Progettazione del Telaio

TELAIO FORMULA SAE

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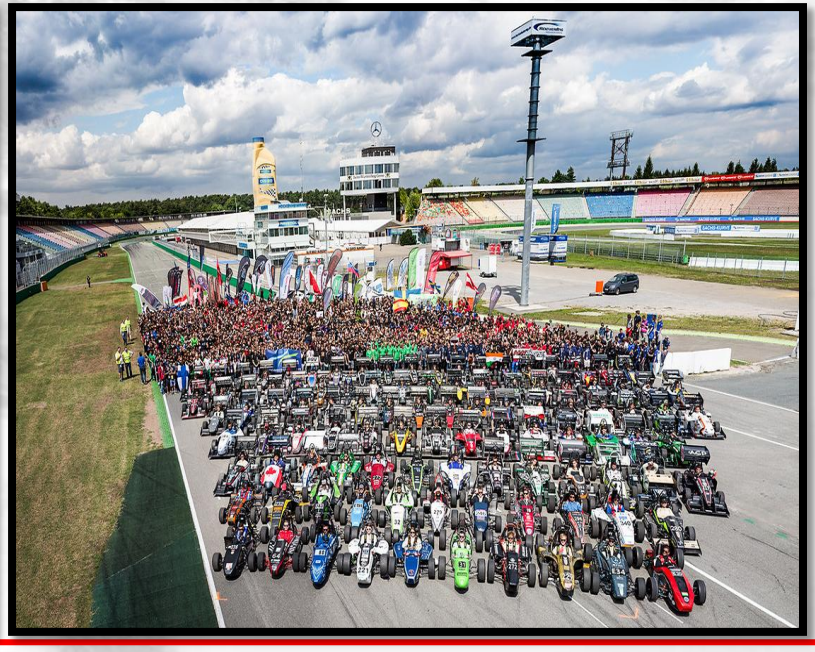
FORMULA SAE

Competizione internazionale tra studenti universitari che prevede la progettazione e la produzione di una monoposto da corsa, valutata durante una serie di prove in base alle sue qualità di design e di efficienza ingegneristica.

- Obiettivo della Formula SAE: offrire agli studenti un'occasione unica di crescita professionale;
- Più di 10 eventi annuali tenuti in tutto il mondo;
- La tappa italiana è tenuta a Varano de' Melegari (PR), promossa da Dallara;
- Ciascuna tappa è composta da 8 tipologie di prove che valutano: affidabilità, economicità, comfort, sicurezza, elevate prestazioni in termini di maneggevolezza, frenata e accelerazione.



FORMULA SAE

Format gara:

1. Verifiche tecniche
2. Prove statiche
3. Prove dinamiche

FORMULA SAE

1. Verifiche tecniche

- «Tech»: conformità al regolamento
- «Tilt»: perdita di liquidi con vettura inclinata a 60°
- «Noise»: non superamento dei 110db
- «Brake»: frenata con tutte le 4 ruote senza spegnimento motore

+ «Egress test»: uscita del pilota dall'abitacolo in < 5 sec

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2. Prove statiche

- «Cost Analysis»: report e discussione sulla stima dei costi di produzione e progettazione
- «Business Presentation Event»: esposizione del business case
- «Engineering Design»: presentare scelte progettuali

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3. Prove dinamiche

- «Acceleration»: accelerazione di 75 m
- «Skidpad»: valutare la capacità della vettura in curva
- «Autocross»: valutare la capacità di sprint su circuito
- «Endurance»: valutare performance complessive su 22 km

- + «Fuel Economy»: risparmio carburante

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2017-18 Formula SAE Rules
PART A - ADMINISTRATIVE REGULATIONS

ARTICLE 1: FORMULA SAE OVERVIEW AND COMPETITION

A1.1 Formula SAE Competition Objective
The Formula SAE ® Series competitions challenge teams of university undergraduate and graduate students to conceive, design, fabricate, develop and compete with small, formula style, vehicles.

