formula HYBRID™

2009 Formula Hybrid™ Rules

The 2009 Formula Hybrid Rules are derived from the 2008 Formula SAE Rules. It is extremely important that teams read and comply with this document because there are significant differences from many of the original 2008 FSAE Rules.

We strongly recommend that teams building new chassis for the 2009 Formula Hybrid competition comply with the 2009 Formula SAE chassis and safety Rules.

THAYER SCHOOL OF ENGINEERING AT DARTMOUTH

2009 Formula Hybrid Rules

1 FORMULA HYBRID – OVERVIEW AND COMPETITION

1.1 Formula Hybrid Competition Objective

The Formula Hybrid™ Series competitions challenge teams of university undergraduate and graduate students to conceive, design, fabricate and compete with small, formula style, autocross racing cars. To give teams the maximum design flexibility and the freedom to express their creativity and imaginations there are very few restrictions on the overall vehicle design. Teams typically spend eight to twelve months designing, building, testing and preparing their vehicles before a competition. The competitions themselves give teams the chance to demonstrate and prove both their creativity and their engineering skills in comparison to teams from other universities around the world.

1.2 Vehicle Design Objectives

For the purpose of this competition, the students are to assume that a manufacturing firm has engaged them to design, fabricate and demonstrate a prototype car for evaluation as a production item. The intended market is the nonprofessional weekend autocross racer. Therefore, the car must have very high performance in terms of its acceleration, braking, and handling qualities. The car must be low in cost, easy to maintain, and reliable. It should accommodate drivers whose stature varies from a 5th percentile female to a 95th percentile male. In addition, the car's marketability is enhanced by other factors such as aesthetics, comfort and use of common parts. The manufacturing firm is planning to produce four (4) cars per day for a limited production run. The challenge to the design team is to develop a prototype car that best meets these goals and intents. Each design will be compared and judged with other competing designs to determine the best overall car

1.3 Good Engineering Practices

Vehicles entered into Formula Hybrid competitions are expected to be designed and fabricated in accordance with good engineering practices.

1.4 Judging Categories

The cars are judged in a series of static and dynamic events including: technical inspection, presentation, and engineering design, solo performance trials, and high performance track endurance. These events are scored to determine how well the car performs. In each event, the manufacturing firm has specified minimum acceptable performance levels that are reflected in the scoring equations.

The following points are possible:

Static Events		
	Presentation	100
	Engineering Design	200
Dynamic Events		
	Acceleration – Electric	75
	Acceleration – Unrestricted	75
	Autocross	150
	Fuel Economy	50
	Endurance	400
Total Points		1000

1.5 Official Announcements and Competition Information

Teams are required to read the newsletters published by SAE and Formula Hybrid and to be familiar with all official announcements concerning the competition and rules interpretations released by the Formula Hybrid Rules Committee.

Formula Hybrid posts announcements to the "News and Important Information" section of the Formula Hybrid forum at http://www.formula-hybrid.org/forums/index.php

1.6 Official Languages

The official language of the Formula Hybrid series is English.

1.7 Formula Hybrid Rules and Organizer Authority

1.7.1 Rules Authority

The Formula Hybrid Rules are the responsibility of the Formula Hybrid Rules Committee and are issued under the authority of the SAE University Programs Committee. Official announcements from the Formula Hybrid Rules Committee shall be considered part of, and shall have the same validity as, these rules.

Ambiguities or questions concerning the meaning or intent of these rules will be resolved by the Formula Hybrid Rules Committee, SAE or by the individual competition organizers as appropriate.

1.7.2 Rules Validity

The Formula Hybrid Rules posted on the Formula Hybrid website and dated for the calendar year of the competition are the rules in effect for the competition. Rule sets dated for other years are invalid.

1.7.3 Rules Compliance

By entering a Formula Hybrid competition the team, members of the team as individuals, faculty advisors and other personnel of the entering university agree to comply with, and be

bound by, these rules and all rule interpretations or procedures issued or announced by SAE, the Formula Hybrid Rules Committee and the other organizing bodies. All team members, faculty advisors and other university representatives are required to cooperate with, and follow all instructions from, competition organizers, officials and judges.

1.7.4 Understanding the Rules

Teams, team members as individuals and faculty advisors, are responsible for reading and understanding the rules in effect for the competition in which they are participating. The section and paragraph headings in these rules are provided only to facilitate reading: they do not affect the paragraph contents.

1.7.5 Participating in the Competition

Teams, team members as individuals, faculty advisors and other representatives of a registered university who are present on-site at a competition are considered to be "participating in the competition" from the time they arrive at the event site until they depart the site at the conclusion of the competition or earlier by withdrawing.

1.7.6 Violations of Intent

The violation of intent of a rule will be considered a violation of the rule itself. Questions about the intent or meaning of a rule may be addressed to the Formula Hybrid Rules Committee or by the individual competition organizers as appropriate.

1.7.7 Right to Impound

SAE and other competition organizing bodies reserve the right to impound any onsite registered vehicles at any time during a competition for inspection and examination by the organizers, officials and technical inspectors.

1.7.8 General Authority

SAE and the competition organizing bodies reserve the right to revise the schedule of any competition and/or interpret or modify the competition rules at any time and in any manner that is, in their sole judgment, required for the efficient operation of the event or the Formula Hybrid series as a whole

2 ELIGIBILITY

2.1 Individual Participant Requirements

Eligibility is limited to undergraduate and graduate students to insure that this is an engineering competition rather than a race. Individual members of teams participating in this competition must satisfy the following requirements:

2.1.1 Student Status

Team members must be enrolled as degree seeking undergraduate or graduate students in a college or university. Team members who have graduated during the seven (7) month period prior to the competition remain eligible to participate.

2.1.2 Society Membership

Team members must be members of at least one of the following societies:

(1) SAE, (2) SAE Australasia, (3) SAE Brasil, (4) ATA, (5) IMechE or (6) IEEE. Proof of membership, such as membership card, is required at the competition. Students who are members of one of the societies listed above are not required to join any of the other societies in order to participate in the Formula Hybrid competition.

Students can join SAE online at: www.sae.org/students or IEEE at http://www.ieee.org/web/membership/join/join.html

Note: SAE membership is required to complete the on-line vehicle registration process, so at least one team member must be a member of SAE.

2.1.3 Age

Team members must be at least eighteen (18) years of age.

2.1.4 Driver's License

Team members who will drive a competition vehicle at any time during a competition must hold a valid, government issued driver's license.

2.1.5 Liability Waiver

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

2.1.6 Medical Insurance

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

2.1.7 Individual Registration Requirements

2.1.7.1 SAE Student Members

If your qualifying professional society membership is with the SAE, you should link yourself to your respective school, and complete the following information on the SAE website:

Medical insurance (provider, policy/ID number, telephone number)

Driver's license (state/country, ID number)

Emergency contact data (point of contact (parent/guardian, spouse), relationship, and phone number)

To do this you will need to go to Student Central on the SAE homepage, then click on the "2009 Competition Date and Registration Information" link under "Student Competitions". Proceed by selecting the "Competition Schedule/Registration" link and then the event(s) you wish to register for. Choose the "Register" link (or "Update" link if after December 22, 2009) next to your desired competition(s) and then select your team link to add yourself to the team profile. The "Add New Member" button will allow individuals to include themselves with the rest of the team.

