed safety wiring
- Cotter pins
- Nylon lock nuts
- Prevailing torque lock nuts

Note: Lock washers, bolts with nylon patches, and thread locking compounds, e.g. Loctite®, DO NOT meet the positive locking requirement.



Figure 20 - Examples of Positive Locking Nuts



- T9.2.3 There must be a minimum of two (2) full threads projecting from any lock nut.
- T9.2.4 All spherical rod ends and spherical bearings on the steering or suspension must be in double shear or captured by having a screw/bolt head or washer with an O.D. that is larger than spherical bearing housing I.D.
- T9.2.5 Adjustable tie-rod ends must be constrained with a jam nut to prevent loosening.

PART IC - INTERNAL COMBUSTION ENGINE

IC1.1 Air Intake System

- IC1.1.1 **Air Intake System Location** - All parts of the engine air and fuel control systems (including the throttle or carburetor, and the complete air intake system, including the air cleaner and any air boxes) must lie within the surface defined by the top of the roll bar and should be inside the skin surface.

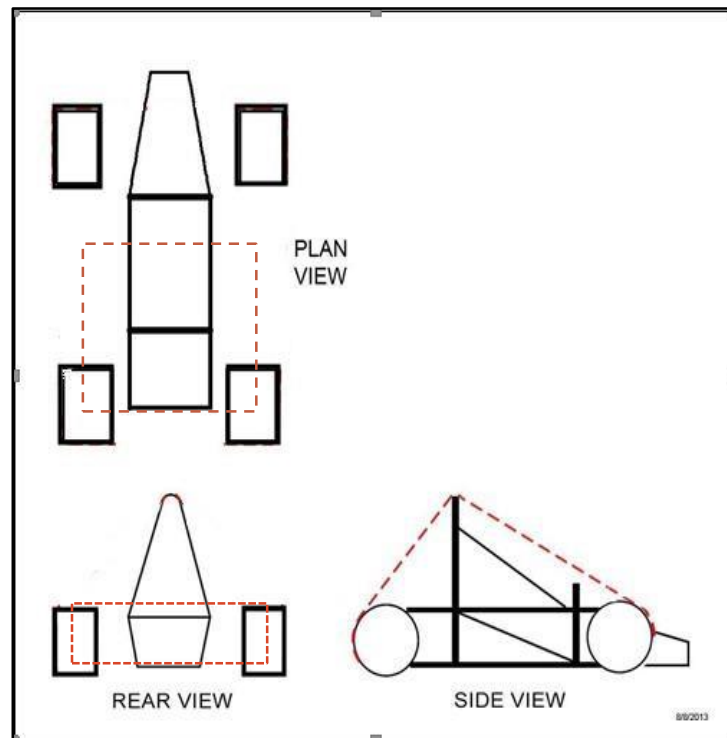


Figure 21 - Surface Envelope

- IC1.1.2 Any portion of the air intake system that is less than 350 mm (13.8 inches) above the ground must be shielded from side or rear impact collisions by structure built



- IC1.1.3 **Intake Manifold** - If an intake manifold is used, it must be securely attached to the engine crankcase, cylinder, or cylinder head with brackets and mechanical fasteners. This precludes the use of hose clamps, plastic ties, or safety wires.
- Original equipment rubber parts that bolt or clamp to the cylinder head and to the throttle body or carburetor are acceptable.
- Note:** These rubber parts are referred to by various names by the engine manufacturers; e.g., “insulators” by Honda, “joints” by Yamaha, and “holders” by Kawasaki.
- Other than such original equipment parts the use of rubber hose is not considered a structural attachment. Intake systems with significant mass or cantilever from the cylinder head must be supported to prevent stress to the intake system.
- Supports to the engine must be rigid. Supports to the frame or chassis must incorporate some isolation to allow for engine movement and chassis flex.
- IC1.1.4 **Air boxes and filters** - Large air boxes must be securely mounted to the frame or engine and connections between the air box and throttle must be flexible. Small air cleaners designed for mounting to the carburetor or throttle body may be cantilevered from the throttle body.
- IC1.1.5 **Air Intake System Location** - All parts of the engine air and fuel control systems (including the throttle or carburetor, and the complete air intake system, including the air cleaner and any air boxes) must lie within the surface defined by the top of the roll bar and should be inside the skin surface.
- IC1.1.6 Any portion of the air intake system that is less than 350 mm (13.8 inches) above the ground must be shielded from side or rear impact collisions by structure built.

ARTICLE IC2 Fuel Tanks

IC2.1 Fuel Tanks

- IC2.1.1 The fuel tank is defined as that part of the fuel containment device that is in contact with the fuel. It may be made of a rigid material.
- IC2.1.2 Fuel tanks made of a rigid material cannot be used to carry structural loads, e.g. from roll hoops, suspension, engine or gearbox mounts, and must be securely attached to the vehicle structure with mountings that allow some flexibility such that chassis flex cannot unintentionally load the fuel tank.
- IC2.1.3 Deduce Fuel tank size based on 2litres fuel requirement.