A1.1.1 To give teams the maximum design flexibility and the freedom to express their creativity and imaginations there are very few restrictions on the overall vehicle design. The challenge to teams is to develop a vehicle that can successfully compete in all the events described in the FSAE Rules. The competitions themselves give teams the chance to demonstrate and prove both their creativity and their engineering skills in comparison to teams from other universities around the world.

A1.2 Vehicle Design Objectives
For the purpose of the Formula SAE competition, teams are to assume that they work for a design firm that is designing, fabricating, testing and demonstrating a prototype vehicle for the non-professional, weekend, competition market.

A1.2.1 The vehicle should have very high performance in terms of acceleration, braking and handling and be sufficiently durable to successfully complete all the events described in the Formula SAE Rules and held at the Formula SAE competitions.

A1.2.2 The vehicle must accommodate drivers whose stature ranges from 5th percentile female to 95th percentile male and must satisfy the requirements of the Formula SAE Rules.

Driver accommodation includes but is not limited to: driver visibility, steering wheel and shifter locations, pedals, lap and shoulder belt angles and head rest position. Detailed anthropometric data for the 5th percentile female and 95th percentile male may be found on the FSAE website http://fsaeonline.com/.

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ARTICLE 2: GENERAL DESIGN REQUIREMENTS

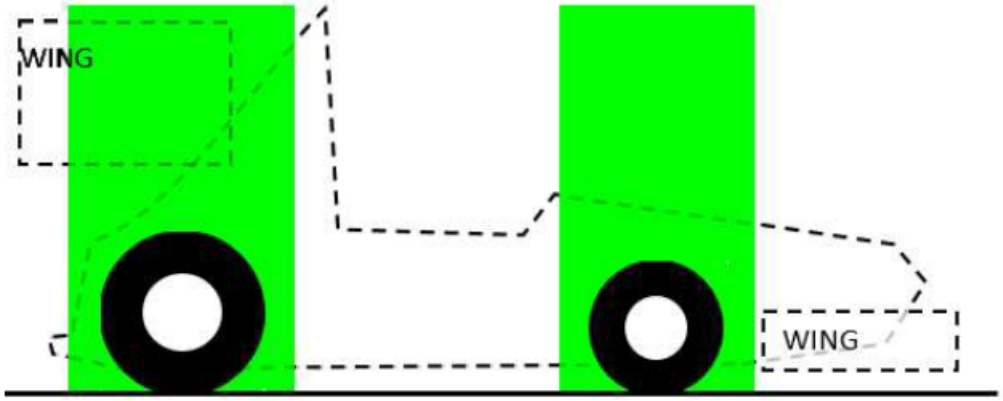
T2.1 Vehicle Configuration

The vehicle must be open-wheeled and open-cockpit (a formula style body) with four (4) wheels that are not in a straight line.

Definition of "Open Wheel" – Open Wheel vehicles must satisfy all of the following criteria:

a. The top 180 degrees of the wheels/tires must be unobstructed when viewed from vertically above the wheel.
b. The wheels/tires must be unobstructed when viewed from the side.
c. No part of the vehicle may enter a keep-out-zone defined by two lines extending vertically from positions 75mm in front of and 75mm behind, the outer diameter of the front and rear tires in the side view elevation of the vehicle, with tires steered straight ahead. This keep-out zone will extend laterally from the outside plane of the wheel/tire to the inboard plane of the wheel/tire. See the figure "Keep Out Zones" below.
d. Must also comply with the dimensions/requirements of ARTICLE 9: Aerodynamic Devices.

The dry tires will be used for all inspections.



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ARTICLE 3: DRIVER'S CELL

T3.1 Vehicle Structure - 2 Options

Teams may, at their option, design their vehicle to comply with either of two (2) separate, but related, sets of requirements and restrictions. Specifically, teams may elect to comply with **either**:

a. Part T Article 3 "Drivers Cell" as defined below **or**
b. Part AF "Alternate Frame Rules" as found in Appendix AF and the FSAE website.