2.1.7.2 All Student Team Members (including SAE members)

IMPORTANT: BRING YOUR OFFICIAL DRIVER'S LICENSE OR PASSPORT TO ONSITE REGISTRATION. ALSO PLEASE BRING YOUR MEDICAL INSURANCE CARD.

All international student participants (or unaffiliated faculty advisors) who are not SAE members are required to complete the International Student Registration form for the entire team found under "Competition Resources" on the event specific webpage. Upon completion, email the form to CollegiateCompetitions@sae.org.

All students, both domestic and international, must affiliate themselves online or submit the International Student Registration form by February 28, 2009. For additional assistance, please contact CollegiateCompetitions@sae.org.

****NOTE: When your team is registering for a competition, only the student or faculty advisor completing the registration needs to be linked to the school. All other students and faculty can affiliate themselves after registration has been completed, however this must be done on or before February 28, 2009.**

2.1.8 Faculty Advisor

Each team is expected to have a Faculty Advisor appointed by the university. The Faculty Advisor is expected to accompany the team to the competition and will be considered by competition officials to be the official university representative.

Faculty Advisors may advise their teams on general engineering and engineering project management theory, but may not design any part of the vehicle nor directly participate in the development of any documentation or presentation. Additionally, Faculty Advisors may neither fabricate nor assemble any components nor assist in the preparation, maintenance, testing or operation of the vehicle.

In Brief – Faculty Advisors may not design, build or repair any part of the car.

2.2 Registration Requirements

2.2.1 Vehicle Eligibility

Vehicles entered into Formula Hybrid 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.

The student team may use any literature or knowledge related to car design and information from professionals or from academics as long as the information is given as a discussion of alternatives with their pros and cons. Professionals may not make design decisions or drawings and the Faculty Advisor must sign a statement of compliance with this restriction.

It is the intent of the SAE Collegiate Design Series competitions to provide direct hands-on experience to the students. Therefore, students should perform all fabrication tasks whenever possible.

2.2.2 Registration – Formula Hybrid Competitions

Registration for the Formula Hybrid competition must be completed on-line. Online registration must be done by either (a) an SAE member or (b) the official faculty advisor connected with the registering university and recorded as such in the SAE record system.

Note: It typically takes at least 1 working day between the time you complete an online SAE membership application and our system recognizes you as eligible to register your team.

2.2.2.1 First Year Vehicles

Universities may enter the same vehicle for multiple years, but must document substantial improvements and/or upgrades to the vehicle as used in the previous year's competition.

The term "substantial" will be applied at the discretion of the organizers. If a team is uncertain if their changes qualify as substantial, they are encouraged to contact the organizers prior to the competition.

2.2.2.2 Entries per University

Universities may enter up to two vehicles per competition.

2.2.2.3 Registration Dates – North American Formula Hybrid Competitions

Registration for the 2009 Formula Hybrid competitions will open at 10:00 am EDT, Monday, October 6th, 2008.

2.2.2.4 Registration Fees

Registration fees must be paid to the organizer by the deadline specified on the respective competition website.

Registration fees are not refundable.

2.2.3 Withdrawals

Registered teams that find that they will not be able to attend the FH competition are requested to officially withdraw by notifying the following not later than one (1) week before the event:

Wynne Washburn: wynne@formula-hybrid.org

2.2.4 United States Visas

Teams requiring visas to enter to the United States are advised to apply at least ninety

(90) days prior to the competition. Although most visa applications seem to go through without an unreasonable delay, occasionally teams have had difficulties and in several instances visas were not issued before the competition.

Don't wait – apply early for your visa.

Neither SAE staff nor any competition organizers are permitted to give advice on either visa or customs matters concerning the United States or any other country.

3 VEHICLE REQUIREMENTS & RESTRICTIONS

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

3.1 General Design Requirements

3.1.1 Body and Styling

The vehicle must be open-wheeled and open-cockpit (a formula style body). There must be no openings through the bodywork into the driver compartment from the front of the vehicle back to the roll bar main hoop or firewall other than that required for the cockpit opening. Minimal openings around the front suspension components are allowed.

3.1.2 Wheelbase and Vehicle Configuration

The car must have a wheelbase of at least 1525 mm (60 inches). The wheelbase is measured from the center of ground contact of the front and rear tires with the wheels pointed straight ahead. The vehicle must have four (4) wheels that are not in a straight line.

3.1.3 Vehicle Track

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

3.1.4 Visible Access

All items on the Inspection Form must be clearly visible to the technical inspectors. Visible access can be provided by removing body panels or by providing removable access panels.

3.1.5 Warning Strobe Light

There must be an amber strobe light compliant with SAE Standard J1318 Class 3 (Federal Signals Renegade®, Star Warning Systems 200Z or equivalent) mounted on the highest point on the roll bar, that will indicate when a vehicle is energized. Energized is defined as any time a High Voltage exists outside the accumulator containers.

3.2 Chassis Rules

3.2.1 Suspension

The car must be equipped with a fully operational suspension system with shock absorbers, front and rear, with usable wheel travel of at least 50.8 mm (2 inches),

25.4 mm (1 inch) jounce and 25.4 mm (1 inch) rebound, with driver seated. The judges reserve the right to disqualify cars which do not represent a serious attempt at an operational suspension system or which demonstrate handling inappropriate for an autocross circuit.

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

3.2.2 Ground Clearance

The ground clearance must be sufficient to prevent any portion of the car (other than tires) from touching the ground during track events, and with the driver aboard there must be a minimum of 25.4 mm (1 inch) of static ground clearance under the complete car at all times.

3.2.3 Wheels and Tires

3.2.3.1 Wheels

The wheels of the car must be 203.2 mm (8.0 inches) or more in diameter.

Any wheel mounting system that uses a single retaining nut must incorporate a device to retain the nut and the wheel in the event that the nut loosens.

3.2.3.2 Tires

Vehicles may have two types of tires as follows:

Dry Tires – The tires on the vehicle when it is presented for technical inspection are defined as its "Dry Tires". The dry tires may be any size or type. They may be slicks or treaded.

Rain Tires – Rain tires may be any size or type of treaded or grooved tire provided:

1) The tread pattern or grooves were molded in by the tire manufacturer, or were cut by the tire manufacturer or his appointed agent. Any grooves that have been cut must have documentary proof that it was done in accordance with these rules.

2) There is a minimum tread depth of 2.4 mms (3/32 inch).

Note: Hand cutting, grooving or modification of the tires by the teams is specifically prohibited.

Within each tire set, the tire compound or size, or wheel type or size may not be changed after static judging has begun. Tire warmers are not allowed. No traction enhancers may be applied to the tires after the static judging has begun.

3.2.4 Steering

The steering system must affect at least two (2) wheels.

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 may be placed on the uprights or on the rack and must prevent the tires from contacting suspension, body, or frame members during the track events.

Allowable steering system free play is limited to 7 degrees total measured at the steering wheel.

Rear wheel steering is permitted only if mechanical stops limit the turn angle of the rear wheels to ± 3 degrees from the straight ahead position.

The steering wheel must be mechanically connected to the front wheels, i.e. “steer-by-wire” of the front wheels is prohibited.