- IC2.1.4 The fuel system must have a drain fitting for emptying the fuel tank. The drain must be at the lowest point of the tank and be easily accessible. It must not protrude below the lowest plane of the vehicle frame, and must have provision for safety wiring.
- IC2.1.5 Safety belly pan need to be provided to ensure no slippage of fuel on the powertrain and other related parts. This safety belly pan will have drain fitting and the delivery pipe connecting from drain plug to the bottom of the frame. The routing of the pipe should take care of good clearance with all the movable (under dynamic condition) and non-movable parts by 30mm.

IC2.2 Fuel System Location Requirements

- IC2.2.1 All parts of the fuel storage and supply system must lie within the surface defined by the top of the roll bar and within the body cover/skin.
- IC2.2.2 All fuel tanks must be shielded from side or rear impact collisions.
- IC2.2.3 A firewall must separate the fuel tank from the driver.

IC2.3 Fuel Tank Filler Neck

- IC2.3.1 All fuel tanks must have a filler neck:
- a) With a minimum inside diameter of 38 mm
 - b) That is vertical (with a horizontal filler cap) or angled at no more than forty-five degrees (30°) from the vertical.
- IC2.3.2 If a sight tube is fitted, it may not run below the top surface of the fuel tank.

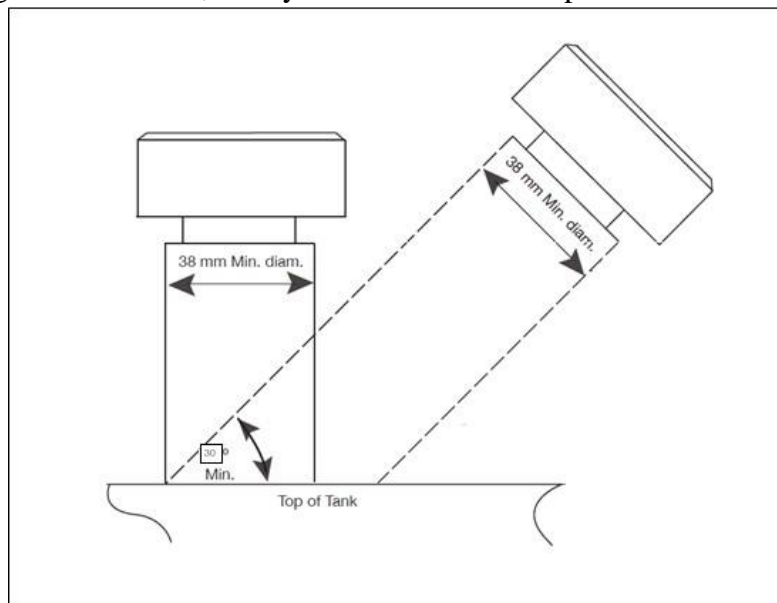




Figure 22 - Filler Neck

IC2.4 Tank Filling Requirement

- IC2.4.1 The tank must be capable of being filled to capacity without manipulating the tank or vehicle in any way (shaking vehicle, etc.).
- IC2.4.2 The fuel system must be designed such that the spillage during refueling cannot contact the driver position, exhaust system, hot engine parts, or the ignition system.
- IC2.4.3 Belly pans must be vented to prevent accumulation of fuel.

IC2.5 Venting Systems

- IC2.5.1 The fuel tank and carburetor venting systems must be designed such that fuel cannot spill during hard cornering or acceleration. This is a concern since motorcycle carburetors normally are not designed for lateral accelerations.
- IC2.5.2 All fuel vent lines must be equipped with a check valve to prevent fuel leakage when the tank is inverted. All fuel vent lines must exit outside the bodywork.

IC2.6 Fuel Lines

- IC2.6.1 Plastic fuel lines between the fuel tank and the engine (supply and return) are prohibited.
- IC2.6.2 If rubber fuel line or hose is used, the components over which the hose is clamped must have annular bulb or barbed fittings to retain the hose. Also, clamps specifically designed for fuel lines must be used. These clamps have three (3) important features; (See Figure 25)

- a) A full 360 degree (360°) wrap,
- b) A nut and bolt system for tightening, and
- c) Rolled edges to prevent the clamp cutting into the hose.

Worm-gear type hose clamps are not approved for use on any fuel line.



Figure 23 - Hose Clamps

- IC2.6.3 Fuel lines must be securely attached to the vehicle and/or engine.
- IC2.6.4 All fuel lines must be shielded from possible rotating equipment failure or collision damage.

ARTICLE IC3 EXHAUST SYSTEM AND NOISE CONTROL

IC3.1 Exhaust System General

- IC3.1.1 **Exhaust Outlet** - The exhaust must be routed so that the driver is not subjected to fumes at a speed considering the draft of the car.
- IC3.1.2 The exhaust outlet(s) must not extend more than 45 cm (17.7 inches) behind the centerline of the rear axle, and must be no more than 60 cm (23.6 inches) above the ground.
- IC3.1.3 Any exhaust components (headers, mufflers, etc.) that protrude from the side of the body in front of the main roll hoop must be shielded to prevent contact by persons approaching the car or a driver exiting the car.
- IC3.1.4 The application of fibrous/absorbent material, e.g. “header wrap”, to the outside of an exhaust manifold or exhaust system is prohibited.