T3.1.1 Notice Requirement – Teams planning to use the Part AF "Alternate Frame Rules" must notify the Rules Committee of their intent by the date posted on the SAE Website. The instructions for notification appear in Part AF. The Rules Committee will review the submission and notify the team if the request is granted. Part AF has significant analytical requirements and this application process will insure that the Committee can handle the workload and give teams the support they may require to show certification as well as insure the teams have the technical capability to analyze their design and prove compliance with the AF Rules.

T3.1.2 Alternate Frame Rules use requires the submission of the "Structural Requirements Certification Form (SRCF)" which **supersedes portions of** the "Structural Equivalency Spreadsheet". See AF Articles 7 and 8 for a list of superseded T3 Driver Cells and EV Article 3 rules.

T3.2 General Requirements

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.

T3.3 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.

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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 or a combination of composite and welded structures.

g. Primary Structure – The Primary Structure is comprised of the following Frame components:
   i. Main Hoop,
   ii. Front Hoop,
   iii. Roll Hoop Braces and Supports,
   iv. Side Impact Structure,
   v. Front Bulkhead,
   vi. Front Bulkhead Support System and
   vii. All Frame Members, guides and supports that transfer load from the Driver's Restraint System into items 1 through 6.

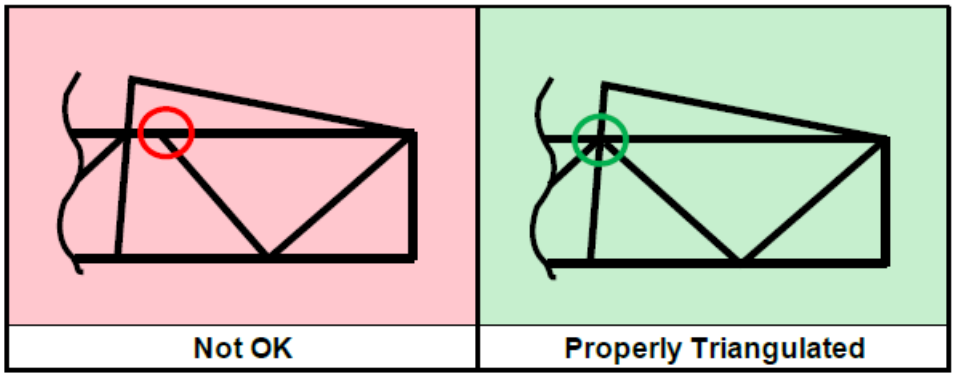
h. Major Structure of the Frame – The portion of the Frame that lies within the envelope defined by the Primary Structure. The portion of the Main Hoop above a horizontal plane located at the top of the upper side impact bar and the Main Hoop Bracing are not included in defining this envelope.

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 (13.8 inches) 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".



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T3.4 Minimum Material Requirements

T3.4.1 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 the following table,
Or: Approved alternatives per Rules T3.5, T3.6 and T3.7.

ITEM or APPLICATION	OUTSIDE DIMENSION X WALL THICKNESS
Main & Front Hoops, Shoulder Harness Mounting Bar	Round 1.0 inch (25.4 mm) x 0.095 inch (2.4 mm) or Round 25.0 mm x 2.50 mm metric
Side Impact Structure, Front Bulkhead, Roll Hoop Bracing, Driver's Restraint Harness Attachment (except as noted above) EV: Accumulator Protection Structure	Round 1.0 inch (25.4 mm) x 0.065 inch (1.65 mm) or Round 25.0 mm x 1.75 mm metric or Round 25.4 mm x 1.60 mm metric or Square 1.00 inch x 1.00 inch x 0.047 inch or Square 25.0 mm x 25.0 mm x 1.20 mm metric
Front Bulkhead Support, Main Hoop Bracing Supports, Shoulder Harness Mounting Bar Bracing EV: Tractive System Components Protection	Round 1.0 inch (25.4 mm) x 0.047 inch (1.20 mm) or Round 25.0 mm x 1.5 mm metric or Round 26.0 mm x 1.2 mm metric
Bent Upper Side-Impact Member (T3.24.3a)	Round 1.375 inch (35.0mm) x 0.047 inch (1.20mm)

T3.4.2 The use of alloy steel does not allow the wall thickness to be thinner than that used for mild steel.

