NxGV Challenge

Rule 2026

Version 1.0

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PART A – Administrative Regulation

A1 COMPETITION OVERVIEW

A1.1 The competition Objective

A1.1.1 The competition challenges teams of university students to conceive, design, fabricate, develop and compete with small, formula style, race cars. The envisaged "target customer" for these vehicles is an amateur (non-professional) driver.

A1.1.2 full time students enrolled in recognized post-secondary institutions include undergraduates and post graduate students.

A1.2 Competition Procedure

A1.2.1 This is based on the Formula SAE International regulation but with some local regulations embedded.

A1.2.2 The competition accepts entries for the following vehicle types:

a) Electric Vehicle (**EV**)
b) Hybrid Vehicle (**HV**)

A1.2.3 All vehicles must meet the requirements defined in **Section T** and **Section EV** or **HV**, depending on their powertrain type.

A1.2.4 The competition starts with a series of technical inspections described in **Section IN** to check the vehicle for safety and compliance with the rules.

A1.2.5 The competition is divided into a series of static and dynamic events described in **Sections S** and **D**.

A1.2.6 The maximum achievable points for each Class are listed in Table 1.

A1.2.7 In either EV Class or HEV Class, if there are no finishers in any dynamic events, then no Overall Winner award will be given for that class.

A1.2.8 The EV Class HEV Class are separate. Although they compete in the same events and may be on the endurance course at the same time, they are scored separately and receive separate awards.

A1.2.9 The official language of the competition is English.

Table 1: Event Points

	EV & HV	
Static Events		
Business Presentation	75 points	
Cost & Manufacturing	100 points	325 points
Design	150 points	
Dynamic Events		
Acceleration	100 points	
Skid Pad	75 points	
Autocross	125 points	675 points
Efficiency	100 points	
Endurance	275 points	
TOTAL	1000 points	

A2 VEHICLE ELIGIBILITY

A2.1 Student Develop Vehicle

A2.1.1 Vehicles entered into Formula SAE competitions must be conceived, designed, fabricated and maintained by the student team members without direct involvement from professional engineers, automotive engineers, racers, machinists or related professionals.

A2.1.2 The student team may use any literature or knowledge related to design and information from professionals or from academics if the information is given as a discussion of alternatives with their pros and cons.

A2.1.3 Professionals must not make design decisions or drawings. The Team Advisor may be required to sign a statement of compliance with this restriction.

A2.1.4 Students should Fabricate, manufacture and assemble as much of the vehicle as possible.

A2.2 First Year Vehicle

A2.2.1 A vehicle must only compete for one competition year, it's "first year", counting from the first day onsite at its first competition. Such a vehicle is defined as "new" or "First Year Vehicle". A vehicle may not compete in Formula Student class of the same event in the following season, even if two events occur within a one-year period.

A2.2.2 To be classified as new (First Year Vehicle), a vehicle must have a newly manufactured chassis, with significant changes in the Primary Structure to its predecessor.

A2.2.3 Second Year Vehicles must not enter Formula SAE Competitions, unless permitted by the organizer of the specific competition. Teams may apply to reuse a previous year's chassis if:

a) Requests must be submitted via the Formula Student Question Database (FSQD) before the Structural Equivalency Spreadsheet (SES) deadline,
b) Requests will be reviewed by the Chief Judge or Chief Technical Scrutineer, their decision will be final.
c) If a team is permitted to reuse a previous year's chassis, this may attract penalty points for the Design Event.

A2.2.4 The existing chassis may be used for one more consecutive year if the team changes the powertrain from EV to HEV or from HEV to EV.

A2.3 Number of Team Per Institutions

A2.3.1 Universities/Institutions may enter more than one vehicle per competition, provided each entry is in a different class.

A2.3.2 Universities/institutions with multiple campuses shall have each campus recognized as a separate entity, represent their specific campus independently.

A2.3.3 Teams which are formed with members from two or more universities are treated as a single team.

A2.3.4 Registration for NxGV Challenge may be restricted depending on available space.

A3 TEAM MEMBERS & PARTICIPANTS

A3.1 Team Members Composition

A3.1.1 Each team should have:

a) Team Leader
b) Team Advisor
c) Electrical System Officer (ESO)
d) Electrical System Advisor (ESA)
e) Rules and Safety Officer (RSO)
f) Team Members

A3.2 Team Leader

A3.2.1 Each team must have one team member identified as the Team Leader.

A3.2.2 The Team Leader is the main contact person for the officials during the registration process and the competition

A3.3 Team Advisor

A3.3.1 Each team must have one Team Advisor.

A3.3.2 Teams may appoint one or more Co-Team Advisor. The Co-Team Advisor will replace the Team Advisor if the Team Advisor is unable to accompany the team at any time during the event.

A3.3.3 Both Team Advisor and Co-Team Advisor must be officially appointed by their respective University or Institution.

A3.3.4 The Team Advisor should accompany the team to the competition and will be considered by the officials to be the official university representative.

A3.3.5 Team Advisors and Co-Team Advisor:

a) May advise their teams on general engineering and engineering project management theory.
b) Must not design, build or repair any part of the vehicle.
c) Must not develop any documentation or presentation.

A3.4 Electrical System Officer (ESO)

A3.4.1 The Electrical System Officer (ESO) is responsible for all electrical operations of the vehicle during the event.

A3.4.2 Each participating team must appoint one or more ESO for the event.

A3.4.3 The ESO(s) is the only person in the team who may declare the vehicle electrically safe, in order for work to be performed on any system of the vehicle by the team.

A3.4.4 The ESO(s) must be contactable by phone at any time during the competition.

A3.4.5 An ESO must accompany the vehicle whenever it is operated or moved around the competition site.

A3.4.6 The ESO must be:

a) A valid team member, see **A4.8**.

b) One or more ESO must not be a driver.
c) Certified or has received appropriate practical training whether formal or informal for working with High Voltage systems in automotive vehicles.

A3.4.7 Details of the training must be provided to the organizers on the ESO/ESA form for approval.

A3.5 Electrical System Advisor (ESA)

A3.5.1 The Electrical System Advisor (ESA) must be a professionally competent person(s) nominated by the team who can advise on the electrical and control systems that will be integrated into the vehicle.

A3.5.2 The Team advisor may also be the ESA if all the requirements below are met.

A3.5.3 The ESA must supply details of their experience of electrical and/or control systems engineering as used in the vehicle on the ESO/ESA form

A3.5.4 The ESA must be sufficiently qualified to advise the team on their proposed electrical and control system designs based on significant experience of the technology being developed and its implementation into vehicles or other safety critical systems.

A3.5.5 More than one person may be needed.

A3.5.6 The ESA:

a) must advise the team on the merits of any relevant engineering solutions. Solutions should be discussed, questioned and approved before they are implemented into the final vehicle design.
b) should advise the students on any required training to work with the systems on the vehicle.
c) must review the Electrical System Form and to confirm that in principle the vehicle has been designed using good engineering practices.
d) must make sure that the team communicates any unusual aspects of the design to reduce the risk of exclusion or significant changes being required to pass Technical Inspection.

A3.6 Rules and Safety Officer (RSO)

A3.6.1 Each team must appoint a person to be the “Rules and Safety Officer (RSO)”.

A3.6.2 The RSO must:

a) Be present at the entire NxGV Challenge event.

b) Be responsible for understanding the NxGV Challenge rules prior to the competition and ensuring that competing vehicles comply with all those rules requirements.
c) System Documentation – Have vehicle designs, plans, schematics and supporting documents available for review by the officials as needed.
d) Component Documentation – Have manufacturer's documentation and information available on all components of the electrical system.
e) Be responsible for team safety while at the event. This includes issues such as:
    i. Use of safety glasses and other safety equipment
    ii. Control of shock hazards such as charging equipment and accessible high voltage sources
    iii. Control of fire hazards such as fuel, sources of ignition (grinding, welding etc.)
    iv. Safe working practices (lock-out/tag-out, clean work area, use of jack stands etc.)
f) Be the point of contact between the team and Formula Hybrid + Electric organizers should rules or safety issues arise.

A3.6.3 If the RSO is also a driver in a dynamic event, a backup RSO must be appointed who will take responsibility for sections A4.6.2(e) and A4.6.2(f) (above) while the primary RSO is in the vehicle.

A3.6.4 Contact information for the primary and backup RSOs (Name, Cell Phone number, etc.) must be provided to the organizers during registration.

A3.7 Driver

A3.7.1 Team Members (A4.8) who will drive a competition vehicle at any time during a competition must hold a valid, government issued driver's license.

A3.7.2 Drivers who have driven for a professional racing team in a national or international series at any time may not drive in any competition event. A "professional racing team" is defined as a team that provides racing cars and enables drivers to compete in national or international racing series and employs full time staff in order to achieve this.

A3.8 Team Members

A3.8.1 Team members must be enrolled as degree seeking undergraduate or graduate students in the college or university or institution of the team with which they are participating.

A3.8.2 Students seeking a post graduate degree or equivalent are eligible to compete.

A3.8.3 Team members who have graduated during the 7 month period prior to the competition remain eligible to participate.

A3.8.4 Each team member may participate at a competition for only one team. This includes competitions where the University or Institution enters both EV and HEV teams.

A3.8.5 Team members must be minimum 18 years of age.

A3.8.6 Persons who have previously attended any official event as a judge are not allowed to participate as team members.

A4 REGISTRATION

A4.1 Team Registration

A4.1.1 Registration for Formula Student must be completed online.

A4.1.2 The online registration must be performed by the Team Leader connected with the registering university.

A4.1.3 Registration fees must be paid to the SAE Malaysia by the deadline specified.

A4.1.4 Registration fees are not refundable and not transferrable to any other competition.

A4.1.5 New registration is required for each team.

A4.2 Team Member Registration

A4.2.1 Team Leaders must ensure that every team member's name, including the Team Advisors, is listed in the Manage Members section of their Team Account.

A4.2.2 It is the Team Leader's responsibility to ensure that all team members have their own individual accounts.

A4.2.3 Team Member studying at a Malaysia university must be a member or student affiliate member of the SAE Malaysia to compete at NxGV Challenge.

A4.2.4 International Team Members with a 'home FS competition' may be a member of the engineering organisation that organises their home event (e.g. we will accept German students who are VDI members). If you do not have one of these home events in your country: SAE International, SAE Australasia, SAE Brazil, VDI, VDE, or ATA, your team must become SAE Malaysia members.

A4.2.5 Individual medical insurance coverage is required and is the sole responsibility of the participant.

A4.2.6 Team members who disable and require accessibility must contact the Organizer prior to start of competition.

A4.3 Onsite Registration

A4.3.1 Onsite registration is required of all team members and faculty advisors.

A4.3.2 All on-site participants, including students, faculty, volunteers and guests, are required to sign a liability waiver upon registering on-site.

A4.3.3 The following is required at registration:

a) Proof of professional society membership (such as card or member number)
b) ID or passport
c) Government issued driver's license for all drivers
d) Medical insurance card or documentation

A4.3.4 Onsite registration must be completed before the vehicle may be unloaded, uncrated or worked upon in any manner.

A4.4 Team Withdraw

A4.4.1 Registered teams that will not attend the competition must Contact the Organizer as soon as possible.

A4.4.2 In the event of a team withdrawing from the competition, registration fees are not refundable.

A4.4.3 In the event that the competition is cancelled entirely by the organisers, the option to defer entry fees to a future competition will be offered. Depending on the circumstances around the cancellation, a full or partial refund may be offered.

A5 RULE OF CONDUCT

A5.1 General Officials Authority

A5.1.1 The officials reserve the right to revise the schedule, date and location of the competition and/or interpret or modify the competition rules at any time and in any manner that is, in their sole judgment, required for safe and efficient operation.

A5.1.2 All team members are required to cooperate with and follow all instructions from the officials.

A5.1.3 Official announcements shall be considered part of the rules.

A5.1.4 All guidelines and clarifications posted in the "Rules and Important Documents" sections on the competition website for the current season including the competition handbook are considered part of the rules. The "Key Dates" document is considered part of the Rules.

A5.2 Official Instructions

A5.2.1 Failure of a team member to follow an instruction or command directed specifically to that team or team member will result in 25 penalty points being deducted from the team's overall score.

A5.3 Unsportsmanlike Conduct

A5.3.1 In the event of unsportsmanlike conduct, 25 penalty points will be deducted from the team's overall score. A second violation will result in the team being disqualified from the competition.

A5.4 Violations of Intent

A5.4.1 Violation of the intent of a rule will be considered a violation of the rule itself.

A5.4.2 Any parts, devices or software fragments designed with the intent to violate a rule, will be considered as a violation.

A5.4. While best efforts are made to prevent them, discrepancies between this rule set and other official documents may occur. In the event of this, this rule set will be considered as authoritative and prevail over other documentation.

A5.5 Arguments with Officials

A5.5.1 Argument with, or disobedience to, any official will result in the team being disqualified from the competition.

A5.6 Questions about the Rules

A5.6.1 Questions about the rules may be asked to the officials.

A5.6.2 Ambiguities or questions concerning the meaning or intent of these rules will be resolved by the NxGV Challenge Rules Committee or by the individual competition organizers as appropriate.

A5.6.2 Clarifications issued by other events may not be valid at Formula Student, if you are entering multiple events ensure you check the legality of your design with all event organizers.

A5.6.3 Any submitted question and the official answer may be reproduced and freely distributed, in complete and edited versions.

A5.7 Protest

A5.7.1 A team may protest any rule interpretation, score or official action which they feel has caused some actual, non-trivial, harm to their team, or has had a substantive effect on their score.

A5.7.2 Protest format:

a) All protests must be filed in writing
b) The completed protest must be presented to the organizer or SAE International staff by the team captain
c) Team video or data acquisition will not be reviewed as part of a protest

A5.7.3 A team must post a 25 point protest bond which will be forfeited if their protest is rejected.

A5.7.4 Protests concerning any aspect of the competition must be filed within the protest period announced by the competition organisers, or within 30 minutes of the scores of the event to which the protest relates being posted.

A5.7.5 The decision of the officials regarding any protest will be in written form and is final.

A6 GENERAL RULES

A6.1 Removing the Vehicle from the Site

A6.1.1 Teams who remove their vehicle Tractive System Battery Pack from the event site after the event has begun will be disqualified from the event.

A6.2 Forfeit for Non-Appearance

A6.2.1 It is the responsibility of each team to be in the right place at the right time.

A6.2.2 If a team is not present and ready to compete at the scheduled time, they forfeit their attempt at that discipline.

A6.3 Event Briefing

A6.3.1 The team leader and all drivers for a particular day must attend the team briefing for that day as per the official Event Schedule for the live event.

A6.4 Testing and Work Safety

A6.4.1 Event organizers are not responsible for the use of the vehicles outside of their events.

A6.4.2 The competition officials disassociate themselves from all activities of the teams besides their own event.

A6.4.3 All teams are advised to follow common practices and common sense when working on the vehicle and when operating the vehicle, before, during and after an event.

A6.4.4 The following listed requirements are considered the minimum for a testing/operating environment to qualify as safe. Following these guidelines does not guarantee safety under all circumstances:

a) Driver wearing full protection gear according to **VE3**
b) Working AMS, APPS, ASSI, BSPD, EBS, ETC plausibility check, IMD, RES and TSAL if applicable
c) Rules compliant chassis and mounted IA
d) No other passenger cars, trucks etc. being parked or driven on the same premise at the same time, unless the areas are clearly separated
e) No running under low visibility conditions
f) No running at speeds above typical competition speeds
g) No running in areas where crashing into obstacles at the height of the driver's head is possible, such that parts of the vehicle may pass below an obstacle, but the driver's head can be trapped between the obstacle and the main hoop for example

A6.4.5 Organizers reserve the right to disqualify a team registered for their event in case of unsafe driving behavior, especially if the reputation of the competition, sponsors and other teams is compromised. Examples of what could be seen as "unsafe driving behaviour" are wheel-towheel racing or racing in unsuitable events, e.g. hill climb races or drag races, depending on the respective circumstances.

A6.4.6 Teams or individuals associated with them, displaying and/or running their vehicles at any events organised by themselves or others, who use the Formula

Student name while doing so, and act irresponsibly or recklessly, may at the organiser's sole discretion be deemed to have acted in breach of this rule.

A6.5 Onsite Working Safety

A6.5.1 Everyone in the dynamic area and everybody working on the vehicle must wear appropriate, closed-toed shoes.

A6.5.2 Appropriate personal protective equipment must be used.

A6.5.3 Hot work and machining operations that generate sparks or chips must only be carried out in the designated power tools area.

A6.5.4 Work that generates hazardous debris and dust, e.g. sanding or cutting of carbon fiber, must be performed in the designated power tools area. This excludes minor tasks, e.g. drilling a small hole, if safety precautions for the operator and nearby personnel are observed and all debris and dust are immediately cleaned up.

A6.5.5 When jacking up the vehicle a safe and stable support device rated for the load must be used.

A6.6 Vehicle Movement

A.6.1 Vehicles must not move under their own power anywhere other than on the practice or competition tracks.

A6.6.2 The vehicles must be pushed at a normal walking pace using the Push Bar (VE.2.2), with a driver in the cockpit and with another team member walking beside.

A6.6.3 The team may move the vehicle with:

a) All four wheels on the ground
b) The rear wheels supported on dollies, by push bar mounted wheels. The external wheels supporting the rear of the vehicle must be non-pivoting so the vehicle travels only where the front wheels are steered. The driver must always be able to steer and brake the vehicle normally.

A6.6.4 When the push bar is attached to the vehicle:

a) the engine/TS must remain switched off.
b) The detachable handle or key of the TSMS must be completely removed and kept by an ESO. The lockout/tagout function of the TSMS, see EV6.9, must be used.

c) The High Voltage Disconnect (HVD), see EV4.8, must be disconnected

A6.6.5 Vehicles with wings are required to have two team members walking on either side of the vehicle's front wing whenever the vehicle is being pushed.

A6.6.6 A 25 point penalty may be assessed for each violation.

A6.7 Powertrain Operation

A6.7.1 In the paddock, Engine for HEV may be run or (EV) Tractive System may be Active if all three:

a) (HEV Class Only) The vehicle has passed Technical Inspection up to and including the Tilt Test OR a Technical Inspector gives permission
b) The vehicle shows the OK to Energize sticker **IN4.5**
c) The vehicle is supported on a stand
d) The drive wheels are minimum 10 cm off the ground, OR the drive wheels are removed

A6.8 Working on the Tractive System

A6.8.1 All activities require the attendance of the ESO.

A6.8.2 For activities on the inactive TS, the following procedure must be carried out:

a) The vehicle must be barred from anyone not involved in the work.
b) The Tractive System Master Switch (TSMS) must be switched off.
c) It must be assured that the TS cannot be activated by, at a minimum, using the lockout/tag out of the TSMS.
d) A check for zero-potential must be carried out.
e) A sign that declares the vehicle is electrically safe must be installed. The name of the ESO who is supervising the activities must be noted on the sign. This ESO is the only person who may remove the sign and the barrier.

A6.8.3 In case of measurements on the active TS or an activation of the TS in the pit for testing purposes, the following steps must be followed:

a) The vehicle must be barred from anyone not involved in the work.
b) The vehicle must be jacked up and the driven wheels removed.
c) One team member must be prepared to push a shutdown button at any time.
d) Appropriate insulated tools and equipment must be used.
e) Safety glasses with side shields and compliant safety gloves must be worn by participating team members when parts of the TS are exposed.

f) No other work on the vehicle is allowed when the TS is active.

A6.8.4 There must be at least one team member present, who is not directly involved in the work, but who could assist in case of an incident.

A6.9 Working on Tractive System Battery Pack

A6.9.1 Opening or working on Tractive System Battery Packs is only allowed in the provided work places in the charging area.

A6.9.2 All activities require the attendance of an ESO.

A6.9.3 Whenever the TS Battery Pack are opened, the cell segments must be separated with the maintenance plugs, see **EV4.5**.

A6.9.4 Appropriate insulated tools and equipment must be used.

A6.9.5 Safety glasses with side shields and compliant safety gloves must be worn by participating team members.

A6.9.6 There must be at least one team member present, who is not directly involved in the work conducted on the accumulator, but who could assist in case of an incident.

A6.9.7 Moving accumulator cells and/or accumulator segment(s) around at the event site is only allowed if they are inside a completely closed TS Battery Pack.

A6.9.8 All parts and modules of the TSAC that are not currently being worked on must be covered at least according to IPxxB while working on the accumulator container.

A6.10 Refueling and Oil

A6.10.1 Fuelling may only take place at the fuel station and must be conducted by officials only.

A6.10.2 The vehicle must be de-energized when refueling, and no other activities (including any mechanical or electrical work) are allowed while refueling.

A6.10.3 Open fuel containers are not permitted at the competition.

A6.10.4 Waste fuel and oil should be disposed of at the specified location.

A6.11 Charging

A6.11.1 There will be a separate charging area on the event site. Charging TS accumulators is only allowed inside this area.

A6.11.2 Accumulators must be removed from the vehicle and placed on the TSAC hand cart, see **EV7.5**, for charging.

A6.11.3 No grinding, drilling, etc. is allowed in the charging area.

A6.11.4 At least one team member who has knowledge of the charging process must stay with the accumulator(s) during charging.

A6.12 Alcohol and Illegal Material

A6.12.1 Alcohol, illegal drugs, weapons or other illegal material are prohibited on the competition site during the entire competition.

A6.12.2 Team members must not be under the influence of alcohol (0.0‰), cannabis, or any other illegal drug while on the event site.

A6.12.2 Any violation of this rule by any team member or Team advisor will cause immediate disqualification and expulsion of the entire team.

A6.12.3 Any law violation will be reported to the local authorities.

A6.12.4 Team members under medication must ensure they will not be impaired in a manner that could compromise safety by any prescription medications and over-the-counter drugs used as directed for medical purposes.

A6.13 Smoking – Prohibited

A6.13.1 Smoking and e-cigarette use is prohibited in all competition areas.

A6.14 Advertising Regulations

A6.14.1 To ensure full compliance with Malaysia legislation, teams are not permitted to display any form of tobacco or cigarette advertising on their vehicles or display areas.

A6.14.2 The organisers also reserve the right to instruct teams to remove or cover any other vehicle or display area markings that may be illegal or likely to cause offence.

A6.15 Car Covering

A6.15.1 Covering or obscuring any competing car or any part of a competing car is considered unsportsmanlike conduct. Teams could receive a penalty of up to 50 points for car covering, at the discretion of the Chief Judge.

A6.15.2 During the entire Competition, except as permitted below, no screen, cover or other obstruction which in any way obscures any part of a car will be allowed at any time in the paddock, garages, pit lane or grid. The following are permitted:

a) A cover over the car in the garage or paddock overnight,
b) A cover over the car in the pit lane or on the grid if it is raining,
c) Covers on the tyres to prevent debris pick-up,
d) Covers over severely damaged cars or components.

A6.15.3 Any car part stored in front of the car will be considered as an obstruction unless it is stored flat on the ground and does not totally or partially hide the car. Anybody standing in front of the car is considered as an obstruction to the visibility unless they must work on the car. A line of people in front of the car is strictly prohibited.

A6.16 Trash Cleanup at Competition Site

A6.16.1 Cleanup of trash and debris is the responsibility of the teams

a) The team's work area should be kept uncluttered
b) At the end of the day, each team must clean all debris from their area and help with maintaining a clean paddock

A6.16.2 Teams must remove all of their material and trash when leaving the site at the end of the competition.

A6.16.3 Teams that abandon furniture, or that leave a paddock that requires special cleaning, will be billed for removal and/or cleanup costs.

Part PS – Pre-Competition Submission

PS1 SUBMISSION DETAIL

PS1.1 Requirement

PS1.1.1 The documents supporting each vehicle must be submitted before the deadlines posted.

PS1.1.2 The procedures for submitting documents are published on the Event Website or otherwise identified by the organizer.

PS1.2 Submission Location

PS1.2.1 Teams entering NxGV Challenge must upload the required documents to the team account on the Event Website.

PS1.3 Submission Format Requirements

PS1.3.1 Refer to Table 2 Submission Information.

PS1.3.2 Template files with the required format must be used when specified in Table 2.

Table 2: Document submission list.

Document	File Format
Structural Equivalency Spreadsheet (SES)	XLSX
ESO/ESA Form	PDF
RSO Form	PDF
Electrical System Form (ESF)	PDF
Charging Plug Spec Form	PDF
Shakedown Certificate Video	MPG, MP4, WMV
Sales presentation Document (SPD)	PDF
Cost Report	XLSX
Cost Event Addendum	PDF
Design Specification Sheet	XLSX
Vehicle Drawing (3 View Drawings)	PDF

PS1.3.3 Template files are available on the Event Website.

PS1.3.4 Do Not alter the format of any provided template files.

PS1.3.5 Each submission must be one single file in the specified format (PDF - Portable Document File, XLSX - Microsoft Excel Worksheet File).

PS1.3.6 Documents or videos that are largely incomplete or not readable/viewable will be considered as not submitted.

PS1.3.7 Team Leaders are responsible for ensuring that all of their team's submissions are uploaded or sent no later than the published deadline.

PS2 SUBMISSION PENALTY

PS2.1 Submission

PS2.1.1 Each team is responsible for confirming that their documents have been properly uploaded or submitted and that the deadlines have been met.

PS2.1.2 If a Submitted Document revision is requested by the Reviewer, a new Submission Deadline for the revised document may apply

PS2.1.3 Teams will not be notified if a document is submitted incorrectly

PS2.2 Penalty Detail

PS2.2.1 Late Submissions get a point penalty as shown in Table 3, subject to official discretion.

PS2.2.2 Additional penalties will apply if Not Submitted, subject to official discretion.

PS2.2.3 Penalties up to and including Removal of Team Entry may apply based on document reviews, subject to official discretion.

Table 3: Submission Penalty.

Document	Late Submission	Not Submitted
Structural Equivalency Spreadsheet (SES)	-10	Disqualified and removal of team entry
ESO/ESA Form	-10	Disqualified and removal of team entry
RSO Form	-10	Disqualified and removal of team entry
Electrical System Form (ESF)	-10	Disqualified and removal of team entry
Charging Plug Spec Form	-10	Cannot allow to charge the Accumulator
Shakedown Certificate Video	-10	Cannot Participate in Vehicle Inspection
Sales presentation Document (SPD)	-10	Disqualified from Business Presentation Event, -20 points from total score

Cost Report	-10	Disqualified from Cost and Manufacturing Event, -100 points from total score PDF
Cost Event Addendum	-10	
Design Specification Sheet	-10	Disqualified from Design Event, -15 points from total score
Vehicle Drawing (3 View Drawings)	-10	-5 points from total score

PS2.3 Removal of Team Entry

PS2.3.1 The organizer may remove the team entry when a:

a) Grounds for Removal document is Not Submitted in 24 hours or less after the deadline. Removals will occur after each Document Submission deadline
b) Team does not respond to Reviewer requests or organizer communications

PS2.3.2 When a team entry will be removed:

a) The team will be notified prior to cancelling registration
b) No refund of entry fees will be given

PS3 SUBMISSION ITEM

PS3.1 SES Approval

PS3.1.1 SES for all vehicles (except DDT) must be submitted in line with the competition Key Dates document.

PS3.1.2 All SES will be reviewed by Scrutineering and awarded a 'Approved or 'Failed' as part of pre-event checks.

PS3.1.3 Teams who have received a 'Failed' result will be able to correct the SES and resubmit prior to the resubmission deadline specified in the competition Key Dates document.

PS3.1.4 Teams with not be able to pass scrutineering and dynamically compete without an approved SES.

PS3.2 Electrical System Form (ESF)

PS3.2.1 Each team must submit an Electrical System Form (ESF) with a clearly structured documentation of the entire vehicle electrical system (including control and Tractive System).

PS3.2.2 Submission and approval of the ESF does not mean that the vehicle will automatically pass Electrical Technical Inspection with the described items / parts

PS3.2 Shakedown Certificate Video (SCV)

PS3.2.1 All teams must submit a video showing the vehicle can be drive before the event.

PS3.2.2 The video must show the following sequences in the described order:

a) Standing still
b) 360◦ video around the vehicle (close up, may overlap with the following two bullet
c) points)
d) [HEV ONLY if applicable] Start engine / [EV ONLY] Activate TS
e) Straight driving, minimum distance is 30m, minimum speed is 10 km/h for manual mode
f) Full stop (not needed for autonomous mode VSV)
g) 180◦ cornering
h) Straight driving back to start point, minimum speed is 10 km/h for manual mode
i) Standing still, [HEV ONLY if applicable] engine off / [EV ONLY] TS deactivated

PS3.2.3 The video must fulfill the following criteria:

a) Continuous video from a third person view - no assembled sequences
b) Vehicle must be clearly visible (light, video resolution, landscape mode, frames and frequency)
c) Vehicle must run under its own power
d) Vehicle must be presented in ready-to-race conditions incl. body work
e) No crossing in front of the vehicle after [EV ONLY] TS activated / [HEV ONLY] engine started
f) TSAL and brake light, must be clearly visible in the video
g) Ready-to-drive (R2D) sound must be audible in the video

h) Must not exceed a length of 60 seconds.

PS3.2.4 A team which uploads a SCV with a previous year vehicle will be de-registered from the event.

Part V – Vehicle Requirements

V1 VEHICLE CONFIGURATION

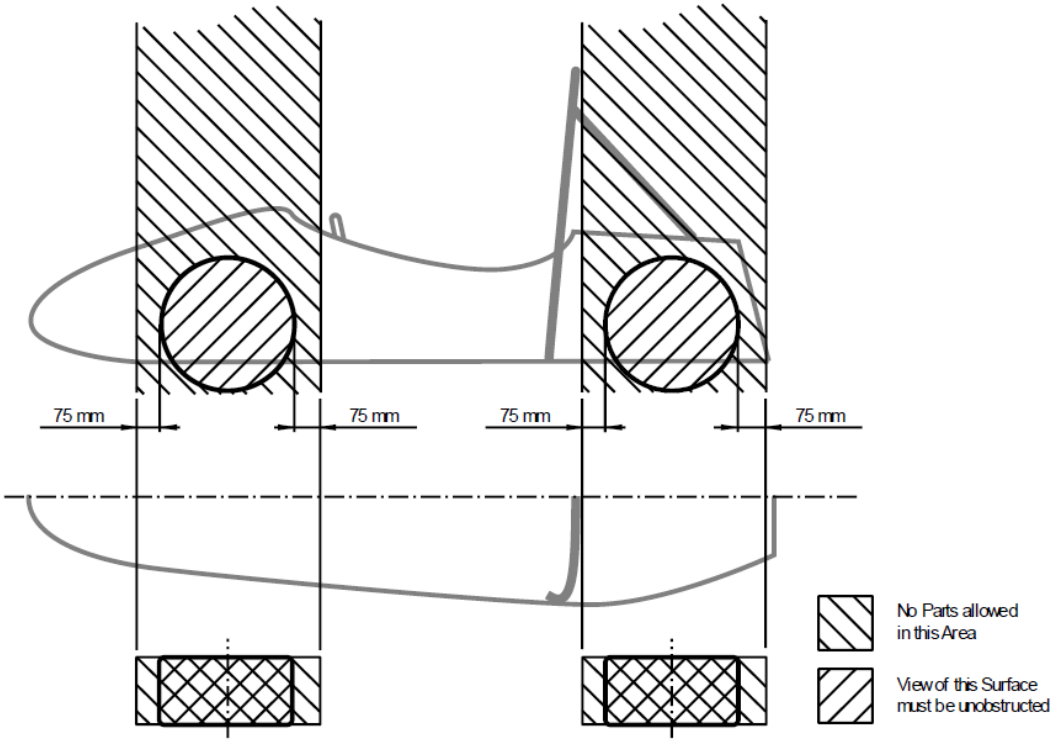
V1.1 Configuration

V1.1.1 The vehicle must be open wheeled and open cockpit (a formula style body) with four wheels that are not in a straight line.

V1.2 Open Wheel

V1.2.1 Open Wheel vehicles must satisfy all of these criteria:

a) The top 180° 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 75 mm in front of and 75 mm aft of, 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.



V1.3 Wheelbase

V1.3.1 The vehicle must have a minimum wheelbase of 1525 mm

V1.4 Vehicle Track

V1.4.1 The track and center of gravity must combine to provide sufficient rollover stability. See IN7.2.

V1.4.2 The smaller track of the vehicle (front or rear) must be no less than 75% of the larger track.

V1.5 Ground Clearance

V1.5.1 Ground clearance must be sufficient to prevent any portion of the vehicle except the tires from touching the ground during dynamic events.

V1.5.2 The distance to the ground below the Lower Side Impact Structure (F4.11.5, F5.4.1) at its lowest point must be 90 mm or less and the distance to the ground should be 75 mm or less.

V1.5.3 There must be an opening for measuring the ride height at that point without removing aerodynamic devices.

V1.5.4 Intentional or excessive ground contact of any portion of the vehicle other than the tires will forfeit a run or an entire dynamic event.

V2 SUSPENSION AND STEERING

V2.1 Suspension

V2.1.1 The vehicle must have a fully operational suspension system with shock absorbers, front and rear, with usable minimum wheel travel of 50 mm, with a driver seated

V2.1.2 Officials may disqualify vehicles which do not represent a serious attempt at an operational suspension system, or which demonstrate handling inappropriate for an autocross circuit

V2.1.3 All suspension mounting points must be visible at Technical Inspection by direct view or by removing any covers

V2.1.4 Fasteners in the Suspension system are **Critical Fasteners, see T10.2**.

V2.1.5 All spherical rod ends and spherical bearings on the suspension and steering must be one of:

a) Mounted in double shear
b) Captured by having a screw/bolt head or washer with an outside diameter that is larger than spherical bearing housing inside diameter.

V2.2 Steering

V2.2.1 The Steering Wheel must be mechanically connected to the front wheels.

V2.2.2 Electrically operated steering of the front wheels is prohibited.

V2.2.3 Steering systems must use a rigid mechanical linkage capable of tension and compression loads for operation.

V2.2.4 The steering system must have positive steering stops that prevent the steering linkages from locking up (the inversion of a four bar linkage at one of the pivots). The stops:

a) Must prevent the wheels and tires from contacting suspension, bodywork, or Chassis during the track events
b) May be put on the uprights or on the rack

V2.2.5 Steering system free play must be less than 7° of total measured at the steering wheel.

V2.2.6 The steering rack must be mechanically attached to the Chassis **T1.8.4**.

V2.2.7 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.

V2.2.8 Fasteners in the steering system are **Critical Fasteners, see T10.2**.

V2.2.9 Spherical rod ends and spherical bearings in the steering must meet **V2.1.5** above.

V2.2.10 Rear wheel steering may be used.

a) Rear wheel steering must incorporate mechanical stops to limit the range of angular movement of the rear wheels to a maximum of six degrees (6°)
b) The team must provide the ability for the steering angle range to be verified at Technical Inspection with a driver in the vehicle
c) Rear wheel steering may be electrically operated

V2.3 Steering Wheel

V2.3.1 In any angular position, the Steering Wheel must meet **T1.8.3**.

V2.3.1 The Steering Wheel must be attached to the column with a quick disconnect.

V2.3.1 The driver must be able to operate the quick disconnect while in the normal driving position with gloves on.

V2.3.1 The Steering Wheel must have a continuous perimeter that is near circular or near oval. The outer perimeter profile may have some straight sections, but no concave sections. “H”, “Figure 8”, or cutout wheels are not permitted.

V3 WHEEL AND TIRES

V3.1 Wheel Size

V3.1.1 Wheels must be 203.2 mm (8.0 inches) or more in diameter.

V3.2 Wheel Attachment

V3.2.1 Any wheel mounting system that uses a single retaining nut must incorporate a device to retain the nut and the wheel if the nut loosens. A second nut (jam nut) does not meet this requirement

V3.2.2 Teams using modified lug bolts or custom designs must provide proof that Good Engineering Practices have been followed in their design.

V3.2.3 Aluminium wheel nuts may be used, but they must be hard anodized and in pristine condition.

V3.2.4 Wheel lug bolts, drive pegs and studs must not be hollow.

V3.2.5 The radial clearance between any non-rotating part and the inside of the rim must be at least 5mm in static condition at any steering angle and any ride height.

V3.3 Tires

V3.3.1 Vehicles may have two types of tires, Dry and Wet

V3.3.2 Dry Tires

a) The tires on the vehicle when it is presented for Technical Inspection.
b) May be any size or type, slicks or treaded.

V3.3.3 Wet Tires, any size or type of treaded or grooved tire where:

a) The tread pattern or grooves were molded in by the tire manufacturer, or were cut by the tire manufacturer or appointed agent. Any grooves that have been cut must have documented proof that this rule was met.
b) There is a minimum tread depth of 2.4 mm

V3.3.4 Tire Set

a) All four Dry Tires and Wheels or all four Wet Tires and Wheels do not have to be identical
b) Once each tire set has been presented for Technical Inspection, any tire compound or size, or wheel type or size must not be changed

V3.3.5 Tire Pressure

a) Tire Pressure must be in the range permitted by the manufacturer at all times
b) Tire Pressure may be inspected at any time

V3.3.6 Requirements for All Tires

a) Teams must not do any hand cutting, grooving or modification of the tires
b) Tire warmers are not permitted
c) No traction enhancers may be applied to the tires at any time onsite at the competition

Part F – Chassis and Structural

F1 DEFINITION

F1.1 Chassis Definition

F1.1.1 Chassis – The fabricated structural assembly that supports all functional vehicle systems. This assembly may be a single fabricated structure, multiple fabricated structures or a combination of composite and welded structures.

F1.1.2 Frame Member – A minimum representative single piece of uncut, continuous tubing.

F1.1.3 Monocoque – A type of Chassis where loads are supported by the external panels.

F1.1.4 Main Hoop – A roll bar located alongside or immediately aft of the driver's torso.

F1.1.5 Front Hoop – A roll bar located above the driver's legs, in proximity to the steering wheel.

F1.1.6 Roll Hoop(s) – Referring to the Front Hoop AND the Main Hoop.

F1.1.7 Roll Hoop Bracing – The structure from a roll hoop to the roll hoop bracing support.

F1.1.8 Roll Hoop Bracing Supports – The structure from the lower end of the Roll Hoop Bracing back to the Roll Hoop(s).

F1.1.9 Front Bulkhead – A planar structure that provides protection for the driver's feet.

F1.1.10 Impact Attenuator – A deformable, energy absorbing device located forward of the Front Bulkhead.

F1.1.11 Primary Structure – The Primary Structure is the combination of these components:

a) Front Bulkhead and Front Bulkhead Support.
b) Front Hoop, Main Hoop, Roll Hoop Braces and Supports.
c) Side Impact Structure.
d) (EV Only) Tractive System Protection and Rear Impact Protection.
e) Any Frame Members, guides, or supports that transfer load from the Driver Restraint System

F1.1.12 Primary Structure Envelope – A volume enclosed by multiple tangent planes, each of which follows the exact outline of the Primary Structure Frame Members

F1.1.13 Major Structure – The portion of the Chassis that lies inside the Primary Structure Envelope, excluding the Main Hoop Bracing and the portion of the Main Hoop above a horizontal plane located at the top of the Upper Side Impact Member or top of the Side Impact Zone.

F1.1.14 Rollover Protection Envelope – The Primary Structure plus a plane from the top of the Main Hoop to the top of the Front Hoop, plus a plane from the top of the Main Hoop to the rearmost Triangulated structural tube, or monocoque equivalent. If there are no Triangulated Structural members aft of the Main Hoop, the Rollover Protection Envelope ends at the rear plane of the Main Hoop.