IC3.2 Noise Measuring Procedure

- IC3.2.1 The sound level will be measured during a static test. Measurements will be made with a free-field microphone placed free from obstructions at the exhaust outlet level, 0.5 m (19.68 inches) from the end of the exhaust outlet, at an angle of forty-five degrees (45°) with the outlet in the horizontal plane. The test will be run with the gearbox in neutral at the engine speed defined below. Where more than one exhaust outlet is present, the test will be repeated for each exhaust and the highest reading will be used.



IC3.2.2 The car must be compliant at all engine speeds up to the maximum test speed

IC3.2.3 If the exhaust has any form of active tuning or throttling device or system, it must be compliant with the device or system in all positions. Manually adjustable tuning devices must require tools to change and must not be moved or modified after the noise test is passed. The position of the device must be visible to the officials for the noise test and must be manually operable by the officials during the noise test.

IC3.3 Maximum Sound Level:

IC3.3.1 At idle the maximum permitted sound level is 103 dBC, fast weighting. At all other speeds the maximum permitted sound level is 110 dBC, fast weighting.

IC3.4 Noise Level Re-testing

IC3.4.1 At the option of the officials, noise may be measured at any time during the competition. If a car fails the noise test, it will be withheld from the competition until it has been modified and re-passes the noise test.

IC3.5 Tank Filling Requirement

IC3.5.1 All fuel tanks must have a filler neck:

PART EV - ELECTRICAL POWERTRAINS AND SYSTEMS

ARTICLE EV1 ELECTRICAL SYSTEMS OVERVIEW

EV1.1 Definitions

EV1.1.1 **Battery** - Batteries that store the electrical energy to be used by the tractive system. This term includes electrochemical batteries with Lithium Ion chemistry only.

EV1.1.2 **Battery Container** - A housing that encloses the battery devices, isolating them both physically and electrically from the rest of the vehicle.

EV1.1.3 **High Voltage** - Whenever a circuit has a potential difference where the nominal operation voltage is greater than or equal to 48V DC or 25 V AC rms, it is defined as part of the High Voltage.

EV1.1.4 **Low voltage** - Any voltage below 48V DC or 25 V AC rms.



- EV1.1.5 **Tractive System (TS)** - The tractive system of the car is defined as every part that is electrically connected to the motor(s) and tractive system battery pack. The tractive system is a high-voltage system by definition. The maximum permitted voltage that may occur between any two electrical connections is 60 V DC or 48 V AC rms.
- EV1.1.1 **Grounded Low Voltage (GLV) System** - Every conductive part that is not part of the tractive system. (This includes the GLV electrical system and all the other components like brake light, reverse lights etc.)
- EV1.1.2 **Insulation** - A material that physically resists a flow of charge. May be rigid or flexible.
- EV1.1.3 **Isolation** - Electrical, or “Galvanic” isolation between two or more electrical conductors such that if a voltage potential exists between them, no current will flow.

ARTICLE EV2 BATTERIES

EV2.1 Permitted Devices

- EV2.1.1 Allowed Battery Specs – 48V nominal, 100Ah Li-ion batteries.
- EV2.1.2 The following battery devices are not permitted; NiMH, lead acid and similar battery chemistries and capacitors, such as super caps or ultra-caps, molten salt batteries, thermal batteries, fuel cells, mechanical storage such as flywheels or hydraulic batteries.
- EV2.1.3 Manufacturer’s data sheets showing the rated specification of the battery cell(s) which are used must be provided in the ESF along with their number and configurations.

EV2.2 Battery Containers

- EV2.2.1 All devices which store the tractive system energy must be enclosed in (an) battery container(s).
- EV2.2.2 Each battery container must be labeled with the words “BATTERY – ALWAYS ENERGIZED”.
- EV2.2.3 Labels must be 3 inches by 9 inches with bold red lettering on a white background and be clearly visible on all sides of the battery container that could be exposed during operation and/or maintenance of the car and at least one such label must be visible with the bodywork in place.

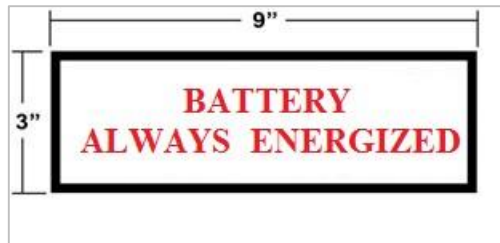


Figure 24 - Battery Sticker

- EV2.2.4 If the battery container(s) is not easily accessible during Electrical Tech Inspection, detailed pictures/assembly drawing need to be made available during the technical inspection. If the pictures do not adequately depict the battery, it may be necessary to disassemble the battery to pass Electrical Tech Inspection.
- EV2.2.5 The battery container shall not contain circuitry or components other than the battery itself and necessary supporting circuitry such as the Accumulator Isolation Relay (AIRs), BMS.
- EV2.2.6 Note 1: The purpose of this requirement is to allow work on other parts of the tractive system without opening the battery container and exposing (always-live) high voltage.
- EV2.2.7 If spare batteries are to be used then they all must be of the same size, weight and type as those that are replaced. Spare battery packs must be presented at Electrical Tech Inspection.