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T3.5 Alternative Tubing, Tubing Geometry and Materials - General Notes for all Applications

T3.5.1 Alternative tubing geometry and/or materials may be used except that the Main Roll Hoop and Main Roll Hoop Bracing must be made from steel, i.e. the use of aluminum or titanium tubing or composites for these components is prohibited.

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

T3.5.3 If a team chooses to use alternative tubing and/or materials, they must submit a "Structural Equivalency Spreadsheet" per Rule T3.9. The teams must submit calculations for the material they have chosen, demonstrating equivalence to the minimum requirements found in Section T3.4.1 for yield and ultimate strengths in bending, buckling and tension, for buckling modulus and for energy dissipation. (The Buckling Modulus is defined as EI, where, E = modulus of Elasticity, and I = area moment of inertia about the weakest axis.)

T3.5.4 Tubing must meet or exceed the minimum wall thickness listed in T3.6 or T3.7.

T3.5.5 If a bent tube (or member consisting of multiple tubes that are not in a line) is used anywhere in the primary structure, other than the front and main roll hoops, an additional tube must be attached to support it. The attachment point must be the position along the tube where it deviates farthest from a straight line connecting both ends. The support tube must have the same diameter and thickness as the bent tube, terminate at a node of the chassis, and be angled no more than 30 degrees from the plane of the bent tube. **Braces attached to the upper side impact member are not required to meet the 30 degrees from the plane of the bent tube requirement.**

T3.5.6 Any chassis design that is a hybrid of the baseline and monocoque rules, must meet all relevant rules requirements, e.g. a sandwich panel side impact structure in a tube frame chassis must meet the requirements of rules T3.27, T3.28, T3.29, T3.30 and T3.33.

It is allowable for the properties of tubes and laminates to be combined to prove equivalence. For example, in a side-impact structure consisting of one tube as per T3.4 and a laminate panel, the panel only needs to be equivalent to two side-impact tubes.

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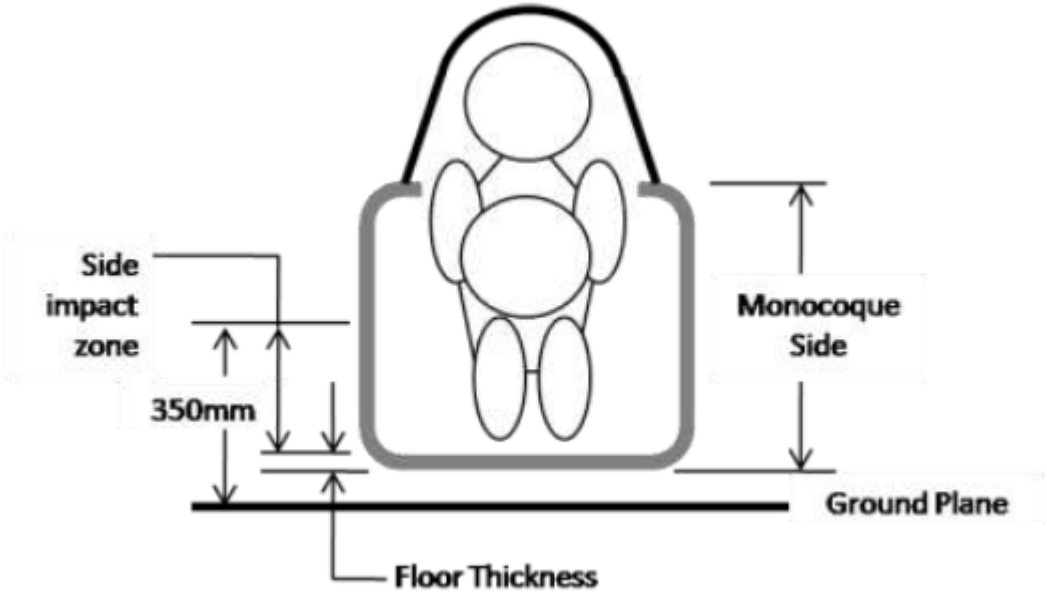
T3.33 Monocoque Side Impact