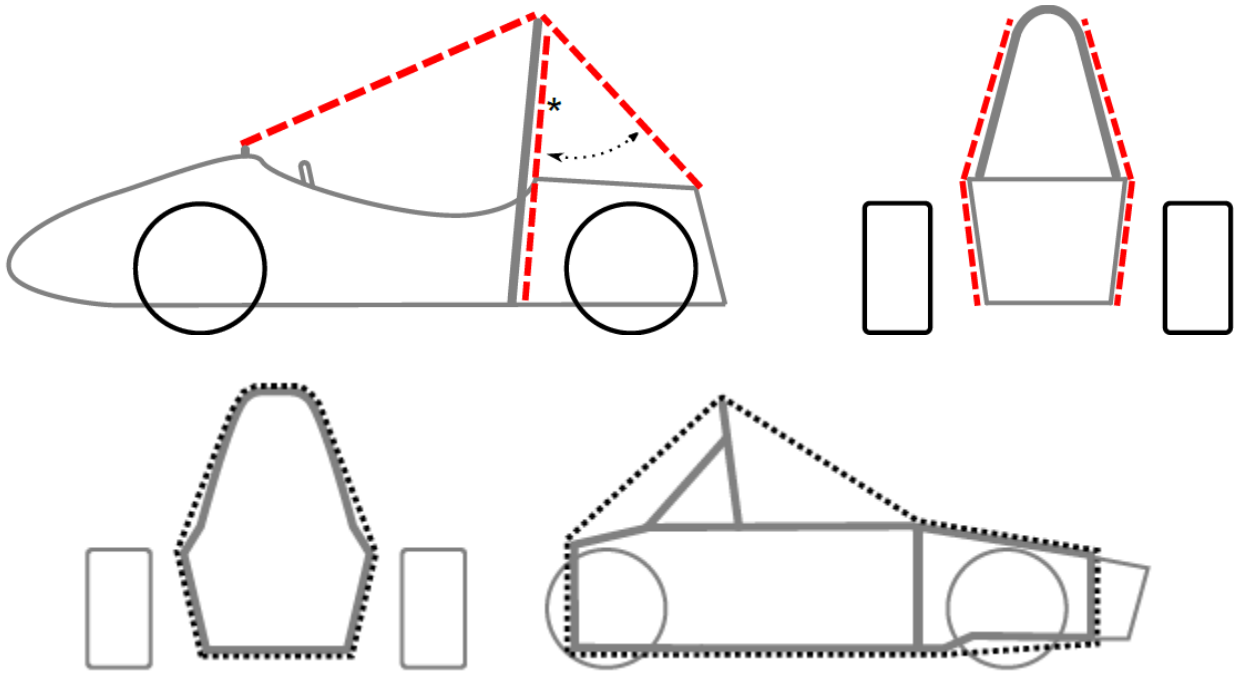


Figure 1: Rollover Protection Envelope.

F1.1.15 Tire Surface Envelope – The volume enclosed by tangent lines between the Main Hoop and the outside edge of each of the four tires.

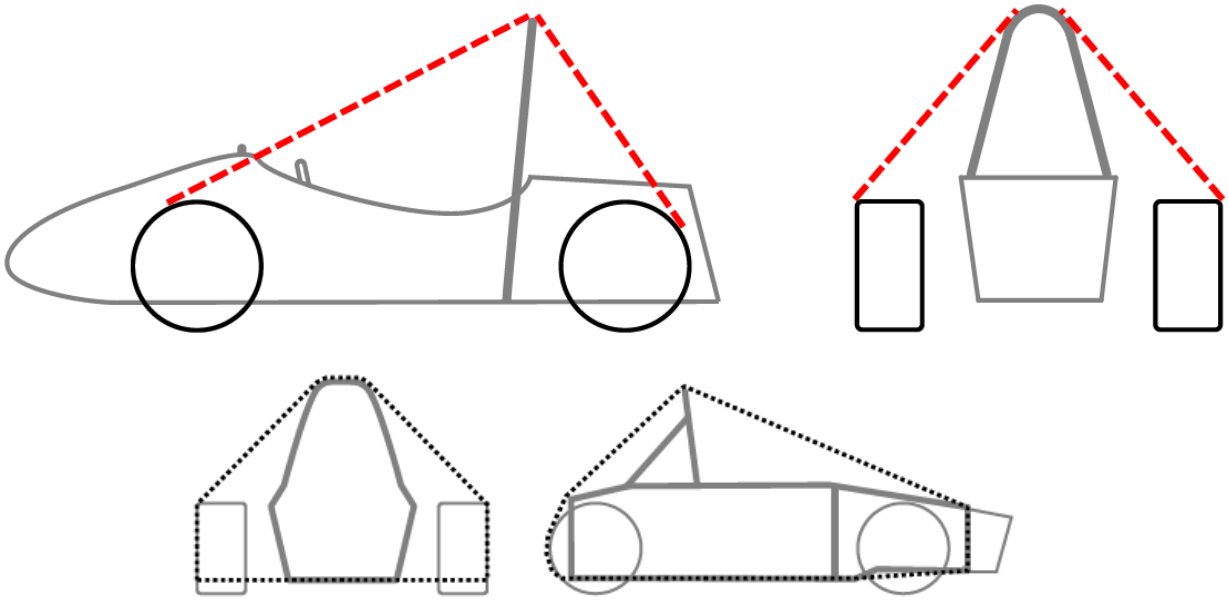


Figure 2: Tire Surface Envelope.

F1.1.16 Component Envelope – The area that is inside a plane from the top of the Main Hoop to the top of the Front Bulkhead, plus a plane from the top of the Main Hoop to the rearmost Triangulated structural tube, or monocoque equivalent. See note in step F1.1.14 above.

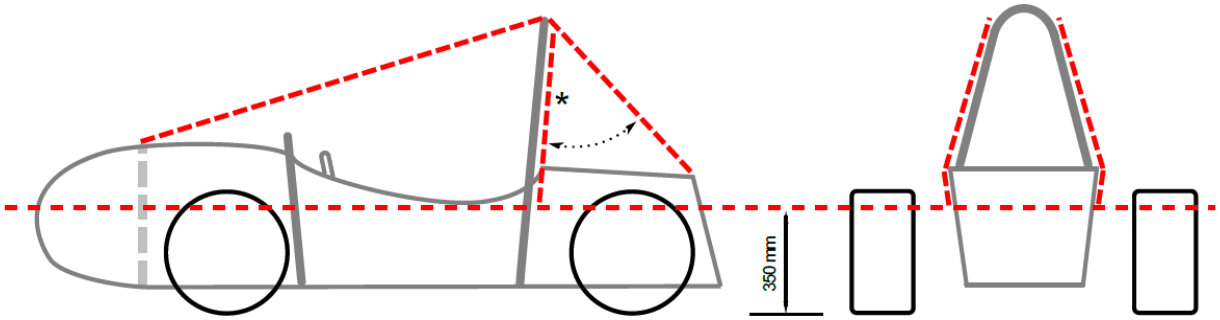


Figure 3: Component Envelope.

F1.1.17 Side Impact Zone – The area of the side of the chassis between the Front Hoop and the Main Hoop and from the chassis floor to the height as required in F4.11 above the lowest inside chassis point between front hoop and main hoop.

F1.1.18 Triangulation – An arrangement of Frame Members where all members and segments of members between bends or nodes with Structural tubes form a structure composed entirely of triangles.

a) This is generally required between an upper member and a lower member, each may have multiple segments requiring a diagonal to form multiple triangles.
b) This is also what is meant by "properly triangulated"

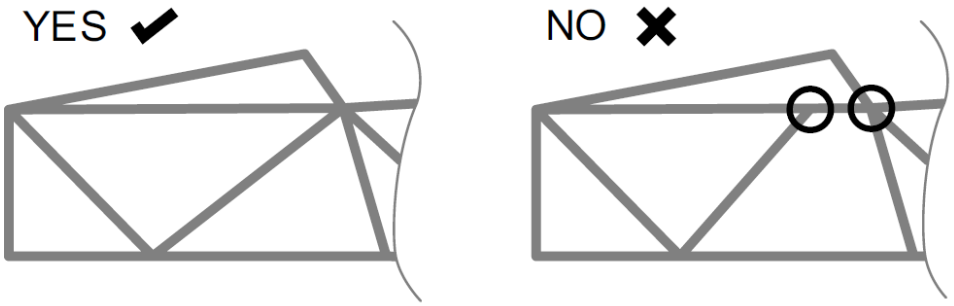


Figure 4: Node-to-node triangulation of chassis members (left correct and right incorrect).

F1.1.19 Nonflammable Material – Metal or a Non Metallic material which meets UL94-V0, FAR25 or approved equivalent.

F1.2 Material Definition

F1.2.1 Fire Retardant – A material meeting one of the following standards:

a) UL94 V-0 for the minimum used material thickness
b) FAR 25.853(a)(1)(i)
c) For foams only: UL94 HF-1 and UL94 VTM-0

F1.2.2 Equivalent standards are only accepted, if the team shows equivalence and this is approved by the officials prior to the event.

F1.2.3 Coolant – a substance used for heat transfer by convection.

F1.3 Electrical Definition

F1.3.1 Direct Connection – Two devices or circuits are directly connected if the connection is not routed through any common PCB and does not include any devices or functionality other than overcurrent protection.

F1.4 Heat Insulated

F1.4.1 The design must address all three types of heat transfer between the heat source (examples include but are not limited to: exhaust pipe, coolant hose/tube, Tractive Battery Pack) and a place that the driver could contact (including seat or floor):

a) Conduction Isolation by one of the two:
   i. No direct contact between the heat source and the panel
   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 one of the two:
   i. A solid metal heat shield with a minimum thickness of 0.4 mm
   ii. Reflective foil or tape when combined with conduction insulation

F2 DOCUMENTATIONS

F2.1 Structural Equivalency Spreadsheet - SES

F2.1.1 The SES is a supplement to the Formula SAE Rules and may provide guidance or further details in addition to those of the Formula SAE Rules.

F2.1.2 The SES provides the means to:

a) Document the Primary Structure and show compliance with the NxGV Challenge Rules
b) Determine Equivalence to NxGV Challange Rules using an accepted basis

F2.2 Structural Documentation

F2.2.1 All teams must submit a Structural Equivalency Spreadsheet (SES) as given in section **PS - Pre-Competition Submissions**.

F2.2.2 Do Not Resubmit SES's unless instructed to do so.

F2.3 Equivalence

F2.3.1 Equivalency in the structural context is determined and documented with the methods in the SES

F2.3.2 Any Equivalency calculations must prove Equivalency relative to Steel Tubing in the same application

F2.3.3 The properties of tubes and laminates may be combined to prove Equivalence For example, in a Side Impact Structure consisting of one tube per **F3.2.1** and a laminate panel, the panel only needs to be Equivalent to two Side Impact Tubes.

F2.4 Tolerance

F2.4.1 Tolerance on dimensions given in the rules is permitted and is addressed in the SES

F2.5 Fabrication

F2.5.1 Vehicles must be fabricated in accordance with the design, materials, and processes described in the SES.

F2.6 Proof of New Vehicle

F2.6.1 As part of the SES submission, teams will be required to provide evidence of a new chassis via a written comparison describing the physical differences between the submitted Primary Structure design with that of the most recent previous.

F2.6.2 SES demonstrating minimal change in design between their old and new chassis will be passed to the Design Judges for consideration of penalty points under Rule S4.5.4.

F2.6.4 Teams who fail to satisfy Rule A2.2 will be disqualified from the competition.

F3 GENERAL CHASSIS DESIGN

F3.1 General Requirements

T3.1.1 Among other requirements, the vehicle's structure must include:

a) Two Roll Hoops that are braced
b) A Front Bulkhead with support system and Impact Attenuator (IA)
c) Side Impact Structures

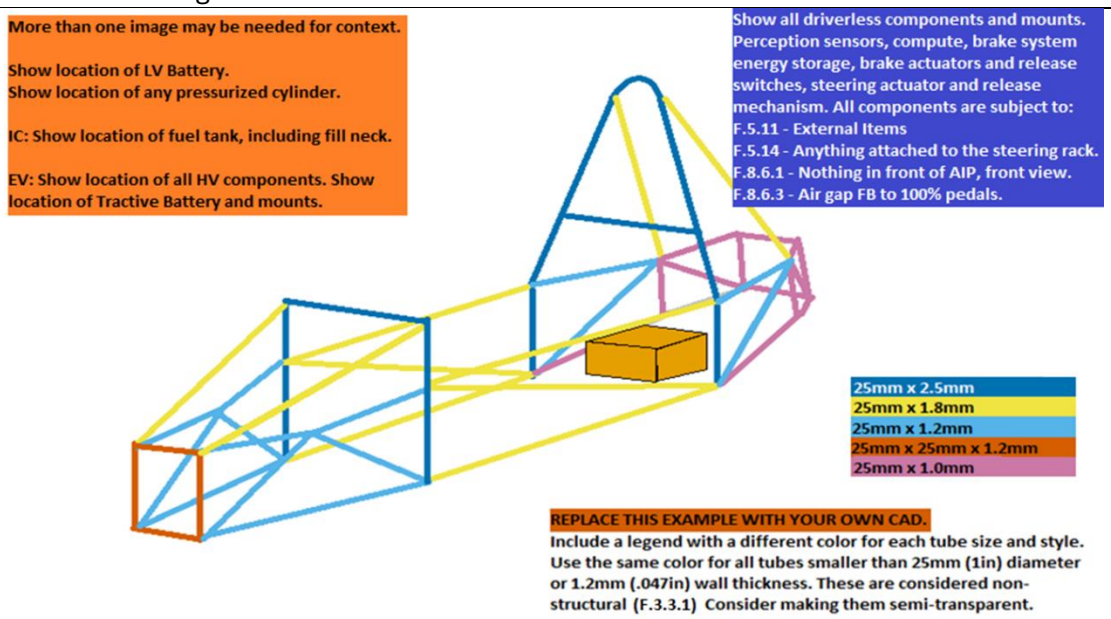
F3.2 Minimum Material Requirements

F3.2.1 Table 3 shows the minimum requirements for the members of the Primary Structure if made from steel tubing.

Table 4: Minimum material requirement.

Item or application	Tube Size	Minimum wall thickness	Minimum cross-sectional area	Minimum area moment of inertia
• Main hoop • Front hoop • Shoulder harness mounting bar	A	2.0 mm	173 mm^2	11320 mm^4
• Front Bulkhead • Front Hoop Bracing • Side Impact Structure • Main Hoop Bracing • Driver Restraint Harness Attachment	B	1.2 mm	119 mm^2	8509 mm^4

• Battery Pack Mounting and Protection				
• Front bulkhead support • Main Hoop Bracing Support • Shoulder Harness Mounting Bar Bracing • Component Protection • Structural Tubing	C	1.2 mm	91 mm^2	6695 mm^4



F3.2.2 The Primary Structure of the car must be constructed of:

a) Round, mild or alloy steel (minimum 0.1% carbon) of the minimum dimensions specified in F3.2.1.
b) Approved 'Alternative Materials' as per F3.3.
c) Approved 'Composite Structure' as per F3.4.

F3.2.3 Except for inspection holes, any holes drilled in any part which is a member of the Primary Structure must be documented in the SES.

F3.2.4 The steel properties used for the calculations in the SES must be the lower of either the material datasheet properties or:

a) Non-welded strength for continuous material calculations:
   i. Young's Modulus (E) = 200 GPa
   ii. Yield Strength (Sy) = 305 MPa
   iii. Ultimate Strength (Su) = 365 MPa
b) Welded strength for discontinuous material such as joint calculations:
   i. Yield Strength (Sy) = 180 MPa
   ii. Ultimate Strength (Su) = 300 MPa

F3.2.5 Any tubing with a wall thickness less than 1.2mm or a minimum area moment of inertia less than 6695 mm^4 is considered non-structural and will be ignored when assessing compliance to any rule regarding the vehicle structure.

F3.2.6 If a member of the Primary Structure (except for the roll hoops) is a bent tube or made from multiple tubes an additional tube must support it. This support tube must:

a) Have its attachment point at the position along the bend tube where it deviates farthest from a straight line connecting both ends.
b) Be of the same dimension as the supported tube(s).
c) Terminate at a node of the chassis.
d) Be angled no more than 30° from the plane of the supported tube(s).

F3.2.7 Any welded seams shape must not be mechanically altered in any way.

F3.2.8 If welded tubing reinforcements are required (such as inserts for bolt holes or material to support suspension cutouts):

a) Equivalence of the Welded tube and reinforcement must be shown to the original Non Welded tube in the SES
b) Welded inserts must use a wall thickness greater than the original Non Welded tube
c) Welded Inserts must use an outer diameter less than the original Non Welded tube diameter or square side

F3.3 Alternative Materials

F3.3.1 Alternative materials may be used for all parts of the Primary Structure and the TSAC with the following exceptions:

a) The main hoop and the main hoop bracing must be steel
b) The front hoop must be metal
c) Any welded structures of the Primary Structure must be steel
d) However, the front hoop may be an aluminium welded structure

F3.3.2 If any materials other than steel tubing are used in the Primary Structure or the TSAC, physical testing is required to show equivalency to the minimum material properties for steel in T3.2.

F3.3.3 If alloyed steel as defined by T3.2.2 is used, the team has to include tests and documentation in the SES to show structural equivalency. This may include, but is not limited to:

a) Receipts and data sheets of the used tubing materials
b) Documentation about welding processes and filler materials
c) Documentation about heat treatments
d) Tests showing adequate strength and elongation at break in the welded condition

T3.3.4 Parts of the steering, brake and suspension system must not be manufactured using additive processes that produce anisotropic strength properties (e.g. consumer-grade FDM).

T3.3.5 Additively manufactured parts are permitted only if proven to have equivalent strength in all load directions.

F3.4 Composite Structures

T3.4.1 If composite structures are used in the primary structure and/or the Tractive Battery Container:

a) The Flexural Rigidity (EI) of that structure must be calculated with the tools and formulas in the SES.
b) The EI must be calculated as the EI of a flat panel about its neutral axis.
c) The structure used for flat panel calculations must have the same composition as the structure used in the primary structure or the Tractive Battery Container.
d) The actual geometry and curvature of the panel may only be considered if the flat panel EI equivalency exceeds 60% of the minimum requirements (F 3.2)
e) Actual geometry calculations are not permitted for the side impact structure, front bulkhead and Tractive Battery Container.

T3.4.2 If composite materials are used in the primary structure or the Tractive Battery Container, the SES must include:

a) Material type(s)
b) Cloth weights
c) Resin type
d) Fiber orientation
e) Number of layers
f) Core material
g) Lay-up technique
h) Adhesive film type(s)

i) 3-point-bend test and shear test data (the AIP is exempt from these tests but must comply with F6.7)

F3.4.3 For any laminate in the primary structure and/or the Tractive Battery Container, the maximum weight content of parallel fibers, relative to the weight of all fibers in the laminate, is 50%. All fibers whose orientation fall within any 20◦ window (+/-10◦) are considered as parallel.

F3.4.3 If an asymmetrical lay-up is used in the primary structure, the thinner skin must have a thickness of at least 40% of the thicker skin or 1mm whichever is lower.

F3.4.3 Wherever backing plates are required, they must be fully supported by the structure they are attached to.

F3.4.3 Backing plates must have a continuous perimeter that is near circular or near oval. The outer perimeter profile may have some straight sections, but no concave sections. Backing plates must not have any cut-outs within their outside perimeter except for the holes for bolts.

F3.4.3 Unidirectional fibers are not allowed in the outermost structural layers of a laminate used in the primary structure.

F3.5 Laminate and Material Testing

F3.5.1 Testing Requirements

a) Any tested samples must be engraved with the full date of construction and sample name
b) The same set of test results must not be used for different monocoques in different years
c) A new Comparison Test F3.5.3 must be done before the laminate tests F3.5.2.

F3.5.2 Primary Structure Laminate Testing – Teams must build new representative test panels for each ply schedule used in the regulated regions of the new chassis as a flat panel and do a 3 point bending test on these panels. Refer to F3.5.4.

a) Test panels must:
   i. Measure one of the two options: 138 mm x 500 mm OR 275 mm x 500 mm
   ii. Have equal surface area for the top and bottom skin
   iii. Have bare edges, without skin material
b) The SES must include:

i. Data from the 3 point bending tests
ii. Pictures of the test samples
iii. A picture of the test sample and test setup showing a measurement documenting the supported span distance used in the SES

c) Test panel results must be used to derive stiffness, yield strength, ultimate strength and absorbed energy properties by the SES formula and limits for the purpose of calculating laminate panels equivalency corresponding to Primary Structure regions of the chassis.
d) Test panels must use the thickest core associated with each skin layup Designs may use core thickness that is 50% - 100% of the test panel core thickness associated with each skin layup
e) Calculation of derived properties must use the part of test data where deflection is 50 mm or less
f) Calculation of absorbed energy must use the integral of force times displacement.

F3.5.3 Comparison Test – Teams must make an equivalent test that will determine any compliance in the test rig and establish an absorbed energy value of the baseline tubes.

a) The comparison test must use two Side Impact steel tubes (F3.2.1)
b) The steel tubes must be tested to a minimum displacement of 19.0 mm
c) The calculation of absorbed energy must use the integral of force times displacement from the initiation of load to a displacement of 19.0 mm

F3.5.4 Test Conduct

a) The Laminate test F3.5.2 and the Comparison test F3.5.3 must use the same fixture
b) The load applicator used to test any panel/tubes as required in this section F3.5 must be:
i. Metallic
ii. Radius 50 mm
c) Test sample supports must:
i. Have a center to center span distance of 400 mm
ii. Be round where the supports touch the sample
d) The load applicator must overhang the test piece to prevent edge loading
e) Any other material must not be put between the load applicator and the items on test

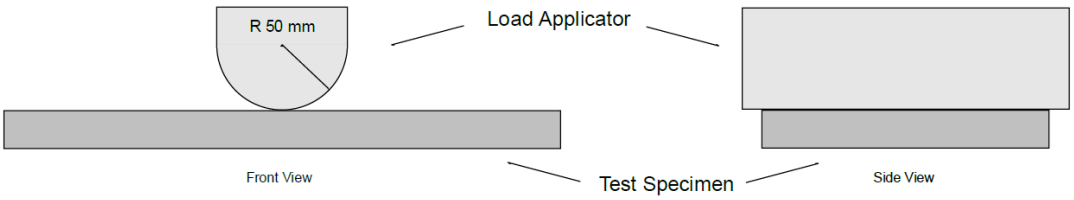


Figure 5: three-point bending test setup.

F3.5.5 Perimeter Shear Test

a) The Perimeter Shear Test must be completed by measuring the force required to push or pull a 25 mm diameter flat punch through a flat laminate sample.
b) The sample must:
    i. Measure 100 mm x 100 mm minimum
    ii. Have core and skin thicknesses identical to those used in the actual application
    iii. Be manufactured using the same materials and processes
c) The fixture must support the entire sample, except for a 32 mm hole aligned coaxially with the punch.
d) The sample must not be clamped to the fixture
e) The edge of the punch and hole in the fixture may include an optional fillet up to a maximum radius of 1 mm.
f) The SES must include force and displacement data and photos of the test setup.
g) 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 **F5.3.3** / **F5.4.2**
h) The maximum force recorded must meet the requirements of **F5.3.3** / **F5.4.2**

F3.5.6 Lap Joint Test – The Lap Joint Test measures the force required to pull apart a joint of two laminate samples that are bonded together

a) A joint design with two perpendicular bond areas may show equivalence using the shear performance of the smaller of the two areas
b) A joint design with a single bond area must have two separate pull tests with different orientations of the adhesive joint:
    i. Parallel to the pull direction, with the adhesive joint in pure shear
    ii. T peel normal to the pull direction, with the adhesive joint in peel

c) The samples used must:
   i. Have skin thicknesses identical to those used in the actual monocoque
   ii. Be manufactured using the same materials and processes
d) The force and displacement data and photos of the test setup must be included in the SES.
e) The shear strength * normal area of the bond must be more than the UTS * cross sectional area of the skin

F3.7 Use of Laminates

F3.7.1 Unidirectional plies must be enclosed by balanced plies. Unidirectional plies should not be the nearest plies to core material.

F3.7.1 The monocoque must have the tested layup direction normal to the cross sections used for Equivalence in the SES, with allowance for taper of the monocoque normal to the cross section.

F3.7.1 Results from the 3 point bending test will be assigned to the 0 layup direction.

F3.7.1 All material properties in the directions specified by the SES must be 50% or more of those in the tested "0" direction as calculated by the SES.

F3.8 Equivalent Flat Panel Calculation

F3.8.1 When specified, the Equivalence of the chassis must be calculated as a flat panel with the same composition as the chassis about the neutral axis of the laminate.

F3.8.2 The curvature of the panel and geometric cross section of the chassis must be ignored for these calculations.

F3.8.3 Calculations of Equivalence that do not reference this section F3.7 may use the actual geometry of the chassis.

F3.9 Bent Tubes or Multiple Tubes

F3.9.1 The minimum radius of any bend, measured at the tube centerline, must be three or more times the tube outside diameter (3 x OD)

F3.9.2 Bends must be smooth and continuous with no evidence of crimping or wall failure.

F3.9.3 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 Roll Hoops (see F4.1 for Roll Hoop requirements), an additional tube must be attached to support it.

a) The support tube attachment point must be at the position along the bent tube where it deviates farthest from a straight line connecting the two ends
b) The support tube must terminate at a node of the chassis
c) The support tube for any bent tube (other than the Upper Side Impact Member or Shoulder Harness Mounting Bar) must be:
    i. The same diameter and thickness as the bent tube
    ii. Angled no more than 30° from the plane of the bent tube

F3.9.4 If multiple tubes are used in place of a bend, the ends should be mitered together for a continuous load path. No open tube ends are allowed in regulated load paths.

F3.10 Holes and Openings in Regulated Tubing

F3.10.1 Any holes in any regulated tubing (other than inspection holes) must be addressed on the SES.

F3.10.1 The inspection holes shall be less than 4 mm in diameter.

F3.10.2 Technical Inspectors may check the compliance of all tubes. This may be done by ultrasonic testing or by the drilling of inspection holes on request.

F3.10.3 Regulated tubing other than the open lower ends of Roll Hoops must have any open ends closed by a welded cap or inserted metal plug.

F3.10.4 When a cutout, or a hole greater in diameter than 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.

F3.11 Fasteners in Primary Structure

F3.11.1 Bolted connections in the Primary Structure must use a removable bolt and nut Bonded fasteners and blind nuts and bolts do not meet this requirement.

F3.11.2 Threaded fasteners used in Primary Structure are **Critical Fasteners, see T10.2**.

F3.11.3 Bolted connections in the Primary Structure using tabs or brackets must have an edge distance ratio “e/D” of 1.5 or higher.

a) “D” equals the hole diameter.
b) “e” equals the distance from the edge of the hole to the nearest free edge

F3.11.4 Tabs attaching the Suspension to the Primary Structure are NOT “in the Primary Structure”.

F3.12 Bonding in Regulated Structure

F3.12.1 Adhesive used and referenced bonding strength must be correct for the two substrate types.

F3.12.2 Document the adhesive choice, age and expiration date, substrate preparation, and the equivalency of the bonded joint in the SES.

F3.12.3 The SES will reduce any referenced or tested adhesive values by 50%.

F3.13 Critical Component Mounting

T3.13.1 Critical Components themselves and their mountings must be able to withstand the following accelerations:

a) 40 g in the longitudinal direction (forward/aft)
b) 40 g in the lateral direction (left/right)
c) 20 g in the vertical direction (up/down)

T3.13.2 Critical Components are:

a) Compressed gas cylinder
b) Compress gas tank
c) Tractive Battery Container
d) High Pressure Hydraulic Pumps

F4 TUBE FRAME

F4.1 Roll Hoops

F4.1.1 The Chassis must include a Main Hoop and a Front Hoop.

F4.1.2 The Main Hoop and Front Hoop must be Triangulated into the Primary Structure with Structural Tubing

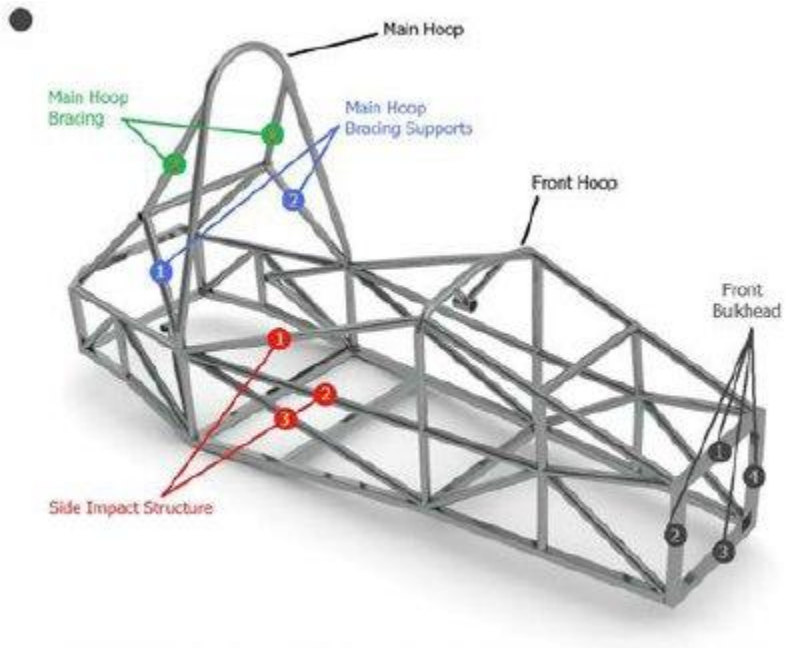
F4.1.3 The minimum radius of any bend, measured at the tube centerline, must be at least three times the tube outside diameter. Bends must be smooth and continuous with no evidence of crimping or wall failure. The minimum area moment of inertia, see F3.2, must be maintained in all areas.

F4.1.3 In a plane perpendicular to the longitudinal axis of the vehicle and through the lower endpoints of the roll hoop, no part of the primary structure may lie below 30 mm of the endpoints of the roll hoop.

F4.1.3 Roll hoops attached to a composite primary structure must be mechanically attached at the top and bottom of both sides of that structure and at intermediate locations if needed to show equivalency. The lower roll hoop tubing attachment points must be within 50 mm of the endpoints of the roll hoop.

F4.1.3 Mounting plates welded to the roll hoops must be at least 2 mm thick steel or 3 mm thick aluminium, dependent of the roll hoop material.

F4.1.3 Both roll hoops must have one 4 mm inspection hole in a non-critical straight location and its surface at this point must be unobstructed for at least 180°.



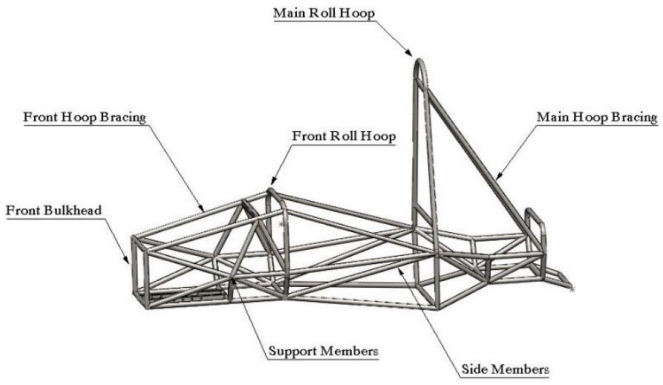


Figure 6: Chassis Key Structural Components.

F4.2 Main Hoop

F4.2.1 The Main Hoop must be a single piece of uncut, continuous, closed section steel tubing meeting F3.2.1.

F4.2.2 The Main Hoop must extend from the lowest Frame Member / bottom of Monocoque on one side of the Frame, up, over and down to the lowest Frame Member / bottom of Monocoque on the other side of the Frame.

F4.2.3 In the side view of the vehicle,

a) The part of the Main Hoop that lies above its attachment point to the upper Side Impact Tube must be less than 10° from vertical
b) The part of the Main Hoop below the Upper Side Impact Member attachment:
    i. May be forward at any angle
    ii. Must not be rearward more than 10° from vertical

F4.2.4 In the front view of the vehicle, the vertical members of the Main Hoop must be minimum 380 mm apart (inside dimension) at the location where the Main Hoop is attached to the bottom tubes of the Major Structure of the Chassis, see Figure 7.

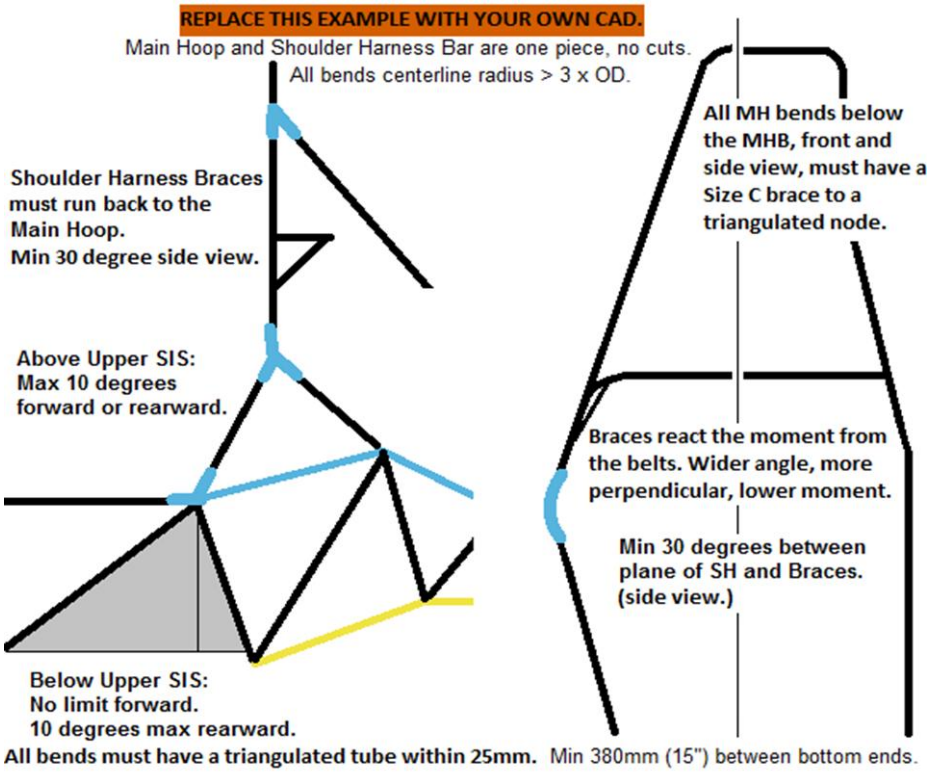


Figure 7: Main hoop requirement.

F4.3 Front Hoop

F4.3.1 The Front Hoop must be constructed of closed section metal tubing meeting F3.2.1.

F4.3.2 With proper Triangulation, the Front Hoop may be fabricated from more than one piece of tubing.

F4.3.3 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.

F4.3.4 The top-most surface of the Front Hoop must be no lower than the top of the steering wheel in any angular position. See Figure 9.

F4.3.5 The Front Hoop must be no more than 250 mm forward of the steering wheel. This distance is 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.

F4.3.6 In side view, any part of the Front Hoop above the Upper Side Impact Structure must be inclined less than 20° from the vertical.

F4.3.7 A Front Hoop that is not steel must have a 4 mm hole drilled in a location to access during Technical Inspection

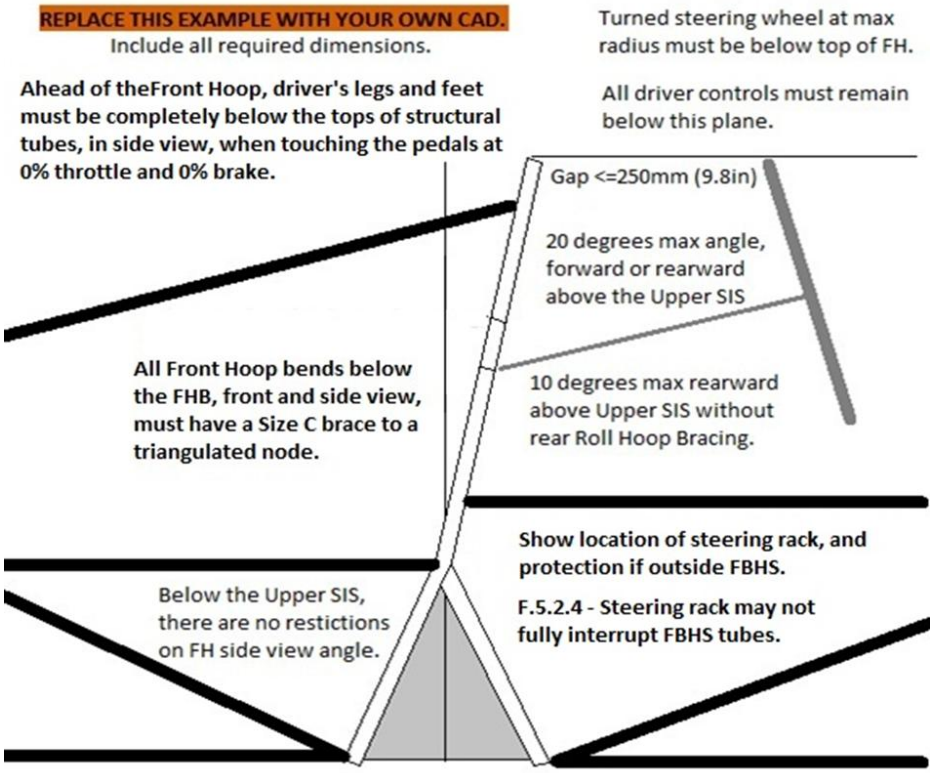


Figure 8: From hoop requirement.

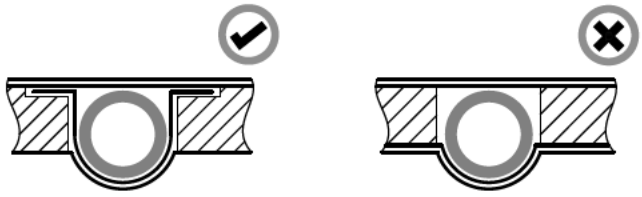


Figure 9: Front hoop laminating requirements.

F4.4 Main Hoop Bracing

F4.4.1 Main Hoop Braces must be constructed of closed section steel tubing meeting F.3.2.1.

F4.4.2 The Main Hoop must be supported by two Braces extending in the forward or rearward direction, one on each of the left and right sides of the Main Hoop.

F4.4.3 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. (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)

F4.4.4 The Main Hoop Braces must be attached 160 mm or less below the top most surface of the Main Hoop. The Main Hoop Braces should be attached as near as possible to the top of the Main Hoop

F4.4.5 The included angle formed by the Main Hoop and the Main Hoop Braces must be 30° or more.

F4.4.6 The Main Hoop Braces must be straight, without any bends.