3.2.5 Brake Systems

The car must be equipped with a braking system that acts on all four wheels and is operated by a single control. It must have two independent hydraulic circuits such that in the case of a leak or failure at any point in the system, effective braking power is maintained on at least two wheels. Each hydraulic circuit must have its own fluid reserve, either by the use of separate reservoirs or by the use of a dammed, OEM-style reservoir.

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

The brake system must be capable of locking all four (4) wheels during the test specified below.

Up to the first 50% of brake pedal travel may be dedicated to activating regenerative or other advanced braking systems, but the remaining travel must mechanically activate the hydraulic system.

Unarmored plastic brake lines are prohibited.

The braking systems must be protected with scatter shields from failure of the drive train (See Section 3.5.4.4) or from minor collisions.

3.2.5.1 Brake Test

The brake system will be dynamically tested and must demonstrate the capability of locking all four (4) wheels and stopping the vehicle in a straight line at the end of an acceleration run specified by the brake inspectors.

3.2.5.2 Brake Over-Travel Switch

A brake pedal over-travel switch must be installed on the car. This switch must be installed so that in the event of brake system failure such that the brake pedal over travels, the switch will be activated and must shut down all drive systems and must trip the accumulator isolation relays. Repeated actuation of the switch must not restore power to these systems and it must be designed so that the driver cannot reset it.

3.2.5.3 Brake Light

The car must be equipped with a red brake light of at least 15 watts, or equivalent, clearly visible from the rear. If an LED brake light is used, it must be clearly visible in very bright sunlight. This light must be mounted between the wheel centerline and driver’s shoulder level vertically and approximately on vehicle centerline laterally.

3.2.6 Jacking Points

A jacking point, which is capable of supporting the car's weight and of engaging the organizers' "quick jacks", must be provided at the rear of the car.

The jacking point is required to be:

- Oriented horizontally and perpendicular to the centerline of the car
- Made from round, 25 – 29 mm (1 – 1 1/8 inch) O.D. aluminum or steel tube
- A minimum of 300 mm (12 inches) long
- Exposed around the lower 180 degrees of its circumference over a minimum length of 280 mm (11 in)

The height of the tube is required to be such that:

- There is a minimum of 75 mm (3 in) clearance from the bottom of the tube to the ground measured at tech inspection.
- With the bottom of the tube 200 mm (7.9 in) above ground, the wheels do not touch the ground when they are in full rebound.

3.3 Structural Requirements

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

Note: Many teams will be retrofitting Formula SAE cars for Formula Hybrid. In most cases these vehicles will be considerably heavier than what the original frame and suspension was designed to carry. It is important to analyze the structure of the car and to strengthen it as required to insure that it will handle the additional stresses.

The technical inspectors will also be paying close attention to the mounting of accumulator systems. These can be very heavy and must be adequately fastened to the main structure of the vehicle.

3.3.1 Definitions

The following definitions apply throughout the Rules document:

Main Hoop - A roll bar located alongside or just behind the driver's torso.

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

Roll Hoops – Both the Front Hoop and the Main Hoop are classified as "Roll Hoops"

Frame Member - A minimum representative single piece of uncut, continuous tubing.

Frame - The "Frame" is the fabricated structural assembly that supports all functional vehicle systems. This assembly may be a single welded structure, multiple welded structures or a combination of composite and welded structures.

Primary Structure – The Primary Structure is comprised of the following Frame components: 1) Main Hoop, 2) Front Hoop, 3) Roll Hoop Braces, 4) Side Impact Structure, 5) Front Bulkhead, 6) Front Bulkhead Support System and 7) all Frame Members, guides and supports that transfer load from the Driver's Restraint System into items 1 through 6.

Major Structure of the Frame – The portion of the Frame that lies within the envelope defined by the Primary Structure. The upper portion of the Main Hoop and the Main Hoop braces are not included in defining this envelope.

Front Bulkhead – A planar structure that defines the forward plane of the Major Structure of the Frame and functions to provide protection for the driver's feet.

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

3.3.2 Structural Equivalency and Structural Equivalency Form (SEF)

ALL TEAMS MUST SUBMIT A STRUCTURAL EQUIVALENCY FORM (SEF), even if they are NOT planning to use alternative materials or tubing sizes to those specified in 3.3.3.1 Baseline Steel Materials.

The use of alternative materials or tubing sizes to those specified in 3.3.3.1"Baseline Steel Material," is allowed, provided they have been judged by a technical review to have equal or superior properties to those specified in 3.3.3.1.

Approval of alternative material or tubing sizes will be based upon the engineering judgment and experience of the chief technical inspector or his appointee.

The technical review is initiated by completing the "Structural Equivalency Form" (SEF) using the format given in Appendix D.

3.3.2.1 Structural Equivalency Form – Submission

Address – SEF's must be submitted to the officials at the competition you are entering at the address shown in the Appendix or indicated at the competition website.

Due Date – SEF's must be submitted no later than the date given in the "Action Deadlines" in the appendix or the date indicated on the competition website. Teams that submit their Structural Equivalency Form after the due date for the competition will be penalized 10 points per day up to a maximum of 50 points, which will be taken off the team's Total Score.

Acknowledgement – North America competitions – SEF's submitted for vehicles entered into competitions held in North America will be acknowledged upon receipt.

Do Not Resubmit SEF's -- Note: Because an SEF may have been previously approved by an FSAE examiner, does not mean that it will automatically be approved for FH.

3.3.3 Minimum Material Requirements

3.3.3.1 Baseline Steel Material

The Primary Structure of the car must be constructed of:

Either: Round, mild or alloy, steel tubing (minimum 0.1% carbon) of the minimum dimensions specified in the following table,

Or: Approved alternatives per Section 3.3.3.2

ITEM or APPLICATION	OUTSIDE DIAMETER x WALL THICKNESS
Main & Front Hoops, Shoulder Harness Mounting Bar	1.0 inch (25.4 mm) x 0.095 inch (2.4 mm) or 25.0 mm x 2.50 mm metric
Side Impact Structure, Front Bulkhead, Roll Hoop Bracing, Driver's Restraint Harness Attachment (except as noted above)	1.0 inch (25.4 mm) x 0.065 inch (1.65 mm) or 25.0 mm x 1.75 mm metric or 25.4 mm x 1.60 mm metric
Front Bulkhead Support	1.0 inch (25.4 mm) x 0.049 inch (1.25 mm) or 25.0 mm x 1.5 mm metric or 26.0 mm x 1.2 mm metric

Note 1: The use of alloy steel does not allow the wall thickness to be thinner than that used for mild steel.

Note 2: For a specific application, tubing of the specified outside diameter but with greater wall thickness, OR of the specified wall thickness and a greater outside diameter to those listed above DOES NOT require an SEF submission.

3.3.3.2 Alternative Tubing and Material

3.3.3.2.1 General

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

If a team chooses to use alternative tubing and/or materials they must submit a "Structural Equivalency Form" per Section 3.3.2. The teams must submit calculations for the material they have chosen, demonstrating equivalence to the minimum requirements found in Section 3.3.3.1 for yield and ultimate strengths in bending, buckling and tension, for buckling modulus and for energy dissipation. (The Buckling Modulus is defined as EI, where, E = modulus of Elasticity, and I = area moment of inertia about the weakest axis.)