T3.33.1 In the region longitudinally forward of the Main Roll Hoop and aft of the Front Roll Hoop and vertically from 350 mm (13.8 inches) above the ground to the bottom surface of the floor of the monocoque must have a Buckling Modulus (E*I) equal to three (3) baseline steel tubes that it replaces.

T3.33.2 The vertical side impact zone between the upper surface of the floor and 350 mm (13.8 inches) above the ground must have a Buckling Modulus (E*I) equivalent to two baseline steel tubes and half the horizontal floor must have a Buckling Modulus (E*I) equivalent to one baseline steel tube per Rule T3.29 Monocoque Buckling Modulus.

T3.33.3 The vertical side impact zone between the upper surface of the floor and 350 mm (13.8 inches) above the ground must have an absorbed energy equivalent to two baseline steel tubes. Proof of equivalent absorbed energy is determined by physical testing per rule T3.30.2 and T3.30.3.



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T3.30 Monocoque Laminate Testing

T3.30.1 **Side Impact Laminate** - Teams must build a representative test panel with the same design, laminate, and fabrication method as used in the monocoque side impact zone (defined in T3.33) as a flat panel and perform a 3-point bending test on this panel. They must prove by physical testing that a panel measuring 275mm (10.8") x 500 mm (19.7") has at least the same properties as two baseline steel side impact tubes (See T3.4.1 "Baseline Steel Materials") for buckling modulus, yield strength, ultimate strength and absorbed energy. The data from these tests and pictures of the test samples must be included in the SES, the test results will be used to derive strength, stiffness, and absorbed energy properties used in the SES formulae for side impact laminate panels. The test specimen must be presented at technical inspection. If the test specimen does not meet these requirements, then the monocoque side impact zone must be strengthened appropriately.

T3.30.2 Teams are required to make an equivalent test with two side impact baseline steel tubes (SAE/AISI 1010) such that any compliance in the test rig can be accounted for and to establish an absorbed energy value of the baseline tubes. Baseline tubes must be tested to a minimum displacement of 12.7mm (0.5 inch). The calculation of absorbed energy will use the integral of force times displacement from the initiation of load to 12.7mm (0.5 inch).

T3.30.3 Primary structure laminate other than side impact – Teams must build representative test panels for each ply schedule used in the regulated regions of the monocoque as a flat panel and perform a 3-point bending test on these panels. The test panels must measure 275mm (10.8") x 500 mm (19.7"). The data from these tests and pictures of the test samples must be included in the SES, the test results