F4.4.7 The Main Hoop Braces must be:

a) Securely integrated into the Frame
b) Capable of transmitting all loads from the Main Hoop into the Major Structure of the Chassis without failing

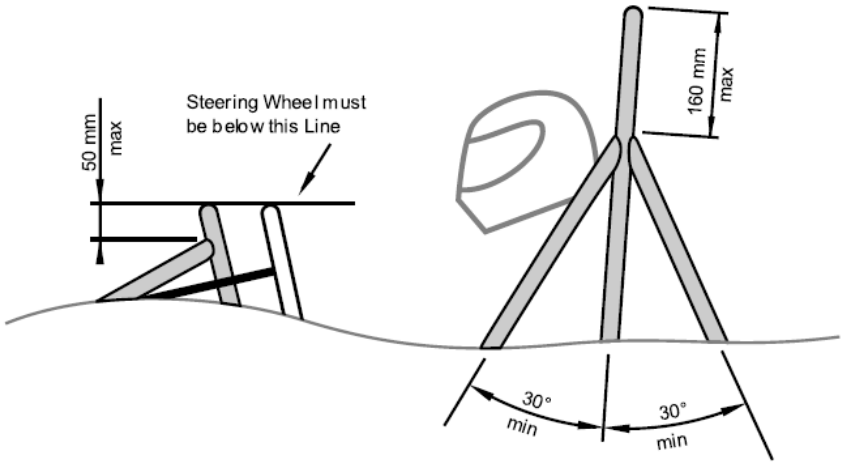


Figure 10: Main hoop bracing requirement.

F4.5 Front Hoop Bracing

F4.5.1 Front Hoop Braces must be constructed of material meeting F.3.2.1.

F4.5.2 The Front Hoop must be supported by two Braces extending in the forward direction, one on each of the left and right sides of the Front Hoop.

F4.5.3 The Front Hoop Braces must extend to one of the two:

a) The Front Bulkhead
b) A triangulated structural node

F4.5.4 The Front Hoop Braces must be attached as near as possible to the top of the Front Hoop but not more than 50 mm below the top-most surface of the Front Hoop. See .

F4.5.5 If the Front Hoop above the Upper Side Impact Structure leans rearwards by more than 10° from the vertical, it must be supported by additional rearward Front Hoop Braces to a fully Triangulated structural node.

F4.5.6 The Front Hoop Braces must be straight, without any bends.

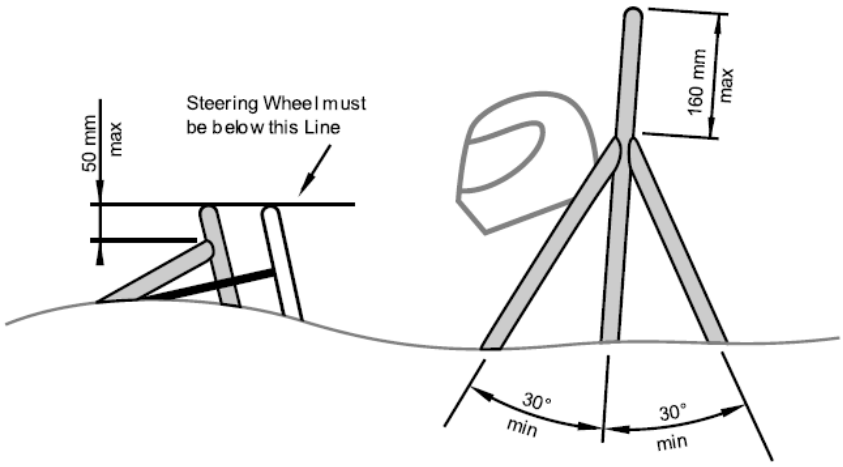


Figure 11: Front hoop bracing requirement.

F4.6 Mechanically Attached Roll Hoop Bracing

F4.6.1 When Roll Hoop Bracing is mechanically attached:

a) The threaded fasteners used to secure non-permanent joints are **Critical Fasteners, see T10.2**. Additional requirements apply in **F4.6.5** and **F4.6.7**
b) Spherical rod ends are not permitted
c) The attachment holes in the lugs, the attached bracing and the sleeves and tubes must be a close fit with the pin or bolt

F4.6.2 Any non-permanent joint at the end(s) must be a Double Lug Joint, see Figure 12 or a Sleeved Butt Joint, see Figure 13.

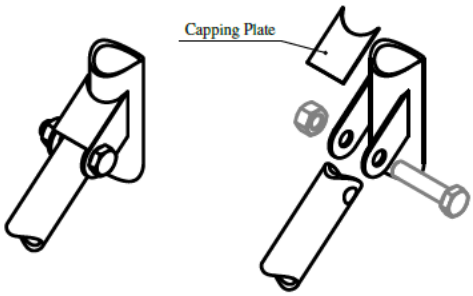


Figure 12: Double lug joint.

F4.6.3 For Double Lug Joints, each lug must:

a) Be minimum 4.5 mm (0.177 in) thickness steel
b) Measure 25 mm minimum perpendicular to the axis of the bracing
c) Be as short as practical along the axis of the bracing.

F4.6.4 All Double Lug Joints, whether fitted parallel or perpendicular to the axis of the tube, must include a capping arrangement.

F4.6.5 In a Double Lug Joint the pin or bolt must be 10 mm Metric Grade 9.8 or 3/8 in SAE Grade 8 minimum diameter and grade. See F4.6.1 above.

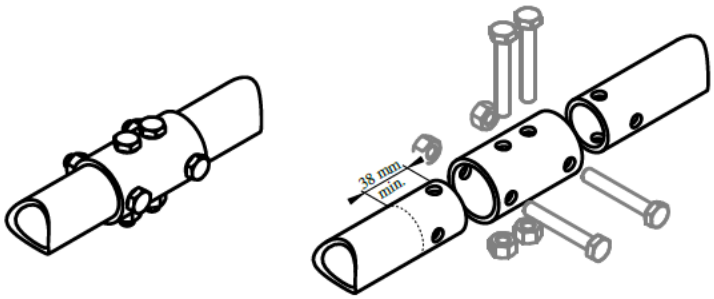


Figure 13: Sleeved joint.

F4.6.6 For Sleeved Butt Joints, the sleeve must:

a) Have a minimum length of 75 mm; 37.5 mm to each side of the joint
b) Be external to the base tubes, with a close fit around the base tubes grade 8.8 minimum. The holes in the sleeves and tubes must be a close-fit with the bolts.
c) Have a wall thickness of 2.0 mm or more

F4.6.7 In a Sleeved Butt Joint, the bolts must be 6 mm Metric Grade 9.8 or 1/4 in SAE Grade 8 minimum diameter and grade. See F4.6.1 above.

F4.7 Other Bracing Requirements

F4.7.1 Where the braces are not welded to steel Frame Members, the braces must be securely attached to the Frame using 8 mm or 5/16" minimum diameter Critical Fasteners, see T10.2.

F4.7.2 Mounting plates welded to Roll Hoop Bracing must be 2.0 mm (0.080 in) minimum thickness steel.

F4.8 Front Bulkhead

F4.8.1 The Front Bulkhead must be constructed of closed section tubing meeting F3.2.1.

F4.8.2 If the front bulkhead is part of a composite structure and is modelled as an "L" shape, the EI of the front bulkhead about the vertical and lateral axes must be equivalent to a steel tube meeting the requirements for the front bulkhead. The length of the section perpendicular to the bulkhead may be a maximum of 25mm measured from the rearmost face of the bulkhead.

F4.8.3 In front view the driver's feet must be within the outside perimeter of the Front Bulkhead.

F4.9 Front Bulkhead Support

F4.9.1 Frame Members of the Front Bulkhead Support system must be constructed of closed section tubing meeting F3.2.1.

F4.9.2 The Front Bulkhead must be securely integrated into the Frame.

F4.9.3 The Front Bulkhead must be supported back to the Upper and Lower Side Impact Structure at the Front Hoop by a minimum of three Frame Members on each side of the vehicle; an upper member; lower member and diagonal brace to provide Triangulation

a) The top of the upper support member must be attached 50 mm or less from the top surface of the Front Bulkhead, and attach to the Front Hoop no more than 50 mm below the top of the Upper Side Impact member
b) If the upper support member is further than 100 mm above the top of the Upper Side Impact member, then properly Triangulated bracing is required to transfer load to the Main Hoop by one of:

i. the Upper Side Impact member
ii. an additional member transmitting load from the junction of the Upper Support Member with the Front Hoop

c) The lower support member must be attached to the base of the Front Bulkhead and the base of the Front Hoop
d) The diagonal brace must properly Triangulate the upper and lower support members

F4.9.4 Each of the above members may be multiple or bent tubes provided the requirements of F3.6 are met.

F4.9.5 Examples of acceptable configurations of members may be found in the SES.

F4.10 Main Hoop Bracing Supports

F4.10.1 Frame Members of the Main Hoop Bracing Support system must be constructed of closed section tubing meeting F3.2.

F4.10.2 The lower end of the Main Hoop Braces must be supported back to the Main Hoop by a minimum of two Frame Members on each side of the vehicle: an upper member and a lower member in a properly Triangulated configuration

a) The upper support member must attach to the node where the upper Side Impact Member attaches to the Main Hoop
b) The lower support member must attach to the node where the lower Side Impact Member attaches to the Main Hoop
c) Each of the above members may be multiple or bent tubes provided the requirements of F3.6 are met

F4.10.3 The lower ends of the Main Hoop Brace tubes should be mitered to the Lower Main Hoop Brace Support tubes for a continuous load path.

F4.11 Side Impact Structure

F4.11.1 Frame Members of the Side Impact Structure must be constructed of closed section tubing meeting F3.2.1, as applicable.

F4.11.2 With proper Triangulation, Side Impact Structure members may be fabricated from more than one piece of tubing.

F4.11.3 The Side Impact Structure must include three or more tubular members located on each side of the driver while seated in the normal driving position.

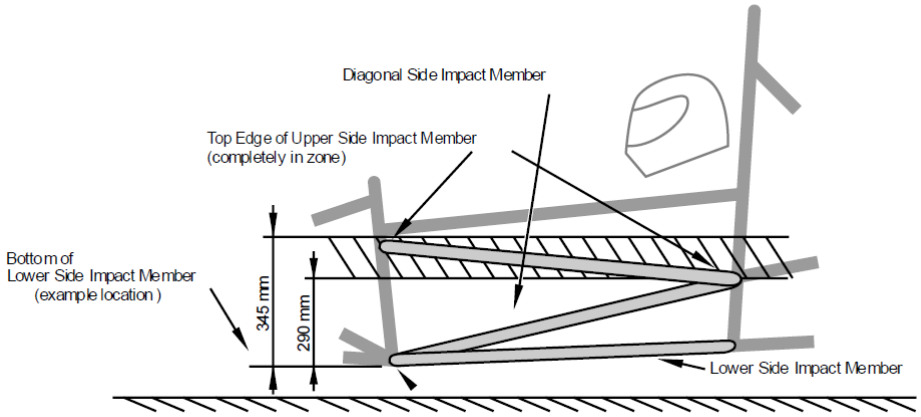


Figure 14: Side Impact Structure.

F4.11.4 The Upper Side Impact Member must:

a) Connect the Main Hoop and the Front Hoop.
b) Have its top edge entirely in a zone that is parallel to the ground between 290 mm and 345 mm above the lowest point of the bottom of the Lower Side Impact Member

F4.11.5 The Lower Side Impact Structure member must connect the bottom of the Main Hoop and the bottom of the Front Hoop.

F4.11.6 The Diagonal Side Impact Member must:

a) Connect the Upper Side Impact Member and Lower Side Impact Member forward of the Main Hoop and rearward of the Front Hoop
b) Completely Triangulate the bays created by the Upper and Lower Side Impact Members.

F4.12 Other Impact Structures

F4.12.1 Components required to be protected by Impact Structures are:

a) Any part of the air intake system that is less than 350 mm above the ground
b) Any part of the TS components that is less than 350 mm above the ground, except Outboard wheel motors
c) All part of Tractive System Battery Container [EV Class Only]

F4.12.2 All components above, see F4.12.1 need to be protected by Impact Structures on each side and rewards. It need to be:

a) Fully triangulated structures.

b) Consist of at least three steel tubes, see F3.2, on each side and rearward of the component(s) requiring protection.
c) If the component projects outwards to the side of the roll hoops, the front of the component must also be protected.
d) The upper member must not be higher than 345 mm above the lowest point inside the chassis between the front and main hoops.

F4.12.3 The side impact protection for the Tractive Battery Pack must reach a minimum height equal to whichever is lower:

a) The height of the Upper Side Impact Structure F4.11.4 / F5.4.1
b) The top of the Tractive Battery Container at that point

F4.12.4 All Tractive System components must be protected from rear impact by a Rear Bulkhead

a) When the Rear Bulkhead is 100 mm or less from a Tractive Battery Pack, the structure must be Equivalent to Side Impact Structure or Tube Size B, see F3.2.1.
b) When the Rear Bulkhead is more than 100 mm from a Tractive Battery Pack, the structure must meet Component Protection or Tube Size C, see F3.2.1.
c) The Tractive Battery Container must not be part of the Equivalent structure

F4.12.3 The Tractive Battery Pack should have a minimum 25 mm total clearance to each of the front, side, and rear impact structures.

F4.12.4 The Tractive System Battery Container must not be attached directly to the rear impact structure; however non-structural components such as cooling ducts are permitted.

F4.12 Non-Crushable Items mounted behind the Rear Bulkhead must not be able to come through the Rear Bulkhead. Non Crushable Items include, but are not limited to motors, differentials, and the chassis itself.

F4.13 Other Side Tube Requirements

F4.13.1 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 attached to the Frame. This is intended to prevent the drivers' shoulders from passing under the Roll Hoop Brace or frame tube, and the driver's neck contacting this brace or tube.

F4.14 External Items

F4.14.1 Definition - items outside the exact outline of the part of the Primary Structure Envelope F1.1.11 defined by the Main Hoop Braces and the parts of the Main Hoop tubes above other tube nodes or composite attachments.

F4.14.2 External Items may be mounted on the outside of the Main Hoop or Main Hoop Brace tubes if the mount is one of the two:

a) With tabs located at the Main Hoop to Main Hoop Brace node and is rotationally free about an axis
b) Above additional bracing meeting F3.2.1, with calculations that show the mount will fail below the permitted load as calculated by the SES.

F4.14.3 If mounted between the tubes of the Main Hoop and Main Hoop Braces, these items may attach to the Main Hoop or Main Hoop Brace tubes and do not need to meet F4.14.2 above:

a) Crushable lightweight bodywork, intake manifolds, Head Restraint, Manual Service Disconnect, Master Switches or Shutdown Buttons
b) Lightweight mounts for items inside the Main Hoop Braces

F4.14.4 Mounts for engine, motor, suspension or Tractive Battery Pack must not attach to the span of the Main Hoop Braces or Main Hoop above other tube nodes or composite attachments.

F4.14.5 Items outside the Primary Structure from the Main Hoop Braces and Main Hoop tubes must be longitudinally offset to avoid point loading in a rollover.

F4.14.6 External Items should not point at the driver

F4.15 Inspection Holes

F4.15.1 To allow the verification of tubing wall thicknesses.

F4.15.2 4.5 mm inspection holes must be drilled in a non-critical location of both the Main Hoop and the Front Hoop.

F4.15.3 Inspection holes must be located so that the outside diameter can be measured across the inspection hole with a caliper, i.e. there must be access for the caliper to the inspection hole and to the outside of the tube one hundred eighty degrees (180°) from the inspection hole.

F4.15.4 In addition, the Technical Inspectors may check the compliance of other tubes that have minimum dimensions specified in F3.2.1. This may be done by the use

of ultra-sonic testing or by the drilling of additional inspection holes at the inspector's request.

F5 MONOCOQUE

F5.1 General Requirements

F5.1.1 The Structural Equivalency Spreadsheet must show that the design is Equivalent to a welded frame in terms of energy dissipation, yield and ultimate strengths in bending, buckling and tension.

F5.1.1 Composite and metallic monocoques have the same requirements.

F5.1.1 Corners between panels used for structural equivalence must contain core.

F5.1.1 An inspection hole approximately 4mm in diameter must be drilled through a low stress location of each monocoque section regulated by the Structural Equivalency Spreadsheet This inspection hole is not required in the Vertical Side Impact Structure **F5.4.2.b**.

F5.1.1 Composite monocoques must:

a) Meet the materials requirements in **F3.4 Composite Structure**.
b) Use data from the laminate testing results as the basis for any strength or stiffness calculations

F5.1.1 Composite monocoques made in two or more pieces must use scarf joints with structural adhesive for the length of the seam.

F5.1.1 Core splice must be used between all adjacent core sections.

F5.2 Front Bulkhead

F5.2.1 When modeled as an "L" shaped section the EI of the Front Bulkhead about vertical and lateral axis must be equivalent to that of the tubes specified for the Front Bulkhead per **F4.8**.

F5.2.1 The length of the section perpendicular to the Front Bulkhead may be a maximum of 25 mm measured from the rearmost face of the Front Bulkhead.

F5.2.1 Any Front Bulkhead which supports the IA plate must have a perimeter shear strength equivalent to a 1.5 mm thick steel plate.

F5.3 Front Bulkhead Support

F5.3.1 In addition to proving that the strength of the monocoque is sufficient, the monocoque must have equivalent EI to the sum of the EI of the six Steel Tubes (F3.2.1) that it replaces.

F5.3.2 The EI of the vertical side of the Front Bulkhead support structure must be equivalent to or more than the EI of one steel tube that it replaces when calculated.

F5.3.3 The perimeter shear strength of the monocoque laminate in the Front Bulkhead support structure must be 4 kN or more for a section with a diameter of 25 mm. This must be proven by a physical test completed per F3.5.5 and the results included in the SES.

F5.4 Side Impact Structure

F5.4.1 Side Impact Zone – the region longitudinally forward of the Main Hoop and aft of the Front Hoop consisting of the combination of a vertical section minimum 290 mm in height from the bottom surface of the floor of the monocoque and half the horizontal floor

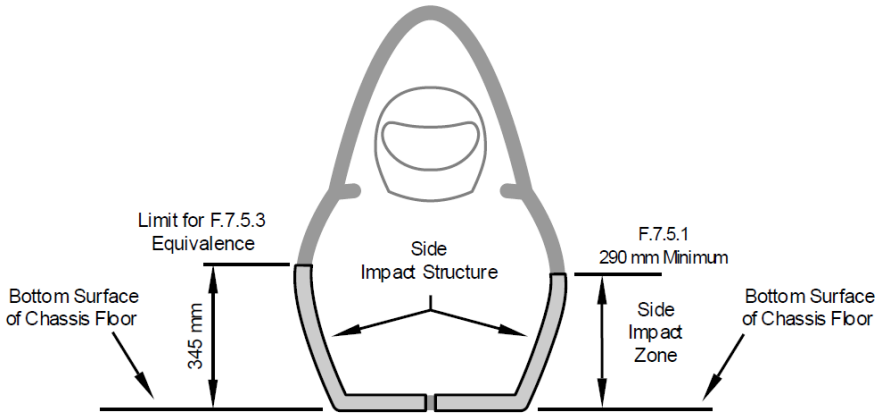


Figure 15: Side impact structure monocoque.

F5.4.2 The Side Impact Zone must have Equivalence to the three (3) Steel Tubes (F3.2.1) that it replaces.

F5.4.2 The portion of the Side Impact Zone that is vertically between the bottom surface of the floor and 345 mm above the lowest point of the bottom surface of the floor (see figure above) must have:

a) Equivalence to minimum two (2) Steel Tubes (F3.2.1) per F3.7.

b) No openings in Side View between the Front Hoop and Main Hoop

F5.4.2 Horizontal floor Equivalence must be calculated per F3.7.

F5.4.2 The perimeter shear strength of the monocoque laminate must be 7.5 kN or ore for a section with a diameter of 25 mm. This must be proven by physical test completed per F3.5.5 and the results included in the SES.

F5.5 Front Hoop Attachment

F5.5.1 The Front Hoop must be mechanically attached to the monocoque

a) Front Hoop Mounting Plates must be the minimum thickness of the Front Hoop F3.2.1.
b) The Front Hoop tube must be mechanically connected to the Mounting Plate with Mounting Plates parallel to the two sides of the tube, with gussets from the Front Hoop tube along the two sides of the mounting plate.

F5.5.2 Front Hoop attachment to a monocoque must obey F4.3.2 or F5.8 within 25 mm of any bends and nodes that are not at the top center of the Front Hoop

F5.5.3 The Front Hoop may be fully laminated into the monocoque if:

a) The Front Hoop has core fit tightly around its entire circumference. Expanding foam is not permitted
b) Equivalence to six or more mounts compliant with F5.8 must show in the SES
c) A small gap in the laminate (approximately 25 mm) exists for inspection of the Front Hoop F4.3.7.

F5.5.4 Adhesive must not be the sole method of attaching the Front Hoop to the monocoque.

F5.6 Main Hoop Attachment

F5.6.1 The Main Hoop must be mechanically attached to the monocoque

a) Main Hoop mounting plates must be 2.0 mm minimum thickness steel
b) The Main Hoop tube must be mechanically connected to the mounting plate with 2.0 mm minimum thickness steel plates parallel to the two sides of the tube, with gussets from the Main Hoop tube along the two sides of the mounting plate

F5.6.2 Main Hoop attachment to a monocoque must obey F5.8 within 25 mm of any bends and nodes that are below the top of the monocoque.

F5.7 Roll Hoop Bracing Attachment

F5.7.1 Attachment of tubular Front or Main Hoop Bracing to the monocoque must obey F5.8.

F5.8 Attachments

F5.8.1 Each attachment point between the monocoque or composite panels and the other Primary Structure must be able to carry a minimum load of 30 kN in any direction.

a) When a Roll Hoop attaches in three locations on each side, the attachments must be located at the bottom, top, and a location near the midpoint
b) When a Roll Hoop attaches at only the bottom and a point between the top and the midpoint on each side, each of the four attachments must show load strength of 45 kN in all directions

F5.8.2 If a tube frame (F4, F4.11) meets the monocoque at the Attachments, the connection must

a) Be 25 mm or less from a node
b) Obey one of the two:
    i. Parallel brackets attached to the two sides of the Main Hoop and the two sides of the Side Impact Structure
    ii. Two mostly perpendicular brackets attached to the Main Hoop and the side and back of the monocoque

F5.8.3 The laminate, brackets, backing plates and inserts must have sufficient stiffness, shear area, bearing area, weld area and strength to carry the load specified in F5.8.1 in any direction. Data obtained from the laminate perimeter shear strength test (F3.5.5) must prove sufficient shear area is provided.

F5.8.4 Each attachment point requires no less than two 8 mm or 5/16” minimum diameter Critical Fasteners, see T10.2.

F5.8.5 Each attachment point requires backing plates which meet one of:

a) Steel with a minimum thickness of 2 mm
b) Alternate materials if Equivalency is approved

F5.8.6 The Front Hoop Bracing, Main Hoop Bracing and Main Hoop Bracing Supports may use only one 10 mm or 3/8” minimum diameter Critical Fasteners, see

T10.2 as an alternative to F5.8.4 above if the bolt is on the centerline of the bracing tube to prevent loading the bolt in bending, similar to the Figure 16.

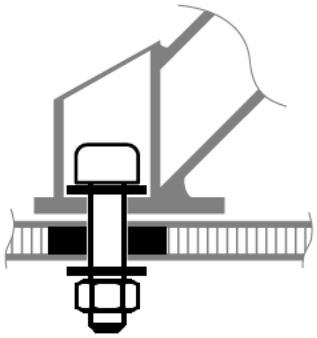


Figure 16: Bolted roll hoop bracing support.

F5.8.7 Each Roll Hoop or Battery Pack to Chassis attachment point must contain one of the two:

a) A solid insert that is fully enclosed by the inner and outer skin
b) Local elimination of any gap between inner and outer skin, with or without repeating skin layups

F5.8.8 Load paths between attachments and the monocoque Side Impact Structure F4.11 must use continuous laminates F3.7 with core.

F6 FRONT CHASSIS PROTECTION

F6.1 Requirements

F6.1.1 Each vehicle must be equipped with an IA Assembly, consisting of an Impact Attenuator (IA) and Anti-Intrusion Plate (AIP).

F6.1.2 All methods of attachment of the Impact Attenuator to the Anti Intrusion Plate, and of the Anti Intrusion Plate to the Front Bulkhead must provide sufficient load paths for transverse and vertical loads if off-axis impacts occur.

F6.2 Anti Intrusion Plate – AIP

F6.2.1 The Anti Intrusion Plate must be one of the three:

a) 1.5 mm minimum thickness solid steel
b) 4.0 mm minimum thickness solid aluminum plate
c) Composite material per F6.3

F6.2.2 The outside profile requirement of the AIP depends on the method of attachment to the Front Bulkhead:

a) Welded joints: the profile must align with or be more than the centerline of the Front Bulkhead tubes on all sides
b) Bolted joints, bonding, laminating: the profile must align with or be more than the outside dimensions of the Front Bulkhead around the entire periphery

F6.2.3 Attachment of the AIP directly to the Front Bulkhead must be documented in the team's SES submission. The accepted methods of attachment are:

a) Welding
    i. All weld lengths must be 25 mm or longer
    ii. If interrupted, the weld/space ratio must be 1:1 or higher
b) Bolted joints
    i. Using no less than eight 8 mm or 5/16" minimum diameter **Critical Fasteners, see T10.2**.
    ii. The distance between any two bolt centers must be 50 mm minimum.
    iii. Each bolt attachment must have pullout and bending capabilities of 15 kN
    iv. Bolt tearout capability must meet one of the two:
        - Each bolt attachment has tearout capability of 15 kN
        - The total tearout strength of the mounting (not individual bolts) must be more than the attachment strength of the Impact Attenuator in **F6.5.3.b**
c) Bonding
    i. The Front Bulkhead must have no openings
    ii. The entire surface of the AIP must be bonded, with shear and peel strength higher than 120 kN
d) Laminating
    i. The Anti Intrusion Plate must be in front of the outer skin of the Front Bulkhead
    ii. The lamination must fully enclose the Anti Intrusion Plate and have shear capability higher than 120 kN

F6.2.4 The only items permitted forward of the Anti Intrusion Plate in front view are the Impact Attenuator, fastener heads, and light bodywork / nosecones.

F6.2.5 Fasteners should be oriented with the nuts rearwards.

F6.3 Composite Anti Intrusion Plate

F6.3.1 Composite Anti Intrusion Plates:

a) Must not fail in a frontal impact
b) Must withstand a minimum static load of 120 kN distributed over the 200 mm x 100 mm minimum Impact Attenuator area

F6.3.2 Strength of the Composite Anti Intrusion Plate must be verified by one of the two methods:

a) Physical testing of the AIP attached to a structurally representative section of the intended chassis
   i. The test fixture must have equivalent strength and stiffness to a baseline front bulkhead or must be the same as the first 50 mm of the Chassis
   ii. Test data is valid for only one Competition Year
b) Laminate material testing under F3.5.2 and F3.5.5 and calculations of 3 point bending and perimeter shear.

F6.4 Impact Attenuator - IA

F6.4.1 Teams must do one of:

a) Use an approved Standard Impact Attenuator from the Event Website
b) Build and test a Custom Impact Attenuator of their own design F6.7

F6.4.2 The Custom Impact Attenuator must meet these:

a) Length 200 mm or more, with its length oriented along the fore/aft axis of the Chassis.
b) Minimum height 100 mm (perpendicular to the ground) and minimum width 200 mm (parallel to the ground) for a minimum distance of 200 mm forward of the Front Bulkhead.
c) Segmented foam attenuators must have all segments bonded together to prevent sliding or parallelogramming.
d) Honeycomb attenuators made of multiple segments must have a continuous panel between each segment.

F6.4.3 If the outside profile of the Front Bulkhead is more than 400 mm x 350 mm, or the team uses the Standard Honeycomb Impact Attenuator, and then one of the two must be met:

a) The Front Bulkhead must include an additional support that is a diagonal or X-brace that meets F3.2.1 or Equivalent (integral or attached) for Monocoque bulkheads

i. The structure must go across the entire Front Bulkhead opening on the diagonal
ii. Attachment points at each end must carry a minimum load of 30 kN in any direction

b) Physical testing per F6.7.6 and F6.7.7 must be done to prove that the Anti Intrusion Plate does not permanently deflect more than 25 mm.

F6.5 Impact Attenuator Attachment

F6.5.1 The attachment of the Impact Attenuator to the Anti Intrusion Plate or Front Bulkhead must be documented in the SES submission

F6.5.2 The Impact Attenuator must attach with an approved method:

a) Standard or Custom Type (Foam, Honeycomb) – Bonding
b) Custom (Other construction) – Bonding, welding, bolting

F6.5.3 If the Impact Attenuator is attached by bonding:

a) Bonding must meet F3.12
b) The shear strength of the bond must be higher than:
i. 95 kN for foam Impact Attenuators
ii. 38.5 kN for honeycomb Impact Attenuators
iii. The maximum compressive force for custom Impact Attenuators
c) The entire surface of a foam Impact Attenuator must be bonded
d) Only the pre-crushed area of a honeycomb Impact Attenuator may be used for bond equivalence

F6.5.4 If the Impact Attenuator is attached by welding:

a) Welds may be continuous or interrupted
b) If interrupted, the weld/space ratio must be 1:1 or higher
c) All weld lengths must be more than 25 mm

F6.5.5 If the Impact Attenuator is attached by bolting:

a) Must have no less than eight 8 mm or 5/16” minimum diameter Critical Fasteners, see T10.2
b) The distance between any two bolt centers must be 50 mm minimum
c) Each bolt attachment must have pullout, tearout and bending capabilities of 15 kN
d) Must be bolted directly to the Primary Structure

F6.5.6 Impact Attenuator Position

a) All Impact Attenuators must mount with the bottom leading edge 175 mm or less above the lowest point on the bottom of the Lower Side Impact Structure
b) A Custom Impact Attenuator must mount with an area of 200 mm or more long and 200 mm or more wide that intersects a plane parallel to the ground that is 175 mm or less above the lowest point on the bottom of the Lower Side Impact Structure

F6.5.7 Impact Attenuator Orientation

a) The Impact Attenuator must be centered laterally on the Front Bulkhead
b) Standard Honeycomb must be mounted 200mm width x 100mm height
c) Standard Foam may be mounted laterally or vertically

F6.6 Front Impact Verification

F6.6.1 The combination of the Impact Attenuator assembly and the force to crush or detach all other items forward of the AIP must not exceed the peak deceleration specified in F6.7.2. Ignore light bodywork, light nosecones, and outboard wheel assemblies

F6.6.2 The peak load for the type of Impact Attenuator:

a) Standard Foam Impact Attenuator 95 kN
b) Standard Honeycomb Impact Attenuator 60 kN
c) Tested Impact Attenuator peak as measured

F6.6.3 Two ways to prove the force requirement:

a) Test Method – Get the peak force from physical testing of the Impact Attenuator and any Non Crushable Object(s) as one of the two:
    i. Tested together with the IA
    ii. Tested with the IA not attached, and add the peak load from F6.6.2
b) Calculation Method
    i. Calculate a failure load for the mounting of the Non Crushable Object(s) from fastener shear, tearout, and/or link buckling
    ii. Add the peak attenuator load from F6.6.2

F6.7 Impact Attenuator Data – IAD

F6.7.1 All teams must include an Impact Attenuator Data (IAD) report as part of the SES.

F6.7.2 Impact Attenuator Functional Requirements (These are not test requirements)

a) Decelerates the vehicle at a rate not exceeding 20 g average and 40 g peak
b) Energy absorbed must be more than 7350 J

F6.7.2 F6.7.2 is required when:

a) Total mass of Vehicle is 300 kg
b) Impact velocity is 7.0 m/s

F6.7.3 When using the Standard Impact Attenuator, the SES must meet these:

a) Test data will not be submitted
b) All other requirements of this section must be included.
c) Photos of the actual attenuator must be included
d) Evidence that the Standard IA meets the design criteria provided in the Standard Impact Attenuator specification must be included with the SES. This may be a receipt or packing slip from the supplier.

F6.7.4 The Impact Attenuator Data Report when NOT using the Standard Impact Attenuator must include:

a) Test data that proves that the Impact Attenuator Assembly meets the **Functional Requirements F6.7.2**
b) Calculations showing how the reported absorbed energy and decelerations have been derived.
c) A schematic of the test method.
d) Photos of the attenuator, annotated with the height of the attenuator before and after testing.

F6.7.5 The Impact Attenuator Test is valid for only one Competition Year.

F6.7.6 Impact Attenuator Test Setup

a) During any test, the IA must be attached to the AIP using the intended vehicle attachment method.
b) The IA Assembly must be attached to a structurally representative section of the intended chassis. The test fixture must have equivalent strength and stiffness to a baseline front bulkhead. A solid block of material in the shape of the front bulkhead is not “structurally representative”.
c) There must be 50 mm minimum clearance rearwards of the AIP to the test fixture.

d) No part of the AIP may permanently deflect more than 25 mm beyond the position of the AIP before the test. The 25 mm spacing represents the front bulkhead support and insures that the plate does not intrude excessively into the cockpit.

F6.7.7 Impact Attenuator constructions may be Dynamic Tested or Quasi-Static Tested (Except for Composite IA, see F6.7.8)

a) Dynamic Testing (sled, pendulum, drop tower, etc.) of the Impact Attenuator must be conducted at a dedicated test facility. This facility may be part of the University, but must be supervised by professional staff or the University faculty. Teams must not construct their own dynamic test apparatus.
b) Quasi-Static Testing may be done by teams using their University's facilities/equipment, but teams are advised to exercise due care

F6.7.8 Composite Impact Attenuators must be Dynamic Tested.

F6.7.9 Test Analysis

a) When using acceleration data from the dynamic test, the average deceleration must be calculated based on the raw unfiltered data.
b) If peaks above the 40 g limit are present in the data, a Channel Filter Class (CFC) 60 (100Hz) filter per SAE Recommended Practice J211 "Instrumentation for Impact Test", or a 100 Hz, 3rd order, low pass Butterworth (-3dB at 100 Hz) filter may be applied.

F7 JACK POINT

F7.1 Definition

F7.1.1 must be provided at the rear of the car.

F7.1.2 A jacking point, which is capable of supporting the vehicle's weight and of engaging the organizers' "Quick Jack".

F7.2 Requirement

F7.2.1 Visible to a person standing 1 m behind the vehicle.

F7.2.1 Orange color.

F7.2.1 Oriented laterally and perpendicular to the centerline of the vehicle.

F7.2.1 Made from round, 25 - 30 mm OD aluminum or steel tube.

F7.2.1 Exposed around the lower 180° of its circumferences over a minimum length of 280 mm.

F7.2.1 Access from the rear of the tube must be unobstructed for 300 mm or more of its length.

F7.2.1 The height of the tube must give 75 mm minimum clearance from the bottom of the tube to the ground.

F7.2.1 When the vehicle is raised to where the bottom of the tube is 200 mm above ground, the wheels do not touch the ground when they are in full rebound.

Part T – Technical Aspect

T1 COCKPIT

T1.1 Cockpit Opening

T1.1.1 The template shown below (see Figure 17) must pass through the cockpit opening 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 meets the two of:

a) Has passed 25 mm below the lowest point of the top of the Side Impact Structure
b) Is less than or equal to 320 mm above the lowest point inside the cockpit

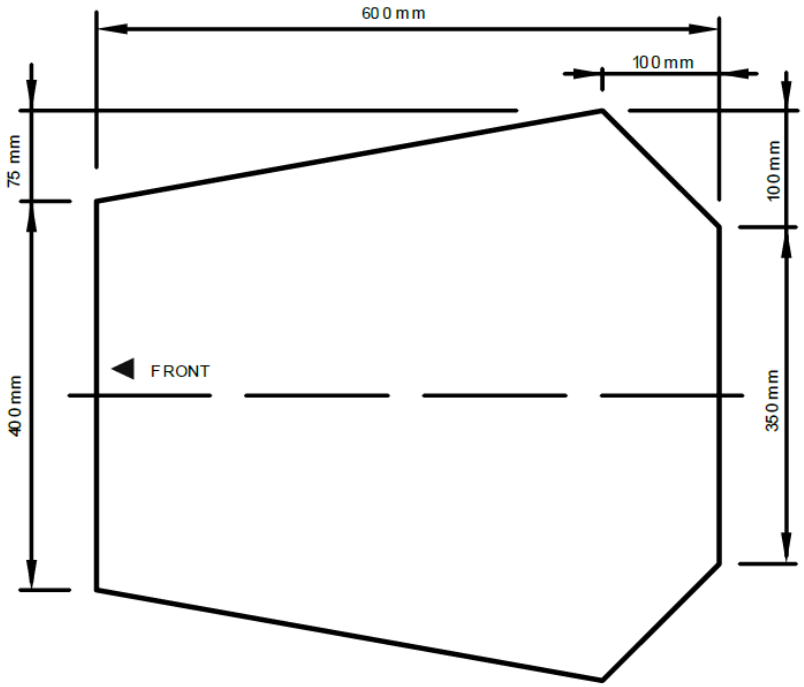


Figure 17: Cockpit opening template.

T1.1.2 During this test:

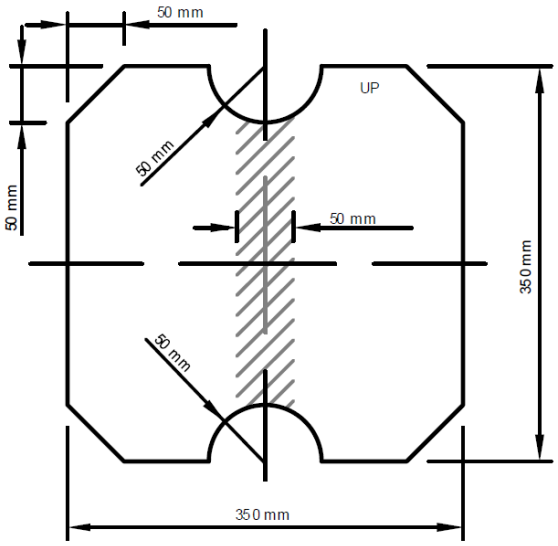
a) The steering wheel, steering column, seat and all padding may be removed

b) The shifter, shift mechanism, or clutch mechanism must not be removed unless it is integral with the steering wheel and is removed with the steering wheel
c) The firewall must not be moved or removed
d) Cables, wires, hoses, tubes, etc. must not block movement of the template

T1.2 Internal Cross Section

T1.2.1 The template shown in must pass through the cockpit, with:

a) Will be held vertically and inserted into the cockpit opening rearward of the rearmost portion of the steering column.
b) Will then be passed horizontally through the cockpit to a point 100 mm rearwards of the face of the rearmost pedal when in the inoperative position
c) May be moved vertically inside the cockpit



Template maximum thickness: 7 mm

Figure 18:cockpit internal cross section template.

T1.2.2 During this test:

a) If the pedals are adjustable, they must be in their most forward position.
b) The steering wheel may be removed
c) Padding may be removed if it can be easily removed without the use of tools with the driver in the seat
d) The seat and any seat insert(s) that may be used must stay in the cockpit
e) Cables, wires, hoses, tubes, etc. must not block movement of the template

f) The steering column and associated components may pass through the 50 mm wide center band of the template.

T1.3 Percy (95th percentile male)

T1.3.1 When seated normally and restrained by the driver's restraint system, the helmet of a 95th percentile male and all the team's drivers must, see Figure 19:

a) Be a minimum of 50mm away from the straight line drawn from the top of the main hoop to the top of the front hoop,
b) Be a minimum of 50mm away 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,
c) Be no further rearwards than the rear surface of the main hoop if the main hoop bracing extends forwards.

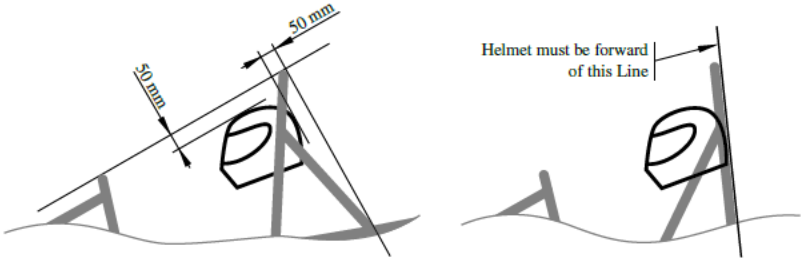


Figure 19: Minimum helmet clearance.