Tubing cannot be of thinner wall thickness than listed in 3.3.3.2.2or 3.3.3.2.3.

3.3.3.2.2 Steel Tubing Requirements

Minimum Wall Thickness Allowed:

MATERIAL & APPLICATION	MINIMUM WALL THICKNESS
Steel Tubing for Front and Main Roll Hoops	2.0 mm (0.079 inch)
Steel Tubing for Roll Hoop Bracing, Front Bulkhead & Driver's Harness Attachment	1.6 mm (0.063 inch)
Steel Tubing for Side Impact Structure & Front Bulkhead Support	1.2 mm (0.047 inch)

Note 1: All steel is treated equally - there is no allowance for alloy steel tubing, e.g. SAE 4130, to have a thinner wall thickness than that used with mild steel.

Note 2: To maintain EI with a thinner wall thickness than specified in **3.3.3.1**, the outside diameter MUST be increased.

Note 3: To maintain the equivalent yield and ultimate tensile strength the same cross-sectional area of steel MUST be maintained.

3.3.3.2.3 Aluminum Tubing Requirements

Minimum Wall Thickness:

MATERIAL & APPLICATION	MINIMUM WALL THICKNESS
Aluminum Tubing	3.0 mm (0.118 inch)

The equivalent yield strength must be considered in the "as-welded" condition, (Reference: WELDING ALUMINUM (latest Edition) by the Aluminum Association, or THE WELDING HANDBOOK, Vol. 4, 7th Ed., by The American Welding Society), unless the team demonstrates and shows proof that the frame has been properly solution heat treated and artificially aged.

Should aluminum tubing be solution heat-treated and age hardened to increase its strength after welding; the team must supply sufficient documentation as to how the process was performed. This includes, but is not limited to, the heat-treating facility used, the process applied, and the fixturing used.

3.3.3.2.4 Composite Materials

If any composite or other material is used, the team must present documentation of material type, e.g. purchase receipt, shipping document or letter of donation, and of the material properties. Details of the composite lay-up technique as well as the structural material used (cloth type, weight, resin type, number of layers, core material, and skin material if metal) must also be submitted. The team must submit calculations demonstrating equivalence of their composite structure to one of similar geometry made to the minimum requirements found in Section 3.3.3.1. Equivalency calculations must be submitted for energy dissipation, yield and

ultimate strengths in bending, buckling, and tension. Submit the completed "Structural Equivalency Form" per Section 3.3.2.

Composite materials are not allowed for the main hoop or the front hoop.

3.3.4 Roll Hoops

The driver's head and hands must not contact the ground in any rollover attitude. The Frame must include both a Main Hoop and a Front Hoop as shown in Figure 1.

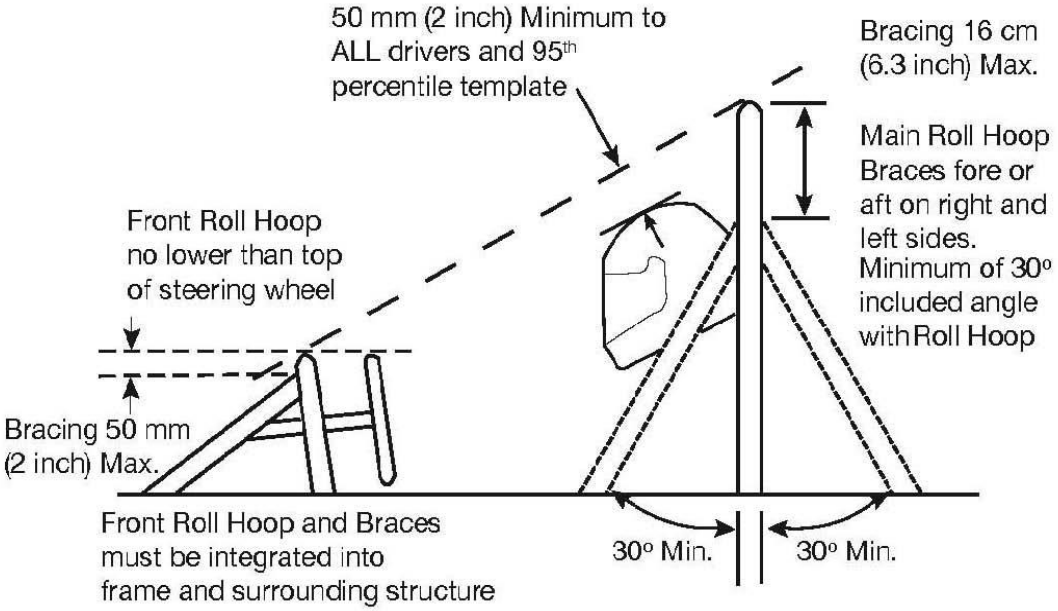


Figure 1

3.3.4.1 Main and Front Hoops – General Requirements

When seated normally and restrained by the Driver's Restraint System, a straight line drawn from the top of the main hoop to the top of the front hoop must clear by 50.8 mm (2 inches) the helmet of all the team's drivers and the helmet of a 95th percentile male (anthropometrical data).

95th Percentile Male Template Dimensions

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

A circle of diameter 200 mm (7.87 inch) will represent the hips and buttocks.

A circle of diameter 200 mm (7.87 inch) will represent the shoulder/cervical region.

A circle of diameter 300 mm (11.81 inch) will represent the head (with helmet).

A straight line measuring 490 mm (19.29 inch) will connect the centers of the two 200 mm circles.

A straight line measuring 280 mm (11.02 inch) will connect the centers of the upper 200 mm circle and the 300 mm head circle.

The 95th percentile male template will be positioned as follows: the seat will be adjusted to the rearmost position, the bottom 200 mm circle will be placed in the seat, and the middle 200 mm circle, representing the shoulders, will be positioned on the seat back. The upper 300 mm circle will be positioned up to 25.4 mm (1 inch) away from the head restraint (i.e. where the driver's helmet would normally be located while driving).

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 Main Hoop and Front Hoop must be securely integrated into the Primary Structure using gussets and/or tube triangulation.

3.3.4.2 Main Hoop

The Main Hoop must be constructed of a single piece of uncut, continuous, closed section steel tubing per Section 3.3.3.

The use of aluminum alloys, titanium alloys or composite materials for the Main Hoop is prohibited.

The Main Hoop must extend from the lowest Frame Member on one side of the Frame, up, over and down the lowest Frame Member on the other side of the Frame.

In the side view of the vehicle, the portion of the Main Roll Hoop that lies above its attachment point to the Major Structure of the Frame must be within 10 (10°) degrees of the vertical.

In the front view of the vehicle, the vertical members of the Main Hoop must be at least 380 mm (15 inch) apart (inside dimension) at the location where the Main Hoop is attached to the Major Structure of the Frame.

On vehicles where the Primary Structure is not made from steel tubes, the Main Hoop must be continuous and extend down to the bottom of the Frame. The Main Hoop must be securely attached to the monocoque structure using 8 mm Grade 8.8 (5/16 in Grade 5) bolts. Mounting

plates welded to the Roll Hoop shall be at least 2.0 mm (0.080 inch) thick steel. Steel backup plates of equal thickness must be installed on the opposing side of the monocoque structure such that there is no evidence of crushing of the core. The attachment of the Main Hoop to the monocoque structure requires an approved Structural Equivalency Form per Section 3.3.2 The form must demonstrate that the design is equivalent to a welded Frame and must include justification for the number and placement of the bolts.