EV2.3 Battery Containers - Construction

- EV2.3.1 The battery container(s) must be built of mechanically robust material.
- EV2.3.2 The container material must be non-conducting, fire resistant according to UL94-V0, FAR25 or equivalent.
- EV2.3.3 All conductive penetrations (mounting hardware, hinges, latches etc.) must be covered on the inside of the battery container by an insulating material.
- EV2.3.4 The cells and/or segments must be appropriately secured against loosening inside the container and all battery devices must be attached to the battery container(s) with mechanical fasteners.
- EV2.3.5 Holes in the container are only allowed for the wiring-harness, ventilation, cooling or fasteners. These holes must be sealed. Teams are suggested to do a complete thermal analysis to design the vehicles cooling system. The results for the same shall be submitted during the technical inspection.



- EV2.3.6 All battery containers must lie within the surface envelope and must be rigidly mounted to the chassis to prevent the containers from loosening during the dynamic events or possible accidents.

EV2.4 Battery Fusing

- EV2.4.1 Every battery container must contain at least one fuse in the high-current TS path.
- EV2.4.2 All the fuses used in the vehicle shall meet the fuse Standards of ISO 20934 - Type SF51 LV 230.
- EV2.4.3 Fuses used shall be 58V rated fuse in case of 48V system & 32V rated fuse in case of 12V system.
- EV2.4.4 All details and documentation for fuse, fusible link and/or internal over current protection must be included in the ESF.

EV2.5 Battery - Isolation Relays

- EV2.5.1 At least two isolation relays (AIRs) must be installed in every battery container, or in the battery section of a segmented container such that no TS voltage will be present outside the battery or battery section when the TS is shut down.
- EV2.5.2 The battery isolation relays must be of a normally open (N.O.) type which are held in the closed position by the current flowing through the shutdown loop. When this flow of current is interrupted, the AIRs must disconnect both poles of the battery such that no TS voltage is present outside of the battery container(s).

EV2.6 Battery – Battery Management System (BMS)

- EV2.6.1 Each battery must be monitored by a battery management system (BMS) whenever the vehicle is on also in the case when battery is connected to a charger.
- EV2.6.2 The BMS must monitor all critical voltages and temperatures in the battery as well the integrity of all its voltage and temperature inputs. If an out-of-range or a malfunction is detected & confirmed by the system, it must open the AIRs to isolate the battery pack from the tractive system.
- EV2.6.3 The tractive system must remain disabled until manually reset by a person other than the driver. It must not be possible for the driver to re-activate the tractive system from within the car in case of a BMS fault.
- EV2.6.4 The BMS must continuously measure cell voltages to keep those voltages inside the allowed minimum and maximum stated in the cell data sheet. If individual cells are directly connected in parallel, only one voltage measurement is required for that group. (Measured at the parallel connections, outside of the cell fuses).



- EV2.6.5 The BMS must monitor the temperature of all the cells individually in the battery.
- EV2.6.6 All voltage sense wires to the BMS must be protected by fuses or resistors so that they cannot exceed their current carrying capacity in the event of a short circuit.
- EV2.6.7 Input channels of the BMS used for different segments of the battery must be isolated from one another with isolation rated for at least the maximum tractive system voltage. This isolation is also required between channels or sections of the BMS that are connected to different sides of a fuse or AIR.
- EV2.6.8 BMS connections that are not isolated, such as cell sense wires, cannot exit the battery container. This requirement should be considered in the selection of a BMS system for a vehicle that uses more than one battery container. TRACTIVE SYSTEM GROUND TO BE GIVEN TO BATT -VE.

ARTICLE EV3 TRACTION MOTOR & CONTROLLER

EV3.1 Traction Motor

- EV3.1.1 Allowed Traction Motor shall be a PMDC Motor with Nominal Power not more than 20 kW and Peak Torque of 50Nm. The Maximum Operating Speed shall be limited to 6000 rpm.
- EV3.1.2 The Maximum power drawn from the battery must not exceed 6kW.

Note: Violating the values will lead to disqualification for the entire dynamic event in which the violation occurred e.g. if a violation occurs during one single acceleration run, the team will be disqualified for the complete acceleration event.
- EV3.1.3 The tractive system motor(s) shall be connected to the battery through a motor controller.
- EV3.1.4 The accelerator control must be a right-foot-operated foot pedal and the Traction Motor controller must be actuated by a foot pedal.
- EV3.1.5 The foot pedal must return to its original, rearward position when released. The foot pedal must have positive stops at both ends of its travel.
- EV3.1.6 The Brake Pedal shall be a right foot operated one and include a Brake-Over-Travel switch.



- EV3.1.7 All acceleration control signals (between the accelerator pedal and the motor controller) must have error checking using redundancy. For analog acceleration control signals, this error checking must detect open circuit, short to ground and short to sensor power whereas for a digital acceleration control signals, this error checking must detect a loss of communication.
- EV3.1.8 An error in the acceleration control signal must shut down the torque production in less than one (1) second when a fault is detected.