T1.3.2 The 95th percentile male is represented by a two-dimensional figure be positioned in the vehicle as follows, see Figure 20:

a) The seat adjusted to the rearmost position,
b) The pedals adjusted to the front-most position,
c) The bottom 200mm circle placed on the seat bottom. The distance between the centre of the circle and the rearmost actuation face of the pedals must be minimum 915mm,
d) The middle circle positioned on the seat back,
e) The upper 300mm circle is positioned no more than 25 mm away from the head restraint.

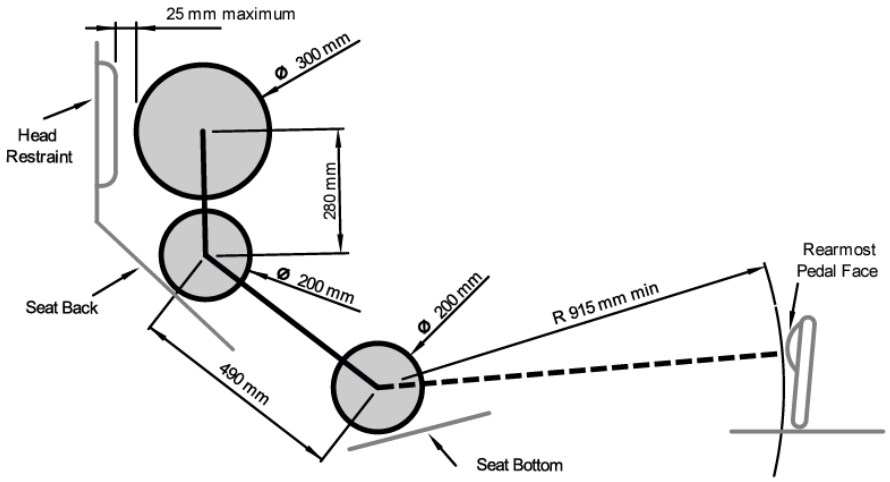


Figure 20: Percy (95th percentile male) placement.

T1.4 Driver's Seat

T1.4.1 The Driver's Seat must be protected by one of the two:

a) In side view, the lowest point of any Driver's Seat must be no lower than the upper surface of the lowest structural tube or equivalent
b) A longitudinal tube (or tubes) that meets the requirements for Side Impact tubing, passing underneath the lowest point of the Driver Seat.

T1.4.2 When seated in the normal driving position, sufficient heat insulation must be provided to make sure that the driver will not contact any metal or other materials which may become heated to a surface temperature above 60°C.

T1.4.3 Insulation may be external to the cockpit or incorporated with the Driver's Seat or Firewall.

T1.5 Driver Leg Protection

T1.5.1 All moving suspension and steering components and other sharp edges inside the cockpit between the front hoop and a vertical plane 100mm rearward of the pedals, must be shielded with solid material.

T1.5.2 Covers over suspension and steering components must be removable to allow inspection of the mounting points.

T1.6 Driver Arm Protection

T1.6.1 The combination of the Primary Structure, driver position and harness installation must be such that while the driver is in the fully seated position,

hands in the driving position on the connected steering wheel (in all possible steering positions) and wearing the required driver equipment:

a) Can turn the steering wheel lock to lock.
b) Cannot move their arms (while still holding onto the connected steering wheel) such that any part of the driver falls outside of the Rollover Protection Envelope. (e.g. the arm restraints or the chassis should prevent arms/elbows from falling outside of the Rollover Protection Envelope).

T1.7 Floor Closeout

T1.7.1 All vehicles must have a Floor Closeout to prevent track debris from entering

T1.7.2 The Floor Closeout must extend from the foot area to the firewall

T1.7.3 The panel(s) must be made of a solid, non brittle material

T1.7.4 If multiple panels are used, gaps between panels must not exceed 3 mm

T1.8 Vehicle Control

T1.8.1 Any mechanism in the throttle system that could become jammed must be covered. This is to prevent debris or interference and includes but is not limited to a gear mechanism

T1.8.2 All Vehicle Controls (steering, gear change, Cockpit Main Switch/ Cockpit Shutdown Button) must be operated from inside the cockpit without any part of the driver, including hands, arms or elbows, being outside of:

a) The Side Impact Structure defined in F4.11
b) Two longitudinal vertical planes parallel to the centerline of the chassis touching the uppermost member of the Side Impact Structure

T1.8.3 All Vehicle Controls must stay below the top-most point of the Front Hoop in any operational position.

T1.8.4 Steering system racks or mounting components that are external (vertically above or below) to the Primary Structure must be protected from frontal impact. The protective structure must:

a) Be F3.2.1 or Equivalent
b) Extend to the vertical limit of the steering component(s)
c) Extend to the local width of the Chassis
d) Meet F5.8 if not welded to the Chassis

T1.9 Pedal Box

T1.9.1 Pedal assembly at full travel and adjustment must have a minimum 25 mm clearance to the:

a) Rear face of the Anti-Intrusion Plate
b) All Front Bulkhead structure F5.2, F5.3, F6.4.3
c) All Non-Crushable Items inside the Primary Structure Non Crushable Items include, but are not limited to batteries, master cylinders, hydraulic reservoirs

T1.9.2 The Brake Pedal must be one of:

a) Fabricated from steel or aluminium
b) Machined from steel, aluminium or titanium

T1.9.3 The Brake Pedal and associated components design must withstand a minimum force of 2000 N without any failure of the Brake System, pedal box, chassis mounting, or pedal adjustment.

T1.9.4 This is not a design criteria. The Brake Pedal and Brake System may be tested by pressing the pedal with the maximum force that can be exerted by any official when seated normally.

T1.9.5 Failure of non-loadbearing components in the Brake System or pedal box must not interfere with Brake Pedal operation or Brake System function.

T1.10 Firewall

T1.10.1 A Firewall(s) must separate the driver compartment and any portion of the Driver Harness from:

a) Fuel Tanks.
b) Tractive System Battery Pack.
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 (Whether contained within conduit or not.)

T1.10.2 The firewall must cover any line projected from any point on the parts mentioned in T1.10.1 to any part of the tallest driver below a plane 100mm above the bottom of the helmet.

T1.10.3 Any Firewall must be:

a) A non-permeable surface made from a rigid, Non-flammable Material
b) Mounted tightly

T1.10.4 The Firewall or the part of the Firewall on the Tractive System side must be:

a) Made of aluminium. The Firewall layer itself must not be aluminium tape.
b) Grounded, refer to **EV5.8 Grounding**

T1.10.5 Conductive parts, except for the chassis and firewall mounting points, must not protrude through the TS firewall or must be properly insulated on the driver's side. The driver must not be able to touch uninsulated firewall mounting points while operating the vehicle.

T1.10.6 The Tractive Battery Container must not be part of the Firewall

T1.10.7 Sealing:

a) Any Firewall must seal completely against the passage of fluids (the Firewall itself, joints, edges, any pass throughs and Floor Closeout)
b) Firewalls that have multiple panels must overlap and be sealed at the joints
c) Sealing between Firewalls must not be a stressed part of the Firewall
d) Grommets must be used to seal any pass through for GLV wiring, cables, etc
e) Any seals or adhesives used with the Firewall must be rated for the application environment

T1.10.8 For those components listed in section T1.10.1positioned under the driver (see Figure 21), 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 (T1.3) 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 T1.10.8(a) and from the rearmost front suspension mounting point to connect (without holes or gaps) behind the driver with the firewall required by T1.10.8(a).

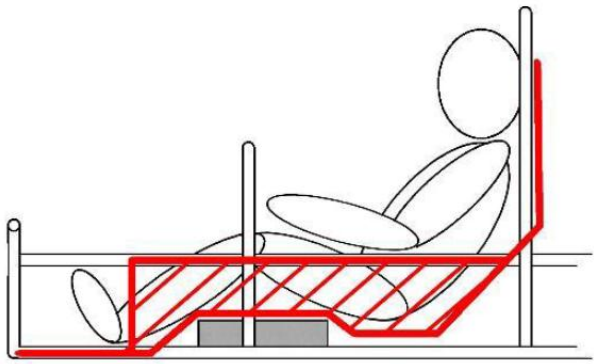


Figure 21: Example firewall configurations with component under the driver.

T1.10.9 For those components listed in section T1.8.1 that are mounted outboard of the Side Impact System (e.g. in side pods)(see), the firewall(s) must extend from 100 mm forward to 100 mm rearward of the of the listed components and

a) alongside the driver at the full height of the listed component, and
b) cover the top of the listed components and
c) run either
   i. under the cockpit between the firewall(s) required by T1.10.9(a), or
   ii. extend 100 mm out under the listed components from the firewall(s) that are required by T1.10.10.

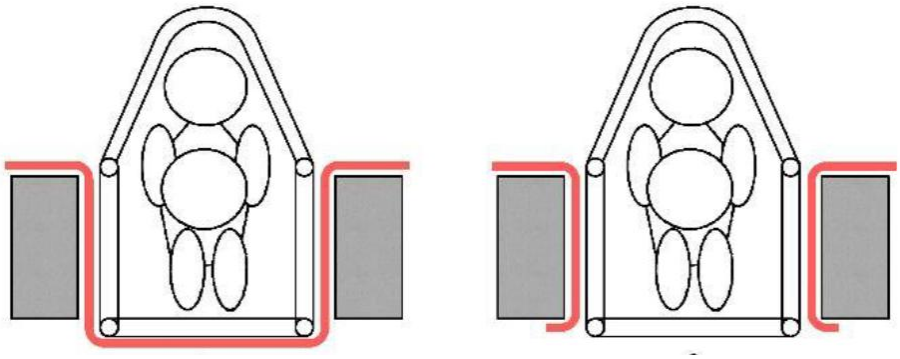


Figure 22: Example firewall configurations with component at the side of the driver.

T1.10.10 For the components listed in section T1.10.1 that are mounted in ways that do not fall clearly under any of sections T1.10.2, T1.10.8 or T1.10.9, the firewall must be configured to provide equivalent protection to the driver.

T1.11 Visibility

T1.11.1 The driver must have sufficient visibility to the front and sides of the vehicle.

T1.11.2 When seated in a normal driving position, the driver must have a minimum field of vision of 100° to the left and the right sides.

T1.11.3 If mirrors are required for this rule, they must remain in position and adjusted to enable the required visibility throughout all Dynamic Events.

T1.12 Driver Egress

T1.12.1 All drivers must be able to exit to the side of the vehicle in less than 5 s with the driver in the fully seated position, hands in the driving position on the connected steering wheel (in all possible steering positions), wearing the required driver equipment as in **VE3** and properly secured by the Driver Restrain System as in **T7**. The egress time will stop when the driver has both feet on the ground.

T2 DRIVER RESTRAINT SYSTEM

T2.1 Harness Definitions

T2.1.1 5 Point Harness – consists of two Lap Belts, two Shoulder Belts and one Anti-Submarine Belt.

T2.1.2 6 Point Harness – consists of two Lap Belts, two Shoulder Belts and two leg or Anti- Submarine Belts.

T2.1.3 7 Point Harness – consists of two Lap Belts, two Shoulder Belts, two leg or Anti-Submarine Belts and a negative g or Z Belt.

T2.1.4 Upright Driving Position – with a seat back angled at 30° or less from the vertical as measured along the line joining the two 200 mm circles of the template of the 95th percentile male as defined in **T1.3.2** and positioned per **T1.3.2**.

T2.1.5 Reclined Driving Position – with a seat back angled at more than 30° from the vertical as measured along the line joining the two 200 mm circles of the template of the 95th percentile male as defined in **T1.3.2** and positioned per **T1.3.2**

T2.1.6 Chest to Groin Line – the straight line that in side view follows the line of the Shoulder Belts from the chest to the release buckle.

T2.2 Harness Specification

T2.2.1 The vehicle must use a 5, 6 or 7 Point Harness meeting one or more of the three:

a) SFI Specification 16.1
b) SFI Specification 16.5

c) SFI Specification 16.5
d) FIA specification 8853/98
e) FIA specification 8853/2016

T.2.2.2 The Harness must meet the following specifications:

a) The belts must bear the appropriate dated labels,
b) The material of all straps must be in new or like new condition, with no signs of wear, cuts, chaffing or other issues,
c) There must be a single metal-to-metal latch type quick release for all straps,
d) All lap belts must incorporate a tilt lock adjuster ("quick adjuster"). A tilt lock adjuster in each portion of the lap belt is highly recommended. Lap belts with "pull-up" adjusters are recommended over "pull-down" adjusters,
e) Vehicles with a "reclined driving position" must have either anti-submarine belts with tilt lock adjusters ("quick adjusters") or have two sets of anti-submarine belts installed,
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) The shoulder harness straps must be threaded through the three bar adjusters in accordance with the manufacturer's instructions,
h) When a Frontal Head Restraint (FHR) is used by the driver, FIA certified 50mm wide shoulder harnesses are allowed.

T2.2.3 The restraint system must be worn tightly at all times.

T2.3 Belt, Strap and Harness Installation - General

T2.3.1 The Lap Belt, Shoulder Belts and Anti-Submarine Belt(s) must be securely mounted to the Primary Structure.

T2.3.2 Any guide or support for the belts must be material meeting F.3.2.1.

T2.3.3 Each tab, bracket or eye to which any part of the Harness is attached must:

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) 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.

c) Have a minimum thickness of 1.6 mm (0.063 inch).
d) Not cause abrasion to the belt webbing

T2.3.4 Attachment of tabs or brackets must meet these:

a) Where brackets are fastened to the chassis, no less than two 6 mm or 1/4" minimum diameter **Critical Fasteners, see T10.2** or stronger must be used to attach the bracket to the chassis
b) Welded tabs or eyes must have a minimum base dimension of the outer diameter of the tab or eye
c) Where a single shear tab is welded to the chassis, the tab to tube welding must be on the two sides of the base of the tab Double shear attachments are preferred. Tabs and brackets for double shear mounts should be welded on the two sides.

T2.3.5 Eyebolts or Weld Eyes must:

a) Be one piece. No eyenuts or swivels.
b) Be harness manufacturer supplied
c) Be aligned to let the harness clip-on bracket pivot freely, and not touch other harness brackets (lap and anti sub) or other vehicle parts
d) Have a positive locking feature on threads or by the belt itself
e) Weld Eyes must have a shank inserted through a **Welded Insert F3.2.8**

T2.3.6 For the belt itself to be considered a positive locking feature, the eyebolt must:

a) Have minimum 10 threads engaged in a threaded insert
b) Be shimmed to fully tight
c) Be properly aligned with the clip-on harness bracket (not twisted) to prevent the belt creating a torque on the eyebolt.

T2.3.3 Harness installation must meet **T1.8.1**.

T2.3.4 All adjusters must be threaded in accordance with manufacturer's instructions. Examples are given in Figure 23.

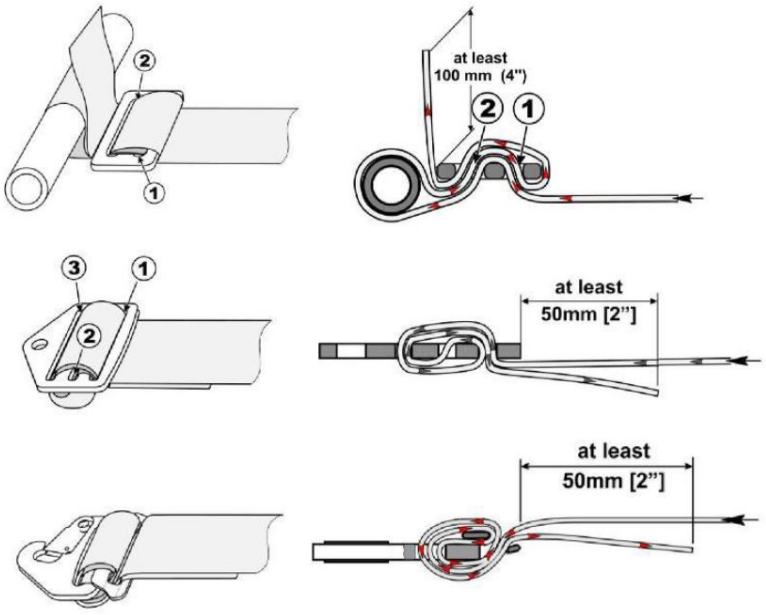


Figure 23: Seat Belt Threading Examples.

T2.4 Lap Belt Mounting

T2.4.1 The Lap Belts must pass around the pelvic area below the Anterior Superior Iliac Spines (the hip bones).

T2.4.2 Installation of the Lap Belts must go in a straight line from the mounting point until they reach the driver's body without touching any hole in the seat or any other intermediate structure.

T2.4.3 The seat must be rolled or grommeted where the Belts or Harness pass through a hole in the seat.

T2.4.4 With an Upright Driving Position:

a) The Lap Belt Side View Angle must be between 45° and 65° to the horizontal.
b) The centerline of the Lap Belt at the seat bottom should be between 0 – 75 mm forward of the seat back to seat bottom junction, see Figure 24.

T2.4.5 With a Reclined Driving Position, the Lap Belt Side View Angle must be between 60° and 80° to the horizontal, see Figure 24.

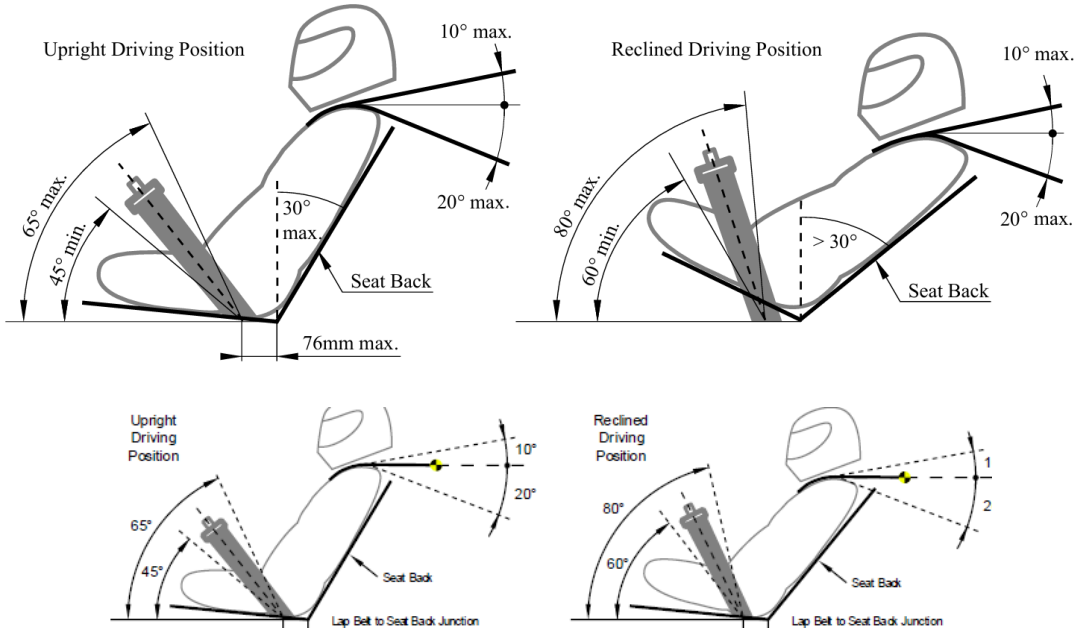


Figure 24: Lap belt and shoulder harness mounting.

T2.4.6 The Lap Belts must attach by one of the two:

a) Bolt or eyebolt through a welded tube insert or tested monocoque attachment F5.8.8
b) Bolt to a tab or bracket, or clip to an eye (T2.3.3) on a tube frame

T2.4.7 In side view, the Lap Belt must be capable of pivoting freely by using a shouldered bolt or an eye bolt attachment

T2.4.8 Any bolt used to attach a Lap Belt, directly to the chassis or to an intermediate bracket, is a **Critical Fasteners, see T10.2**, with a minimum diameter that is the smaller of:

a) The bolt diameter specified by the manufacturer
b) 10 mm or 3/8”

T2.5 Shoulder Harness

T2.5.1 From the driver’s shoulders rearwards to the mounting point or structural guide, the Shoulder Belt Side View Angle must be between 10° above the horizontal and 20° below the horizontal, see Figure 25.

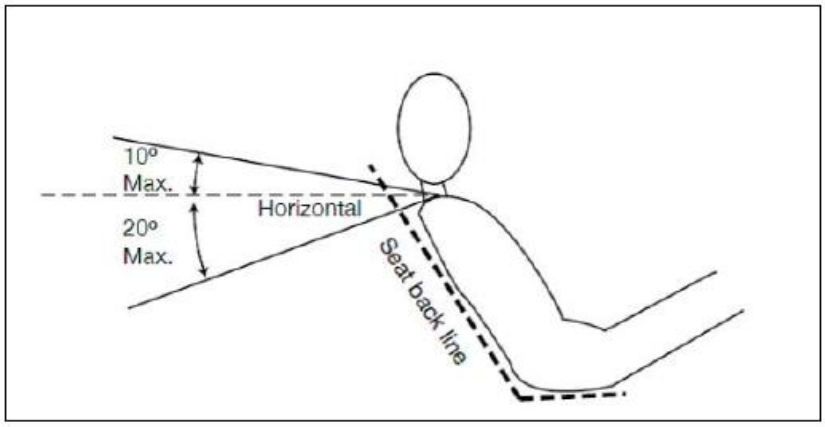


Figure 25: Shoulder Harness Mounting side view.

T2.5.2 The Shoulder Belt Mount Spacing must be between 175 mm and 235 mm, center to center, see Figure 26.

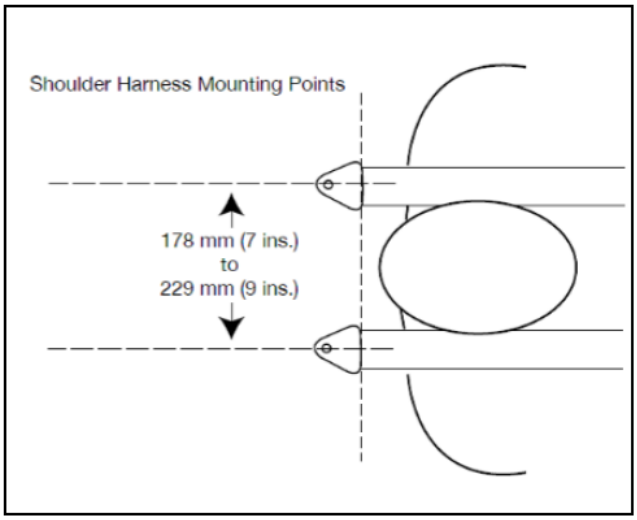


Figure 26: Shoulder Harness Mounting point top view.

T2.5.3 The Shoulder Belts must attach by one of the four:

a) Wrap around the Shoulder Harness Mounting bar, T2.5.4
b) Bolt through a welded tube insert or tested monocoque attachment F5.8.8
c) Bolt to a well gusseted tab behind the Shoulder Harness Mounting Bar or clip to an eye (T2.3.3) loaded in tension on the Shoulder Harness Mounting bar
d) Wrap around physically tested hardware attached to a monocoque

T2.5.4 The Shoulder Harness Mounting Bar must:

a) Be a single piece of uncut, continuous, closed section steel tubing that meets F3.2.1
b) Attach to the Main Hoop on the left and right sides of the chassis

T2.5.4 Any bolt used to attach a Shoulder Belt, directly to the chassis or to an intermediate bracket, is a Critical Fasteners, see T10.2, with a minimum diameter that is the smaller of:

a) The bolt diameter specified by the manufacturer
b) 10 mm or 3/8”

T2.6 Anti-Submarine Belt Mounting

T2.6.1 The Anti-Submarine Belt of a 5 point harness must be mounted with the mounting point in line with or slightly forward of the driver’s Chest to Groin Line with an Anti-Submarine Belt Side View Angle no more than 20°.

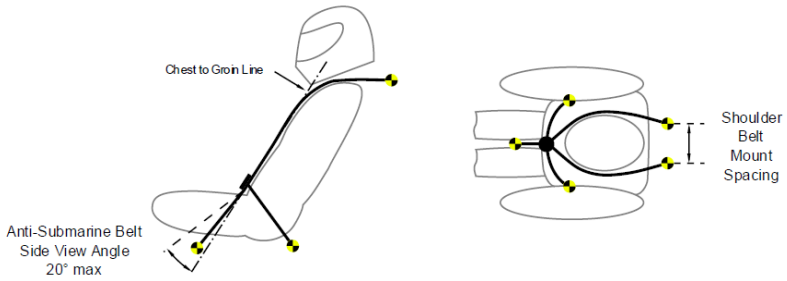


Figure 27: Anti-submarine belt angled mounting arrangement.

T2.6.2 The Anti-Submarine Belts of a 6 point harness must mount in one of the two:

a) With the belts going vertically down from the groin, or with an Anti-Submarine Belt Side View Angle up to 20° rearwards. The Anti-Submarine Belt Mount Spacing should be approximately 100 mm apart.

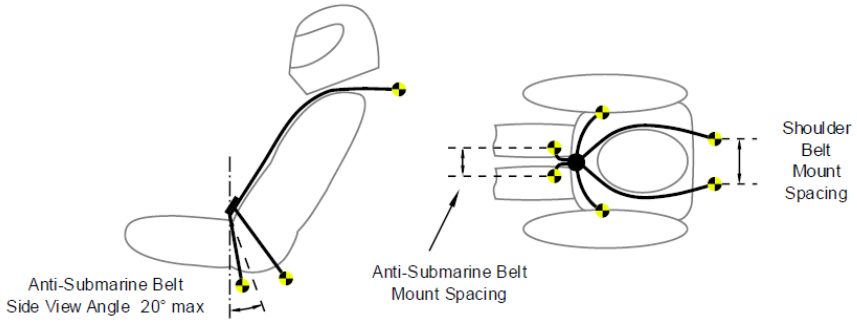


Figure 28: Anti-submarine belt mounting arrangement - vertically down from the groin.

b) With the Anti-Submarine Belt Mounting 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.

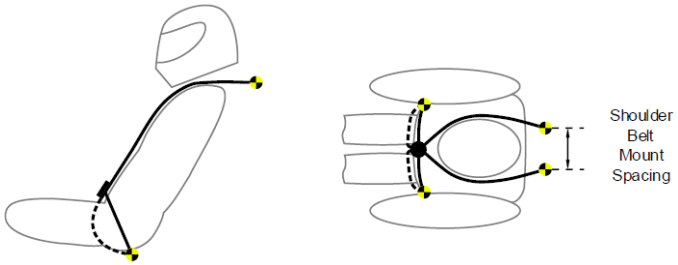


Figure 29Anti-submarine belt mounting arrangement - Primary Structure.

T2.6.3 Installation of all Anti-Submarine Belts must go in a straight line from the Anti-Submarine Belt. Mounting Point(s) without touching any hole in the seat or any other intermediate structure until they reach:

a) The release buckle for the 5 Point Harness mounting per **T2.6.1**
b) The first point where the belt touches the driver's body for the 6 Point Harness mounting per **T2.7.2**

T2.6.4 The Anti Submarine Belts must attach by one of the three:

a) Bolt or eyebolt through a welded tube insert or tested monocoque attachment **F5.8.8**
b) Bolt to a tab or bracket, or clip to an eye (**T2.3.3**) on a tube frame
c) Wrap around a tube meeting **F3.2.1** that connects the **Lower Side Impact tubes F5.4.5**. The belt must not be able to touch the ground.

T2.6.5 Any bolt used to attach an Anti-Submarine Belt, directly to the chassis or to an intermediate bracket, is a **Critical Fasteners, see T10.2**, with a minimum diameter that is the smaller of:

a) The bolt diameter specified by the manufacturer
b) 8 mm or 5/16”

T2.7 Driver’s Harness Attachment

T2.7.1 Any harness attachment to a monocoque must use one 10 mm metric grade 8.8 bolt or two 8 mm metric grade 8.8 bolts (or bolts of an equivalent standard) and steel backing plates with a minimum thickness of 2 mm.

T2.7.2 Any harness that is fastened to the Primary Structure using brackets must use two 8 mm metric grade 8.8 or stronger fasteners.

T2.7.3 It must be proven that the attachments for shoulder and lap belts can support a load of 13kN and the attachment points of the anti-submarine belts can support a load of 6.5kN.

T2.7.4 If the lap belts and anti-submarine belts are attached less than 100mm apart, these must support a total load of 19.5kN.

T2.7.5 If the belts are attached to a laminated structure or the mounting brackets and tabs are not made from steel at least 1.6mm thick, physical testing is required. The following requirements must be met:

a) Load is applied to a test sample representing the tubular or laminated structure and must use the same brackets and/or tabs,
b) Edges of the test fixture supporting the sample must be a minimum of 125mm from the load application point,
c) The width of the shoulder harness test sample must not be any wider than the shoulder harness panel height used to show equivalency for the shoulder harness mounting bar,
d) Designs with attachments near a free edge may not support the free edge during the test,
e) Harness loads must be tested with the worst case for the range of the angles specified for the driver’s harness.

T2.8 Head Restraint

T2.8.1 A Head Restraint must be provided to limit the rearward motion of the driver’s head.

T2.8.2 The Head Restraint must be vertical or near vertical in side view.

T2.8.3 All material and structure of the Head Restraint must be inside the Rollover Protection Envelope **F1.1.14**

T2.8.5 The Head Restraint, attachment and mounting must be strong enough to withstand a minimum force of:

a) 900 N applied in a rearward direction
b) 300 N applied in a lateral or vertical direction

T2.8.6 For all drivers, the Head Restraint must be located and adjusted where:

a) The Head Restraint is no more than 25 mm away from the back of the driver's helmet, with the driver in their normal driving position.
b) The contact point of the back of the driver's helmet on the Head Restraint is no less than 50 mm from any edge of the Head Restraint.

T2.8.7 Approximately 100 mm of longitudinal adjustment should accommodate range of specified drivers. Several Head Restraints with different thicknesses may be used

T2.8.8 The Head Restraint padding must:

a) Be an energy absorbing material that is one of the two:
   i. Meets SFI Spec 45.2
   ii. CONFOR CF45 (Blue) or CONFOR CF45M (Blue) FIA Technical List No 17
b) Have a minimum thickness of 38 mm
c) Have a minimum width of 15 cm
d) Meet one of the two:
   i. minimum area of 235 cm^2 AND minimum total height adjustment of 17.5 cm
   ii. minimum height of 28 cm
e) Be covered with a thin, flexible material that contains a ~20 mm diameter inspection hole in a surface other than the front surface

T2.9 Roll Bar Padding

T2.9.1 Any portion of the roll bar, roll bar bracing or Chassis which might be contacted by the driver's helmet must be covered with a minimum thickness of 12 mm of padding which meets SFI Spec 45.1 or FIA 8857-2001.

T3 BRAKES

T3.1 Brake System

T3.1.1 The vehicle must be equipped with a hydraulic brake system that must:

a) Act on all four wheels
b) Be operated by a single control
c) Be capable of locking all four wheels

T3.1.2 The Brake System must have two independent hydraulic circuits A leak or failure at any point in the Brake System must maintain effective brake power on minimum two wheels.

T3.1.3 Each hydraulic circuit must have its own fluid reserve using separate reservoirs or an OEM style reservoir.

T3.1.4 A single brake acting on a limited slip differential may be used.

T3.1.5 "Brake by Wire" systems are prohibited.

T3.1.6 Unarmored plastic brake lines are prohibited.

T3.1.7 The Brake System must be protected with scatter shields from failure of the drive train (see **T7.1.2**) or from minor collisions.

T3.1.8 In side view any portion of the Brake System that is mounted on the sprung part of the vehicle must not project below the lower surface of the chassis.

T3.1.9 Fasteners in the Brake System are **Critical Fasteners, see T10.2**.

T3.1.10 Requirement of vehicle with regenerative braking:

a) The first 90% of the Brake Pedal travel may be used to regenerate energy without actuating the hydraulic brake system
b) The remaining Brake Pedal travel must directly

T3.2 Brake Over Travel Switch - BOTS

T3.2.1 The vehicle must have a Brake Over Travel Switch (BOTS), see Figure 30. Brake pedal travel exceeding the normal range will operate the switch.

Figure 30: Example of BOTS.

T3.2.2 The BOTS must:

a) Be a mechanical single pole, single throw (two position) switch (push-pull, push-rotate or flip type)
b) Hold if operated to the OFF position

T3.2.3 Operation of the BOTS to the OFF position must Open the Shutdown Circuit EV6.2.2.

T3.2.4 The driver must not be able to reset the BOTS.

T3.2.1 The BOTS circuit must be implemented with analog components, not using programmable logic controllers, engine control units, or similar functioning digital controllers.

T3.3 Brake System Encoder - BSE

T3.3.1 The vehicle must have a sensor or switch to measure brake pedal position or brake system pressure.

T3.3.2 The BSE must be able to be checked during Technical Inspection by having one of:

a) A separate detachable connector(s) for any BSE signal(s) to the main ECU without affecting any other connections
b) An inline switchable breakout box available that may disconnect each BSE signal(s) to the main ECU without affecting any other connections

T3.3.3 The BSE or switch signals must be sent directly to a controller using an analogue signal or via a digital data transmission bus such as CAN or FlexRay Any failure of the BSE or BSE wiring that persists more than 100 msec must be detectable by the controller and treated like an implausibility and power to the (IC) electronic throttle / (EV) Motor(s) must be immediately stopped completely.

T3.3.4 It is not necessary to completely deactivate the Tractive System, the motor controller(s) stopping power to the motor(s) is sufficient.

T3.3.5 When an analogue signal is used, the BSE sensors will be considered to have failed when they achieve an open circuit or short circuit condition which generates a signal outside of the normal operating range, for example <0.5 V or >4.5 V.

T3.3.6 The circuitry used to evaluate the sensor must use pull down or pull up resistors to make sure that open circuit signals result in a failure being detected.

T3.3.7 When any kind of digital data transmission is used to transmit the BSE signal:

a) The ETC Systems Form must contain a detailed description of all the potential failure modes that can occur, the strategy that is used to detect these failures and the tests that have been conducted to prove that the detection strategy works.
b) The failures modes must include but are not limited to the failure of the sensor, sensor signals being out of range, corruption of the message and loss of messages and the associated time outs.
c) In all cases a sensor failure must immediately shutdown power to the motor(s)

T3.4 Brake System Plausibility Device (BSPD)

T3.4.1 The vehicle must have a standalone nonprogrammable circuit to check for simultaneous braking and high power output.

T3.4.2 Standalone is defined as there is no additional functionality implemented on all required Printed Circuit Boards (PCBs). The interfaces must be reduced to the minimum necessary signals, i.e. power supply, required sensors and the shutdown circuit. Supply and sensor-signals must not be routed through any other devices before entering the BSPD.

T3.4.3 The BSPD must be directly supplied from the LVMS, see **T11.3**.

T3.4.4 The BSPD must **Open the Shutdown Circuit EV6.2.2** when the two of these exist:

a) Demand for Hard Braking EV.4.6
b) Tractive System current is at a level where 5 kW of electrical power in the DC circuit is delivered to the Motor(s) at the nominal battery voltage

T3.4.5 The Shutdown Circuit must remain open until power cycling the LVMS or the BSPD may reset itself if the opening condition is no longer present for more than 10 s.

T3.4.6 To measure power delivery, a DC circuit current sensor only must be used. The threshold must be chosen to an equivalent of ≤5kW for maximum TS voltage.

T3.4.7 To detect hard braking, a brake system pressure sensor must be used. The threshold must be chosen such that there are no locked wheels and the brake pressure is ≤30 bar.

T3.4.8 It must be possible to separately disconnect each sensor signal wire for Technical Inspection.

T3.4.9 The BSPD including all required sensors must not be installed inside the Tractive Battery Container.

T4 ELECTRONIC THROTTLE PEDAL

T4.1 Accelerator Pedal Position Sensor (APPS)

T4.1.1 The Accelerator Pedal must operate with:

a) Two springs must be used to return the foot pedal to 0% Pedal Travel
b) Each spring must be capable of returning the pedal to 0% Pedal Travel with the other disconnected. The springs in the APPS are not acceptable pedal return springs.

T4.1.2 Two or more electrically separate sensors must be used as APPSs. A single OEM type APPS with two completely separate sensors in a single housing is acceptable.

T4.1.3 The APPS sensors must meet the three:

a) Have different transfer functions which have different gradients and/or offsets to the other(s)
b) Have a pull-up or pull-down resistor in circuit to bring an open circuit input to 0% pedal travel
c) At any pedal position above 10%, the pedal travel output of a single sensor must differ by minimum 10% from any other sensor Opposite slope sensors that do not meet this requirement will not be permitted

T4.1.4 Implausibility is defined as a deviation of more than 10% Pedal Travel between the APPS.

T4.1.5 If an Implausibility occurs between the values of the APPSs and persists for more than 100 msec, the power to the Motor(s) must be immediately stopped completely.

T4.1.6 When T4.1.4 happen, It is not necessary to Open the Shutdown Circuit, the motor controller(s) stopping the power to the Motor(s) is sufficient.

T4.1.7 If three sensors are used, then if one APPS failure, any two sensors that agree within 10% Pedal Travel may be used Pedal Travel may be used to continue running the Motor(s) and the 3rd APPS may be ignored.

T4.1.8 Each APPS must be able to be checked during Technical Inspection by having one of the two:

a) A separate detachable connector that enables a check of functions by unplugging it
b) An inline switchable breakout box available that may disconnect each APPS signal

T4.1.9 The APPS signals must be sent directly to a controller using an analogue signal or via a digital data transmission bus such as CAN or FlexRay.

T4.1.10 Any failure of the APPS or APPS wiring must be detectable by the controller and must be treated like an Implausibility, see T4.1.4 above.

T4.1.11 When an analogue signal is used, the APPS will be considered to have failed when they achieve an open circuit or short circuit condition which generates a signal outside of the normal operating range, for example <0.5 V or >4.5 V.

T4.1.12 The circuitry used to evaluate the sensor must use pull down or pull up resistors to make sure that open circuit signals result in a failure being detected.

T4.1.13 When any kind of digital data transmission is used to transmit the APPS signal, the failures to be considered must include but are not limited to the failure of the APPS, APPS signals being out of range, corruption of the message and loss of messages and the associated time outs

T4.2 APPS/Brake Pedal Plausibility Check

T4.2.1 Must monitor for the two conditions:

a) The mechanical brakes are engaged T3.3, T3.1.10
b) The APPS signals more than 25% Pedal Travel T4.1

T4.2.2 If the two conditions in T4.2.1 occur at the same time:

a) Power to the Motor(s) must be immediately and completely shut down
b) The Motor shut down must stay active until the APPS signals less than 5% Pedal Travel, with or without brake operation

T4.2.3 The team must be able to demonstrate these actions at Technical Inspection

T5 INDICATORS AND LIGHTINGS

T5.1 Brake Light

T5.1.1 The vehicle must have a Brake Light that is clearly visible from the rear in very bright sunlight.

T5.1.2 The Brake Light must be:

a) Red in color on a Black background
b) Rectangular, triangular or near round shape with a minimum shining surface of 15 cm^2
c) Mounted between the wheel centerline and driver's shoulder level vertically and approximately on vehicle centerline laterally.

T5.1.3 When LED lights are used without a diffuser, they must not be more than 20 mm apart.