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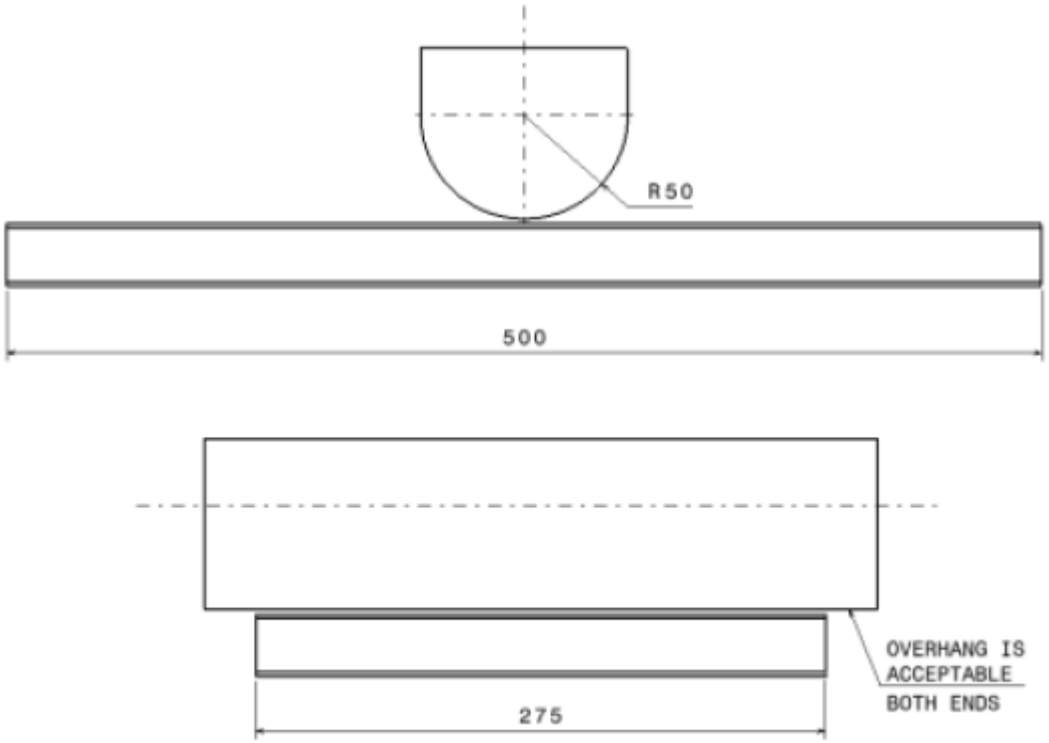
will be used to derive strength and stiffness properties used in the SES formula for all laminate panels. The test specimen must be presented at technical inspection.

T3.30.4 The load applicator used to test any panel/tubes as required by T3.30.1, T3.30.2, or T3.30.3 must be metallic and have a radius of 50mm (2 inch).

The load applicator must overhang the test piece to prevent edge loading.

It is not acceptable to place any other material between the load applicator and the items on test.



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T3.30.5 Perimeter shear tests must be completed by measuring the force required to push or pull a 25mm (1") diameter flat punch through a flat laminate sample.

The sample, measuring at least 100mm x 100mm (3.9" x 3.9"), must have core and skin thicknesses identical to those used in the actual monocoque and be manufactured using the same materials and processes.

The fixture must support the entire sample, except for a 32mm (1.25") hole aligned co-axially with the punch. The sample must not be clamped to the fixture.

The force-displacement data and photos of the test setup must be included in the SES.

The first peak in the load-deflection curve must be used to determine the skin shear strength; this may be less than the minimum force required by T3.32.3/T3.33.4.

The maximum force recorded must meet the requirements of T3.32.3/T3.33.4.
N: The edge of the punch and hole in the fixture may include an optional fillet up-to a maximum radius of 1mm (0.040").

T3.30.6 Laminate schedules that deviate from a quasi-isotropic layup must be tested in each orthogonal direction, i.e. two bending and shear test samples are required for each unique layup. All material properties in the weaker test direction must be at least 50% of those in the stronger test direction.

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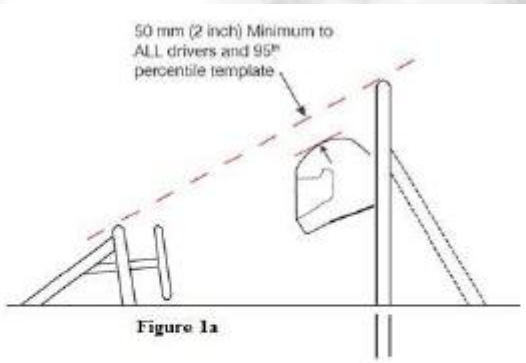

Figure 1a

T3.10.4 The 95th percentile male template will be positioned as follows: (See Figure 2.)

a. The seat will be adjusted to the rearmost position,
b. The pedals will be placed in the most forward position.
c. 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 (36 inches).
d. The middle 200 mm circle, representing the shoulders, will be positioned on the seat back.
e. The upper 300 mm circle will be positioned no more than 25.4 mm (1 inch) away from the head restraint (i.e. where the driver's helmet would normally be located while driving).