Note: If these capabilities are built into the motor controller, then no additional errorchecking circuitry is required

EV3.2 Positioning of Electrical parts

- EV3.2.1 Housings and/or covers must prevent inadvertent human contact with any part of the tractive system circuitry. This includes people working on or inside the vehicle. Covers must be secure and adequately rigid. Body panels that must be removed to access other components, etc. are not a substitute for enclosing tractive system conductors.
- EV3.2.2 Tractive system components and wiring must be mechanically protected from damage by rotating and/or moving parts.
- EV3.2.3 Every housing or enclosure containing parts of the tractive system must be labeled with the words “Danger”, “High Voltage” and a black lightning bolt on a yellow background. The label must be at least 4 x 6 cm. (See **FIGURE 25.**)

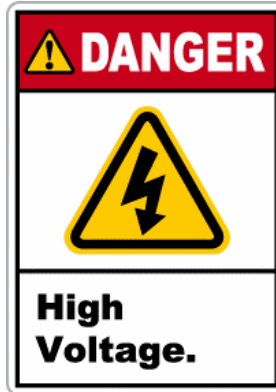


Figure 25 - High Voltage Label

- EV3.2.4 All parts belonging to the tractive system including conduit, cables and wiring must be contained within the Surface Envelope of the vehicle such that they are protected against being damaged in case of a crash or roll-over situation or being caught (snagged) by road hazards.
- EV3.2.5 If tractive system parts are mounted in a position where damage could occur from a rear or side impact (below 350 mm from the ground), such as side mounted batteries or rear mounted motors, they must be protected by a fully triangulated structure.



- EV3.2.6 Drive motors shall be located fully within the frame, No part of the tractive-system may project below the lower surface of the frame in either side or front view. Tractive systems and containers must be protected from moisture in the form of rain or puddles.

EV3.3

EV3.4 Electrical Wiring Architecture and conduits

- EV3.4.1 All tractive system wiring must be done to professional standards with adequate strain relief and protection from loosening due to vibration etc.
- EV3.4.2 Soldering in the high current path is prohibited.
- EV3.4.3 All wires, terminals and other conductors used in the tractive system must be sized appropriately for the continuous rating of the fuse which protects them. Wires must be marked with wire gauge, temperature rating and insulation voltage rating.
- EV3.4.4 The minimum acceptable temperature rating for TS wiring is 120°C.
- EV3.4.5 All the Ground wires of the Low Voltage System shall be colored in Black and the wires associated with the communication modules shall be Green.
- EV3.4.6 All tractive system wiring that runs outside of electrical enclosures must be either:
EV3.4.7 Orange/Red shielded, dual-insulated cable rated for automotive application, at least 5 mm overall cable diameter. , **Or**
- EV3.4.8 Enclosed in ORANGE non-conductive conduit
- EV3.4.9 All electrical circuits shall be protected from short circuits to ground and other electrical overload conditions.
- EV3.4.10 If electrical currents must pass from one non-welded structural sheet metal member to another structural member, care must be taken to ensure that proper electrically conductive fasteners are utilized between the structural components or else a properly sized ground wire, cable, or strap must be provided.
- EV3.4.11 The ground wire(s) must be designed to handle the maximum load currents.
- EV3.4.12 Avoid routing high voltage and/or high current circuits adjacent to critical signal circuits to reduce conditions for noise coupling or "crosstalk".

Table : Separation Requirements			
Category	A	B	C



A	-	50 mm	100 mm
B	50 mm	-	10 mm
C	100mm	10 mm	-

Table 3 - Cable Separation Requirements

EV3.4.13 Category A = High Voltage Cables: Includes high voltage cables for onboard chargers, 3-phase cables for electric machines.

EV3.4.14 Category B = Main 12V DC Vehicle Power Cables: Includes 12VDC cables from Battery to Starter Motor and Battery to Generator/Alternator.

EV3.4.15 Category C = Other 12VDC Power, Control, and Signal Lines: Includes data transmission lines, sensor and actuator leads, antenna leads, individual component power feeds, etc.

EV3.4.16 The wiring protection device should be a "Slow Blow" type fuse to be able to sustain the load for longer period. In case of a relay, total resistance to a relay coil should not be allowed to be less than 50 ohms to ensure reliable operation of the relay.

EV3.5 Motor Controller & Main Controller Module

EV3.5.1 Commercially available motor controllers containing boost converters that have internal voltages greater than 300 VDC may be used provided the unit is approved in writing by the rules committee.

EV3.5.2 The tractive system motor(s) must be connected to the battery through a motor controller. Bypassing the control system and connecting the tractive system battery directly to the motor(s) is prohibited.

EV3.5.3 The accelerator control must be a right-foot-operated foot pedal

EV3.5.4 The foot pedal must return to its original, rearward position when released. The foot pedal must have positive stops at both ends of its travel, preventing its sensors from being damaged or overstressed.

EV3.5.5 Motor controller inputs that are not galvanically isolated from TSV may not be present in the cockpit. This includes accelerator input, forward/reverse, on/off switches etc.