T5.1.4 If a single line of LEDs is used, the minimum length is 150 mm.

T5.2 Voltage Indicator

T5.2.1 Each Tractive Battery Pack must have a prominent indicator when High Voltage EV1.1.1 is present at the vehicle side of the Isolation Relays EV4.6.

T5.2.2 The Voltage Indicator must always function, including when the Tractive Battery Pack is disconnected or removed.

T5.2.3 The voltage present at the vehicle side of the Isolation Relays must directly control and power the Voltage Indicator using hard wired electronics with no software control.

T5.2.4 The control signal which closes the Isolation Relays EV4.6 must not control the Voltage Indicator

T5.2.4 The Voltage Indicator must:

a) Be located where it is clearly visible when connecting/disconnecting the Tractive Battery Pack connections
b) Be labeled “High Voltage Present”

T5.3 Ready to Move Light (RTML)

T5.3.1 The vehicle must have two Ready to Move Lights:

a) One pointed forward
b) One pointed aft

T5.3.2 Each Ready to Move Light must be:

a) A Marker Light that complies with DOT FMVSS 108
b) Color: Amber
c) Luminous area: minimum 1800 mm^2

T5.3.3 Mounting location of each Ready to Move Light must:

a) Be near the Main Hoop near the highest point of the vehicle
b) Be inside the Rollover Protection Envelope **F1.1.14**
c) Be no lower than 150 mm from the highest point of the Main Hoop
d) Not let the driver’s helmet touch it
e) Be visible from 1300 mm vertically from ground level, inside a 2000 mm horizontal radius from the light

T5.3.4 Visibility is checked with Bodywork and Aerodynamic Devices in place.

T5.3.5 Ready to Move Light must:

a) Be powered by the GLV system
b) Be directly controlled by the voltage present in the Tractive System using hard wired electronics. Software control is not permitted.
c) Flash with a frequency between 2 Hz and 5 Hz with 50% duty cycle when the voltage outside the Tractive Battery Container(s) exceeds **EV1.1.1**
d) Not do any other functions

T5.4 Tractive System Status Indicator (TSSI)

T5.4.1 The vehicle must have a Tractive System Status Indicator

T5.4.2 The Tractive System Status Indicator must have two different lights:

a) One Green light
b) One Red light

T5.4.3 Each of the Tractive System Status Indicator Lights:

a) Must have a minimum luminous area of 130 mm^2
b) Must be visible in direct sunlight
c) May have one or more of the same elements

T5.4.4 Mounting location of the Tractive System Status Indicator must be:

a) Near the Main Hoop at the highest point of the vehicle
b) Above the Ready to Move Light
c) In the Rollover Protection Envelope F.1.14
d) No lower than 150 mm from the highest point of the Main Hoop
e) Not able to let the driver's helmet touch it
f) Easily visible from the front of the vehicle

T5.4.5 The Tractive System Status Indicator must show when the GLV System is energized:

Condition	Green Light	Red Light
No Fault	Always ON	OFF
Fault in one or the two: • BMS • IMD	OFF	Flash 2 Hz to 5 Hz, 50% Duty Cycle

T5.5 Battery Management System (BMS) Indicator Light

T5.5.1 The BMS Indicator Light will light up when detecting one or more of the conditions:

a) Voltage values outside the permitted range
b) Voltage sense Overcurrent Protection device(s) blown or tripped
c) Temperature values outside the permitted range
d) Missing or interrupted voltage or temperature measurements
e) A fault in the BMS

T5.5.2 The BMS Indicator Light must be:

a) Color: Red
b) Located at the driver's cockpit
c) Clearly visible to the seated driver in bright sunlight
d) Clearly marked with the lettering "BMS"

T5.6 Insulation Monitoring Device (IMD) Indicator Light

T5.6.1 The IMD Indicator Light will light up when detecting one or more of the conditions:

a) An isolation failure
b) A failure in the IMD operation

T5.6.2 The IMD Indicator Light must be:

a) Color: Red
b) Located at the driver's cockpit
c) Clearly visible to the seated driver in bright sunlight
d) Clearly marked with the lettering "IMD"

T5.7 Ready to Drive Sound

T5.7.1 The vehicle must make a characteristic sound when it is Ready to Drive

T5.7.2 The Ready to Drive Sound must be:

a) Sounded continuously for minimum 1 second and maximum 3 seconds
b) A minimum sound level of 80 dBA, fast weighting IN.10.3
c) Easily recognizable. No animal voices, song parts or sounds that could be interpreted as offensive will be accepted

T5.5.3 The vehicle must not make other sounds similar to the Ready to Drive Sound.

T6 TRACTIVE BATTERY CONTAINER

T6.1 General Requirements

T6.1.1 All devices which store the tractive system energy must be enclosed in (an) Tractive Battery container(s).

T6.1.2 All Tractive Battery Containers must be:

a) Designed to withstand forces from deceleration in all directions
b) Made from a Nonflammable Material (F1.1.19)
c) Lie inside the Primary Structure (F1.1.11)

T6.1.3 Design of the Tractive Battery Container must be documented in the SES Documentation includes materials used, drawings/images, fastener locations, Cell/Module weight and Cell/Module position.

T6.1.4 The Tractive Battery Container and mounting systems are subject to approval during SES review and Technical Inspection.

T6.1.5 Tractive Battery Container must

a) be removable from the vehicle while still remaining rules compliant.
b) Be completely closed at all times (when mounted to the vehicle and when removed from the vehicle) without the need to install extra protective covers

T6.1.6 If the Tractive Battery Container is not constructed from steel or aluminum, the material properties should be established at a temperature of 60°C.

T6.1.7 If adhesives are used for credited bonding, the bond properties should be established for a temperature of 60°C.

T6.1.8 Open ended pop rivets must not be used in the Tractive Battery Container.

T6.1.9 If the Tractive Battery Container is made from electrically conductive material:

a) The poles of the Modules(s) and/or Cells must be isolated from the inner wall of the Tractive Battery Container with an insulating material that is rated for the maximum Tractive System voltage
b) All conductive surfaces on the outside of the Tractive Battery Container must have a low resistance connection to the GLV System Ground, see **EV5.8**
c) Any conductive penetrations, such as mounting hardware, must be protected against puncturing the insulating barrier

T6.1.10 Each Module must be electrically insulated with suitable Nonflammable Material (F.1.18) (not air) for the two:

a) Between the Modules in the Tractive Battery Container
b) On top of the Module

T6.2 Structure

T6.2.1 The Floor or Bottom must be made from one of the three:

a) Steel 1.25 mm minimum thickness
b) Aluminum 3.2 mm minimum thickness
c) Equivalent Alternate / Composite materials (**F3.4**, **F3.5**)

T6.2.2 All Walls (Internal and External), Covers and Lids must be made from one of the three:

a) Steel 0.9 mm minimum thickness
b) Aluminum 2.3 mm minimum thickness
c) Equivalent Alternate / Composite materials (F3.4, F3.5)

T6.2.3 Internal Vertical Walls:

a) Must surround and fully enclosed in its own six-sided box
b) Separate each Module EV.5.1.1
c) Must have minimum height of the full height of the Module. The Internal Walls should extend to the lid above any Module
d) Must surround no more than 12 kg on each side

T6.2.4 If Modules are arranged vertically above other Modules, each layer of Modules must have a load path to the Chassis attachments that does not pass through another layer of Modules.

T6.2.5 Floors and all Wall (Internal and External) sections must be joined on each side. The accepted methods of joining Walls to Walls and Walls to Floor are:

a) Welding
    i. Welds may be continuous or interrupted.
    ii. If interrupted, the weld/space ratio must be 1:1 or higher
    iii. All weld lengths must be more than 25 mm
b) Fasteners
    i. Combined strength of the fasteners must be Equivalent to the strength of the welded joint (F6.2.5.a above)
c) Bonding
    i. Bonding must meet F3.12
    ii. Strength of the bonded joint must be Equivalent to the strength of the welded joint (F6.2.5.a above)
    iii. Bonds must run the entire length of the joint

T6.2.6 Folding or bending plate material to create flanges or to eliminate joints between walls is recommended.

T6.2.7 Covers and Lids must be mechanically attached and include Critical Fasteners, see T10.2.

T6.3 Cells and Modules

T6.3.1 The structure of the Modules (without the structure of the Tractive Battery Container and without the structure of the Cells) must prevent Cells from being crushed in any direction under the following accelerations:

a) 40 g in the longitudinal direction (forward/aft)
b) 40 g in the lateral direction (left/right)
c) 20 g in the vertical direction (up/down)

T6.3.2 Modules must be held by attachments to the Tractive Battery Container must show they can support the acceleration loads **F6.3.1 above** in the direction of removal.

T6.3.3 Module attachments must include **Positive Locking Mechanisms, T10.3**.

T6.4 Holes and Openings

F6.4.1 The Tractive Battery Container(s) exterior or interior walls may contain holes or openings, only for:

a) wiring harness
b) ventilation
c) cooling
d) fasteners

F6.4.2 Any Holes and Openings must be the minimum area necessary.

F6.4.3 Exterior and interior walls must cover a minimum of 75% of each face of the Modules.

F6.4.4 Holes and Openings:

a) Must be round. Slots are prohibited
b) Should be maximum 10 mm diameter
c) Must not have line of sight to the driver, with the Firewall installed or removed

F6.5 Pressure Relief Valve

F6.5.1 Any Tractive Battery Container that may vent an explosive gas must have a ventilation system or pressure relief valve to release the vented gas.

F6.5.2 Modules sealed in Tractive Battery Containers must have a path to a pressure relief valve.

F6.5.3 Pressure relief valves must not have line of sight to the driver, with the Firewall installed or removed.

F6.6 Attachment

F6.6.1 Attachment of the Tractive Battery Container must be documented in the SES

F6.6.2 Tractive Battery Containers must:

a) Attach to the Major Structure of the chassis
b) Use a maximum of two attachment points on a chassis tube between two triangulated nodes
c) Not attach to the
    i. Shoulder Harness Mounting Bar,
    ii. Shoulder Harness Mounting Braces,
    iii. Main Hoop Braces
    iv. Main Hoop above other tube nodes
    v. composite attachments

F6.6.3 Any fasteners used to attach Tractive Battery Container(s) are **Critical Fasteners, see T10.2**

F6.6.4 Each fastened attachment point to a composite Tractive Battery Container requires backing plates that are one of the two:

a) Steel with a thickness of 2 mm minimum
b) Alternate materials Equivalent to 2 mm thickness steel

F6.6.5 Teams must justify the Tractive Battery Container attachment using one of the two methods:

a) Corner Attachments and Analysis per **F6.6.6** and **F6.6.8**
b) Load Based Analysis per **F6.6.7** and **F6.6.8**

F6.6.6 Tractive Battery Pack Attachment – Corner Attachments

a) Eight or more attachments are required for any configuration
    i. One attachment for each corner of a rectangular structure of multiple Modules
    ii. More than the minimum number of fasteners may be required for non rectangular arrangements. Examples: If not filled in with additional structure, an extruded L shape would require attachments at 10 convex

corners (the corners at the inside of the L are not convex); an extruded hexagon would require 12 attachments

b) The mechanical connections at each corner must be 50 mm or less from the corner of the Module

c) Each attachment point must be able to withstand a Test Load equal to 1/4 of total mass of the Tractive Battery Pack accelerating at 40 g

F6.6.7 Tractive Battery Pack Attachment – Load Based

a) The minimum number of attachment points depends on the total mass of the Pack:

Table 5: Minimum number of Attachment Point based on Tractive Battery Pack Weight.

Pack Weight	Minimum Attachment Point
< 20 kg	4
20 – 30 kg	6
30 – 40 kg	8
> 40 kg	10

b) Each attachment point, including any brackets, backing plates and inserts, must be able to withstand 15 kN minimum in any direction

F6.6.8 Tractive Battery Pack Attachment – All Types

a) Each fastener must withstand the Test Load in pure shear, using the minor diameter if any threads are in shear

b) Each Tractive Battery Container bracket, chassis bracket, or monocoque attachment point must withstand the Test Load in bending, in pure tearout, pure pullout, pure weld shear if welded, and pure bond shear and pure bond tensile if bonded

c) Monocoque attachment points must meet F5.8.7

d) Fasteners must be spaced minimum 50 mm apart to be counted as separate attachment points

T7 POWERTRAIN

T7.1 Drivetrain Shields and Guards

T7.1.1 Exposed high speed final drivetrain equipment such as Continuously Variable Transmissions (CVTs), sprockets, gears, pulleys, torque converters, clutches, belt drives, clutch drives and electric motors, must be fitted with scatter shields to contain drivetrain parts during radial failure

T7.1.2 The final drivetrain shield must:

a) Be made with solid material (not perforated)
b) Cover the chain or belt from the drive sprocket to the driven sprocket/chain wheel/belt or pulley
c) Start and end no higher than parallel to the lowest point of the chain wheel/belt/pulley as in Figure 31.

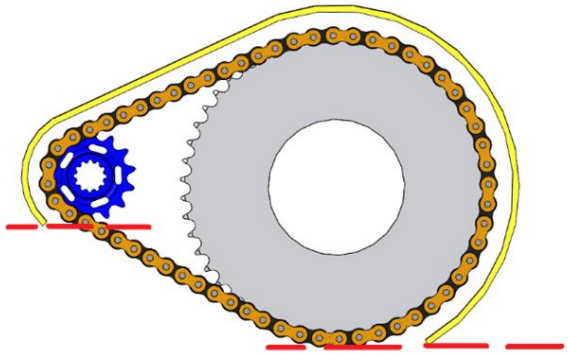


Figure 31: Final Drive Scatter Shield Example.

d) Cover the bottom of the chain or belt or rotating component when fuel, brake lines T3.1.7, control, pressurized, electrical components are located below

T7.1.3 Body panels or other existing covers are acceptable when constructed per T7.1.7/ T7.1.8

T7.1.4 Frame Members or existing components that exceed the scatter shield material requirements may be used as part of the shield.

T7.1.5 Scatter shields may have multiple pieces. Any gaps must be small (< 3 mm)

T7.1.6 If equipped, the engine drive sprocket cover may be used as part of the scatter shield system.

T7.1.7 Chain Drive - Scatter shields for chains must:

a) Be made of 3.0 mm minimum thickness steel (no alternatives are permitted)
b) Have a minimum width equal to three times the width of the chain
c) Be centered on the center line of the chain
d) Stay aligned with the chain under all conditions

T7.1.8 Non-metallic Belt Drive - Scatter shields for belts must:

a) Be made from 3.0 mm minimum thickness aluminum alloy
b) Have a minimum width that is equal to 1.7 times the width of the belt.
c) Be centered on the center line of the belt
d) Stay aligned with the belt under all conditions

T7.1.9 Attachment Fasteners - All fasteners attaching scatter shields and guards must be 6 mm or 1/4" minimum diameter **Critical Fasteners, see T10.2**.

T7.1.10 A Scatter Shield must be included around the Motor(s) when one or the two:

a) The motor casing rotates around the stator
b) The motor case is perforated

T7.1.11 The Motor Scatter Shield must be:

a) Made from aluminum alloy or steel
b) Minimum thickness: 1.0 mm

T7.1.12 Finger Guards

a) Must cover any drivetrain parts that spin while the vehicle is stationary with the engine running.
b) Must be made of material sufficient to resist finger forces.
c) Mesh or perforated material may be used but must prevent the passage of a 12 mm diameter object through the guard.

T7.2 Coolant Fluid

T7.2.1 Water cooled engines must use only plain water with no additives of any kind.

T7.2.2 Liquid coolant for electric motors, Tractive Battery(s) or HV electronics must be one of:

a) plain water with no additives
b) oil

T7.2.3 Liquid coolant must not directly touch the cells in the Tractive Battery.

T7.3 System Sealing

T7.3.1 Any cooling or lubrication system must be sealed to prevent leakage.

T7.3.2 The vehicle must be capable of being tilted to a 45° angle without leaking fluid of any type.

T7.3.3 Flammable liquid and vapors or other leaks must not collect or contact the driver.

T7.3.4 Absorbent material and open collection devices (regardless of material) are prohibited in compartments containing engine, drivetrain, exhaust and fuel systems below the highest point on the exhaust system.

T7.4 Catch Cans

T7.4.1 The vehicle must have separate containers (catch cans) to retain fluids from any vents from the powertrain systems.

T7.4.1 Catch cans must be:

a) Able to hold boiling water without deformation
b) Located rearwards of the Firewall below the driver's shoulder level
c) Positively retained, using no tie wraps or tape

T7.4.1 Catch cans for the engine coolant system and engine lubrication system must have a minimum capacity of 10% of the fluid being contained or 0.9 liter, whichever is higher

T7.4.1 Catch cans for any vent on other systems containing liquid lubricant or coolant, including a differential, gearbox, or electric motor, must have a minimum capacity of 10% of the fluid being contained or 0.5 liter, whichever is higher.

T7.4.1 Any catch can on the cooling system must vent through a hose with a minimum internal diameter of 3 mm down to the bottom levels of the Chassis.

T8 COMPRESSED GAS SYSTEM AND HIGH PRESSURE HYDRAULIC SYSTEM

T8.1 Definitions

T8.1.1 Compressed Gas System (CGS) – any system that uses a compressed gas as an actuating medium, except for gas springs.

T8.1.2 High Pressure Hydraulic System (HPHS) – any system that uses a non-compressible fluid that is pressurized at 2100 kPa or higher as an actuating medium. Any part of the brake system, see T3, is not considered HPHS.

T8.2 General requirements

T8.2.1 All parts of any CGS or HPHS must be designed for the maximum possible operating pressure.

T8.2.2 All parts of any CGS or HPHS and their mountings must be located within the rollover protection envelope, see F1.1.14, and must be protected from collision or damage.

T8.2.3 Any shielding required for any CGS or HPHS must be steel or aluminium with a minimum thickness of 1 mm.

T8.3 Compressed Gas Systems (CGS)

T8.3.1 The working gas of any CGS must be air or pure nitrogen (N2).

T8.3.2 The maximum possible operating pressure inside any CGS must not exceed 10 bar. Gas cylinders/tanks may exceed this limit, if a (series connection of) pressure regulator(s) which limit(s) the output pressure to a maximum of 10 bar is mounted directly onto them.

T8.3.3 Gas cylinders/tanks and the pressure regulators mounted directly onto them must be of proprietary manufactureand labeled with p, DOT, TC or equivalent certification. The purchase date of any gas cylinder/tank must be within the last five years.

T8.3.4 The maximum possible operating pressure of any CGS must be limited by means of a pressure relief valve. The relief pressure threshold of the valve must be non-adjustable.

T8.3.5 Gas cylinders/tanks must be mounted according to F3.13.1 and their axis must not point at the driver.

T8.3.6 The driver must be shielded, see T8.2.3, from any gas cylinders/tanks and their pressure regulators.

T8.3.7 Gas cylinders/tanks must be insulated from any heat sources.

T8.4 High Pressure Hydraulic Systems (HPHS)

T8.4.1 The driver and anyone standing outside the vehicle must be shielded, see T8.2.3, from all parts of any HPHS.

T9 BODYWORK AND AERODYNAMIC DEVICES

T9.1 Aerodynamic Devices

T9.1.1 Aerodynamic Device – A part on the vehicle which guides airflow for purposes including generation of downforce and/or change of drag. Examples include but are not limited to: wings, undertray, splitter, endplates, vanes

T9.1.2 No power device may be used to move or remove air from under the vehicle. Power ground effects are strictly prohibited.

T9.1.3 All Aerodynamic Devices must meet:

a) The mounting system provides sufficient rigidity in the static condition
b) The Aerodynamic Devices do not oscillate or move excessively when the vehicle is moving.

T9.1.4 All forward facing edges that could contact a pedestrian (wings, end plates, and undertrays) must have a minimum radius:

a) 5 mm for all horizontal edges
b) 3 mm for vertical edges.

T9.1.5 This may be the radius of the edges themselves, or additional permanently attached pieces designed to meet this requirement.

T9.1.6 Other edges that a person may touch must not be sharp.

T9.2 Bodywork

T9.2.1 Bodywork, a nose cone, or another component mounted to the vehicle is an Aerodynamic Device if is designed to, or may possibly, produce force due to aerodynamic effects.

T9.2.2 Bodywork must not contain openings into the cockpit from the front of the vehicle back to the Main Hoop or Firewall.

T9.2.3 The cockpit opening and minimal openings around the front suspension components are permitted.

T9.2.4 All forward facing edges on the Bodywork that could contact people, including the nose, must have forward facing radii minimum 38 mm. This minimum radius must extend 45° or more relative to the forward direction, along the top, sides and bottom of all affected edges.

T9.2.5 Front Wing and Bodywork Attachment in front of AIP:

a) The front wing and front wing mounts must be able to move completely aft of the Anti Intrusion Plate and not touch the front bulkhead during a frontal impact
b) The attachment points for the front wing and bodywork mounts should be aft of the Anti Intrusion Plate

c) Tabs for wing and bodywork attachment must not extend more than 25 mm forward of the Anti Intrusion Plate

T9.3 Measurement

T9.3.1 All Aerodynamic Device limitations are measured:

a) With the wheels pointing in the straight ahead position
b) Without a driver in the vehicle

T9.3.2 Any part of any Aerodynamic Device or Bodywork must meet

a) Open wheel, see **V1.2**
b) Ground Clearance, see **V1.5**

T9.3.3 Head Restraint Plane – A transverse vertical plane through the rearmost portion of the front face of the driver head restraint support, excluding any padding, set (if adjustable) in its fully rearward position

T9.3.4 Rear Aerodynamic Zone - The volume that is:

a) Rearward of the Head Restraint Plane
b) Inboard of two vertical planes parallel to the centerline of the chassis touching the inside of the rear tires at the height of the hub centerline

T9.4 Length

T9.4.1 In plan view, any part of any Aerodynamic Device must be:

a) No more than 700 mm forward of the fronts of the front tires
b) No more than 250 mm rearward of the rear of the rear tires

T9.5 Width

T9.5.1 All aerodynamic devices lower than 500mm from the ground and further rearward than the front axle, must not be wider than a vertical plane touching the most outboard point of the front and rear wheel/tyre.

T9.5.2 All aerodynamic devices higher than 500mm from the ground, must not extend outboard of the most inboard point of the rear wheel/tyre.

T9.6 Height

T9.6.1 Any part of any Aerodynamic Device that is located:

a) In the Rear Aerodynamic Zone must be no higher than 1200 mm above the ground

b) Outside of the Rear Aerodynamic Zone must be no higher than 500 mm above the ground

c) Forward of the centerline of the front wheel axles and outboard of two vertical planes parallel to the centerline of the chassis touching the inside of the front tires at the height of the hubs must be no higher than 250 mm above the ground

T9.6.1 Bodywork height is not restricted when the Bodywork is located:

a) Between the transverse vertical planes positioned at the front and rear axle centerlines

b) Inside two vertical fore and aft planes 400 mm outboard from the centerline on each side of the vehicle

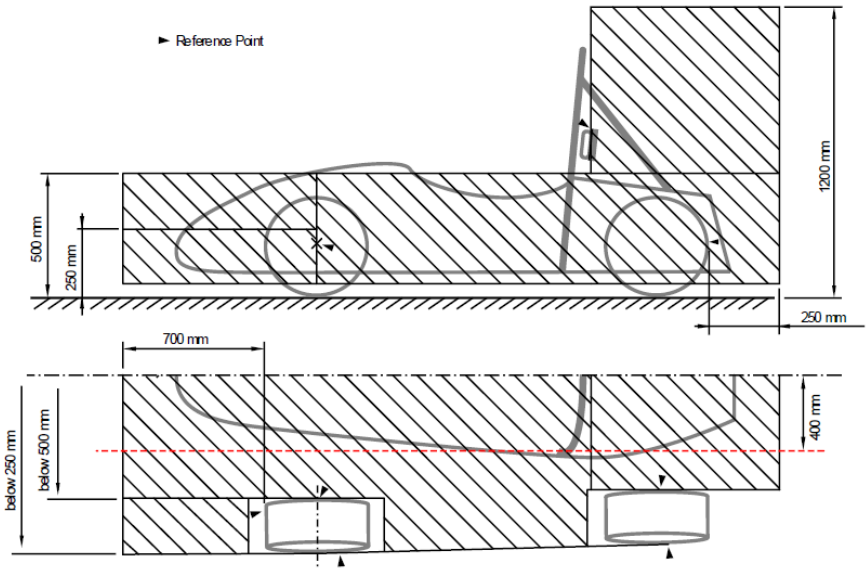


Figure 32: Maximum dimensions and positioning of aerodynamic devices.

T10 FASTENERS

T10.1 Critical Fasteners

T10.1.1 A fastener (bolt, screw, pin, etc) used in a location specified in the applicable rule.

T10.2 Critical Fastener Requirements

T10.2.1 Any Critical Fastener must meet, at minimum, one of these:

a) SAE Grade 5

b) Metric Class 8.8

c) AN/MS Specifications
d) Equivalent to or better than above, as approved by a Rules Question or at Technical Inspection

T10.2.2 All threaded Critical Fasteners must be one of the two:

a) Hex head
b) Hexagonal recessed drive with cap head (Socket Head Cap Screws or Allen screws/bolts)

T10.2.3 Critical Fasteners must not be countersunk types.

T10.2.4 All Critical Fasteners must be secured from unintentional loosening with Positive Locking Mechanisms see **T10.3**

T10.2.5 A minimum of two full threads must project from any lock nut.

T10.2.6 Some Critical Fastener applications have additional requirements that are provided in the applicable section

T10.3 Positive Locking Mechanisms

T10.3.1 Positive Locking Mechanisms are defined as those which:

a) Technical Inspectors / team members can see that the device/system is in place (visible)
b) Do not rely on the clamping force to apply the locking or anti vibration feature. Meaning If the fastener begins to loosen, the locking device still prevents the fastener coming completely loose

T10.3.2 Examples of acceptable Positive Locking Mechanisms include, but are not limited to:

a) Correctly installed safety wiring
b) Cotter pins
c) Nylon lock nuts (where temperature does not exceed 80°C)
d) Prevailing torque lock nuts

Figure 33: Examples of positive locking nuts.

T10.3.3 Lock washers, bolts with nylon patches and thread locking compounds (Loctite®), DO NOT meet the positive locking requirement.

T10.3.4 A latch requires an additional Positive Locking Mechanism

T10.3.5 If the Positive Locking Mechanism is by prevailing torque lock nuts:

a) Locking fasteners must be in as new condition
b) A supply of replacement fasteners must be presented in Technical Inspection, including any attachment method

T10.4 Requirements for All Fasteners

T10.4.1 Adjustable tie rod ends must be constrained with a jam nut to prevent loosening.

PART VE – Vehicle and Equipment

VE1 VEHICLE IDENTIFICATION

VE1.1 Vehicle Number

VE1.1.1 Each vehicle will be assigned a number at the time of its entry into an event.

VE1.1.2 The assigned vehicle number must appear on the vehicle as follows:

a) Locations: in three places, on the front of the chassis and the left and right sides
b) Height: 150 mm minimum
c) Font: Block numbers (sans serif characters without italic, outline, shadow, or cursive numbers)
d) Stroke Width and Spacing between numbers: 18 mm minimum
e) Color: White numbers on a black background OR black numbers on a white background
f) Background: round, oval, square or rectangular
g) Spacing: 25 mm minimum between the edge of the numbers and the edge of the background
h) The numbers must not be obscured by parts of the vehicle

VE1.1.3 Additional letters or numerals must not show before or after the vehicle number

VE1.2 School Name

VE1.2.1 Each vehicle must clearly display the school name.

a) Abbreviations are permitted if unique and generally recognized
b) The name must be in Roman characters minimum 50 mm high on the left and right sides of the vehicle.
c) The characters must be put on a high contrast background in an easily visible location
d) The school name may also appear in non Roman characters, but the Roman character version must be uppermost on the sides.

VE1.3 Perodua, MARii & SAE Malaysia Logos

VE1.3.1 Perodua, MARii & SAE Malaysia logos must be prominently displayed on:

a) Front end of the nose of the vehicle
b) Both sides within the top third of the side panels

VE1.3.2 The event decals are available for download on our website:

a) Perodua, 8 cm x 11.6 cm
b) MARii, 8 cm x 19.2 cm
c) SAE Malaysia, 8 cm x 9.6 cm

VE1.4 Inspection Sticker

VE1.4.1 The vehicle must have space for the Inspection Sticker(s) IN1.3 that is:

a) A clear and unobstructed area, minimum 25 cm wide x 20 cm high
b) Located on the upper front surface of the nose along the vehicle centerline

VE2 VEHICLE EQUIPMENT

VE2.1 Timing Equipment

VE2.1.1 All vehicles will get timing equipment provided by the event organizers.

VE2.2 Push Bar

VE2.2.1 Each vehicle must have a removable device which attaches to the rear of the vehicle that:

a) Lets two people, standing erect behind the vehicle, to push the vehicle around the competition site
b) Is capable of slowing and stopping the forward motion of the vehicle and pulling it rearwards

VE2.3 Fire Extinguisher

VE2.3.1 Each team must have two or more fire extinguishers.

a) One extinguisher must readily be available in the team's paddock area
b) One extinguisher must accompany the vehicle when moved using the Push Bar

VE2.3.2 Hand held fire extinguishers must NOT be mounted on or in the vehicle

VE2.3.3 Each fire extinguisher must meet these:

a) Capacity: 0.9 kg (2 lbs)
b) Working Medium: Dry chemical/dry powder. Aqueous Film Forming Foam (AFFF) and Halon extinguishers and systems are prohibited.
c) Equipped with a manufacturer installed pressure/charge gauge.
d) Minimum acceptable ratings:
    i. USA, Canada & Brazil: 10BC or 1A 10BC

ii. Europe: 34B or 5A 34B
iii. Australia: 20BE or 1A 10BE

e) Extinguishers of larger capacity (higher numerical ratings) are acceptable.

VE2.4 Electrical Equipment (EV Only)

VE2.4.1 These items must accompany the vehicle at all times:

a) Two pairs of High Voltage insulating gloves
b) Two 4 mm banana test lead with A multimeter CATIII rating

VE2.5 Camera Mounts

VE2.5.1 The mounts for video/photographic cameras must be of a safe and secure design.

VE2.5.2 All camera installations must be approved at Technical Inspection.

VE2.5.3 Helmet mounted cameras and helmet camera mounts are prohibited.

VE2.5.4 The body of a camera or recording unit that weighs more than 0.25 kg must be secured at a minimum of two points on different sides of the camera body.

VE2.5.5 If a tether is used to restrain the camera, the tether length must be limited to prevent contact with the driver.

VE3 DRIVER EQUIPMENT

VE3.1 General

VE3.1.1 Any Driver Equipment:

a) Must be in good condition with no tears, rips, open seams, areas of significant wear, abrasions or stains which might compromise performance.
b) May be inspected at any time

VE3.1.2 Flame Resistant Material

VE3.1.3 Synthetic Material – Prohibited. Shirts, socks or other undergarments (not to be confused with flame resistant underwear) made from nylon or any other synthetic material which could melt when exposed to high heat are prohibited.

VE3.2 Helmet

VE3.2.1 The driver must wear a helmet which:

a) Is closed face with an integral, immovable chin guard

b) Contains an integrated visor/face shield supplied with the helmet
c) Meets an approved standard
d) Is properly labeled for that standard

VE3.2.3 Acceptable helmet standards are listed below:

a) Snell: K2015, K2020, M2015, M2020D, M2020R, M2025D, M2025R, SA2015, SA2020, SA2025
b) SFI Specs: 31.1/2015, 41.1/2015
c) FIA Standards: FIA 8860-2010 (or newer), FIA 8859-2015 (or newer)

VE3.3 Frontal Head Restraint systems (FHR)

VE3.3.1 If FHR are used, they must be certified to one of the following standards and be labeled as such:

a) FIA 8858-2010
b) FIA 8860-2004
c) SFI 38.1

VE3.3.2 FHR and shoulder harnesses must be properly adjusted as per the manufacturer's recommendations.

VE3.3.3 Any driver using an FHR must wear the FHR during their driver egress test.

VE3.4 Driver Suit

VE3.4.1 A one piece suit, made from a minimum of two layers of Flame Resistant Material that covers the body from the neck to the ankles and the wrists.

VE3.4.2 Each suit must meet one or more of these standards and be labeled as such:

a) SFI 3.2A/5 (or higher ex: /10, /15, /20)
b) SFI 3.4/5 (or higher ex: /10, /15, /20)
c) FIA Standard 1986
d) FIA Standard 8856-2000
e) FIA Standard 8856-2018

VE3.5 Other Driving Gear

VE3.5.1 Underclothing – All competitors should wear fire retardant underwear (long pants and long sleeve shirt) under their approved Driver Suit.

VE3.5.1 Balaclava – A Balaclava (head sock) which covers the driver's head, hair and neck, made from Flame Resistant Material

VE3.5.1 Socks – Socks made from Flame Resistant Material that cover the bare skin between the driver's suit and the Shoes.

VE3.5.1 Shoes – Shoes or boots made from Flame Resistant Material that meet an approved standard and labeled as such:

a) SFI Spec 3.3
b) FIA Standard 8856-2000
c) FIA Standard 8856-2018

VE3.5.1 Gloves – Gloves made from Flame Resistant Material. Gloves of all leather construction or fire retardant gloves constructed using leather palms with no insulating Flame Resistant Material underneath are not acceptable.

VE3.5. Arm Restraints

a) must be worn in a way that the driver can release them and exit the vehicle unassisted regardless of the vehicle's position.
b) must be commercially manufactured. Arm restraints certified to SFI Spec 3.3 and labeled as such meet this requirement.

PART EV – Electric Vehicle System

EV1 DEFINITIONS

EV1.1 Electrical

EV1.1.1 High Voltage (HV) – Any voltage more than 60 V DC or 25 V AC RMS.

EV1.1.2 Low Voltage (LV) – Any voltage less than and including 60 V DC or 25 V AC RMS.

EV1.1.3 Normally Open – A type of electrical relay or contactor that lets current flow only in the energized state.

EV1.1.4 High Current Path – any path of a TS circuitry that, during normal operation, carries more than 1 A.

EV1.1.5 Grounded Low Voltage (GLV) – Every electrical part that is not part of the Tractive System.

EV1.1.6 Galvanic Isolation – two electric circuits are defined as galvanically isolated if all of the following conditions are true:

a) The resistance between both circuits is ≥500 Ω/V, related to the maximum TS voltage of the vehicle, at a test voltage of maximum TS voltage or 250V, whichever is higher.
b) The isolation test voltage RMS, AC for 1 min, between both circuits is higher than three times the maximum TS voltage or 750 V, whichever is higher.
c) The working voltage of the isolation barrier, if specified in the datasheet, is higher than the maximum TS voltage.

EV.1.2 Tractive Systems (TS)

EV1.2.1 Tractive System (TS) – Every part electrically connected to the Motor(s) and/or Tractive Battery(s). The Tractive System is always High Voltage, more than 60 V.

EV1.2.2 Cell – Electrochemical energy storage unit consisting of a positive electrode, negative electrode, and an electrolyte

EV1.2.3 Module – A single unit containing a set of electrically connected and mechanically assembled Cells

EV1.2.4 Tractive Battery – A group of electrically connected Modules that is the storage device of electrical energy for the Tractive System

EV1.2.5 Tractive Battery Container – The enclosure and mechanical supports used to contain, mount and protect the Tractive Battery and components in the Container

EV1.2.6 Tractive Battery Pack – The assembly of the Tractive Battery Container and components in the Container (Tractive Battery, Isolation Relays, Precharge and Discharge Circuits, and Fuses)

EV1.2.7 Accumulator capacity:

a) Energy (Wh) = Number of Cells x Vnom x Cell Capacity (Inom in AH) x 80%
b) Energy (MJ) = Number of Cells x Vnom x Cell Capacity (Inom in AH) x 0.0036.

EV1.2.8 OK to Energize – Vehicle may be Tractive System Active in the Paddock **A7.7.1** or in the Dynamic Area **D1.2.1**

EV2 TRACTIVE SYSTEM (TS) LIMITATIONS

EV2.1 Operation

EV2.1 (HEV Class Only) The Internal Combustion Engine (ICE) shall not be mechanically connected to the drive wheels, differential, transmission output shaft, or any component capable of transmitting torque to the wheels (**HY1.1**).

EV2.2 Supplying power to the motor(s) such that the car is driven in reverse is prohibited.

EV2.2 Power and Voltage

EV2.2.1 The maximum power measured by the Energy Meter (**EV2.3**) must not exceed 80 kW.

EV2.2.2 The maximum permitted voltage that may occur between any two points must not exceed:

a) (EV) EV Class 600 V
b) (HEV) Hybrid Class 480 V

EV2.2.3 Negative TS power (regenerating energy), measured by the Energy Meter, is permissible and unrestricted.

EV2.2.4 The powertrain must not regenerate energy when vehicle speed is between 0 and 5 km/hr.

EV2.2.5 The maximum current measured by the Energy Meter (EV2.3) must not exceed 500 A.

EV2.2.6 Maximum permitted battery capacity:

a) (EV) EV Class unlimited
b) (HEV) Hybrid Class 3.3 kW, see EV1.2.7

EV2.3 Energy Meter

EV2.3.1 All Electric Vehicles must run with the Energy Meter provided at the event.

EV2.3.3 The Energy Meter, connections and sensors must be installed per the Energy Meter User Manual.

EV2.3.4 All power flowing between the Accumulator and the Tractive System must pass through the Energy Meter, (HEV Class Only) with the sole exception that power transmitted from the Generator (see HY 1.4) to the Accumulator shall be exempt from this requirement.

EV2.4 Violations

EV2.4.1 The Energy Meter will monitor for the:

a) Use of more than the specified maximum power EV2.2.1
b) Exceed the maximum voltage EV2.2.2

EV2.4.2 A Violation occurs when any of EV2.4.1 happen for one or the two conditions:

a) Continuously for 100 ms or more
b) After a moving average over 500 ms is applied

EV2.4.3 Missing Energy Meter data may be treated as a Violation, subject to official discretion.

EV2.4.4 Tampering or trying to tamper with the Energy Meter or its data may result in Disqualification (DQ).

EV2.5 Penalties

EV2.5.1 Violations during the Acceleration, Skidpad, Autocross Events:

a) Each run with one or more Violations will Disqualify (DQ) the best run of the team
b) Multiple runs with Violations will DQ multiple runs, ex two runs with Violations DQ the two best runs

EV2.5.2 For each violation during the Endurance event will receive 60 second penalty.

EV2.5.3 Repeated Violations may void Inspection Approval or receive additional penalties up to and including Disqualification, subject to official discretion.

EV2.5.4 The respective data of each run in which a team has a Violation and the resulting decision may be made public.

EV3 GENERAL TRACTIVE SYSTEM

EV3.1 Motors and Motor Controllers

EV3.1.1 Only electrical motors are permitted. The number of motors is not limited.

EV3.1.2 If Motors are mounted to the suspension uprights, their cables and wiring must:

a) Include an Interlock EV6.8. This Interlock(s) must Open the Shutdown Circuit EV.7.2.2 before failure of the Tractive System wiring when the wiring is damaged or the Wheel/Motor assembly is damaged or knocked off the vehicle
b) Stay in the Primary Structure Envelope F1.1.11 between the Front Hoop and the Main Hoop
c) Reduce the length of the parts of wiring and other connections that do not meet F4.12.3 to the extent possible (no dangling cables, loops, coils, etc)

EV3.1.3 The Tractive System Motor(s) must be connected to the Tractive Battery through a Motor Controller. No direct connections between Motor(s) and Tractive Battery.