3.3.4.3 Front Hoop

The Front Hoop must be constructed of closed section metal tubing per Section 3.3.3.

The use of composite materials is prohibited for the Front Hoop.

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. With proper gusseting and/or triangulation, it is permissible to fabricate the Front Hoop from more than one piece of tubing.

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

The Front Hoop must be no more than 250 mms (9.8 inches) forward of the steering wheel. This distance shall be measured horizontally, on the vehicle centerline, from the rear surface of the Front Hoop to the forward most surface of the steering wheel rim with the steering in the straight-ahead position.

In side view, no part of the Front Hoop can be inclined at more than twenty degrees (20°) from the vertical.

3.3.5 Roll Hoop Bracing

3.3.5.1 Main Hoop Bracing

Main Hoop braces must be constructed of closed section steel tubing per Section **3.3.3**.

The use of aluminum alloys, titanium alloys or composite materials for the Main Hoop braces is prohibited.

The Main Hoop must be supported by two braces extending in the forward or rearward direction on both the left and right sides of the Main Hoop. In the side view of the Frame, the Main Hoop and the Main Hoop braces must not lie on the same side of the vertical line through the top of the Main Hoop, i.e. if the Main Hoop leans forward, the braces must be forward of the Main Hoop, and if the Main Hoop leans rearward, the braces must be rearward of the Main Hoop.

The Main Hoop braces must be attached as near as possible to the top of the Main Hoop but not more than 160 mm (6.3 in) below the top-most surface of the Main Hoop. The included angle formed by the Main Hoop and the Main Hoop braces must be at least thirty degrees (30°).

The Main Hoop braces must be straight, i.e. without any bends.

The attachment of the Main Hoop braces must not compromise the function of the bracing i.e. the attachment method and supporting structure must be capable of transmitting all loads from the Main Hoop into the Major Structure of the Frame without failing. The braces must either transmit this load directly to the Major Structure of the Frame, or through a properly triangulated structure. Bracing loads must not be fed solely into the engine, transmission or differential, i.e. the bracing must terminate at a node where there is a load path through the Primary Structure.

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

3.3.5.2 Front Hoop Bracing

Front Hoop braces must be constructed of material per Section 3.3.3.

The Front Hoop must be supported by two braces extending in the forward direction on both the left and right sides of the Front Hoop.

The Front Hoop braces must be constructed such that they protect the driver's legs and should extend to the structure in front of the driver's feet.

The Front Hoop braces must be attached as near as possible to the top of the Front Hoop but not more than 50.8 mm (2 in) below the top-most surface of the Front Hoop.

Monocoque construction used as Front Hoop bracing requires an approved Structural Equivalency Form per Section **3.3.2**.

If the Front Hoop leans rearwards by more than 10 degrees (10°) from the vertical, it must be supported by additional bracing to the rear. This bracing must be constructed of material per Section 3.3.3.

3.3.5.3 Other Bracing Requirements

Where the braces are not welded to steel Frame Members, the braces must be securely attached to the Frame using 8 mm Grade 8.8 (5/16 in Grade 5), or stronger, bolts. Mounting plates welded to the Roll Hoop braces must be at least 2.0 mm (0.080 in) thick steel.

Where Main Hoop braces are attached to a monocoque structure, backup plates, equivalent to the mounting plates, must be installed on the opposing side of the monocoque structure such that there is no evidence of crushing of the core. The attachment of the Main Hoop braces to the monocoque structure requires an approved Structural Equivalency Form per Section 3.3.2. The form must demonstrate that the design is equivalent to a welded frame and must include justification for the number and placement of the bolts.

3.3.5.4 Other Side Tube Requirements

If there is a Roll Hoop brace or other frame tube alongside the driver, at the height of the neck of any of the team's drivers, a metal tube or piece of sheet metal must be firmly attached to the

Frame to prevent the drivers' shoulders from passing under the roll hoop brace or frame tube, and his/her neck contacting this brace or tube.

3.3.5.5 Mechanically Attached Roll Hoop Bracing

Roll Hoop bracing may be mechanically attached. Any non-permanent joint at either end must be either a double-lug joint as shown in Figures 2 and 3, or a sleeved butt joint as shown in Figure 4. The threaded fasteners used to secure non-permanent joints are considered critical fasteners and must comply with paragraph 3.7.2.2. No spherical rod ends are allowed.

MECHANICALLY ATTACHED ROLL BAR BRACES ATTACHMENT DETAILS (FIGURES 2, 3 & 4

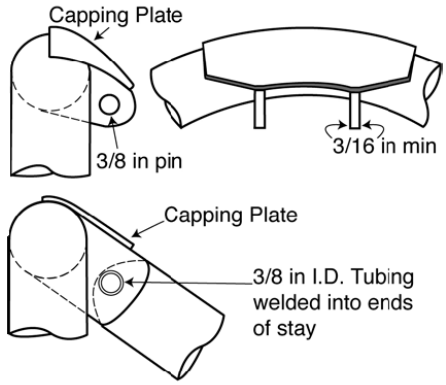


Figure 2

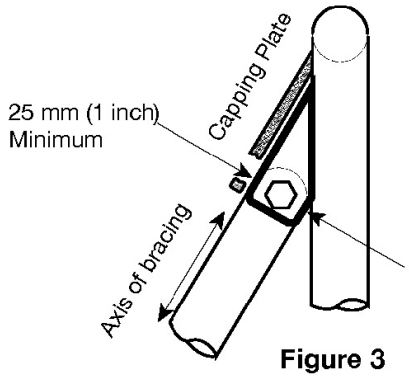


Figure 3

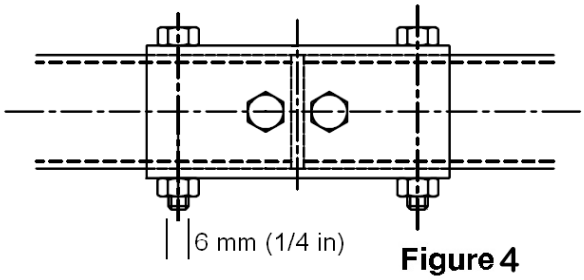


Figure 4

For double-lug joints, each lug must be at least 4.5 mm (0.177 in) thick steel, measure 25 mm (1.0 in) minimum perpendicular to the axis of the bracing and be as short as practical along the axis of the bracing. All double-lug joints, whether fitted at the top or bottom of the tube, must include a capping arrangement (Figures 2 & 3). The pin or bolt must be 10 mm Grade 9.8 (3/8 in. Grade 8) minimum. The attachment holes in the lugs and in the attached bracing must be a close fit with the pin or bolt.

For sleeved butt joints, the sleeve must have a minimum length of 76 mm (3 inch), 38 mm (1.5 inch) either side of the joint, and be a close-fit around the base tubes. The wall thickness of the

sleeve must be at least that of the base tubes. The bolts must be 6 mm Grade 9.8 (1/4 inch Grade 8) minimum. The holes in the sleeves and tubes must be a close-fit with the bolts.