- EV3.5.6 Motor controller inputs that are galvanically isolated from the TSV may be run throughout the vehicle, but must be positively bonded to GLV ground.
- EV3.5.7 If the power supply to MCM is shut down, the emergency shut off shall be triggered.
- EV3.5.8 The Master Controller shall be able to detect the loss of communication (LOC) of the signals with the sources connected to it e.g.: Inputs from Accelerator pedal, Brake pedal.
- EV3.5.9 If LOC with accelerator pedal to BMS is detected, MCM shall shut down all the systems and bring the vehicle to halt.
- EV3.5.10 If LOC with Brake Pedal is detected then Brake Pedal signal to Motor Controller shall be defaulted to Zero.
- EV3.5.11 LOC with the Generator shall result in making the generator inactive.
- EV3.5.12 LOC with the charging module shall cease the charging process.
- EV3.5.13 The Master Controller shall receive the Voltage, Current and SOC measurements from BMS any interruption in the data or erratic behavior of the BMS shall result in shutdown of vehicle and a feedback shall be sent to Driver.
- EV3.5.14 Master Controller shall continuously monitor the fuel present in the tank (optional)
- EV3.5.15 The Engine RPM shall always be communicated back to Master Controller, failure in doing so shall make the Engine Run at a constant RPM which is predefined.
- EV3.5.16 Any Emergency Shut off signal shall be communicated to MCM and shall be given high priority in MCM and a feedback shall be given to driver.
- EV3.5.17 Master Controller shall cut off / reduce the power flow to the Traction motor when there is any fault reported to Master Controller.
- EV3.5.18 Master Controller shall safeguard the batteries from over charging either from Off board charger or by on board power plant or by Regenerative Braking.
- EV3.5.19 Master controller shall also control the 12 V battery charging and shall cut off the Power supply when the 12V battery has reached its maximum capacity.

EV3.6 Electrical Regenerative Braking

- EV3.6.1 The Regenerative Braking Transducer shall revert to its original position when released.



- EV3.6.2 The Braking control signals shall have error checking and reporting capabilities.
- For Analog** Transducer, the error checks shall be open circuit and short circuit to ground as well as short circuit to battery
 - For Digital** Transducer, the error checks shall be Loss of Communication of the signal.

An Error detected shall shutoff the brake input to Master Controller and error shall be notified to the driver.

EV3.6.3 Regenerative Braking System shall be secondary to primary friction Braking System.

EV3.6.4 The primary friction brake system shall be able to stop the vehicle in all circumstances. Regenerative Braking shall be disabled when the battery is fully charged.

ARTICLE EV4 GROUNDED LOW VOLTAGE SYSTEM

EV4.1 Grounded Low Voltage System (GLV)

EV4.1.1 The GLV system shall not have a voltage greater than 13.5 V.

EV4.1.2 All GLV batteries must be attached securely to the frame.

EV4.1.3 The hot (ungrounded) terminal of the battery must be insulated with industry standard insulation caps.

EV4.1.4 Negative terminal of the GLV battery or other GLV power source must be connected to the chassis by a stranded ground wire or flexible strap, with a minimum size of 12 AWG or equivalent cross-section.

EV4.1.5 The ground wire must run directly from the battery to the nearest frame ground and must be properly secured at both ends.

Note: Through-bolting a ring terminal to a gusset plate or dedicated tab welded to the frame is highly recommended.

EV4.1.6 Any wet-cell battery located in the driver compartment must be enclosed in a nonconductive marine-type container or equivalent and include a layer of 1.5 mm aluminum or equivalent between the container and driver.

EV4.1.7 GLV battery packs based on Lithium Chemistry (other than commercially assembled packs) are not permitted.

ARTICLE EV5 TRACTIVE SYSTEM VOLTAGE ISOLATION



EV5.1 Isolation Requirements

- EV5.1.1 All TS wiring and components must be galvanically (electrically) isolated from GLV by separation and/or insulation.
- EV5.1.2 All interaction between TS and GLV must be by means of galvanically isolated devices such as opto-couplers, transformers, digital isolators or isolated dc-dc converters.
- EV5.1.3 All connections from external devices such as laptops to a tractive system component must be galvanically isolated, and include a connection between the external device ground and the vehicle frame ground.
- EV5.1.4 All isolation devices must be rated for an isolation voltage of at least twice the maximum TS voltage.
- EV5.1.5 TS wiring must be separated from the driver's compartment by a firewall.

EV5.2 Insulation, Spacing and Segregation

- EV5.2.1 Tractive system wiring must be constructed using spacing, insulation, or both, to prevent short circuits between TS conductors.
- EV5.2.2 All required spacing must be clearly defined. Components and cables must be securely restrained to prevent movement and maintain spacing.
- EV5.2.3 All electrical insulating material must be appropriate and adequately robust for the application in which it is used and the based on the application voltage and temperature.
- EV5.2.4 Insulating materials must extend far enough at the edges to meet spacing and creepage requirements between conductors.
- EV5.2.5 Thermoplastic materials such as vinyl insulation tape may not be used. Thermoset materials such as heat-shrink and self-fusing tapes (typically silicone) are acceptable.

EV5.3 Printed circuit board (PCB) isolation

- EV5.3.1 Any kind of Printed circuit boards designed and/or fabricated by teams must comply with the following:
- EV5.3.2 If tractive system circuits and GLV circuits are on the same circuit board they must be on separate, clearly defined areas of the board. Furthermore, the tractive system and GLV areas must be clearly marked on the PCB.
- EV5.3.3 Prototyping boards having plated holes and/or generic conductor patterns may not be used for applications where both GLV and TS circuits are present on the same board.



- EV5.3.4 All layers of unpopulated boards (inner layers or top/bottom layers that don't photograph well can be provided as copies of artwork files.) Both top and bottom of fully populated and soldered boards. If dimensional information is not obvious (i.e. 0.1 in x 0.1 in spacing) then a dimensional reference must be included in the photo.
- EV5.3.5 Spare boards should be made available for inspection. Teams should also be prepared to remove boards for direct inspection if asked to do so during the technical inspection. Printed circuit boards located inside the battery container and having tractive system connections on them must be fused at 1 amp or lower.
- EV5.3.6 If the fuses are located on the board, the spacing between tractive system conductors on the source side of the fuse must be at least 3.2 mm.