EV3.2 Grounded Low Voltage System (GLV)

EV3.2.1 The GLV System must be:

a) A Low Voltage system (EV1.1.2) that is Grounded to the Chassis
b) Able to operate with the Tractive Battery Pack removed from the vehicle

EV3.2.2 The GLV System must include a Grounded Low Voltage Master Switch (GLVMS), see EV6.9.2

EV3.2.3 GLV Measuring Point (GLVMP) must be installed which is:

a) Connected to GLV System Ground
b) Next to the TSMP EV6.9
c) 4 mm shrouded banana jack
d) Color: Black

e) Marked “GND”

EV3.2.4 Low Voltage Batteries must meet **EV3.5**

EV3.3 Tractive System Part Positioning

EV3.3.1 All parts belonging to the Tractive System must meet **F1.1.11**

EV3.4 Housings and Enclosures

EV3.4.1 Each housing or enclosure containing parts of the Tractive System other than Motor housings, must be labelled with the:

a) Symbol specified in ISO 7010-W012 (triangle with black lightning bolt on yellow background)
b) Text “High Voltage”

EV3.4.2 If the material of the housing containing parts of the Tractive System is electrically conductive, it must have a low resistance connection to GLV System Ground, see **EV3.2**

EV3.5 Low Voltage Batteries

EV3.5.1 All Low Voltage Batteries and onboard power supplies must be fully and securely mounted inside chassis structure below the height of the Shoulder Belt Mount **T.2.5.**

EV3.5.2 All Low Voltage batteries must have Overcurrent Protection that trips at or below the maximum specified discharge current of the cell batteries.

EV3.5.3 The hot (ungrounded) terminal must be insulated.

EV3.5.4 LV batteries must have overcurrent protection, not more than 100mm from ungrounded terminals, that trips at or below the maximum specified discharge current of the cells within the time periods specified on the datasheet for the battery.

EV3.5.5 Any wet cell battery located in the driver compartment must be enclosed in a nonconductive marine type container or equivalent.

EV3.5.6 Completely closed LV battery cases must have overpressure relief. Venting gases must be separated from the driver by a firewall.

EV3.5.7 Batteries or battery packs based on lithium chemistry must meet one of the two:

a) Have a rigid, sturdy casing made from Nonflammable Material

b) A commercially available battery designed as an OEM style replacement

EV3.5.8 All batteries using chemistries other than lead acid must be presented at Technical Inspection with markings identifying it for comparison to a datasheet or other documentation proving the pack and supporting electronics meet all rules requirements.

EV3.6 Tractive System Measuring Points (TSMP)

EV3.6.1 Two Tractive System Measuring Points (TSMP) must be installed in the vehicle which are:

a) Connected to the positive and negative motor controller/inverter supply lines
b) Next to the Master Switches EV6.9
c) Protected by a nonconductive housing that can be opened without tools
d) Protected from being touched with bare hands / fingers once the housing is opened

EV3.6.2 Two TSMPs must be installed in the Charger EV7.2 which are:

a) Connected to the positive and negative Charger output lines
b) Available during charging of any Tractive Battery Pack(s)

EV3.6.3 The TSMPs must be:

a) 4 mm shrouded banana jacks rated to an appropriate voltage level
b) Color: Red
c) Marked “HV+” and “HV-“

EV3.6.4 Each TSMP must be secured with a current limiting resistor

a) The resistor must be sized for the voltage:

Maximum TS Voltage (Vmax)	Resistor Value
Vmax <= 200 V DC	5 kOhm
200 V DC < Vmax <= 400 V DC	10 kOhm
400 V DC < Vmax <= 600 V DC	15 kOhm

b) Resistor continuous power rating must be more than the power dissipated across the TSMPs if they are shorted together
c) Direct measurement of the value of the resistor must be possible during Electrical Technical Inspection

EV3.6.5 Any TSMP must not contain additional Overcurrent Protection

EV4 TRACTIVE BATTERY PACK

EV4.1 Battery Cell

EV4.1.1 Below are acceptable as the Tractive Battery Pack's Cell:

a) batteries (e.g. lithium-ion, NiMH, lead acid and similar battery chemistries)
b) capacitors, such as super caps or ultracaps

EV4.1.2 Not permitted batteries or energy storage:

a) molten salt batteries
b) thermal batteries
c) fuel cells
d) mechanical storage such as flywheels or hydraulic accumulators

EV4.2 Battery Module

EV4.2.1 Tractive Battery Packs can be constructed with multiple Battery Modules.

EV4.2.2 Each Module must contain:

a) Static voltage of 120 V DC maximum
b) Energy of 6 MJ maximum, see **EV1.2.7**
c) Mass of 12 kg maximum
d) Must be separated by wall or internal wall, see **T6.2**, **T6.3**.

EV4.3 Battery Pack and Label

EV4.3.1 Each Tractive Battery Container must be labelled with the:

a) School Name and Vehicle Number
b) Symbol specified in ISO 7010-W012 (triangle with black lightning bolt on yellow background) with:
    i. Triangle side length of 100 mm minimum
    ii. Visibility from all angles, including when the lid is removed
c) Text "Always Energized"
d) Text "High Voltage"

EV4.3.2 All Tractive Battery components and/or Tractive Battery Containers (including spares and replacement parts) must be identical to the design documented in the ESF and SES.

EV5 TRACTIVE BATTERY PACK COMPONENTS

EV5.1 Maintenance Plugs

EV5.1.1 Maintenance Plugs must let electrical separation of the Modules meet the two:

a) The separated Modules meet voltage and energy limits of EV4.3.2
b) The separation must affect the two poles of the Module

EV5.1.2 Maintenance Plugs must:

a) Require the physical removal or separation of a component. Contactors or switches are not acceptable Maintenance Plugs
b) Have access after opening the Tractive Battery Container and not necessarily move or remove any other components
c) Not be physically possible to make electrical connection in any configuration other than the design intended configuration
d) Not require tools to install or remove
e) Include a positive locking feature which prevents the plug from unintentionally becoming loose
f) Be nonconductive on surfaces that do not provide any electrical connection

EV5.1.3 When the Tractive Battery Containers are opened or Modules are removed, the Modules must be separated by using the Maintenance Plugs.

EV5.2 Isolation Relays (IR)

EV5.2.1 All Tractive Battery Packs must contain two or more Isolation Relays (IR)

EV5.2.2 The Isolation Relays must:

a) Be a Normally Open type
b) Open the two poles of the Tractive Battery Pack

EV5.2.3 When the Isolation Relays are open, High Voltage EV1.1.1 must not be external of the Tractive Battery Container

EV5.2.4 The Isolation Relays must be separated from the rest of the Tractive Battery with an electrically insulated and Nonflammable Material (F.1.18)

EV5.2.5 A capacitor may be used to hold the Isolation Relays closed for up to 250 ms after the Shutdown Circuit Opens EV6.2.2

EV5.3 Manual Service Disconnect (MSD)

EV5.3.1 A Manual Service Disconnect (MSD) must be included to quickly disconnect one or the two poles of the Tractive Battery Pack.

EV5.3.2 The Manual Service Disconnect (MSD) must be:

a) A directly accessible element, fuse or connector that will visually show disconnected
b) More than 350 mm from the ground
c) Easily visible when standing behind the vehicle
d) Operable in 10 seconds or less by an untrained person
e) Operable without removing any bodywork or obstruction or using tools
f) Directly operated. Remote operation through a long handle, rope or wire is not acceptable.
g) Clearly marked with "MSD"

EV5.3.3 The Energy Meter must not be used as the Manual Service Disconnect (MSD)

EV5.3.4 An Interlock EV6.8 must Open the Shutdown Circuit when the MSD is removed.

EV5.3.5 A dummy connector or similar may be used to restore isolation to meet EV5.1.2.

EV5.4 Precharge Circuits

EV5.4.1 The Tractive Battery Pack must contain a Precharge Circuit. The Precharge Circuit must:

a) Be able to charge the Intermediate Circuit to minimum 90% of the Tractive System voltage before closing the second IR
b) Be supplied from the Shutdown Circuit EV6.1

EV5.4.2 The Intermediate Circuit must precharge before closing the second IR. The end of precharge must be controlled by feedback by monitoring the voltage in the Intermediate Circuit.

EV5.4.3 The precharge relay must be a mechanical type relay.

EV5.4.4 Positive Temperature Coefficient (PTC) devices must not be used to limit current for the Precharge Circuit.

EV5.5 Discharge Circuit

EV5.5.1 The Tractive System must contain a Discharge Circuit. The Discharge Circuit must be:

a) Wired in a way that it is always active when the Shutdown Circuit is open
b) Able to discharge the Intermediate Circuit capacitors if the MSD has been opened
c) Not be fused
d) Designed to handle the maximum Tractive System voltage for minimum 15 seconds

EV5.5.2 The Discharge Circuit is not necessarily be inside the Tractive Battery Container.

EV5.5.3 Positive Temperature Coefficient (PTC) devices must not be used to limit current for the Discharge Circuit.

EV5.6 Battery Management System (BMS)

EV5.6.1 A Battery Management System must monitor the

a) Tractive Battery Voltage **EV4.11**
b) Tractive Battery Temperature **EV4.12**

EV5.6.2 BMS must monitor both measurements when the:

a) Tractive System is Active **OP2.6**
b) Tractive Battery is connected to a Charger **EV7.3**

EV5.6.3 Cell balancing is not permitted when the Shutdown Circuit is Open (EV.7.2, EV.8.4)

EV5.6.4 The BMS must monitor for:

a) Voltage values outside the permitted range **EV4.11.3**
b) Voltage sense Overcurrent Protection device(s) blown or tripped
c) Temperature values outside the permitted range **EV4.12.2**
d) Missing or interrupted voltage or temperature measurements
e) A fault in the BMS

EV5.6.5 If the BMS detects one or more of the conditions of EV.7.3.4 above, the BMS must:

a) Open the Shutdown Circuit **EV6.2.2**
b) Turn on the BMS Indicator Light **T5.5**
c) Turn on TSSI **T5.4.5**

EV5.6.6 The BMS Indicator Light and Tractive System Status Indicator must stay on until the BMS is manually reset **T5.5.3**

EV5.7 Tractive Battery Voltage

EV5.7.1 The BMS must measure the voltage of each Cell

EV5.7.2 When single Cells are directly connected in parallel, only one voltage measurement is needed.

EV5.7.3 Cell Voltage levels must stay inside the permitted minimum and maximum cell voltage levels stated in the cell data sheet. Measurement accuracy must be considered.

EV5.7.4 All voltage sense wires to the BMS must have Overcurrent Protection that must meet the two:

a) The Overcurrent Protection must occur in the conductor, wire or PCB trace which is directly connected to the cell tab.
b) The voltage rating of the Overcurrent Protection must be equal to or higher than the maximum Module voltage

EV5.8 Tractive Battery Temperature

EV5.8.1 The BMS must measure the temperatures of critical points of the Tractive Battery.

EV5.8.2 Temperatures (considering measurement accuracy) must stay below the lower of the two:

a) The maximum cell temperature limit stated in the cell data sheet
b) 60°C

EV5.8.3 Cell temperatures must be measured at the negative terminal of the respective cell.

EV5.8.4 The temperature sensor used must be in direct contact with one of:

a) The negative terminal itself
b) he negative terminal busbar less than 10 mm away from the spot weld or clamping source on the negative cell terminal

EV5.8.5 For lithium based cells,

a) The temperature of a minimum of 20% of the cells must be monitored by the BMS
b) The monitored cells must be equally distributed inside the Tractive Battery Container(s)The temperature of each cell should be monitored

EV5.8.6 Multiple cells may be monitored with one temperature sensor, if EV4.12 is met for all cells sensed by the sensor.

EV5.8.7 Temperature sensors must have appropriate electrical isolation that meets one of the two:

a) Between the sensor and cell
b) In the sensing circuit

EV5.8.7 Temperature sensors isolation must consider GLV/TS isolation as well as common mode voltages between sense locations.

EV5.9 Insulation Monitoring Device (IMD)

EV5.9.1 The vehicle must have an Insulation Monitoring Device (IMD) installed in the Tractive System.

EV5.9.2 The response value of the IMD must be set to 500 Ohm / Volt or higher, related to the maximum Tractive System operation voltage.

EV5.9.3 The IMD must monitor the Tractive System for:

a) An isolation failure
b) A failure in the IMD operation

EV5.9.4 If the IMD detects one or more of the conditions of EV4.13.4 above the IMD must:

a) Open the Shutdown Circuit EV6.2.2
b) Turn on the IMD Indicator Light T5.6
c) Turn on TSSI T5.4.5

EV5.9.5 The IMD Indicator Light and the TSSI must stay on until the BMS is manually reset EV5.6.3

EV6 ELECTRICAL SYSTEM DESIGN

EV6.1 Electrical Configuration

EV6.1.1 All Tractive System components must be rated for the maximum Tractive System voltage.

EV6.1.2 Soldering electrical connections in the high current path is prohibited.

EV6.1.3 Each wire used in a Tractive Battery Container, whether it is part of the GLV or Tractive System, must be rated to the maximum Tractive System voltage.

EV6.2 Covers

EV6.2.1 Nonconductive material or covers must prevent inadvertent human contact with any Tractive System voltage.

EV6.2.2 Covers must be secure and sufficiently rigid.

EV6.2.3 Removable Bodywork is not suitable to enclose Tractive System connections.

EV6.2.4 Contact with any Tractive System connections with a 100 mm long, 6 mm diameter insulated test probe must not be possible when the Tractive System enclosures are in place.

EV6.2.5 Tractive System components and Tractive Battery(s) must be protected from moisture, rain or puddles. A rating of IP65 is recommended.

EV6.3 Insulations

EV6.3.1 Insulation material must:

a) Be appropriate for the expected surrounding temperatures
b) Have a minimum temperature rating of 90°C

EV6.3.2 Insulating tape or paint may be part of the insulation but must not be the only insulation.

EV6.4 Wiring

EV6.4.1 All wires and terminals and other conductors used in the Tractive System must be sized for the continuous current they will conduct.

EV6.4.2 All Tractive System wiring must:

a) Be marked with wire gauge, temperature rating and insulation voltage rating. A serial number or a norm printed on the wire is sufficient if this serial number or norm is clearly bound to the wire characteristics for example by a data sheet.
b) Have temperature rating more than or equal to 90°C

EV6.4.3 Tractive System wiring must be:

a) Done to professional standards with sufficient strain relief
b) Protected from loosening due to vibration
c) Protected against damage by rotating and / or moving parts
d) Located out of the way of possible snagging or damage

EV6.4.4 Any Tractive System wiring that runs outside of electrical enclosures:

a) Must meet one of the two:
   i. Enclosed in separate orange nonconductive conduit
   ii. Use an orange shielded cable
b) The conduit or shielded cable must be securely anchored at each end to let it withstand a force of 200 N without straining the cable end crimp
c) Any shielded cable must have the shield grounded

EV6.4.5 Wiring that is not part of the Tractive System must not use orange wiring or conduit.

EV6.5 Connections

EV6.5.1 All Tractive System connections must:

a) Be designed to use intentional current paths through conductors designed for electrical current
b) Not rely on steel bolts to be the primary conductor
c) Not include compressible material such as plastic in the stack-up

EV6.5.2 If external, uninsulated heat sinks are used, they must be properly grounded to the GLV System Ground, see **EV3.2**

EV6.5.3 Bolted electrical connections in the high current path of the Tractive System must include a positive locking feature to prevent unintentional loosening.

EV6.5.4 Lock washers or thread locking compounds (Loctite®) or adhesives are not acceptable.

EV6.5.5 Bolts with nylon patches are permitted for blind connections into OEM components.

EV6.5.6 Information about the electrical connections supporting the high current path must be available at Electrical Technical Inspection.

EV6.6 Voltage Separation

EV6.6.1 Separation of Tractive System and GLV System:

a) The entire Tractive System and GLV System must be completely galvanically separated
b) The border between Tractive System and GLV System is the galvanic isolation between the two systems.

EV6.6.2 There must be no connection between the Chassis of the vehicle (or any other conductive surface that might be inadvertently touched by a person), and any part of any Tractive System circuits.

EV6.6.3 Tractive System and GLV circuits must not be in the same conduit or connector except as permitted in in **EV6.8.1**.

EV6.6.4 GLV Systems other than the items below must not be inside the Tractive Battery Container:

a) IRs **EV4.6**,
b) parts of the Precharge **EV4.8**,
c) Discharge Circuits **EV4.9**,
d) HV DC/DC converters,
e) BMS **EV4.10**,
f) IMD **EV4.13**,
g) parts of the Ready to Move Light **T5.3**,
h) cooling fans

EV6.6.5 Where Tractive System and GLV are included inside the same enclosure, they must meet one of the two:

a) Be separated by insulating barriers (in addition to the insulation on the wire) made of moisture resistant, UL recognized or equivalent insulating materials rated for 90° C or higher (such as Nomex based electrical insulation)
b) Maintain spacing through air, or over a surface of:

Tractive Battery Pack Voltage	Minimum spacing through air
U < 100 VDC	10 mm
100 < U < 200 VDC	20 mm
U > 200 VDC	30 mm

EV6.6.6 Spacing must be clearly defined. Components and cables capable of movement must be positively restrained to maintain spacing.

EV6.6.7 If Tractive System and GLV are on the same circuit board:

a) They must be on separate, clearly defined and clearly marked areas of the board
b) Required spacing related to the spacing between traces / board areas are as follows:

Voltage	Over Surface	Through Air (cut in board)	Under Conformal Coating
0 – 50 VDC	1.6 mm	1.6 mm	1 mm
50 – 150 VDC	6.4 mm	3.2 mm	2 mm
150 – 300 VDC	9.5 mm	6.4 mm	3 mm
300 – 600 VDC	12.7 mm	9.5 mm	4 mm

EV6.6.8 Teams must be prepared to show spacing on team built equipment. For inaccessible circuitry, spare boards or appropriate photographs must be available for inspection

EV6.6.9 All connections to external devices such as laptops from a Tractive System component must include galvanic isolation

EV6.7 Overcurrent Protection

EV6.7.1 All electrical systems (LV and HV) must have appropriate Overcurrent Protection/Fusing.

EV6.7.2 Unless otherwise permitted in the Rules, all Overcurrent Protection devices must:

a) Be rated for the highest voltage in the systems they protect. Overcurrent Protection devices used for DC must be rated for DC and must carry a DC rating equal to or more than the system voltage
b) Have a continuous current rating less than or equal to the continuous current rating of any electrical component that it protects
c) Have an interrupt current rating higher than the theoretical short circuit current of the system that it protects

EV6.7.3 Each parallel element of multiple parallel battery cells, capacitors, strings of battery cells, strings of capacitors, or conductors must have individual Overcurrent Protection.

EV6.7.4 Any conductors (wires, busbars, etc) conducting the entire pack current must meet one of:

a) Be appropriately sized for the total current that the individual Overcurrent Protection devices could transmit
b) Contain additional Overcurrent Protection to protect the conductors

EV6.7.5 Battery packs with Low Voltage or non voltage rated fusible links for cell connections may be used when all three conditions are met:

a) An Overcurrent Protection device rated at less than or equal to one third the sum of the parallel fusible links and complying with EV5.7.2.b above is connected in series.
b) The BMS can detect an open fusible link and will Open the Shutdown Circuit EV6.2.2 if a fault is detected.
c) Fusible link current rating is specified in manufacturer's data or suitable test data is provided.

EV6.7.6 Cells with internal Overcurrent Protection may be used without external Overcurrent Protection if suitably rated. Most cell internal Overcurrent Protection devices are Low Voltage or non voltage rated and conditions of EV5.7.5 above will apply.

EV6.7.7 If conductor ampacity is reduced below the ampacity of the upstream Overcurrent Protection, the reduced conductor longer than 150 mm must have additional Overcurrent Protection. This additional Overcurrent Protection must be:

a) 150 mm or less from the source end of the reduced conductor
b) On the positive and the negative conductors in the Tractive System
c) On the positive conductor in the Grounded Low Voltage System

EV6.8 Grounding

EV6.8.1 Grounding is required for:

a) Parts of the vehicle which are 100 mm or less from any Tractive System component that are not separated from the Tractive System component by a Firewall T1.10.4
b) Any Firewall T1.10.4, The part itself must meet the grounding requirement if conductive tape is applied

EV6.8.2 Grounded parts of the vehicle must have a resistance to GLV System Ground less than the values specified below.

a) Electrically conductive parts 300 mOhms (measured with a current of 1 A). Examples: parts made of steel, (anodized) aluminum, any other metal parts
b) Parts which may become electrically conductive 5 Ohm. Example: carbon fiber parts Carbon fiber parts may need special measures such as using copper mesh or similar to keep the ground resistance below 5 Ohms.

EV6.8.3 Electrical conductivity of any part may be tested by checking any point which is likely to be conductive. Where no convenient conductive point is available, an area of coating may be removed.

EV7 SHUTDOWN SYSTEM

EV7.1 Shutdown Circuit

EV7.1.1 The Shutdown Circuit consists of these components, connected in series:

a) Battery Management System (BMS) **EV4.10**
b) Insulation Monitoring Device (IMD) **EV4.13**
c) Brake System Plausibility Device (BSPD) **T3.4**
d) Interlocks **EV6.8**
e) Master Switches (GLVMS, TSMS) **EV6.9**
f) Shutdown Buttons **EV6.10**
g) Brake Over Travel Switch (BOTS) **T3.2**
h) Inertia Switch **EV6.11**

EV7.1.2 The Shutdown Circuit must directly carry the current driving the Isolation Relays (IRs) and the Precharge Circuit Relay.

EV7.1.3 The BMS, IMD, and BSPD parts of the Shutdown Circuit must be Normally Open.

EV7.1.4 The BMS, IMD and BSPD must have completely independent circuits to Open the Shutdown Circuit. The design of the respective circuits must make sure that a failure cannot result in electrical power being fed back into the Shutdown Circuit.

EV7.1.5 The Shutdown Buttons, BOTS, TSMS, GLVMS and Interlocks must directly carry the Shutdown Circuit current

EV7.1.6 The team must be able to demonstrate all features and functions of the Shutdown Circuit and components at Electrical Technical Inspection.

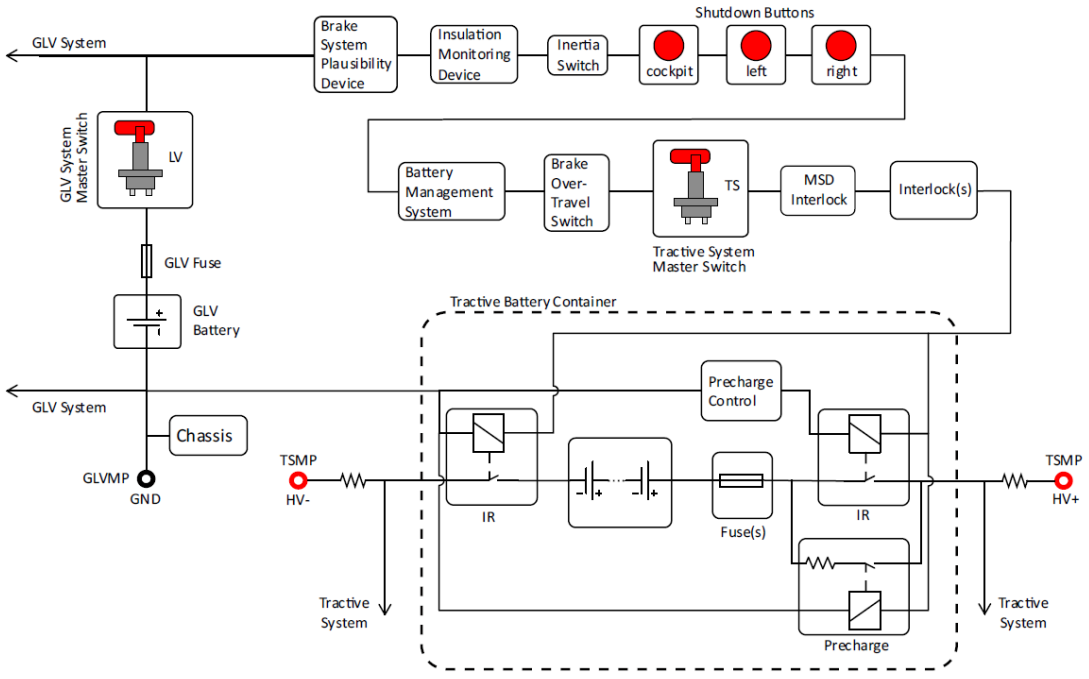


Figure 34: Shutdown Circuit for EV Class.

EV7.2 Shutdown Circuit Operation

EV7.2.1 The Shutdown Circuit must Open when any of these exist:

a) Operation of, or detection from any of the components listed in EV6.1.1
b) Any shutdown of the GLV System

EV7.2.2 When the Shutdown Circuit Opens:

a) The Tractive System must Shutdown
b) All Tractive Battery current flow must stop immediately EV4.6.3
c) The voltage in the Tractive System must be Low Voltage EV1.1.2 in five seconds or less
d) The Motor(s) must spin free. Torque must not be applied to the Motor(s)

EV7.2.3 When the BMS, IMD or BSPD Open the Shutdown Circuit:

a) The Tractive System must stay disabled until manually reset
b) The Tractive System must be reset only by manual action of a person directly at the vehicle
c) The driver must not be able to reactivate the Tractive System from inside the vehicle

d) Operation of the Shutdown Buttons or TSMS must not let the Shutdown Circuit Close

EV7.3 Interlocks

EV7.3.1 Interlocks must be incorporated where specified:

a) Tractive System connectors outside of a housing must contain an Interlock
b) If Motors are mounted to the suspension uprights, see EV3.1.2
c) MSD, see EV4.7

EV7.3.2 Additional Interlocks may be included in the Tractive System or components.

EV7.3.3 The Interlock is a wire or connection that must:

a) Open the Shutdown Circuit EV6.2.2 if the Interlock connection is broken or interrupted
b) Not be in the low (ground) connection to the IR coils of the Shutdown Circuit

EV7.3.4 Interlock circuits or connections do not require physical separation (EV5.6) from Tractive System wiring or components when the Interlock circuit is:

a) In the same wiring harness as Tractive System wiring
b) Part of a Tractive System Connector
c) Inside the Tractive Battery Container or Tractive System Enclosure less than 75 mm from the connection to a Tractive System connector

EV7.4 Master Switches

EV7.4.1 Each vehicle must have two Master Switches:

a) Grounded Low Voltage Master Switch (GLVMS), see EV6.9.5
b) Tractive System Master Switch (TSMS), see EV6.9.6

EV7.4.2 Both Master Switches that must be direct acting, not act through a relay or logic.

EV7.4.3 Master Switch must be Located at:

a) On the driver's right hand side of the vehicle
b) In proximity to the Main Hoop
c) At the driver's shoulder height
d) Able to be easily operated from outside the vehicle

EV7.4.4 The characteristics must:

a) Be of the rotary mechanical type

b) Be rigidly mounted to the vehicle and must not be removed during maintenance
c) Mounted where the rotary axis of the key is near horizontal and across the vehicle
d) The ON position must be in the horizontal position and must be marked accordingly
e) The OFF position must be clearly marked
f) Operated with a red removable key that must only be removable in the electrically open position

EV7.4.5 The Grounded Low Voltage Master Switch (GLVMS) must:

a) Completely stop all power to the GLV System EV3.2
b) Be in the center of a completely red circular area of > 50 mm in diameter
c) Be labeled “LV”

EV7.4.6 The Tractive System Master Switch (TSMS) must:

a) Open the Shutdown Circuit in the OFF position EV6.2.2
b) Be the last switch before the IRs except for Precharge circuitry and Interlocks.
c) Be in the center of a completely orange circular area of > 50 mm in diameter
d) Be labeled “TS” and the symbol specified in ISO 7010-W012 (triangle with black lightning bolt on yellow background).
e) Be fitted with a "lockout/tagout" capability in the OFF position

EV7.5 Shutdown Buttons

EV7.5.1 Three Shutdown Buttons must be installed on the vehicle

EV7.5.2 Each Shutdown Button must:

a) Be a push-pull or push-rotate emergency stop switch
b) Open the Shutdown Circuit EV6.2.2 when operated to the OFF position
c) Hold when operated to the OFF position
d) Let the Shutdown Circuit Close when operated to the ON position

EV7.5.3 One Shutdown Button must be on each side of the vehicle which:

a) Is located aft of the Main Hoop near the junction of the Main Hoop and Main Hoop Bracing F4.4
b) Has a diameter of 40 mm minimum
c) Must not be easily removable or mounted onto removable body work

EV7.5.4 One Shutdown Button must be mounted in the cockpit which:

a) Is located in easy reach of the belted in driver, adjacent to the steering wheel, and unobstructed by the steering wheel or any other part of the vehicle
b) Has diameter of 24 mm minimum

EV7.5.5 The international electrical symbol (a red spark on a white edged blue triangle) must be near each Shutdown Button.

EV7.6 Inertia Switch

EV7.6.1 The vehicle must have an Inertia Switch

EV7.6.2 The Inertia Switch must be:

a) A resettable automotive crash sensor
b) Mechanically and rigidly attached to the vehicle
c) Removable to test functionality

EV7.6.3 Inertia Switch operation:

a) Must trigger due to a longitudinal impact load which decelerates the vehicle at between 8 g and 11 g depending on the duration of the deceleration
b) Must Open the Shutdown Circuit EV6.2.2 if triggered
c) Must latch until manually reset
d) May be reset by the driver from inside the driver's cell

EV8 CHARGER

EV8.1 Charger Requirements

EV.8.1.1 All features and functions of the Charger and Charging Shutdown Circuit must be demonstrated at Electrical Technical Inspection, IN3.

EV.8.1.2 Chargers will be sealed after approval, IN3.1.2.

EV8.2 Charger Features

EV8.2.1 The Charger must be galvanically isolated (AC) input to (DC) output.

EV8.2.2 If the Charger housing is conductive it must be connected to the earth ground of the AC input.

EV8.2.3 All connections of the Charger(s) must be isolated and covered.

EV8.2.4 The Charger connector(s) must incorporate a feature to let the connector become live only when correctly connected to the Tractive Battery Pack.

EV8.2.5 High Voltage charging leads must be orange.

EV8.2.6 The Charger must have two TSMPs installed, see EV6.9.6

EV8.2.7 The Charger must include a Charger Shutdown Button which must:

a) Be a push-pull or push-rotate emergency stop switch
b) Have a minimum diameter of 25 mm
c) Open the Charging Shutdown Circuit EV7.3.2 when operated to the OFF position
d) Hold when operated to the OFF position
e) Be labelled with the international electrical symbol (a red spark on a white edged bluetriangle)

EV8.3 Charging Shutdown Circuit

EV8.3.1 The Charging Shutdown Circuit consists of:

a) Charger Shutdown Button EV7.2.7
b) Battery Management System (BMS), see EV4.10
c) Insulation Monitoring Device (IMD), see EV4.13

EV8.3.2 The BMS and IMD parts of the Charging Shutdown Circuit must:

a) Be designed as Normally Open contacts
b) Have completely independent circuits to Open the Charging Shutdown Circuit.

EV8.3.3 Design of the respective circuits must make sure that a failure cannot result in electrical power being fed back into the Charging Shutdown Circuit.

EV8.4 Charging Shutdown Circuit Operation

EV8.4.1 When Charging, the BMS and IMD must:

a) Monitor the Tractive Battery
b) Open the Charging Shutdown Circuit if a fault is detected

EV8.4.2 When the Charging Shutdown Circuit Opens:

a) All current flow to the Tractive Battery must stop immediately
b) The voltage in the Tractive System must be Low Voltage EV1.1.2 in five seconds or less

c) The Charger must be turned off
d) The Charger must stay disabled until manually reset

EV8.5 Hand Cart

EV8.5.1 Teams must have a Hand Cart to transport their Tractive Battery Pack(s).

EV8.5.2 The Hand Cart must be used when the Tractive Battery Pack(s) are transported on the competition site, **OP2.4.2**

EV8.5.3 The Hand Cart must:

a) Be able to carry the load of the Tractive Battery Pack(s) without tipping over
b) Contain a minimum of two wheels
c) Have a brake that must be:
    i. Released only using a dead man type switch (where the brake is always on until released by pushing and holding a handle) or by manually lifting part of the cart off the ground
    ii. Able to stop the Hand Cart with a fully loaded Tractive Battery Pack Tractive Battery Pack(s) must be securely attached to the Hand Cart

EV8.5.4 Teams must have a Hand Cart to transport their Tractive Battery Pack(s).

EV8.5.5 The Hand Cart must be used when the Tractive Battery Pack(s) are transported on the competition site.

PART HY – Hybrid System

HY1 HYBRID POWERTRAIN

HY1.1 Hybrid Configuration

HY1.1.1 The vehicle must be configured as a Range Extender Electric Vehicle (REEV).

HY 1.1.2 Tractive power must be provided exclusively by the Motor(s).

HY 1.1.3 Direct or mechanical drive from the Engine to the wheels is strictly prohibited. Any mechanical connection between the Engine and the drivetrain (beyond the Generator) is a violation of these rules.

HY1.1.4 All these components need to be inside the Tire Surface Envelope F1.14:

a) Generator
b) Engine:
   i. All parts of engine intake air system (including throttle, carburetor, air cleaner and air boxes)
   ii. All parts of engine fuel control, delivery and storage system (including fuel injectors, fuel line and fuel tank)

HY1.1.5 All Tractive System must follow **Part EV** unless mentioned in **Part HY**.

HY1.2 Engine Limitation

HY1.2.1 The engine(s) used to power the vehicle must:

a) Be a piston engine(s) using a four stroke primary heat cycle
b) Fuel type: petrol
c) Have a total combined displacement less than or equal to 550 cc per cycle.

HY1.2.2 The Engine must be used solely to drive the generator for electrical energy production.

HY1.2.3 All waste/rejected heat from the primary heat cycle may be used.

HY1.2.4 The engine may be modified within the restrictions of the rules. Permitted modifications to an engine are:

a) Modification or removal of the clutch, primary drive and/or transmission,
b) Changes to fuel mixture, ignition or cam timings,
c) Replacement of camshaft (Any lobe profile may be used).
d) Replacement or modification of any exhaust system component.

e) Replacement or modification of any intake system component; i.e., components upstream of (but NOT including) the cylinder head. The addition of forced induction will move the engine into the modified category.
f) Modifications to the engine casings. (This does not include the cylinders or cylinder head).
g) Replacement or modification of crankshafts for the purpose of simplifying mechanical connections (Stroke must remain stock).

HY1.2.5 The organizers reserve the right to tear down any number of engines to confirm conformance to the rules.

HY1.2.6 Any dimension must be made with 1% accuracy.

HY1.3 Generator and Control System

HY1.3.1 A generator must be mechanically coupled to the Engine to convert mechanical energy into electrical energy.

HY1.3.2 The electrical energy produced by the generator may be used to:

a) Charge the Tractive Battery Pack (Accumulator).
b) Directly power the Tractive Motor(s).

HY1.3.3 The Generator must be managed by a dedicated Generator Controller.

HY1.3.4 The Generator Controller must ensure that both the Tractive Battery Pack and the Motor(s) operate within their defined safe and acceptable ranges (voltage, current, and temperature) as specified in the team's Technical Description.

HY1.3.5 The Generator system may only produce power when the vehicle is in "Ready-To-Drive" (RTD) mode or during a supervised stationary charging session in the designated area.

HY1.3.6 The Generator output must be isolated behind an appropriate Overcurrent Protection Device (OCPD), such as a fuse or circuit breaker.

HY1.4 Energy Meter

HY1.4.1 The vehicle must be equipped with an Official Energy Meter as per EV rules.

HY1.4.2 The Energy Meter must be wired to measure only the energy transfer from the Tractive Battery Pack to the Tractive System (e.g., inverters/motors).

HY1.4.3 Energy generated by the Generator unit and supplied directly to the Tractive System or Battery Pack will not be counted by the Energy Meter for the purposes of efficiency scoring or power limit violations.

HY1.4.4 The Energy Meter wiring must exclude the generator's output path to ensure only battery-to-load energy is recorded.

HY2 GENERATOR

HY2.1 Function

HY2.1.1 The primary function of the Generator is to convert mechanical energy from the Engine into electrical energy to charge the Tractive Battery Pack (Accumulator) as required.

HY2.1.2 Other function for the generator may:

a) act as a starter motor to initiate the Engine combustion cycle
b) The Generator may provide supplemental electrical power (Boost) directly to the Tractive System (DC Bus) to support peak load demands from the propulsion motor(s).

HY2.2 Mechanical Coupling

HY2.2.1 The generator must be mechanically coupled to the ICE power takeoff (PTO) or crankshaft.

HY 2.2.2 Acceptable methods of coupling include, but are not limited to:

a) Direct Drive: Shared shaft or rigid coupling.
b) Indirect Drive: Chain drives, synchronous (toothed) belts, or gear trains.

HY2.2.3 Friction-based couplings (e.g., flat belts or V-belts) are prohibited if they allow slippage that would result in inaccurate RPM monitoring by the Generator Controller.

HY2.2.4 All moving parts of the coupling assembly (chains, gears, or belts) must be shielded according to Section T (General Technical Requirements) to prevent injury in the event of a mechanical failure.

HY2.2.5 The Mechanical Coupling must be designed to withstand the maximum torque pulse of the ICE and the maximum braking torque of the generator during a short-circuit event.

HY2.3 Generator Controller

HY The generator must be managed by a dedicated Generator Controller capable of regulating electrical output based on the Tractive Battery's State of Charge (SoC).

HY 1.3.2.2 The coupling ratio (if using gears or belts) must be fixed. Variable-ratio couplings (CVTs) between the ICE and Generator are prohibited.

HY 1.3.2.3 The Controller must include an Over-speed Protection logic that initiates an ICE shutdown if the generator exceeds its rated RPM or if a failure in the mechanical coupling is detected.

HY3 AIR INTAKE SYSTEM

HY3.1 Intake System Location

HY3.1.1 The Intake System must lie inside the Tire Surface Envelope F.1.14

HY3.2 Intake System Mounting

HY3.2.1 The intake manifold must be securely attached to the engine block or cylinder head with brackets and mechanical fasteners.

a) Hose clamps, plastic ties, or safety wires do not meet this requirement.
b) The use of rubber bushings or hose is acceptable for creating and sealing air passages, but is not a structural attachment.

HY3.2.2 Threaded fasteners used to secure and/or seal the intake manifold must have a Positive Locking Mechanism, see **T10.3**.

HY3.2.3 Intake systems with significant mass or cantilever from the cylinder head must be supported to prevent stress to the intake system.

a) Supports to the engine must be rigid
b) Supports to the Chassis must incorporate some isolation for engine movement and chassis flex

HY3.3 Intake System Restrictor

HY3.3.1 All airflow to the engine(s) must pass through a single circular restrictor in the intake system.

HY3.3.2 The only permitted sequence of components is:

a) For naturally aspirated engines, the sequence must be: throttle body, restrictor, and engine. (**Figure 35**)

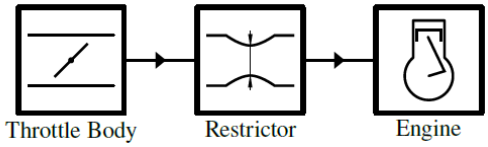


Figure 35: Intake configuration for naturally aspirated engines.

b) For turbocharged or supercharged engines, the sequence must be: restrictor, compressor, throttle body, engine (**Figure 36**).