3.3.6 Frontal Impact Structure

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

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

3.3.6.1 Bulkhead

The Front Bulkhead must be constructed of closed section tubing per Section 3.3.3.

The Front Bulkhead must be located forward of all non-crushable objects, e.g. batteries, master cylinders, hydraulic reservoirs.

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

Monocoque construction requires an approved Structural Equivalency Form, per Section 3.3.2. The form must demonstrate that the design is equivalent to a welded Frame in terms of energy dissipation, yield and ultimate strengths in bending, buckling and tension.

3.3.6.2 Front Bulkhead Support

The Front Bulkhead must be securely integrated into the Frame.

The Front Bulkhead must be supported back to the Front Roll Hoop by a minimum of three (3) Frame Members on each side of the vehicle with one at the top (within 50.8 mm (2 inches) of its top-most surface), one (1) at the bottom, and one (1) as a diagonal brace to provide triangulation.

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

All the Frame Members of the Front Bulkhead Support system listed above must be constructed of closed section tubing per Section 3.3.3.

Monocoque construction requires an approved Structural Equivalency Form, per Section 3.3.2. The form must demonstrate that the design is equivalent to a welded Frame in terms of energy dissipation, yield and ultimate strengths in bending, buckling and tension.

3.3.6.3 Impact Attenuator

The Impact Attenuator must be:

a) Installed forward of the Front Bulkhead.

b) At least 200 mm (7.8 in) long, with its length oriented along the fore/aft axis of the Frame.
c) At least 100 mm (3.9 in) high and 200 mm (7.8 in) wide for a minimum distance of 200 mm (7.8 in) forward of the Front Bulkhead.
d) Such that it cannot penetrate the Front Bulkhead in the event of an impact. If the Impact Attenuator is foam filled or honeycomb, a 1.5 mm (0.060 in) solid steel or 4.0 mm (0.157 in) solid aluminum metal plate must be integrated into the Impact Attenuator. The metal plate must be the same size as the Front Bulkhead and bolted or welded to the Front Bulkhead.
e) Attached securely and directly to the Front Bulkhead and not by being part of non-structural bodywork. The attachment of the Impact Attenuator must be constructed to provide an adequate load path for transverse and vertical loads in the event of off-center and off-axis impacts. If not integral with the frame, i.e. welded, a minimum of four (4) 8 mm Grade 8.8 (5/16 inch Grade 5) bolts must attach the Impact Attenuator to the Front Bulkhead.

Alternative designs that do not comply with the minimum specifications given above require an approved "Structural Equivalency Form" per Section 3.3.2.

The attachment of the Impact Attenuator to a monocoque structure requires an approved Structural Equivalency Form per Section 3.3.2.

3.3.6.4 Impact Attenuator Data Requirement

The team must submit calculations and/or test data to show that their Impact Attenuator, when mounted on the front of their vehicle and run into a solid, non-yielding impact barrier with a velocity of impact of 7.0 meters/second (23.0 ft/sec), would give an average deceleration of the vehicle not to exceed 20 g.

Calculations must be based on the ACTUAL VEHICLE MASS[1] with a 175 lb. driver, full fluids, and rounded up to the nearest 100 lb.

The calculations and/or test data must be submitted electronically in Adobe Acrobat™ format (*.pdf file) to the address and by the date provided in the Appendix or provided on the relevant competition website. This material must be a single file (text, drawings, data or whatever you're including). The Impact Attenuator Data must be named as follows: *carnumber_schoolname_FH_IAD.pdf* using the assigned car number, the complete school name and initials of the competition. Example: **087_University of SAE_FH_IAD.pdf**

3.3.6.5 Non-Crushable Objects

All non-crushable objects (e.g. batteries, master cylinders, hydraulic reservoirs) must be rearward of the bulkhead. No non-crushable objects are allowed in the impact attenuator zone.

[1] If the actual vehicle mass has not yet been determined, the team must use their best estimate.

3.3.7 Front Bodywork

Sharp edges on the forward facing bodywork or other protruding components are prohibited. All forward facing edges on the bodywork that could impact people,

e.g. the nose, must have forward facing radii of at least 38 mm (1.5 inches). This minimum radius must extend to at least 45 degrees (45°) relative to the forward direction, along the top, sides and bottom of all affected edges.

3.3.8 Side Impact Structure

The Side Impact Structure must meet the requirements listed below.

3.3.8.1 Tube Frames

The Side Impact Structure must be comprised of at least three (3) tubular members located on each side of the driver while seated in the normal driving position, as shown in Figure 5. The three (3) required tubular members must be constructed of material per Section 3.3.3. The locations for the three (3) required tubular members are as follows:

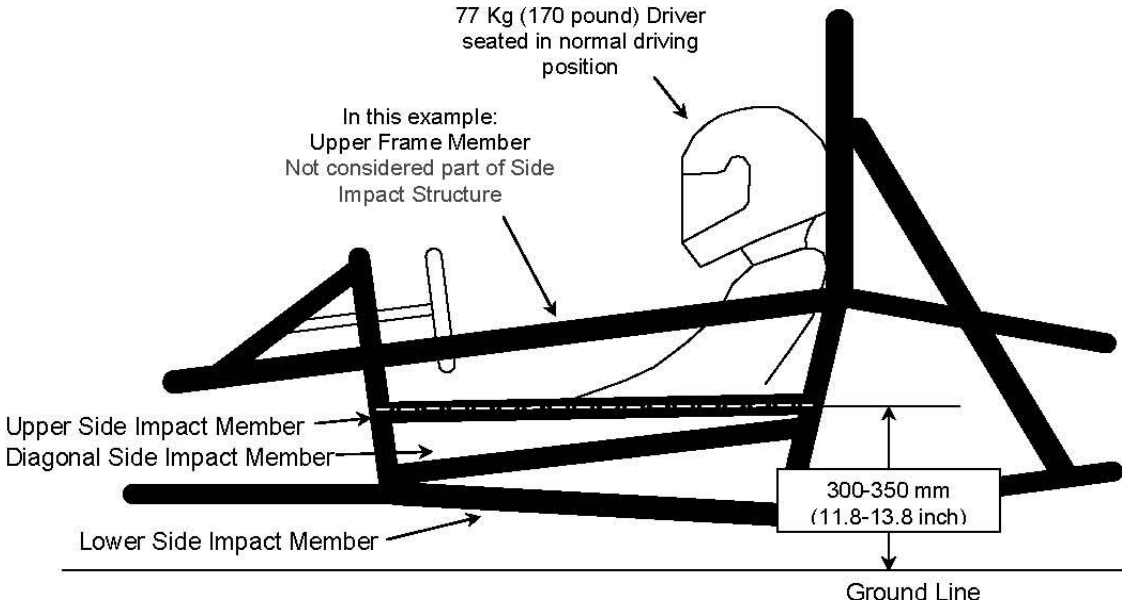
The upper Side Impact Structural member must connect the Main Hoop and the Front Hoop at a height between 300 mm (11.8 inch) and 350 mm (13.8 inch) above the ground with a 77kg (170 pound) driver seated in the normal driving position. The upper frame rail may be used as this member if it meets the height, diameter and thickness requirements.