ARTICLE EV6 SHUTDOWN CIRCUIT AND SYSTEMS

EV6.1 Shutdown Circuit

- EV6.1.1 The shutdown circuit is the primary safety system within a vehicle. Shutdown may be initiated by several devices having different priorities.
- EV6.1.2 The shutdown circuit shall consist of:
- Tractive System Master Switch (TSMS)
 - Two side mounted shutdown buttons (BRBs)
 - Cockpit-mounted shutdown button.
 - Brake over-travel switch.
- EV6.1.3 Any failure causing the GLV system to shut down must immediately deactivate the tractive system as well.
- EV6.1.4 The shutdown circuit must directly carry 12V current energizing the battery isolation relays (AIRs).
- EV6.1.5 All components in the shutdown circuit must be rated for the maximum continuous current in the circuit (i.e. AIR and relay current).
- Note:** A normally-open relay may be used to control AIR coils upon application to the rules committee.
- EV6.1.6 In the event of a BMS, Brake over-travel fault, it should shut down the vehicle and must not be possible for the driver to re-activate the tractive system from within the cockpit.



EV6.2 Tractive System Master Switch (TSMS)

- EV6.2.1 Master switch must be located on the right side of the vehicle, in proximity to the Main Hoop, at the driver's shoulder height and be easily actuated from outside the car.
- EV6.2.2 Master switches must be of the rotary type, with a red, removable key, similar to the one shown in Figure 38. Master switch must be direct acting. i.e. they may not operate through a relay. It is not allowed to be easily removable, e.g. mounted onto removable body work.
- EV6.2.3 The "ON" position of both switches must be parallel to the fore-aft axis of the vehicle.
- EV6.2.4 The TSMS must open the Tractive System shutdown circuit. The TSMS must be identified with a label with a red lightning bolt in a blue triangle. (See **FIGURE 26**).



Figure 26 - Typical Master Switch



Figure 27 - International Kill Switch Symbol

EV6.3 Side-mounted Shutdown Buttons



- EV6.3.1 The side-mounted shutdown buttons (Big Red Buttons – or BRBs) are the first line of defense for a vehicle that is malfunctioning or in trouble. Corner and safety workers are instructed to push the BRB first when responding to an emergency.
- EV6.3.2 One button must be located on each side of the vehicle behind the driver's compartment at approximately the level of the driver's head. They must be installed facing outward and be easily visible from the sides of the car.
- EV6.3.3 The side-mounted BRBs must be red and a minimum of 38 mm. in diameter.
- EV6.3.4 The side-mounted shut-down buttons must be normally-closed (N.C.) push-pull or push-rotate where pushing the button opens the circuit.
- EV6.3.5 The side-mounted shutdown buttons must shut down all electrical systems with the exception for the MCM.
- EV6.3.6 The shut-down buttons may not act through logic such as a micro-controller or relays.
- EV6.3.7 The shutdown buttons may not be easily removable, e.g. they may not be mounted onto removable body work.

EV6.4 Cockpit Shutdown Button

- EV6.4.1 The shutdown circuit is the primary safety system within a vehicle. Shutdown may be initiated by One shutdown button must be mounted in the cockpit and be easily accessible by the driver while fully belted in and with the steering wheel in any position.
- EV6.4.2 The cockpit shut-down button must be a normally-closed (N.C.) push-pull (latching) device where pushing the button opens the circuit.
- EV6.4.3 The cockpit shutdown button must be red and at least 24 mm in diameter.
- EV6.4.4 Pushing the cockpit mounted button must open the AIRs and shut down the I.C. engine.
- EV6.4.5 The cockpit shutdown button must be driver resettable. I.e. if the driver disables the system by pressing the cockpit-mounted shutdown button, the driver must then be able to restore system operation by pulling the button back out.

EV6.5 Shutdown system sequencing

- EV6.5.1 Teams must submit the complete circuit details as well as demonstrate the sequence of the shutdown systems.

IMPORTANT NOTE: If during technical inspection, it is found that the shutdown circuit operates differently from the rules, the car will be considered to have failed inspection.



ARTICLE EV7 Grounding

EV7.1 General

- EV7.1.1 The Tractive System shall be grounded to the Negative Terminal of the Battery while the GLV System shall be grounded to the Chassis Frame. All accessible metal parts of the vehicle (except for GLV system components) must have a resistance below 300 mΩ to GLV system ground.
- EV7.1.2 Accessible parts are defined as those that are exposed in the normal driving configuration or when the vehicle is partially disassembled for maintenance or charging.
- EV7.1.3 All non-metal parts of the vehicle containing conductive material (e.g. coated metal, carbon fiber parts, etc.) that could potentially become energized (including post collision or accident), no matter if tractive system or GLV, must have a resistance below 100 ohms to GLV system ground.
- Note:** Carbon fiber parts may require specific measures such as imbedding copper mesh or similar modifications to keep the ground resistance below 100 Ω.
- EV7.1.4 If exposed heat sinks are used in any TS system, they must be properly grounded to the GLV system ground.
- EV7.1.5 Grounding conductors or straps used for compliance with this section must be a minimum of 16 AWG and be stranded.