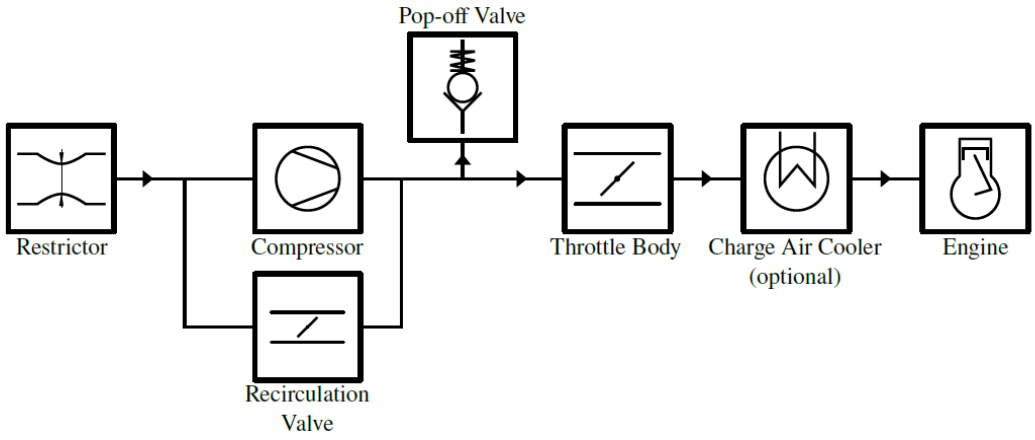


Figure 36: Intake configuration for turbocharged or supercharged engines.

HY3.3.3 The maximum restrictor diameters at any time during the competition are 17.5 mm.

HY3.3.4 The restrictor must be located to facilitate measurement during Technical Inspection.

HY3.3.5 The circular restricting cross section must NOT be movable or flexible in any way.

HY3.3.6 The restrictor must not be part of the movable portion of a barrel throttle body.

HY3.3.7 If more than one engine is used, the intake air for all engines must pass through the one restrictor.

HY3.4 Turbochargers & Superchargers

HY3.4.1 The intake air may be cooled with an intercooler (a charge air cooler).

a) It must be located downstream of the throttle body
b) Only ambient air may be used to remove heat from the intercooler system
c) Air to air and water to air intercoolers are permitted
d) The coolant of a water to air intercooler system must meet T7.2

HY3.4.2 If pop-off valves, recirculation valves, or heat exchangers (intercoolers) are used, they must be positioned in the intake system as shown in **Figure 36**.

HY3.4.3 Plenums must not be located anywhere upstream of the throttle body For the purpose of definition, a plenum is any tank or volume that is a significant enlargement of the normal intake runner system. Teams may submit their designs via a Rules Question for review prior to competition if the legality of their proposed system is in doubt.

HY3.4.4 The maximum permitted area of the inner diameter of the intake runner system between the restrictor and throttle body is 2825 mm^2.

HY3.5 Crankcase / Engine Lubrication Venting

HY3.5.1 Any crankcase or engine lubrication vent lines routed to the intake system must be connected upstream of the intake system restrictor.

HY3.5.2 Crankcase breathers that pass through the oil catch tank(s) to exhaust systems, or vacuum devices that connect directly to the exhaust system, are prohibited.

HY4 THROTTLE

HY4.1 General

HY4.1.1 All engines must be equipped with either:

a) a carburetor, or
b) a throttle body.

HY4.1.2 The carburetor or throttle body may be of any size or design.

HY4.1.3 Boosted applications must not use carburetors.

HY4.1.4 The throttle system mechanism must be protected from debris ingress to prevent jamming.

HY4.1.5 The throttle must be operated by Electronic Throttle Control.

HY4.2 Idle Position

HY4.2.1 The electronic throttle must automatically close (return to idle) when power is removed.

HY4.2.2 The electronic throttle must use minimum two sources of energy capable of returning the throttle to the idle position:

a) One of the sources may be the device (such as a DC motor) that normally operates the throttle
b) The other device(s) must be a throttle return spring that can return the throttle to the idle position if loss of actuator power occurs.
c) Springs in the TPS are not acceptable throttle return springs

HY4.3 Throttle Position Sensor - TPS

HY4.3.1 The TPS must measure the position of the throttle or the throttle actuator.

HY4.3.2 Throttle position is defined as percent of travel from fully closed to wide open where 0% is fully closed and 100% is fully open.

HY4.3.3 Two or more separate sensors must be used as TPSs. The TPSs may share the same supply and reference lines.

HY4.3.4 Implausibility is defined as a deviation of more than 10% throttle position.

HY4.3.5 If an Implausibility occurs between the values of the two TPSs and persists for more than 100 msec, the power to the electronic throttle must be immediately shut down.

HY4.3.6 If three sensors are used, then if one TPS failure, any two TPSs that agree within 10% throttle position may be used to define the throttle position target and the 3rd TPS may be ignored.

HY4.3.7 Each TPS must be able to be checked during Technical Inspection by having one of:

a) A separate detachable connector(s) for any TPS signal(s) to the main ECU without affecting any other connections

b) An inline switchable breakout box available that may disconnect each TPS signal(s) to the main ECU without affecting any other connections

HY4.3.8 The TPS signals must be sent directly to the throttle controller using an analogue signal or via a digital data transmission bus such as CAN or FlexRay.

HY4.3.9 Any failure of the TPSs or TPS wiring must be detectable by the controller and must be treated like Implausibility.

HY5 FUEL AND FUEL SYSTEM

HY5.1 Fuel

HY5.1.1 Vehicles must be operated with the fuels provided at the competition

HY5.1.2 Fuels provided are expected to be only Gasoline.

HY5.1.3 No agents other than the provided fuel and air may go into the combustion chamber.

HY5.2 Fuel System

HY5.2.1 The Fuel System must meet these design criteria:

a) The Fuel Tank is capable of being filled to capacity without manipulating the tank or the vehicle in any manner.
b) During refueling on a level surface, the formation of air cavities or other effects that cause the fuel level observed at the sight tube to drop after movement or operation of the vehicle (other than due to consumption) are prevented.
c) Spillage during refueling cannot contact the driver position, exhaust system, hot engine parts, or the ignition system.

HY5.2.3 A Firewall must separate the Fuel Tank from the driver, per **T1.10**

HY5.3 Protection

HY5.3.1 The Fuel System location must meet **HY1.1.4**.

HY5.3.2 Fuel System components must be inside the Primary Structure (**F1.1.11**):

a) Any part of the Fuel System that is below the Upper Side Impact Structure
b) Parts of the Fuel Tank other than the Fuel Filler Neck and Sight Tube above the Upper Side Impact Structure and **Tire Surface Envelope F1.1.15**

HY5.3.3 In side view, any portion of the Fuel System must not project below the lower surface of the chassis.

HY5.3.4 All Fuel Tanks must be shielded from side or rear impact.

HY5.4 Fuel Tank

HY5.4.1 Fuel Tanks made of a rigid material must:

a) Be securely attached to the vehicle structure.
b) The mounting method must not let chassis flex to load the Fuel Tank.
c) Not carry any structural loads; from Roll Hoops, suspension, engine or gearbox mounts

HY5.4.2 Any Fuel Tank that is made from a flexible material, for example a bladder fuel cell or a bag tank:

a) Must be enclosed inside a rigid fuel tank container which is securely attached to the vehicle structure.
b) The Fuel Tank container may be load carrying

HY5.4.3 Any size Fuel Tank may be used.

HY5.4.4 The Fuel Tank, by design, must not have a variable capacity.

HY5.4.5 The Fuel System must have a provision for emptying the Fuel Tank if required.

HY5.5 Fuel Filler Neck & Sight Tube

HY5.5.1 All Fuel Tanks must have a Fuel Filler Neck which must be with minimum 35 mm inner diameter at any point between the Fuel Tank and the Fuel Filler cap.

HY5.5.2 The portion of the Fuel Filler Neck nearest to the Fuel Filler cap must be:

a) Minimum 125 mm vertical height above the top level of the Fuel Tank
b) Angled no more than 30° from the vertical

HY5.5.3 The Fuel Filler Neck must be accompanied by a clear fuel resistant sight tube for reading the fuel level which must be:

a) Visible vertical height: 125 mm minimum
b) Inside diameter: 6 mm minimum
c) Above the top surface of the Fuel Tank

HY5.5.3 A clear Fuel Filler Neck tube may be used as a sight tube, subject to approval by a Rules Question or technical inspectors at the event.

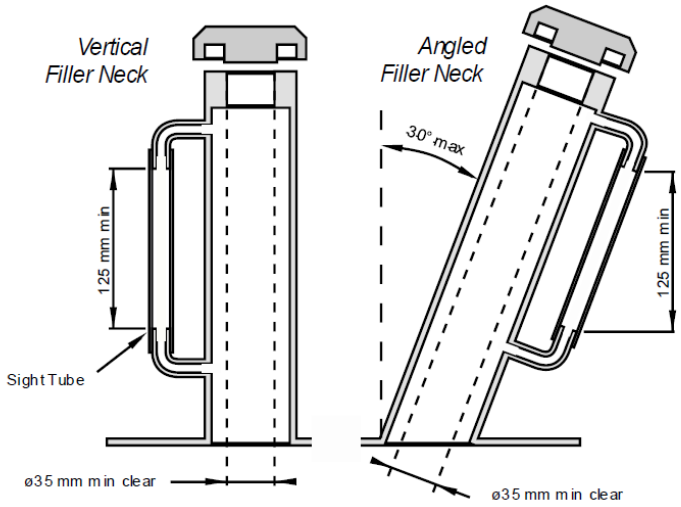


Figure 37: Filler Neck.

HY5.5.4 Fuel Level Line – A permanent, non movable fuel level line must be located between 12 mm and 25 mm below the top of the visible portion of the sight tube.

HY5.5.5 Fuel Level Line will be used as the fill line for the Tilt Test, and before and after Endurance to measure the amount of fuel used during the Endurance Event.

HY5.5.6 The sight tube and fuel level line must be clearly visible to two individuals (one to fill the tank, the other to visually verify fill) without the need of assistance (artificial lighting, magnifiers, etc) or the need to remove any parts (body panels, etc).

HY5.5.7 The individual filling the tank must have complete direct access to the filler neck opening with a standard two gallon fuel can assembly.

Figure 38: An example of standard two gallon fuel can assembly.

HY5.5.8 The filler neck must have a fuel cap that can withstand severe vibrations or high pressures such as could occur during a vehicle rollover event.

HY5.6 Fuel Tank Filling

HY5.6.1 Fuelling / Refuelling policies and procedures are at the discretion of the fuel crew and officials.

HY5.6.2 Fuel pumps must be on and fuel valves must be opened during refuelling.

HY5.6.3 The fuel tank must be capable of being filled to capacity without manipulating the tank or the vehicle in any manner.

HY5.6.4 The fuel system must be designed in a way that during refuelling of the vehicle on a level surface, the formation of air cavities or other effects that cause the fuel level observed at the sight tube to drop after movement or operation of the vehicle (other than due to consumption) is prevented.

HY5.7 Venting Systems

HY5.7.1 Venting systems for the fuel tank and fuel delivery system must not let fuel spill during hard cornering or acceleration.

HY5.7.2 All fuel vent lines must have a check valve to prevent fuel leakage when the tank is inverted.

HY5.7.3 All fuel vent lines must exit outside the bodywork.

HY5.8 Fuel Lines

HY5.8.1 Fuel lines must be securely attached to the vehicle and/or engine.

HY5.8.1 All fuel lines must be shielded from possible rotating equipment failure or collision damage.

HY5.8.2 Plastic fuel lines between the fuel tank and the engine (supply and return) are prohibited.

HY5.8.3 Any rubber fuel line or hose used must meet the two:

a) The components over which the hose is clamped must have annular bulb or barbed fittings to retain the hose
b) Clamps specifically designed for fuel lines must be used.

HY5.8.4 The fuel hose clamps must have three features:

a) a full 360° wrap,
b) a nut and bolt system for tightening,
c) rolled edges to prevent the clamp cutting into the hose

HY5.8.5 Worm gear type hose clamps must not be used on any fuel line.

Figure 39: Fuel hose clamps examples.

HY6 FUEL INJECTION

HY6.1 Definition

HY6.1.1 Low Pressure Injection (LPI) system – Low Pressure fuel injection systems are those functioning at a pressure below 10 Bar. Most Port Fuel Injected (PFI) fuel systems are low pressure.

HY6.1.2 High Pressure Injection (HPI) systems – those functioning at 10 Bar pressure or above.

HY6.1.3 Direct Injection (DI) fuel systems – where the injection occurs directly into the combustion system.

HY6.1.4 Low Pressure Fuel Lines – fuel lines runs lower than 10 bar:

a) For HPI / DI – fuel line from the electric supply pump to the boost pump.

b) For LPI – line from electric supply pump to the fuel injectors.

HY6.1.5 High Pressure Fuel Lines – fuel lines for HPI or DI system between the boost pump and injectors that runs at 10 bar pressure or more.

HY6.1 Low Pressure Fuel Line

HY6.1.2 Any Low Pressure flexible fuel lines must be one of:

a) Metal braided hose with threaded fittings (crimped on or reusable)
b) Reinforced rubber hose with some form of abrasion resistant protection

HY6.1.3 Fuel rail and mounting requirements:

a) Unmodified OEM Fuel Rails are acceptable, regardless of material.
b) Non OEM fuel rails made from plastic, carbon fiber or rapid prototyping flammable materials are prohibited.
c) The fuel rail must be securely attached to the manifold, engine block or cylinder head with brackets and mechanical fasteners. Hose clamps, plastic ties, or safety wires do not meet this requirement.
d) Threaded fasteners used to secure the fuel rail are Critical Fasteners, see **T10.2**

HY6.3 High Pressure Fuel Line

HY6.3.1 All High Pressure Fuel Lines must:

a) Be stainless steel rigid line or Aeroquip FC807 smooth bore PTFE hose with stainless steel reinforcement and visible Nomex tracer yarn. Equivalent products may be used with prior approval.
b) Not incorporate elastomeric seals
c) Be rigidly connected every 100 mm by mechanical fasteners to structural engine components such as cylinder heads or block

HY6.3.2 High Pressure Fuel Pump or fuel boost pump must be rigidly mounted to structural engine components such as the cylinder head or engine block.

HY6.3.3 Pressure Regulator must be fitted between the High Pressure and Low Pressure sides of the fuel system in parallel with the DI boost pump. The external regulator must be used even if the DI boost pump comes equipped with an internal regulator.

HY6.3.4 Fuel rail mounting requirements:

a) The fuel rail must be securely attached to the engine block or cylinder head with brackets and mechanical fasteners. Hose clamps, plastic ties, or safety wires do not meet this requirement.
b) The fastening method must be sufficient to hold the fuel rail in place with the maximum regulated pressure acting on the injector internals and neglecting any assistance from cylinder pressure acting on the injector tip.
c) Threaded fasteners used to secure the fuel rail are Critical Fasteners, see T10.2

HY7 EXHAUST SYSTEM

HY7.1 Exhaust Protection

HY7.1.1 The exhaust system must be separated and heat insulated (F1.4) from any of these components:

a) Flammable materials, including the fuel and fuel system, the oil and oil system
b) Thermally sensitive components, including brake lines, composite materials, and batteries

HY7.2 Exhaust Outlet

HY7.2.1 The exhaust must be routed to prevent the driver from fumes at any speed considering the draft of the vehicle.

HY7.2.2 The Exhaust Outlet(s) must be:

a) No more than 45 cm aft of the centerline of the rear axle
b) No more than 60 cm above the ground.

HY7.2.3 Any exhaust components (headers, mufflers, etc.) that protrude from the side of the body in front of the Main Hoop must be shielded to prevent contact by persons approaching the vehicle or a driver exiting the vehicle

HY7.2.4 Fibrous/absorbent material, (such as header wrap), must not be used on the outside of an exhaust manifold or exhaust system.

HY7.2.5 Crankcase breathers that pass through the oil catch tank(s) to exhaust systems, or vacuum devices that connect directly to the exhaust system, are prohibited.

HY7.3 Noise Level and Testing

HY7.3.1 The vehicle must stay below the permitted sound level at all times:

a) At idle 103 dBC, fast weighting
b) At all other speeds 110 dBC, fast weighting

HY7.3.2 Sound level will be verified during Technical Inspection

HY7.3.3 The car must be compliant at all engine speeds to the test speed defined in HY7.3.4

HY7.3.4 The test speed for a given engine will be the engine speed that corresponds to an average piston speed of 914.4 m/min. The calculated speed will be rounded to the nearest 500 rpm.

HY7.3.5 The test speeds for typical engines will be published by the organizers.

HY7.3.6 Vehicles not equipped with engine tachometers must provide some external means for measuring RPM, such as a hand-held meter or lap top computer.

HY7.3.7 Vehicles that do not have manual throttle control must provide some means for running the engine at the test RPM.

HY7.3.8 When the exhaust has a manually adjustable tuning device(s):

a) The position of the device must be visible to the officials for the noise test
b) The device must be manually operable by the officials during the noise test
c) The device must not be moved or modified after the noise test is passed

HY8 SHUTDOWN SYSTEM

HY8.1 Shutdown Circuit

HY8.1.1 Shutdown circuit consist the same component as in EV6.1.1.

HY8.1.2 The team must be able to demonstrate all features and functions of the Shutdown Circuit and components at Technical Inspection.

HY8.2 Shutdown Circuit Operation

HY8.2.1 The Shutdown Circuit must Open upon operation of, or detection from any of the components listed in HY8.1.1/EV6.1.1

HY8.2.2 The Shutdown Circuit Operation follows the operation in EV6.2.

HY8.2.3 In addition to HY8.2.2, pens, when the Shutdown Circuit Open, it must:

a) Stop the engine
b) Disconnect power to the:

i. Fuel Pump(s)
ii. Ignition
iii. Electronic Throttle

HY8.2.4 The Shutdown Circuit (SDC) directly controls all electric power to the ignition, fuel injectors and all fuel pumps.

PART OP – Vehicle Safety and Operation

OP1 VEHICLE OPERATION

OP1.1 Activation Requirement

OP1.1.1 The driver must complete the Activation Sequence without external assistance after the **Master Switches EV6.9** are ON

OP1.2 Activation Sequence

OP1.2.1 The vehicle systems must energize in this sequence:

a) GLV System **EV3.2**
b) Tractive System Active **OP1.3**
c) Ready to Drive **OP1.4**

OP1.2.2 The Shutdown Circuit may be Closed when or after the GLV System is energized

OP1.3 Tractive System Active

OP1.3.1 Tractive System Active means High Voltage is present outside of the Tractive Battery Container.

OP1.3.2 Tractive System Active must not be possible until the two:

a) GLV System is Energized
b) Shutdown Circuit is Closed

OP1.4 Ready to Drive

OP1.4.1 Ready to Drive means the Motor(s) will respond to the input of the APPS

OP1.4.2 Ready to Drive must not be possible until the three at the same time:

a) Tractive System Active **OP1.3**
b) The Brake Pedal is pressed and held to engage the mechanical brakes **T3.1**
c) The driver does a manual action to start Ready to Drive. Such as pressing a specific button in the cockpit

OP1.4.3 The vehicle is in Ready to Drive mode with two indications:

a) RTML, see **T5.3**
b) Ready to Drive Sound, see **T5.7**

OP2 WORK PRACTISE

OP2.1 Personnel

OP2.1.1 The Electrical System Officer (ESO), A4.4:

a) Is the only person on the team that may declare the vehicle electrically safe to allow work on any system
b) Must accompany the vehicle when operated or moved at the competition site
c) Must be immediately available by phone at all times during the event

OP2.2 Lockout

OP2.2.1 The TSMS EV6.9.6 must be locked in the OFF position when any work is done on the vehicle.

OP2.2.2 The MSD EV4.7 must be disconnected when vehicles are:

a) Moved around the competition site
b) Participating in Static Events

OP2.3 Maintenance

OP2.3.1 All participating team members must wear safety glasses with side shields at any time when:

a) Parts of the Tractive System are exposed while energized
b) Work is done on the Tractive Battery Pack

OP2.3.2 Appropriate insulated tools must be used when working on the Tractive Battery Pack or Tractive System.

OP2.4 Tractive System

OP2.4.1 below work activities at competition are permitted only in the designated area and during **Electrical Technical Inspection IN4**

a) Opening Tractive Battery Containers
b) Any work on Tractive Battery(s), Cells, or Modules
c) Energized electrical work

OP2.4.2 Cells and/or Modules must be moved at the competition site inside one of the two:

a) Completely closed **Tractive Battery Container T6** with **Hand Kart EV7.5**
b) **Module/Cell Transport Container OP2.4.3**

OP2.4.3 The Module/Cell Transport Container(s) must be:

a) Electrically insulated
b) Protected from shock hazards and arc flash

OP2.4.4 Modules/Cells inside the Transport Container must agree with the voltage and energy limits of EV4.3.2

OP2.5 Tractive Battery Pack Removal

OP2.5.1 After the team registers onsite, the Tractive Battery Pack must remain on the competition site until the end of the competition, or the team withdraws and leaves the site.

OP2.5.2 Violators will be disqualified from the competition and must leave immediately.

OP2.6 Charging

OP2.6.1 The Tractive Battery Pack must be removed from the vehicle and put onto the Hand Cart EV7.5 for Charging.

OP2.6.2 Tractive Battery charging must occur only inside the designated area.

OP2.6.3 A team member(s) who has knowledge of the Charging process must stay with the Tractive Battery Pack during Charging.

OP2.6.4 Each Tractive Battery Pack must have a label with this data during Charging:

a) Team Name
b) Electrical System Officer phone number(s)

OP2.6.5 Additional site specific rules or policies may apply.

OP3 RED CAR CONDITION

OP3.1 Definition

OP3.1.1 A vehicle will be a Red Car if any of the following:

a) Actual or possible damage to the vehicle affecting the Tractive System
b) Vehicle fault indication (EV.5.11 or equivalent)
c) Other conditions, at the discretion of the officials

OP3.2 Actions

OP3.2.1 Actions required with Red Car Condition:

a) Isolate the vehicle

b) No contact with the vehicle unless the officials give permission
c) Call out Red Car responders

OP3.2.2 Contact with the vehicle may require trained personnel with proper Personal Protective Equipment.

PART IN – Inspection

IN1 GENERAL

IN1.1 Objectives

IN1.1.1 The objective of Technical Inspection is to determine if the vehicle meets the NxGV Challenge Rules requirements and restrictions and if, considered as a whole, it satisfies the intent of the Rules.

IN1.1.2 Technical Inspection is divided into the following parts:

a) Pre-Inspection
b) Accumulator Inspection
c) Electrical Inspection
d) Mechanical Inspection
e) Tilt Test
f) Vehicle Weighing
g) [HEV ONLY] Noise Test
h) Rain Test
i) Brake Test

IN1.2 General Rules

IN1.2.1 Each vehicle must pass all parts of Technical Inspection before it may be driven under its own power.

IN1.2.2 Passing Technical Inspection is not a certification of complete rules compliance of the vehicle.

IN1.2.3 The officials may inspect other points not mentioned on the Technical Inspection Sheet to ensure compliance with the rules.

IN1.2.4 Teams are responsible for confirming that their vehicle and the required equipment satisfies the requirements and restrictions of the rules before presenting it for Technical Inspection.

IN1.2.5 Vehicles must be presented for Technical Inspection in ready-to-race condition.

IN1.2.6 Safety-uncritical violations without team benefit that cannot be changed at the event may result in at least 20 penalty points, depending on officials decision. If such violations give a minor benefit, at least 40 points may be applied. Penalties are deducted from the team's overall score.

IN1.2.7 All items on the Inspection Sheet must be clearly visible for the officials without using instruments such as endoscopes or mirrors. Visible access may be provided by removing body panels or by providing removable access panels.

IN1.2.8 The vehicle must maintain all required specifications throughout the event.

IN1.2.9 Officials reserve the right to ask the team for drilling of additional inspection holes to check the chassis for compliance with the rules.

IN1.2.10 Officials will mark or seal various different approved parts. Removal of or damage to the seals will void the Technical Inspection approval.

IN1.2.11 Once the vehicle is approved for competition, any damage to the vehicle that requires repair(s) will void the Technical Inspection approval. After completion of the repair(s), the vehicle must be re-submitted to Technical Inspection for re-approval.

IN1.2.12 The officials reserve the right to prohibit the use of parts that could pose a safety risk to drivers, track marshals or the environment.

IN1.3 Technical Inspection Sticker

IN1.3.1 The event's Technical Inspection stickers will be placed on the nose of the vehicle.

IN1.3.2 If a vehicle is no longer in compliance with the rules, the officials will set the vehicle's Technical Inspection status to fail, remove the respective Technical Inspection sticker(s) from the vehicle and note the reason for revoking the Technical Inspection approval in the Technical Inspection Sheet.

IN1.4 Inspection Responsible Person

IN1.4.1 To accelerate the Technical Inspection process, the team must appoint one team member as Technical Inspection responsible person. For Electrical Inspection and Accumulator Inspection this has to be an ESO.

IN1.4.2 This inspection responsible person must be:

a) Familiar with the vehicle.
b) Able to show compliance of the vehicle with all points mentioned on the Technical Inspection Sheet.
c) Able to perform Technical Inspection autonomously observed by the officials, when asked.

IN1.4.3 Should the inspection responsible person be unable to perform one of these requirements, or the vehicle and all necessary items are not ready, Technical Inspection will be aborted and the team will be asked to leave the Technical Inspection area.

IN1.5 Modifications and Repairs

IN1.5.1 After Technical Inspection, the only modifications allowed to the vehicle are:

a) Adjustment of belts, chains and clutches
b) Adjustment of the brake bias
c) Adjustment of the driver restraint system, head restraint, seat and pedal assembly
d) Substitution of the head restraint or seat insert for different drivers
e) Adjustment to engine operating parameters, e.g. fuel mixture and ignition timing
f) Adjustment of mirrors
g) Adjustment of the suspension where no part substitution, other than springs, sway bars and shims, is required
h) Adjustment of tire pressure
i) Adjustment of winglet angles, but not the position of the complete aerodynamic device in relation to the vehicle
j) Replenishment of fluids
k) Replacement of defective tires or brake pads. Replacement tires and brake pads must be identical in material/composition/size to those presented and approved at Technical Inspection.
l) Changing wheels and tires for “wet” or “damp” conditions as allowed in D2.2 and D7.9
m) Software calibration changes
n) Recharging LV batteries
o) Recharging TS accumulators
p) Installing and removing protective sensor covers, if approved during Technical Inspection
q) Replacement of LV batteries. Replacement LV batteries must be identical and approved at Technical Inspection.

IN1.5.2 Any other modification must be either approved by or performed under the supervision of Technical Inspection officials.

IN1.6 Reinspection

IN1.6.1 Any vehicle may be Reinspected at any time for any reason.

IN1.6.2 Specific areas or items to be inspected are at the discretion of the Chief Technical Inspector.

IN1.6.3 With Voided Inspection Approval, successful completion of Reinspection will restore Inspection Approval.

IN1.6.4 During Dynamic Events

a) Issues found during Reinspection will void Inspection Approval
b) Penalties may be applied to the Dynamic Events the vehicle has competed in. Applied penalties may include additional time added to event(s), loss of one or more fastest runs, up to Disqualification, subject to official discretion

IN2 PRE-INSPECTION

IN2.1 Required Items

IN2.1.1 The following items must be presented for Pre-Inspection:

a) All helmets
b) All driver's equipment and other safety gear
c) Two fire extinguishers
d) One set of four tires on rims for wet conditions
e) One set of four tires on rims for dry conditions

IN2.1.2 The tire type/rim type combination presented during Pre-Inspection must be the same during the whole event (including Technical Inspection). The rims for dry tires and wet tires may be different, but for all dry tire sets and all wet tire sets the same.

IN3 TRACTIVE BATTERY PACK AND CHARGER INSPECTION

IN3.1 General Definitions

IN3.1.1 Cell modules or stacks do not need to be disassembled when AIRs, fuses, pre- and discharge circuit and positive locking mechanism of the maintenance plugs are reachable and visible for the officials.

IN3.1.2 All or portions of the Tractive Battery Pack, Tractive System, Charger and other components may be marked or sealed.

IN3.1.3 The set of basic tools will be checked.

IN3.2 Required Items

IN3.2.1 The following items must be presented at Accumulator Inspection:

a) Tractive Battery Pack mounted on the Hand Cart
b) Spare Battery Pack(s) and Tractive Battery components (if applicable)
c) Tractive Battery Pack charger
d) Tractive Battery Container samples
e) Basic Tools, see IN3.2.2
f) Tools needed for the (dis)assembly of parts
g) Electrical Systems Form (ESF) and Component Data Sheets

IN3.2.2 The following basic tools in good condition must be presented:

a) Insulated cable shears
b) Insulated screw drivers
c) Multimeter with protected probe tips and two 4mm banana plug test leads rated for 600V CAT III or better
d) Insulated tools, if bolted connections are used in the TS
e) Face shield
f) at least two pairs of HV insulating gloves
g) Safety glasses with side shields for all team members that might work on the TS or accumulator

IN3.2.3 All electrical safety items must be rated for at least the maximum TS voltage.

IN4 ELECTRICAL INSPECTION

IN4.1 General Definition

IN4.1.1 The insulation resistance between the TS and LVS ground will be measured. The measured insulation resistance must be at least 500 Ω/V related to the maximum TS voltage of the vehicle.

IN4.1.2 The IMD will be tested by short circuiting between the TSMPs and GLVMP. The test is passed if the IMD shuts down the TS within 30 s.

IN4.1.3 The BSPD will be tested by sending an appropriate signal that represents the current, to achieve ≤5kW whilst pressing the brake pedal. This test must prove the functionality of the complete BSPD.

IN4.2 Required Items

IN4.2.1 The following items must be presented at Electrical Inspection:

a) Vehicle with mounted Tractive Battery Pack
b) Jacks and push bar
c) Samples of self designed PCBs that are part of the TS and are outside of the Tractive Battery Container
d) Tools needed for the BSPD check, see IN4.1.3
e) Data sheets for all parts used in the TS
f) Tools needed for the (dis)assembly of parts for Electrical Inspection
g) LV Battery (if applicable), and possible replacement batteries

IN4.3 Insulation Measurement Test

IN4.3.1 The insulation resistance between the TS and LVS ground will be measured.

a) All vehicles with a maximum nominal operation voltage below 500 V will be measured with the next available voltage level
b) All vehicles with a system voltage of 500 V or more will be measured with 500 V

IN4.3.2 To pass the Insulation Measurement Test the measured insulation resistance must be minimum 500 Ohm/Volt related to the maximum nominal Tractive System operation voltage

IN4.4 Insulation Monitoring Device Test

IN4.4.1 The Insulation Monitoring Device will be tested by short circuiting between the Tractive System Measuring Points and, and several electrically conductive vehicle parts while the Tractive System is active.

IN4.4.2 The test passes if the IMD shuts down the Tractive System in 30 seconds or less at a fault resistance of 50% below the response value corresponding to 250 Ohm /Volt.

IN4.5 Ready to Drive Sound

IN4.5.1 The sound level may be measured with a free field microphone placed free from obstructions in a radius of 2 m around the vehicle against the criteria in T5.7

IN4.6 Active Inspection

IN4.6.1 A separate OK to Energize Inspection Sticker IN1.3 may be given to show that the vehicle may be Tractive System Active EV1.2.8.

IN4.6.2 Electric Vehicles must pass Active Inspection / EV Active before the vehicle may try any further Inspections

IN5 MECHANICAL INSPECTION

IN5.1 Required Items

IN5.1.1 \ The following items must be presented at Mechanical Inspection:

a) Jacks and push bar
b) The tallest driver of the team
c) Copies of any safety structure equivalency forms
d) Copies of any impact attenuator data requirement
e) Physically tested IA assembly, including (representative) test fixture (if applicable)
f) Teams with a monocoque: laminate test specimen(s)
g) Teams using alloyed steel: test specimen(s)
h) Only tools needed for the (dis)assembly of parts for Mechanical Inspection

IN5.2 Aerodynamic Devices Stability and Strength

IN5.2.1 Any Aerodynamic Devices may be checked by pushing on the device in any direction and at any point. This is guidance, but actual conformance will be up to technical inspectors at the respective competitions. The intent is to reduce the likelihood of aerodynamic device detaching.

IN5.2.2 If any deflection is significant, then a force of approximately 200 N may be applied

a) Loaded deflection should not be more than 25 mm
b) Any permanent deflection less than 5 mm

IN5.2.3 If any vehicle on track is observed to have large, uncontrolled movements of Aerodynamic Devices, then officials may Black Flag the vehicle for Reinspection.

IN5.3 Engine Inspection

IN5.3.1 The organizer may measure or tear down engines to confirm conformance to the rules.

IN5.4 Driver Template Inspection

IN5.4.1 The Driver Template shown in T1.3 will be positioned.

IN5.4.2 To pass Mechanical Technical Inspection, the Driver Template must meet the clearance specified in T1.3.

IN5.5 Cockpit Template Inspection

IN5.5.1 The Cockpit Opening will be checked using the template and procedure given in T1.1.

IN5.5.1 The Internal Cross Section will be checked using the template and procedure given in T1.2.

IN5.5.1 To pass Mechanical Technical Inspection, the two Cockpit Templates must fit as described

IN5.6 Driver Clearance

IN5.6.1 Each driver in the normal driving position is checked for the three:

a) Helmet clearance T1.3.1
b) Head Restraint positioning T2.8.6
c) Harness fit and adjustment T2.4, T2.5, T2.6

IN5.7 Egress Test

IN5.7.1 Each driver must be able to exit to the side of the vehicle in no more than 5 seconds

IN5.7.2 The Egress Test will be conducted for each driver as follows:

a) The driver must wear the specified Driver Equipment VE3
b) Egress time begins with the driver in the fully seated position, with hands in driving position on the connected steering wheel
c) Egress test may have the driver touch the Shutdown Button EV6.10.4
d) Egress time will stop when the driver has two feet on the pavement

IN6 VEHICLE WEIGHING

IN6.1 Vehicle Weighing Procedure

IN6.1.1 All vehicles must be weighed in ready-to-race condition.

IN6.1.2 All fluids must be at their maximum fill level for weighing.

IN7 TILT TEST

IN7.1 Requirements

IN7.1.1 The Tilt Test requirement:

a) The vehicle must contain the maximum amount of fluids it may carry
b) The tallest driver must be seated in the normal driving position
c) Tilt tests may be conducted in one, the other, or the two directions to pass
d) (HEV only) Engines fitted with mechanically operated fuel pumps must be run to fill and pressure the system downstream of the High Pressure pump.

IN7.2 Tilt Test Criteria

IN7.2.1 No fluid leakage of any type when the vehicle is tilted to a 45° angle to the horizontal

IN7.2.2 Vehicle does not roll when tilted at an angle of 60° to the horizontal, corresponding to 1.7 g

IN7.3 Tilt Test Completion

IN7.3.1 Tilt Tests must be passed before a vehicle may try any further inspections

IN8 (HEV ONLY) NOISE TEST

IN8.1 Noise Measurement Procedure

IN8.1.1 The sound level will be measured during a stationary test, with the vehicle gearbox in neutral.

IN8.1.2 The car must be compliant at all engine speeds up to the test speed defined below (NI7.3).

IN8.1.3 Measurements will be made with a free field microphone placed:

a) free from obstructions.
b) at the Exhaust Outlet vertical level **HY7.2.2**
c) 0.5 m from the end of the Exhaust Outlet **HY7.2.2**
d) at an angle of 45° with the outlet in the horizontal plane (see **IN8.3.2** below).

IN8.2 Special Configurations

IN8.2.1 Where the Exhaust has more than one Exhaust Outlet:

a) The noise test is repeated for each outlet.
b) The highest sound level is used.

IN8.2.2 Exhaust Outlets that are not parallel to the ground may be tested outside of the horizontal plane.

IN8.2.3 If the exhaust has any form of active tuning or throttling device or system, the exhaust must meet all requirements with the device or system in all positions.

IN8.2.4 When the exhaust has a manually adjustable tuning device(s):

a) The position of the device must be visible to the officials for the noise test
b) The device must be manually operable by the officials during the noise test
c) The device must not be moved or modified after the noise test is passed

IN8.2.5 Vehicles that do not have manual throttle control must provide some means for running the engine at the test RPM.

IN8.3 Test Speed

IN8.3.1 The vehicle must be compliant at all engine speeds up to the maximum defined Test Speed.

IN8.3.2 Maximum Test Speed corresponds to an average piston speed of:

a)	Automotive / Motorcycle engines	914.4 m/min (3,000 ft/min)
b)	Industrial Engines (HY1.1.1)	731.5 m/min (2,400 ft/min)

IN8.3.3 The calculated speed will be rounded to the nearest 500 rpm. Test Speeds for typical engines are published on the Event Website.

IN8.3.4 Idle Test Speed (If applicable:

a) Determined by the vehicle's calibrated idle speed.
b) If the idle speed varies then the vehicle will be tested across the range of idle speeds determined by the team.

IN8.4 Maximum Permitted Sound Level

IN8.4.1 Two maximum permitted sound level depends on engine speed:

a)	At idle	103 dBC, fast weighting
b)	At all other speeds	110 dBC, fast weighting

IN8.5 Noise Level Retesting

IN8.5.1 Noise levels may be monitored at any time.

IN8.5.2 The Noise Test may be repeated at any time.

IN8.6 Noise Test Completion

IN8.6.1 Noise Tests must be passed before a vehicle may try any further inspections.

IN9 RAIN TEST

IN9.1 Requirements

IN9.1.1 The Rain Test requirement:

a) Tractive System must be Active
b) The vehicle must not be in Ready to Drive mode (EV.7)
c) Any driven wheels must not touch the ground or removed
d) A driver must not be seated in the vehicle

IN9.2 Rain Test Conduct

IN9.2.1 The water spray will be rain like, not a direct high pressure water jet

a) Spray water at the vehicle from any possible direction for 120 seconds
b) Stop the water spray
c) Observe the vehicle for 120 seconds

IN9.3 Rain Test Completion

IN9.3.1 The test is passed if the:

a) Insulation Monitoring Device (EV4.13) does not react during the entire 240 seconds duration
b) Insulation Monitoring Device functionality is verified after the 240 seconds test

IN9.3.2 The Rain Test must be passed before a vehicle may try any further inspections

IN10 BRAKE TEST

IN10.1 Objective

IN10.1.1 The Brake System will be dynamically tested and must demonstrate the capability to lock all four wheels when stopping the vehicle in a straight line at the end of an acceleration run specified by the brake inspectors.

IN10.2 Brake Test Conduct

IN10.2.1 The Brake Test must use only the mechanical Brakes with no aid from the powertrain EV2.2.4.

IN10.2.2 Brake Test procedure:

a) Accelerate to speed into the designated braking zone
b) Switch off the Tractive System EV6.10.4

c) Apply the brakes with force sufficient to demonstrate full lockup of all four wheels
d) The brake light, and TSSI, illumination will be checked and the officials will verify if the illumination is satisfactory for external observation.

IN10.3 Brake Test Completion

IN10.3.1 The Brake Test passes if all four wheels lock.

IN10.3.2 The Ready to Move Light may switch a short time after the vehicle has come to a complete stop as the reduction of the system voltage is not immediate. See **EV6.2.1.c**.

IN10.3.3 After the Brake Test, the vehicle must be able to continue driving under its own power without external assistance.

PART S – Static Event

S1 GENERAL

S1.1 Scoring

S1.1.1 The Static Event scoring is as follows:

Table 6: Statci Event Scoing.

Presentation	75 points
Cost	100 points
Design	150 points
Total	325 points

S1.1.2 HEV Class and EV Class scoring are separated.