The lower Side Impact Structural member must connect the bottom of the Main Hoop and the bottom of the Front Hoop. The lower frame rail/frame member may be this member if it meets the diameter and wall thickness requirements.

The diagonal Side Impact Structural member must connect the upper and lower Side Impact Structural members forward of the Main Hoop and rearward of the Front Hoop.

With proper gusseting and/or triangulation, it is permissible to fabricate the Side Impact Structural members from more than one piece of tubing.

Alternative geometry that does not comply with the minimum requirements given above requires an approved “Structural Equivalency Form” per Section 3.3.2.



3.3.8.2 Composite Monocoque

The section properties of the sides of the vehicle must reflect impact considerations. Non-structural bodies or skins alone are not adequate. Teams building composite monocoque bodies must submit the "Structural Equivalency Form" per Section 3.3.2. Submitted information should include: material type(s), cloth weights, resin type, fiber orientation, number or layers, core material, and lay-up technique.

3.3.8.3 Metal Monocoque

These structures must meet the same requirements as tube frames and composite monocoque. Teams building metal monocoque bodies must submit the "Structural Equivalency Form" per Section 3.3.2

3.3.9 Inspection Holes

To allow the verification of tubing wall thicknesses, 4.5 mm (0.18 inch) inspection holes must be drilled in a non-critical location of both the Main Hoop and the Front Hoop.

In addition, the Technical Inspectors may check the compliance of other tubes that have minimum dimensions specified in 3.3.3. This may be done by the use of ultra sonic testing or by the drilling of additional inspection holes at the inspector's request.

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

3.4 Driver and Cockpit Equipment

3.4.1 Driver Restraint System

All drivers must use a 5, 6 or 7 point restraint harness meeting the following specifications. The restraint system installation is subject to approval of the Chief Technical Inspector. The restraint system must be worn as tightly as possible at all times.

(A) Material Requirements

The material of all straps must be Nylon or Dacron polyester and in new or perfect condition. There must be a single release common to the lap belt and shoulder harness using a metal-to-metal quick-release type latch. All driver restraint systems must meet either SFI Specification 16.1, or FIA specification 8853/98. The belts must bear the appropriate dated labels.

(B) Harness Replacement

SFI spec harnesses must be replaced following December 31st of the 2nd year after the date of manufacture as indicated by the label. FIA spec harnesses must be replaced following December 31st of the year marked on the label. (Note: FIA belts are normally certified for five (5) years from the date of manufacture.)

(C) 5-Point System

A 5-point system consists of a 76 mm (3 inch) wide lap belt, approximately 76 mm (3 inch) wide shoulder straps and a single approximately 51 mm (2 inch) wide anti-submarine strap. The single anti-submarine strap must have a metal-to-metal connection with the single release common to the lap belt and shoulder harness.

(D) 6 and 7-Point Systems

A 6-point system consists of a 76 mm (3 inch) wide lap belt, approximately 76 mm (3 inch) wide shoulder straps and two approximately 51 mm (2 inch) wide leg or anti-submarine straps. A 7-point system is the same as the 6-point except it has three (3) antisubmarine straps, two (2) from the 6-point system and one (1) from the 5-point system.

6 and 7-point harnesses to FIA specification 8853/98 with approximately 51 mm (2 inch) lap belts are acceptable.

The double leg straps of the 6 or 7-point system may be attached to the Primary Structure, or be attached to the lap belt so that the driver sits on them, passing them up between his or her legs and attaching to the single release common to the lap belt and shoulder harness. The leg straps may also be secured at a point common with the lap belt attachment to Primary Structure, passing them under the driver and up between his or her legs to the harness release.

(E) Belt and Strap Mounting

The lap belt, shoulder harness and anti-submarine strap(s) must be securely mounted to the Primary Structure. Such structure and any guide or support for the belts must meet the minimum requirements of 3.3.3

The attachment of the Driver's Restraint System to a monocoque structure requires an approved Structural Equivalency Form per Section 3.3.2.

(F) Lap Belt Mounting

The lap belt must pass around the pelvic area below the Anterior Superior Iliac Spines (the hip bones) (Figure 6a). Under no condition may the lap belt be worn over the area of the intestines or abdomen. The lap belts should come through the seat at the bottom of the sides of the seat to maximize the wrap of the pelvic surface and continue in a straight line to the anchorage point.

In side view, the lap belt must be at an angle of between 45 degrees (45°) and 65 degrees (65°) to the horizontal. This means that the centerline of the lap belt at the seat bottom should be between 0 - 76 mm (0 - 3 inch) forward of the seat back to seat bottom junction (see Figure 6).

To fit drivers of differing statures correctly, in side view, the lap belt must be capable of pivoting freely by using either a shouldered bolt or an eye bolt attachment, i.e. mounting lap belts by wrapping them around frame tubes is no longer acceptable.

The lap belts should not be routed over the sides of the seat. The seat must be rolled or grommeted to prevent chafing of the belts.

(G) Shoulder Harness

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.

It is mandatory that the shoulder harness, where it passes over the shoulders, be 76 mm (3 inch) wide, except as noted below. The shoulder harness straps must be threaded through the three bar adjusters in accordance with manufacturer's instructions.

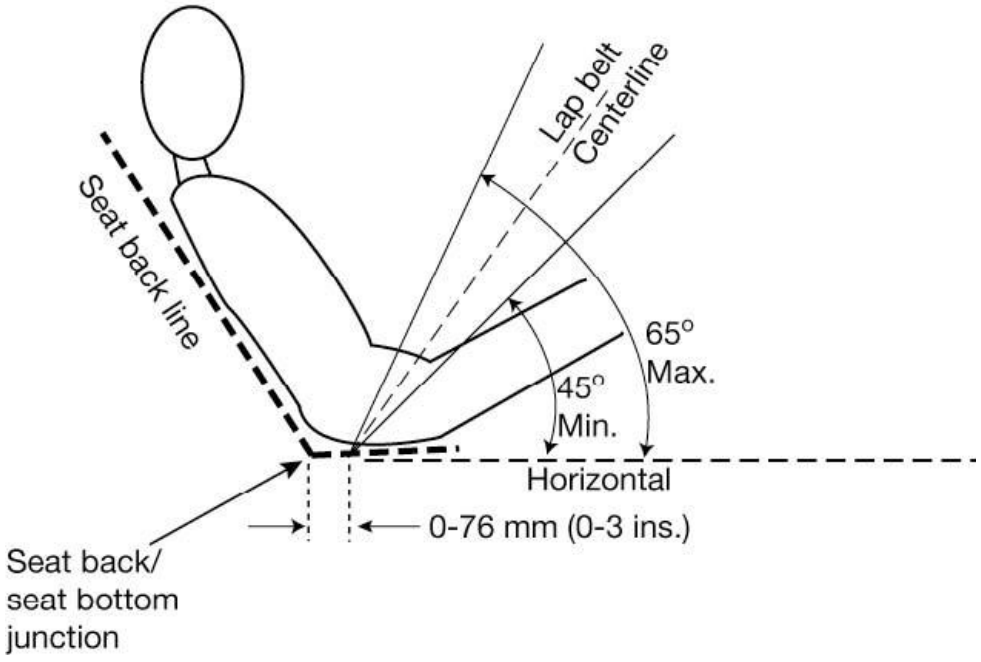
When the HANS device is used by the driver, FIA certified 51 mm (2 inch) wide shoulder harnesses are allowed. Should a driver, at anytime not utilize the HANS device, then 76 mm (3 inch) wide shoulder harnesses are required.