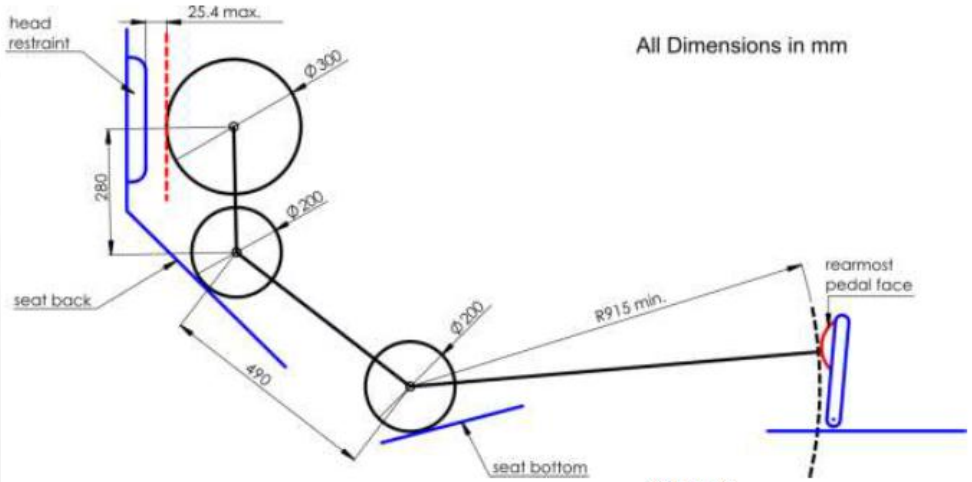

Figure 2

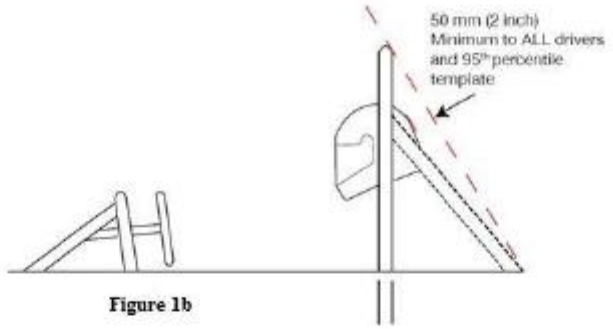

Figure 1b

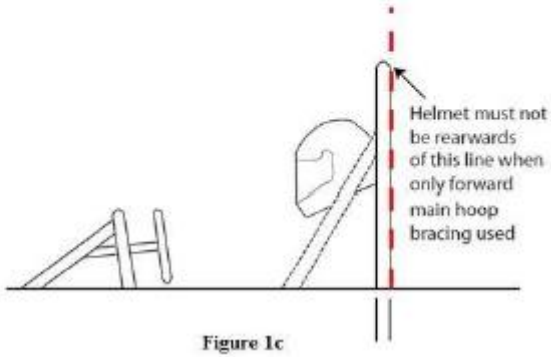

Figure 1c

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ARTICLE 4: COCKPIT

T4.1 Cockpit Opening

T4.1.1 In order to ensure that the opening giving access to the cockpit is of adequate size, the template shown in Figure 8 will be inserted into the cockpit opening.

T4.1.2 The template will be held horizontally, parallel to the ground, and inserted vertically from a height above any Primary Structure or bodywork that is between the Front Hoop and the Main Hoop until it has passed below the top bar of the Side Impact Structure (or until it is 350 mm (13.8 inches) above the ground for monocoque cars). Fore and aft translation of the template is permitted during insertion.