S1.2 Vehicle

S1.2.1 Vehicles may be presented for judging without having passed Technical Inspection, even if final tuning and setup is in progress.

S1.2.2 Covers and/or parts may be removed during the judging to facilitate access and presentation of components or concepts.

S2 PRESENTATION EVENT

S2.1 Objective

S2.1.1 The Presentation Event evaluates the team's ability to develop and deliver a comprehensive business, logistical, production, or technical case that will convince outside interests to invest in the team's concept.

S2.1.2 The business model must offer a product or a service integrating the team's specific prototype vehicle or a specific component of it.

S2.2 Concept

S2.2.1 The concept for the Presentation Event may change for each competition.

S2.2.2 The team presentation must meet the concept.

S2.2.3 The team presentation must relate specifically to the vehicle as entered in the competition.

S2.2.4 Teams should assume that the judges represent different areas, including engineering, production, marketing and finance, and may not all be engineers.

S2.2.5 The judges should be treated as if they were potential investors or partners for the presented business model.

S2.2.6 The Business Plan Presentation Judging will take place in two parts:

a) Initial judging of all teams,
b) Final judging of up to the 3 top teams. Qualifying teams will be notified in advance of the final.

S2.3 Presentation Format

S2.3.1 Presentation format is as follows:

a) 10 minute BPP presentation
b) 5 minute Q&A
c) 5-10 minute Judges' feedback (if applicable)

S2.3.2 Penalties will be imposed if the presentation is

a) less than 9 minutes, or
b) exceeds 11 minutes.

S2.3.2 Teams that fail to make their presentation during their assigned time period get zero points for the Presentation Event.

S.2.4 Presentation Submissions

S2.4.1 The Presentation Concept may require information to be submitted prior to the event.

S.2.4.2 Submissions may be graded as part of the Presentation Event score.

S.2.4.3 Pre event submissions will be subject to penalties as given in section **PS - Pre-Competition Submissions**.

S2.5 Presentation Format

S2.5.1 One or more team members will give the presentation to the judges.

S2.5.2 All team members who will give any part of the presentation, or who will respond to judges' questions must be:

a) In the presentation area when the presentation starts
b) Introduced and identified to the judges

S2.5.3 Presentations will be time limited. The judges will stop any presentation exceeding the time limit.

S2.5.4 Teams must covers the following topics as a minimum:

a) The potential customers and market analysis,
b) How the business will be marketed,
c) The development and production proposal of the vehicle or component,
d) The business financial proposition,
e) Vehicle Strategy and Performance for promoting its sales.

S2.6 Scoring

S2.6.1 The Presentation Event will be evaluated on the categories specified in Table 7:

Table 7: Presentation Event evaluation categories and points.

Categories	Points
Content	50
Visual Aid	20
Delivery	15
Q&A	15
Total	100

S2.6.2 The scoring for the non-finalist is calculated as followed:

$$[Presentation\ Event\ Score] = 70\left(\frac{P_{team}}{P_{max}}\right)$$

P_{team} is the score awarded to the team

P_{max} is the highest score awarded to any team not participating in the finals

S2.6.3 The scoring of the BPP finalists will vary from 75 to 71 points and is scored immediately after the BPP finals by all judges.

S3 COST AND MANUFACTURING EVENT

S3.1 Objectives

S3.1.1 The Cost and Manufacturing Event evaluates the ability of the team to consider budget and incorporate production considerations for production and efficiency.

S3.1.2 This includes making tradeoff decisions between content and cost based on the performance of each part and assembly and accounting for each part and process to meet a budget is part of Project Management.

S3.1.3 The Cost and Manufacturing Event has 3 parts:

Cost Report, S3.2

S3.2 Cost Report

S3.2.1 The Cost Report must:

a) List and cost each part on the vehicle using the standardized Cost Tables
b) Base the cost on the actual manufacturing technique used on the prototype
c) Include Tooling Cost (welding jigs, molds, patterns and dies) for processes requiring it.
d) Exclude R & D and capital expenditures (plant, machinery, hand tools and power tools).
e) Include supporting documentation to let officials verify part costing

S3.2.2 Generate and submit the Cost Report using the Event Website, see **PS - Pre-Competition Submissions**

S3.3 Bill of Materials (BOM)

S3.3.1 The BOM is a list of all vehicle parts, showing the relationships between the items.

a) The overall vehicle is broken down into separate Systems
b) Systems are made up of Assemblies
c) Assemblies are made up of Parts
d) Parts consist of Materials, Processes and Fasteners
e) Tooling is associated with each Process that requires production tooling

S3.4 Vehicle Condition

S3.4.1 Vehicles must be presented for cost and manufacturing judging in finished condition, fully assembled, complete, ready-to-race and with its dry tyres mounted.

S3.4.2 The judges may not evaluate any vehicle, that is presented at the cost and manufacturing event, in what they consider to be an unfinished state and may

apply a penalty in line with standard tariff (e.g. not attending Cost Judging session or a documentation fault).

S3.4.3 Vehicles may be presented for judging without having passed technical inspection, even if final tuning and setup is in progress.

S3.4.4 Covers and/or parts may be removed during the judging to facilitate access and presentation of components or concepts.

S3.4.5 Only sealed TSACs which passed the accumulator inspection may be presented or mounted in the vehicle. They must not be opened.

S3.5 Scoring

S3.5.1 The cost and manufacturing event will be evaluated on the categories specified in the following table:

Table 8: Cost Event Points.

Category	Points
BOM Discussion	70
Cost Understanding	30
Total	100

S3.5.2 If items are missing from the BOM, points are deducted until 0 points are scored for “BOM Discussion”.

S4 DESIGN EVENT

S4.1 Design Event Objective

S4.1.1 The Design Event evaluates the engineering effort that went into the vehicle and how the engineering meets the intent of the market in terms of vehicle performance and overall value.

S4.1.2 The team and vehicle that illustrate the best use of engineering to meet the design goals, a cost effective high performance vehicle, and the best understanding of the design by the team members will win the Design Event.

S4.1.3 Components and systems that are incorporated into the design as finished items are not evaluated as a student designed unit, but are assessed on the team’s selection and application of that unit.

S4.2 Design Documents

S4.2.1 Teams must submit the:

a) Design Specification Sheet
b) Vehicle Drawing (3 View Drawings)

S4.2.2 These Design Documents will be used for:

a) Design Judge reviews prior to the Design Event
b) Sorting teams into appropriate design groups based on the quality of their review.

S4.2.3 Penalties for Late Submission of all or any one of the Design Documents will be added as given in section **PS - Pre-Competition Submissions**.

S4.2.4 The Design Briefing must use the template from organizer.

S4.2.5 The Vehicle Drawings must meet:

a) Three view line drawings showing the vehicle, from the front, top, and side
b) Each drawing must appear on a separate page

S4.3 Vehicle Condition

S4.3.1 Inspection Approval is not required prior to Design judging.

S4.3.2 Vehicles must be presented for Design judging in finished condition, fully assembled, complete and ready to run

a) The Tractive Battery Pack must pass Inspection to be at the Design Event **IN3**
b) The judges will not evaluate any vehicle that is presented at the Design event in what they consider to be an unfinished state

S4.3.3 Covers and/or parts may be removed during the design judging to facilitate access and presentation of components or concepts.

S4.4 Judging Criteria

S4.4.1 Design judging may be conducted in one or more phases.

S4.4.2 The Design Judges will:

a) Evaluate the engineering effort based upon the team's Design Documents, discussion with the team, and an inspection of the vehicle

b) Inspect the vehicle to determine if the design concepts are adequate and appropriate for the application (relative to the objectives stated in the rules)
c) Deduct points if the team cannot adequately explain the engineering and construction of the vehicle

S4.4.3 The Design Judges may assign a portion of the Design Event points to the Design Documents

S4.5 Scoring

S4.5.1 The overall Engineering Design maximum scoring is 150 points.

S4.5.2 The maximum scores listed in Table 9 apply for Engineering Design.

Table 9: Maximum scores in Design Event.

Category	Points
Design Specification Sheet	10
Overall Vehicle Concept	20
Vehicle Performance	15
Suspension, Steering, Braking, Tires.	15
Aerodynamic	10
Chassis / Frame / Body	10
Cockpit	5
Control, Software, Driver Interface	20
Tractive System, Powertrain, Differential	20
LV, Harnessing, Electronics	20
Cooling System	5
Total	150

S4.5.3 Penalty points may be subtracted from the Design score.

S4.5.4 Up to 50 penalty points may be given to teams that demonstrate a fundamental lack of engineering knowledge and are unable to provide justification for their designs, including the use of ‘carry-over parts’ from previous competition vehicles.

S4.5.5 Vehicles that are excluded from Design judging or refused judging get zero points for Design, and may receive penalty points.

PART D – Dynamic Event

D1 GENERAL

D1.1 Dynamic Events and Maximum Scores

D1.1.1 Below are the Dynamic Events maximum score

Acceleration	100
Skid Pad	75
Autocross	125
Efficiency	100
Endurance	275
Total	675

D1.2 Definition

D1.2.1 Dynamic Area – Any designated portion(s) of the competition site where the vehicles may move under their own power. This includes competition, inspection and practice areas.

D1.2.2 Staging Area – Any area(s) inside the Dynamic Area prior to the entry to an event for the purpose of gathering those vehicles that are about to start.

D1.2.3 Starting – crossing the light barrier at the starting line starts a lap.

D1.2.4 Finishing – crossing the light barrier at the finish line ends a lap. Can be the same as the starting line.

D1.2.5 Lap – a complete trip on a defined track, beginning at the start line and ending at the finish line.

D1.2.6 Run – a single attempt to compete in a dynamic discipline. Runs consist of one or more lap(s). A run is started when receiving a GREEN FLAG or the go-signal by the officials.

D1.2.7 Did Not Finish (DNF) – starting a run without finishing it. For the purpose of scoring, a DNF is treated as a DQ.

D1.2.8 Disqualified (DQ) – being removed from the scoring due to a rule violation.

D1.2.9 Valid Run – a run that is neither DNF nor DQ.

D1.2.10 Running Order – the sequence in which teams take part in a dynamic discipline. If not defined otherwise, the running order is queue based and teams on their first run receive priority.

D1.2.11 DOO - Cone is Down or Out when one or the two:

a) Cone has been knocked over (Down)
b) The entire base of the cone lies outside the box marked around the cone in its undisturbed position (Out)

D1.2.12 OC – Off Course

a) The vehicle did not pass through a gate in the required direction.
b) The vehicle has all four wheels outside the course boundary as indicated by cones, edge marking or the edge of the paved surface.

D1.3 Driver Limitations

D1.3.1 In total, a minimum of four and a maximum of six drivers are allowed for each team.

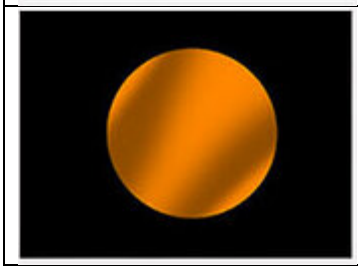
D1.3.2 An individual driver may not drive in more than two dynamic events.

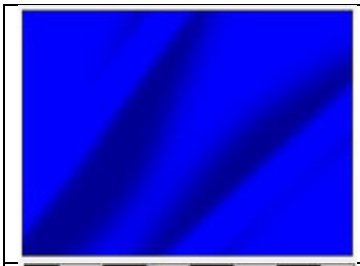
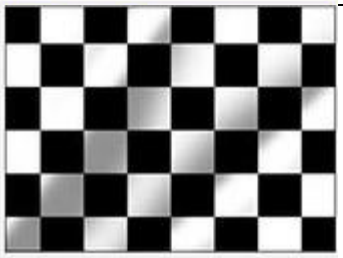
D1.3.3 The endurance and efficiency event are considered a single event.

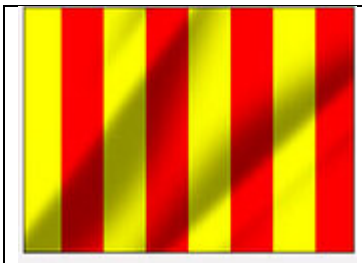
D1.4 Flags

D1.3.1 Any Command Flag must be obeyed immediately and without question.

D1.3.2 Below are all the flags

	Black Flag	Pull into the Driver Change Area for discussion with the track officials. A time penalty may be assessed.
	Black Flag with Orange Dot	Pull into the Driver Change Area for a mechanical inspection, something has been observed that needs closer inspection.

	Blue Flag	Pull into the designated passing zone to be passed by a faster competitor. Obey the corner workers signals at the end of the passing zone to merge into competition.
	Checkered Flag	Run has been completed. Exit the course at the designated point.
	Green Flag	Approval to begin your run, enter the course under direction of the starter. If you stall the vehicle, please restart and await another Green Flag
	Red Flag	Come to an immediate safe controlled stop on the course. Pull to the side of the course as much as possible to keep the course open. Follow corner worker directions.
	Yellow Flag (Stationary)	Danger, SLOW DOWN, be prepared to take evasive action, something has happened beyond the flag station. NO PASSING unless directed by the corner workers.
	Yellow Flag (Waved)	Great Danger, SLOW DOWN, evasive action is most likely required, BE PREPARED TO STOP, something has happened beyond the flag station, NO PASSING unless directed by the corner workers.

	Red and Yellow Striped Flag	Something is on the racing surface that should not be there. Be prepared for evasive manoeuvres.
	White Flag	There is a slow moving vehicle on the course. Be prepared to approach it at a cautious rate.

D2 WEATHER AND TIRE

D2.1 Operating Conditions

D2.1.1 The following track conditions are recognized:

a) Dry,
b) Damp,
c) Wet.

D2.1.2 The operating conditions are decided by the officials and may change at any time.

D2.1.3 The current operating condition will be prominently displayed at the dynamic area.

D2.2 Tyres Change

D2.2.1 Teams must run the tyres allowed for each operating condition:

Operating Condition	Tyres Allowed
Dry	Dry
Damp	Dry or Wet
Wet	Wet

D2.2.2 When the operating condition is damp, teams may change between dry tyres and wet tyres:

a) Any time during the acceleration, skidpad, and autocross events.

b) Any time before taking the green flag to start endurance and according to D7.9.

D2.2.3 If an event had varied operating conditions, the minimum performance levels to score points may be adjusted if deemed appropriate by the officials.

D2.2.4 Only one set of tyres per type (dry/wet) may be used during all the dynamic events.

D3 DRIVING

D3.1 Driving Under Power

D3.3.1 Vehicles must move under their own power only when inside the designated Dynamic Area(s), unless otherwise directed by the officials.

D3.3.2 Driving a vehicle outside of scheduled events or scheduled practice is a 200 point penalty for the first violation and disqualification for a second violation.

D3.2 Driving Offsite - Prohibited

D3.2.1 Teams found to have driven their vehicle at an offsite location during the period of the competition will be excluded from the competition.

D3.3 Driver Equipment

D3.3.1 All Driver Equipment and Harness must be worn by the driver anytime in the cockpit with:

a) Tractive System Active
b) Anytime between starting a Dynamic run and finishing or abandoning that Dynamic run

D3.3.2 Removal of any Driver Equipment during a Dynamic event will result in Disqualification.

D3.4 Practice Area

D3.4.1 A practice area for testing and tuning may be available.

D3.4.2 The practice area will be controlled and may only be used during the scheduled times.

D3.4.3 Vehicles using the practice area must have a complete Inspection Sticker.

D3.5 Vehicle Integrity

D3.5.1 Officials may revoke the Inspection Approval for any vehicle condition that could compromise vehicle integrity, compromise the track surface, or pose a potential hazard. This could result in DNF or DQ of any Dynamic event.

D3.6 Stalled & Disabled Vehicles

D3.6.1 If a vehicle stalls and cannot restart without external assistance, or is damaged and not able to complete the run, it will be scored DNF for that run

D3.6.2 Disabled vehicles will be cleared from the track by the track workers.

D4 ACCELERATION EVENT

D4.1 Acceleration Layout

D4.1.1 Course length will be 75 m from starting line to finish line.

D4.1.2 Course width will be minimum 4.9 m wide as measured between the inner edges of the bases of the course edge cones

D4.1.3 Cones are put along the course edges at intervals, approximately 6 m.

D4.1.4 Cone locations are not marked on the pavement.

D4.2 Acceleration Procedure

D4.2.1 Each team may try up to four runs, using two drivers, limited to two runs for each driver.

D4.2.2 Each Acceleration run is done as follows:

a) The foremost part of the vehicle will be staged at 0.30 m behind the starting line
b) A Green Flag or light signal will give the approval to begin the run
c) Timing starts when the vehicle crosses the starting line
d) Timing ends when the vehicle crosses the finish line

D4.3 Acceleration Penalties

D4.3.1 Cones (DOO) – Two second penalty for each DOO (including entry and exit gate cones) on that run.

D4.3.2 Off Course (OC) – DNF for that run.

D4.4 Acceleration Scoring

D4.4.1 Scoring Term Definitions:

a) Corrected Time = Acceleration Run Time + (DOO * 2)
b) Tyour – the best Corrected Time for the team
c) Tmin – the lowest Corrected Time recorded for any team
d) Tmax – 150% of Tmin

D4.4.2 When Tyour < Tmax. the team score is calculated as:

$$Acceleration\ Score = 95.5 \times \frac{(T_{max}/T_{your}) - 1}{(T_{max}/T_{min}) - 1} + 4.5$$

D4.4.3 When Tyour > Tmax , Acceleration Score = 4.5.

D5 SKIDPAD EVENT

D5.1 Skidpad Layout

D5.1.1 Course Design

a) Two pairs of concentric circles in a figure of eight pattern
b) Centers of the circles 18.25 m apart
c) Inner circles 15.25 m in diameter
d) Outer circles 21.25 m in diameter
e) Driving path the 3.0 m wide path between the inner and outer circles

D5.1.2 Cone Placement

a) 16 or 17 cones will be put around the inside of each inner circle and 13 cones will be positioned around the outside of each outer circle in the pattern shown in the Skidpad layout diagram
b) Each circle will be marked with a chalk line, inside the inner circle and outside the outer circle
c) Additional pylons will establish the entry and exit gates
d) A cone may be put in the middle of the exit gate until the finish lap

D5.1.3 Course Operation:

a) Vehicles will enter and exit through gates on a 3.0 m wide path that is tangential to the circles where they meet.
b) The line between the centers of the circles defines the start/stop line.
c) A lap is defined as traveling around one of the circles from the start/stop line and returning to the start/stop line.

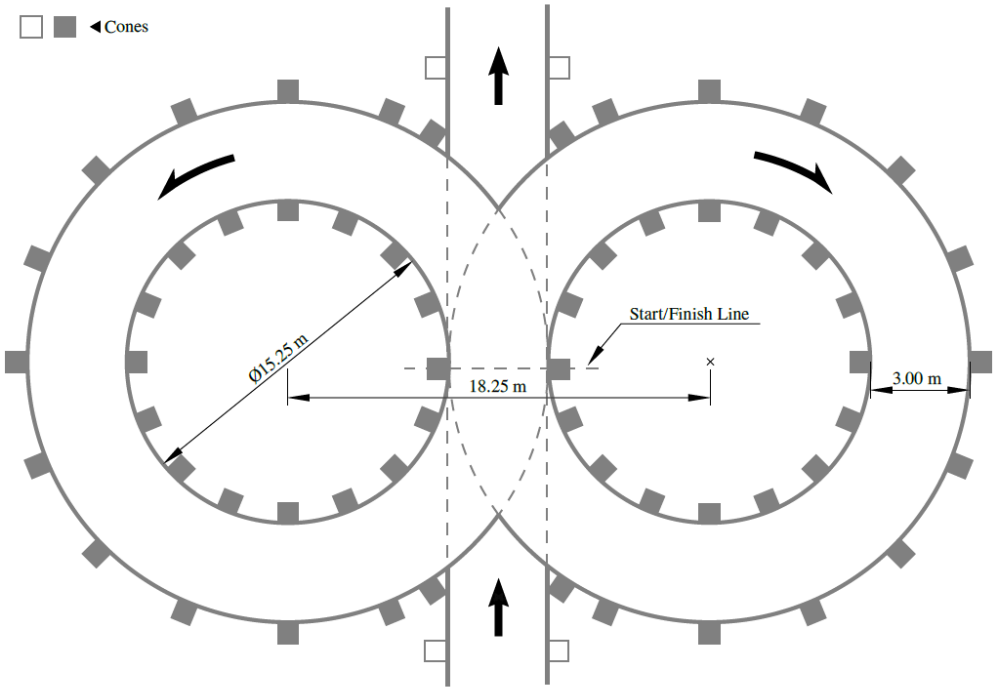


Figure 40: Skidpad Track Layout.

D5.2 Skidpad Procedure

D5.2.1 Each team may try up to four runs, using two drivers, limited to two runs for each driver.

D5.2.2 Runs with the first driver have priority

D5.2.3 Each Skidpad run is done as follows:

a) A Green Flag or light signal will give the approval to begin the run
b) The vehicle will enter perpendicular to the figure eight and go one full lap on the right circle
c) The next lap will be on the right circle and will be timed
d) Immediately after the second lap, the vehicle will enter the left circle for the third lap
e) The fourth lap will be on the left circle and will be timed
f) Immediately upon finishing the fourth lap, the vehicle will exit the track. The exit is at the intersection moving in the same direction as entered

D5.3 Skidpad Penalties

D5.3.1 Cones (DOO) – A 0.125 second penalty for each DOO (including entry and exit gate cones) on that run

D5.3.2 Off Course (OC) – DNF for that run. Vehicles that stall or spin out may continue if they have not gone Off Course.

D5.3.3 Incorrect Laps – Vehicles that run an incorrect number of laps or run the laps in the wrong sequence will be DNF for that run.

D5.4 Skidpad Scoring

D5.4.1 Scoring Term Definitions

a) Corrected Time = (Right Lap Time + Left Lap Time) / 2 + (DOO * 0.125)
b) Tyour - the best Corrected Time for the team
c) Tmin - is the lowest Corrected Time recorded for any team
d) Tmax - 125% of Tmin

D5.4.2 When Tyour < Tmax. the team score is calculated as:

$$Skidpad\ Score = 71.5 \times \frac{\left(T_{max}/T_{your}\right)^2 - 1}{(T_{max}/T_{min})^2 - 1} + 3.5$$

D5.4.3 When Tyour > Tmax , Skidpad Score = 3.5.

D6 AUTOCROSS EVENT

D6.1 Autocross Layout

D6.1.1 The Autocross course will be designed with these specifications. Average speeds should be 40 km/hr to 48 km/hr

a) Straights: No longer than 60 m with hairpins at the two ends
b) Straights: No longer than 45 m with wide turns on the ends
c) Constant Turns: 23 m to 45 m diameter
d) Hairpin Turns: 9 m minimum outside diameter (of the turn)
e) Slaloms: Cones in a straight line with 7.62 m to 12.19 m spacing
f) Miscellaneous: Chicanes, multiple turns, decreasing radius turns, etc.
g) Minimum track width: 3.5 m
h) Length of each run should be approximately 0.80 km

D6.1.2 The Autocross course specifications may deviate from the above to accommodate event site requirements.

D6.2 Autocross Procedure

D6.2.1 Each team may try up to four runs, using two drivers, limited to two runs for each driver

D6.2.1 Each Autocross run is done as follows:

a) The vehicle will be staged at a specific distance behind the starting line
b) A Green Flag or light signal will give the approval to begin the run
c) Timing starts when the vehicle crosses the starting line
d) Timing ends when the vehicle crosses the finish line

D6.3 Autocross Penalties

D6.3.1 Cones (DOO) – Two second penalty for each DOO (including cones after the finish line) on that run.

D6.3.2 Off Course (OC):

a) When an OC occurs, the driver must reenter the track at or prior to the point of exit or receive a 20 second penalty
b) Penalties will not be assessed to bypass an accident or other reasons at the discretion of track officials.

D6.3.3 Missed Slalom – Missing one or more gates of a given slalom will be counted as one Off Course.

D6.4 Autocross Scoring

D6.4.1 Scoring Term Definitions:

a) Corrected Time = Autocross Run Time + (DOO * 2) + (OC * 20)
b) Tyour - the best Corrected Time for the team
c) Tmin - the lowest Corrected Time recorded for any team
d) Tmax - 145% of Tmin

D6.4.2 When Tyour < Tmax. the team score is calculated as:

$$Autocross\ Score\ Score = 188.5 \times \frac{(T_{max}/T_{your}) - 1}{(T_{max}/T_{min}) - 1} + 6.5$$

D6.4.3 When Tyour > Tmax , Autocross Score = 6.5.

D7 ENDURANCE EVENT

D7.1 Endurance General Information

D7.1.1 The organizer may establish one or more requirements to let teams compete in the Endurance event.

D7.1.2 Each team may try the Endurance event once.

D7.1.3 The Endurance event consists of two Endurance runs, each using a different driver, with a Driver Change between.

D7.1.4 Teams may not work on their vehicles once their Endurance event has started.

D7.1.5 Multiple vehicles may be on the track at the same time.

D7.1.6 Wheel to Wheel racing is prohibited.

D7.1.7 Vehicles must not be driven in reverse.

D7.2 Endurance Layout

D7.2.1 The Endurance event will consist of multiple laps over a closed course to a total distance of approximately 22 km.

D7.2.2 The Endurance course will be designed with these specifications. Average speed should be 48 km/hr to 57 km/hr with top speeds of approximately 105 km/hr.

a) Straights: No longer than 77 m with hairpins at the two ends
b) Straights: No longer than 61 m with wide turns on the ends
c) Constant Turns: 30 m to 54 m diameter
d) Hairpin Turns: 9 m minimum outside diameter (of the turn)
e) Slaloms: Cones in a straight line with 9 m to 15 m spacing
f) Miscellaneous: Chicanes, multiple turns, decreasing radius turns, etc.
g) Minimum track width: 4.5 m
h) Designated passing zones at several locations

D7.2.3 The Endurance course specifications may deviate from the above to accommodate event site requirements.

D7.3 Endurance Run Order

D7.3.1 The Endurance Run Order is established to let vehicles of similar speed potential be on track together to reduce the need for passing.

D7.3.2 The Endurance Run Order:

a) Should be primarily based on the Autocross event finish order
b) Should include the teams eligible for Endurance which did not compete in the Autocross event.
c) May be altered by the organizer to accommodate specific circumstances or event considerations

D7.3.3 Each team must keep track of the Endurance Run Order and have their vehicle fueled, in line and prepared to start when their turn to run arrives.

D7.4 Endurance Vehicle Starting / Restarting

D7.4.1 Teams that are not ready to run or cannot start their Endurance event in the permitted time when their turn in the Run Order arrives:

a) Get a time penalty (D7.13.5)
b) May then run at the discretion of the Officials

D7.4.2 After Driver Change, the vehicle will be permitted up to 120 seconds (two minutes) to enter Ready to Drive:

a) The time will start when the driver first tries to restart the engine or to enable the Tractive System
b) The time to try to start / restart is not counted towards the Endurance time

D7.4.3 If a vehicle stalls on the track, it will be permitted one lap by the vehicle that follows it (approximately 60 seconds) to restart. This time counts toward the Endurance time.

D7.4.4 If starts / restarts are not accomplished in the above times, the vehicle may be DNF.

D7.5 Endurance Event Procedure

D7.5.1 Vehicles will be staged per the Endurance Run Order

D7.5.2 Endurance Event sequence:

a) The first driver will do an Endurance Run per D7.6 below
b) The Driver Change must then be done per D7.8 below
c) The second driver will do an Endurance Run per D7.6 below

D7.5.3 The Endurance Event is complete when the two:

a) The tebam has completed the specified number of laps
b) The second driver crosses the finish line

D7.6 Endurance Run Procedure

D7.6.1 A Green Flag or light signal will give the approval to begin the run.

D7.6.2 The driver will drive approximately half of the Endurance distance.

D7.6.3 A Checkered Flag will be displayed.

D7.6.4 The vehicle must exit the track into the Driver Change Area.

D7.7 Driver Change Limitations

D7.7.1 The team may bring only these items into the Driver Change Area:

a) The three team members must consist of an ESO and two drivers.
b) Minimal tools necessary to adjust the vehicle to fit the second driver and/or change tires Team members may only carry tools by hand (no carts, tool chests etc)
c) Each extra person entering the Driver Change Area: 20 point penalty

D7.7.2 The only work permitted during Driver Change is:

a) Operation of Master Switches, or Shutdown Buttons
b) Adjustments to fit the driver
c) Tire changes

D7.8 Driver Change Procedure

D7.8.1 The Driver Change will be done in this sequence:

No	Sequence Items	Timer
1	Vehicle will stop in Driver Change Area	
2	First Driver turns off the Tractive System	time starts
3	First Driver exits the vehicle	
4	Any necessary adjustments may be made to the vehicle to fit the Second Driver	
5	Second Driver is secured in the vehicle	
6	Second Driver is ready to enable the Tractive System	time stops
7	Second Driver receives permission to continue	
8	The vehicle Tractive System enabled	
9	The vehicle stages to go back onto course, at the direction of the event officials	

D7.8.2 Three minutes are permitted for the team to complete the Driver Change

a) Any additional time for inspection of the vehicle and the Driver Equipment is not included in the Driver Change time
b) Time more than permitted will be added to the team Endurance time

D7.8.2 The Driver Change Area will be in a location where the timing system will see the Driver Change as a long lap which will be deleted from the total time.

D7.9 Endurance Event Tyre Changes

D7.9.1 All tyre changes after a vehicle has received the green flag to start the endurance event must take place in the driver change area.

D7.9.2 If the operating condition changes to wet during endurance, the track will be red flagged, and all vehicles brought into the driver change area.

D7.9.3 If a team wants to change tyres, the officials must be informed beforehand.

D7.9.4 In some cases, tyre changes can be carried out directly after the driver change, for others the team must make an extra stop.

D7.9.5 The allowed tyre changes and associated conditions are given in the following tables.

Table 10: Road condition and tires change.

Current Road Condition	Current Running Tires	Road Condition Change to		
		Dry	Damp	Wet
Dry	Dry Tires	-	A	B
Damp	Dry Tires	-	A	B
Damp	Wet Tires	C	C	-
Wet	Wet Tires	C	C	-

Table 11: Tire change requirement and timing calculation.

	Requirement	Allowed at Driver Change	Time calculation
A	May change from dry to wet	Yes	D7.9.6.a
B	Must change from dry to wet	Yes	D7.9.6.a
C	May change from wet to dry	No	D7.9.6.b

D7.9.6 Time permitted to change tires:

a) Change to Wet Tires – Any time in excess of 10 minutes without driver change, or 13 minutes with Driver Change, will be added to the team's total time for Endurance
b) Change to Dry Tires – The time used to change to Dry Tires will be added to the team’s total time for Endurance

D7.9.7 If the vehicle has a tire puncture,

a) The wheel and tire may be replaced with an identical wheel and tire

b) When the puncture is caused by track debris and not a result of component failure or the vehicle itself, the tire change time will not count towards the team's total time.

D7.10 Breakdowns & Stalls

D7.10.1 If a vehicle breaks down or cannot restart, it will be removed from the course by track workers and scored DNF.

D7.10.1 If a vehicle stalls, or ingests a cone, etc., it may be permitted to continue, subject to D7.4.

D7.11 Endurance Event – Black Flags

D7.11.1 A Black Flag will be shown at the designated location

D7.11.2 The vehicle must pull into the Driver Change Area at the first opportunity

D7.11.3 The amount of time spent in the Driver Change Area is at the discretion of the officials.

D7.11.4 Driving Black Flag

a) May be shown for any reason such as aggressive driving, failing to obey signals, not yielding for passing, not driving inside the designated course, etc.
b) Course officials will discuss the situation with the driver
c) The time spent in Black Flag or a time penalty may be included in the Endurance Run time.
d) If not possible to give a penalty by a stop under a Black Flag, (not enough laps left), or during post event review, officials may add a penalty D9.2

D7.11.5 Mechanical Black Flag

a) May be shown for any reason to question the vehicle condition
b) Time spent off track is not included in the Endurance Run time.

D7.11.6 Based on the inspection or discussion during a Black Flag period, the vehicle may not be permitted to continue the Endurance Run and will be scored DNF.

D7.12 Endurance Event – Passing

D7.12.1 Passing during Endurance may only be done in the designated passing zones, under the control of the track officials.

D7.12.2 Passing zones have two parallel lanes – a slow lane for the vehicles that are being passed and a fast lane for vehicles that are making a pass.

D7.12.3 When a pass is to be made:

a) A slower leading vehicle gets a Blue Flag
b) The slower vehicle must move into the slow lane and decelerate
c) The faster vehicle will continue in the fast lane and make the pass
d) The vehicle that had been passed may reenter traffic only under the control of the passing zone exit flag

D7.12.4 Passing rules do not apply to vehicles that are passing disabled vehicles on the course or vehicles that have spun out and are not moving. When passing a disabled or off track vehicle, slow down, drive cautiously and be aware of all the vehicles and track workers in the area.

D7.13 Endurance Penalties

D7.13.1 Cones (DOO) – Two second penalty for each DOO (including cones after the finish line) on that run.

D7.13.2 Off Course (OC):

a) When an OC occurs, the driver must reenter the track at or prior to the point of exit or receive a 20 second penalty
b) Penalties will not be assessed to bypass an accident or other reasons at the discretion of track officials.

D7.13.3 Missed Slalom – Missing one or more gates of a given slalom will be counted as one Off Course.

D7.13.4 Penalties for Moving or Post Event Violations

a) Black Flag penalties per D7.10, if applicable
b) Post Event Inspection penalties per D9.2, if applicable

D7.13.5 Endurance Starting (D7.4.1), Two minutes (120 seconds) penalty.

D7.13.6 The Chief Marshall/Director of Operations may end the Endurance event (DNF) a vehicle if, for any reason including driver inexperience or mechanical problems, it is too slow or being driven in a manner that demonstrates an inability to properly control.

D7.14 Endurance Scoring

D7.14.1 Scoring Term Definitions:

a) Endurance Run Time - Total Time for the two Drivers, minus the Driver Change lap, minus any Mechanical Black Flag Time, plus any Penalty time D9.2
b) Corrected Time = Endurance Run Time + (DOO * 2) + (OC * 20)
c) Tyour - the Corrected Time for the team
d) Tmin - the lowest Corrected Time recorded for any team
e) Tmax - 145% of Tmin

D7.14.2 The vehicle must complete the Endurance Event to receive a score based on their Corrected Time.

D7.14.3 If Tyour < Tmax, the team score is calculated as:

$$Endurance\ Time\ Score = 250 \times \frac{\left(T_{max}/T_{your}\right) - 1}{\left(T_{max}/T_{min}\right) - 1}$$

D7.14.4 If Tyour > Tmax, Endurance Time Score = 0

D7.14.5 The vehicle receives points based on the laps and/or parts of Endurance completed. The Endurance Laps Score is worth up to 25 points

D7.14.6 The Endurance Score is calculated as:

$$Endurance\ Score = Endurance\ Time\ Score + Endurance\ Laps\ Score$$

D8 EFFICIENCY EVENT

D8.1 General Information

D8.1.1 The Efficiency is based on a metric of the amount of fuel consumed or energy used and the lap time on the endurance course, averaged over the length of the event.

D8.1.2 The Efficiency score is based only on the distance the vehicle runs on the course during the Endurance event, and the total fuel/energy used. No adjustment to distance or fuel/energy will be made.

D8.2 Efficiency Procedure

D8.2.1 Vehicles must power down after leaving the Endurance course and be pushed to the fueling station or data download area.

D8.2.2 For EV Class:

a) Energy Meter data must be downloaded to measure energy used and check for Violations EV2.2
b) Penalties will be applied per EV2.5 and/or D.13.3.4

D8.2.3 For HEV Class:

a) The Fuel Tank must be filled to the Fuel Level Line (HY5.5.4) to measure fuel used HY5.6.
b) If the fuel level changes after refuelling:
   i. Additional fuel will be added to return the fuel tank level to the fuel level line.
   ii. Twice this amount will be added to the previously measured fuel consumption
c) If damage or a potential environmental hazard (example - Fuel Tank leakage) exists, the Fuel Tank will not be refilled D8.3.4.

D8.3 Efficiency Eligibility

D8.3.1 Maximum Time – Vehicles whose average Endurance laptime exceeds 1.45 times the average Endurance laptime of the fastest team that completes the Endurance event get zero points.

D8.3.2 Maximum Fuel/Energy Used – Vehicles whose corrected average (EV Class) energy equivalent / (HEV Class) fuel consumption per lap exceeds the values in D8.4.4 get zero points.

D8.3.3 Partial Completion of Endurance:

a) Vehicles which cross the start line after Driver Change are eligible for Efficiency points
b) Other vehicles get zero points

D8.3.4 Cannot Measure Fuel/Energy Used – The vehicle gets zero points.

D8.3.5 Full credit is given for energy recovered through regenerative braking.

D8.4 Efficiency Scoring

D8.4.1 Conversion Factors are used based on:

a) Petrol 2.31 kg of CO_2 per liter
b) Electric 0.65 kg of CO_2 per kWh

D8.4.2 Scoring Term Definitions:

a) CO2min – the smallest mass of CO_2 used by any competitor who is eligible for Efficiency
b) CO2your – the mass of CO_2 used by the team being scored
c) Tmin – the lowest Endurance time of the fastest team which is eligible for Efficiency
d) Tyour – same as Endurance (D.12.13.1)
e) Lapyours – the number of laps driven by the team being scored
f) Laptotal Tmin and Latptotal CO_2 min – be the number of laps completed by the teams which set Tmin and CO2min, respectively

D8.4.3 The Efficiency Factor is calculated by:

$$Efficiency\ Factor = \frac{T_{min}/LapTotal_{Tmin}}{T_{your}/Lap_{your}} \times \frac{CO_{2\ min}/LapTotal_{CO2\ min}}{CO_{2\ your}/Lap_{your}}$$

D8.4.4 EfficiencyFactor min is calculated using the above formula with:

a) CO_2 your (EV Class) equivalent to 20.02 kg CO_2/100km
b) CO_2 your (HEV Class) equivalent to 60.06 kg CO_2/100km (based on gasoline 26 ltr/100km)
c) Tyour 1.45 times Tmin

D8.4.5 When the team is eligible for Efficiency. the team score is calculated as:

$$Efficiency\ Score = 100 \times \frac{Efficiency\ Factor\ your - Efficiency\ Factor\ min}{fficiency\ Factor\ max - Efficiency\ Factor\ min}$$

D9 POST ENDURANCE

D9.1 Technical Inspection Required

D9.1.1 After Endurance and refuelling are completed, all vehicles must report to Technical Inspection.

D9.1.2 Vehicles may then be subject to **IN1.6 Reinspection**.

D9.2 Post Endurance Penalties

D9.2.1 Penalties may be applied to the Endurance and/or Efficiency events based on:

a) Infractions or issues during the Endurance Event (including **D7.10.4.d**)
b) Post Endurance Technical Inspection
c) Energy Meter violations **EV2.2**, **EV2.5.2**

D9.2.2 Any penalty will be at the discretion of the officials.

D9.3 Post Endurance Penalty Guidelines

D9.3.1 One or more minor violations (rules compliance, but no advantage to team): 15-30 sec.

D9.3.2 Violation which is a potential or actual performance advantage to team: 120-360 sec.

D9.3.3 Violation with potential or actual effect on safety or environment: 240 sec up to DNF or DQ

D9.3.4 Team may be DNF or DQ for:

a) Multiple violations involving safety, environment, or performance advantage
b) A single substantial violation