ARTICLE EV8 SYSTEM STATUS INDICATORS

EV8.1 Brake Light

- EV8.1.1 The vehicle must be equipped with a red brake light that is SAE “S” or “U” rated or it must be equal to or exceed these standards (e.g.: OEM brake light assemblies)/ AIS and ISI rated brake lights are also permitted.
- EV8.1.2 They must be clearly visible and appear bright in daylight. Light must be mounted such that it shines parallel to the ground, not up at an angle, up to a distance of 10 meters.

EV8.2 Brake Light Switch

- EV8.2.1 The brake light must be activated by hydraulic pressure switches. Each independent brake hydraulic circuit must be equipped with a brake light switch, so that no brake, including cutting brakes may be activated without lighting the brake light. This means each vehicle is required to have a minimum of two (2) hydraulic pressure switches.



ARTICLE EV9 INSTRUMENTATION AND DATA ACQUISITION

EV9.1 Live Data or Driver Feedback Instrumentation and Data Acquisition

- EV9.1.1 Systems that provide live information about the cars operation or performance and driver feedback instrumentation shall be installed. The information of Battery Voltage Level, State of Charge, Vehicle Speed shall be displayed to the driver. Any additional information to be displayed is up to the team's choice are allowed.
- EV9.1.2 Any system that provides data back to the driver or team track side must be included on the Cost Report. Additionally, any batteries used to power the system must comply with the battery rules of GLV System.

ARTICLE EV10 HIGH VOLTAGE PROCEDURES & TOOLS

EV10.1 Working on Tractive System Battery Containers

- EV10.1.1 Whenever the Battery or tractive system is being worked on, only appropriate insulated tools should be used.
- EV10.1.2 Safety glasses with side shields and safety gloves i.e. Class 0 voltage rated gloves with leather protectors must be worn by all participating team members when (a) parts of the tractive system are exposed while it is active, or (b) work is being done on the batteries.
- EV10.1.3 The cables for the battery and the wiring harness shall be of ISO 6722, DN72551 standards and the fasteners used for the battery connections shall be of nickel plated.

EV10.2 Charging

- EV10.2.1 Charger shall be off board and of 54V.
- EV10.2.2 Only chargers presented and sealed at Electrical Tech Inspection are allowed. All connections of the charger(s) must be isolated and covered. No open connections are allowed.
- EV10.2.3 HV charging leads must be orange.
- EV10.2.4 **NO WORK IS ALLOWED ON ANY OF THE CAR'S SYSTEMS DURING CHARGING, IF THE BATTERIES ARE INSIDE THE CAR.**

ARTICLE EV11 REQUIRED ELECTRICAL DOCUMENTATION



EV11.1 Electrical System Form – Part 1

EV11.1.1 Part 1 of the ESF requests preliminary design information. This is so that the technical reviewers can identify areas of concern early and provide feedback to the teams.

EV11.2 Electrical System Form – Part 2

EV11.2.1 Note that many of the fields in Part 2 ask for the same information that was entered in Part 1. This information must be reentered in Part 2. However, it is not expected that the fields will contain identical information, since many aspects of a design will change as a project evolves.

EV11.2.2 The final ESF must illustrate the interconnection of all electric components including the voltage level, the topology, the wiring in the car and the construction and build of the battery(s).

EV11.2.3 Teams must present data pages with rated specifications for all tractive system parts used and show that none of these ratings are exceeded (including wiring components). This includes stress caused by the environment e.g. elevated temperatures, vibration, etc.

EV11.2.4 A template containing the required structure for the ESF will be made available online. The ESF must be submitted as a Microsoft Word format file.

EV11.3 Failure Modes and Effects Analysis (FMEA)

EV11.3.1 Teams must submit a complete system level failure modes and effects analysis (FMEA) of the tractive system prior to the event.

EV11.3.2 A template including required failures to be described will be made available online.

Note: Do not change the format of the templates. Pictures, schematics and data sheets to be referenced in the FMEA must be included in the ESF.

ARTICLE EV12 STATIC TESTS

EV12.1 Rain test (Optional)

EV12.1.1 Vehicles that pass the rain test will receive a “Rain Certified” sticker and may be operated in damp or wet conditions.

EV12.1.2 If a vehicle does not pass the rain test, or if the team chooses to forego the rain test, then the vehicle is not rain certified and will not be allowed to operate in damp or wet conditions.



EV12.1.3 During the rain test the tractive system must be active and none of the driven wheels may touch the ground.

EV12.1.4 It is not allowed to have a driver seated in the car during the rain test.

EV12.1.5 Water will be sprayed at the car from any possible direction for 120 seconds. The water spray will be rain-like. There will be no high-pressure water jet directed at the car.

EV12.1.6 The total time of the rain test is 240 seconds, 120 seconds with water-spray and 120 seconds without.

EV12.1.7 Teams must ensure that water cannot aggregate anywhere in the chassis.

EV12.1.8 Before and After Water Wading Test the isolation resistance of the vehicle will be measured. The functioning of the kit should not be hampered after the Water Wading test for the successful completion of the test.

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