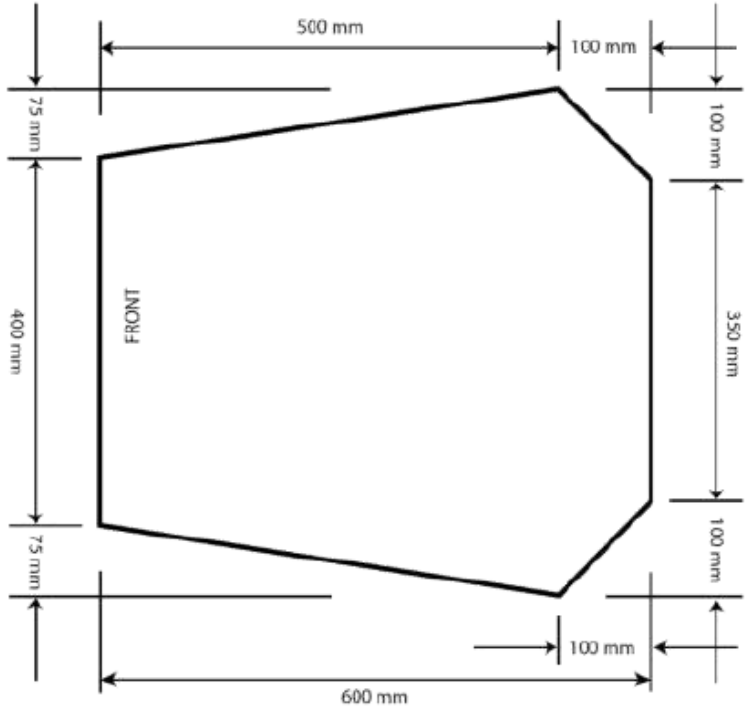

FIGURE 8

T4.1.3 During this test, the steering wheel, steering column, seat and all padding may be removed. The shifter or shift mechanism may not be removed unless it is integral with the steering wheel and is removed with the steering wheel. The firewall may not be moved or removed.

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T4.2 Cockpit Internal Cross Section:

T4.2.1 A free vertical cross section, which allows the template shown in Figure 9 to be passed horizontally through the cockpit to a point 100 mm (4 inches) rearwards of the face of the rearmost pedal when in the inoperative position, must be maintained over its entire length. If the pedals are adjustable, they will be put in their most forward position.

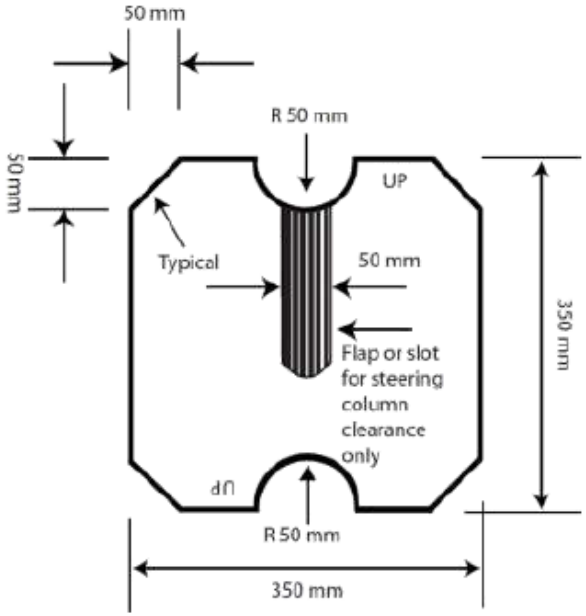

FIGURE 9

T4.2.2 The template, with maximum thickness of 7mm (0.275 inch), will be held vertically and inserted into the cockpit opening rearward of the rear-most portion of the steering column.

T4.2.3 The only items that may be removed for this test are the steering wheel, and any padding required by Rule T5.8 "Driver's Leg Protection" that can be easily removed without the use of tools with the driver in the seat. The seat may NOT be removed.

T4.2.4 Cables, wires, hoses, tubes, etc. must not impede the passage of the templates required by T4.1.1 and T4.2.