The shoulder harness must be mounted behind the driver to structure that meets the requirements of 3.3.3. However, it cannot be mounted to the Main Roll Hoop Bracing or attendant structure without additional bracing to prevent loads being transferred into the Main Hoop Bracing.

The shoulder harness mounting points must be between 178 mm (7 inches) and 229 mm (9 inches) apart.

From the driver's shoulders rearwards to the mounting point or structural guide, the shoulder harness must be between 10 degrees (10°) above the horizontal and 20 degrees (20°) below the horizontal.

FIGURE 6 a
Lap Belt Angle



3.4.2 Driver's Equipment

The following equipment must be worn by the driver anytime he or she is in the cockpit with the engine running.

There must be no bare skin below the driver's neck level when seated in the vehicle.

3.4.2.1 Helmet

A well-fitting, closed face helmet that meets one of the following certifications and is labeled as such:

- Snell M2000, SA2000, M2005, K2005, SA2005
- SFI 31.2A, SFI 31.1/2005
- FIA 8860-2204
- British Standards Institution BS 6658-85 types A or A/FR rating (Type B is not accepted)

Open faced helmets are not approved. All helmets to be used in the competition must be presented during Technical Inspection where approved helmets will be stickered. The organizer reserves the right to impound all non-approved helmets until the end of the competition.

3.4.2.2 Suit

A fire resistant suit that covers the body from the neck down to the ankles and the wrists. The suit must be in good condition, i.e. it must have no tears or open seams, or oil stains that could compromise its fire resistant capability. The suit must be certified to one of the following standards and be labeled as such:

-SFI 3-2A/1 (or higher)

Figure A

-FIA Standard 8856-1986

Figure B

-FIA Standard 8856-2000

Figure C

3.4.2.3 Gloves

Fire resistant gloves which are free of any holes. Leather gloves are not acceptable.

3.4.2.4 Goggles or Face Shields

Goggles or face shields, made of impact resistant materials.

3.4.2.5 Shoes

Shoes of durable fire resistant material and which are free from any holes.

3.4.2.6 Socks

Socks made from an accepted fire resistant material, e.g. Nomex, that cover the bare skin between the driver's suit and the boots or shoes. Socks made from wool or cotton are acceptable. Socks of nylon or polyester are not acceptable.

3.4.2.7 Arm Restraints

Arm restraints must be worn such that the driver can release them and exit the vehicle unassisted regardless of the vehicle's position.

3.4.2.8 Hair Covering

A head, hair and neck covering (balaclava) of accepted fire resistant material, e.g. a Nomex balaclava, or a full helmet skirt of accepted fire resistant material. Note: This applies to ALL drivers.

3.4.3 Driver Visibility

3.4.3.1 General Requirement

The driver must have adequate visibility to the front and sides of the car. With the driver seated in a normal driving position he/she must have a minimum field of vision of 200 degrees. (A minimum 100 degrees to either side of the driver). The required visibility may be obtained by the driver turning his/her head and/or the use of mirrors.

3.4.3.2 Mirrors

If mirrors are required to meet Rule 3.4.3.1, they must remain in place and adjusted to enable the required visibility throughout all dynamic events.

3.4.4 Head Restraint

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

- Have a minimum area of 232 sq. cm (36 sq. inches)

- Be vertical or near vertical in side view
- Be padded with an energy absorbing material such as Ethafoam™ or Ensolite™ with a minimum thickness of 38 mm (1.5 inches). It is recommended that the padding meet SFI Spec. 45.2
- Be located so that:
    - It is no more than 25 mm (1 inch) away from the back of the driver's helmet in the uncompressed state.
    - The contact point of the back of the driver's helmet on the head restraint is no less than 50 mm (2 inch) from any edge of the head restraint

The restraint, its attachment and mounting must be strong enough to withstand a force of 890 Newtons (200 lbs. force) applied in a rearward direction.

The head restraint must meet the above requirements for all drivers.

3.4.5 Roll Bar Padding

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

3.4.6 Floor Closeout

All vehicles must have a floor closeout made of one or more panels, which separate the driver from the pavement. If multiple panels are used, gaps between panels are not to exceed 3 mm (1/8 inch). The closeout must extend from the foot area to the firewall and prevent track debris from entering the car. The panels must be made of a solid, non-brittle material.

3.4.7 Steering Wheel

3.4.7.1 Circular Shape

The steering wheel must have a continuous perimeter that is near circular or near oval. , i.e. the outer perimeter profile can have some straight sections, but no concave sections. "H", "Figure 8", or cutout wheels are not allowed.

3.4.7.2 Quick Disconnect

The steering wheel must be attached to the column with a quick disconnect. The driver must be able to operate the quick disconnect while in the normal driving position with gloves on.

3.4.8 Driver Egress

All drivers must be able to exit to the side of the vehicle in no more than 5 seconds.

Egress time begins with the driver in the fully seated position, hands in driving position on the connected steering wheel, wearing the required driver equipment. Egress time will stop when the driver has both feet on the pavement.

3.4.9 Roll Over Stability

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

3.4.9.1 Tilt Table

Rollover stability will be evaluated using a pass/fail test. The vehicle must not roll when tilted at an angle of 60 degrees (60°) to the horizontal in either direction, corresponding to 1.7 G's. The tilt test will be conducted with the tallest driver in the normal driving position.

3.4.10 Master Switches ("Big Red Buttons")

There must be a minimum of three shutdown buttons (Master Switches), one on each side of the car just behind the driver's compartment at approximately the level of the driver's head, and one on or near the instrument panel easily reachable by the driver. These buttons, when pushed, must break the flow of current holding the accumulator isolation relays closed, and shut down the engine and any other energy generation systems (see section **4.6**). Once pushed, these buttons must stay in until manually pulled outward to reset the system

The two outer buttons must be red, 60 mm (2.4 inch) diameter (Omron A22E-LP-01[2] or equivalent) the driver's shutdown button must be red, with a minimum diameter of 25.4 mm (1 inch).

3.4.11 Fire Protection

3.4.11.1 Firewall

A firewall must separate the driver compartment from all components of the fuel supply, the engine oil and the liquid cooling systems. It must protect the neck of the tallest driver. It must extend sufficiently far upwards and/or rearwards such that any point less than 100 mm (4 ins.) above the bottom of the helmet of the tallest driver shall not be in direct line of sight with any part of the fuel system, the cooling system or the engine oil system.

The firewall must be a non-permeable surface made from a fire resistant material. Pass-throughs for wiring, cables, etc. are allowable if grommets are used to seal the pass-throughs. Also, multiple panels may be used to form the firewall but must be sealed at the joints.

[2] Omron is a Formula Hybrid team sponsor. See the Formula Hybrid website for more information.

3.4.11.2 Fire Extinguishers

During initial inspection all fire extinguishers must accompany the car. At all other times at least one (1) extinguisher of each type, standard and specific hazard, must be readily available in the team paddock area and at least (1) of each type must accompany the vehicle whenever it is moved.

Note: Halon extinguishers and systems are not acceptable at Formula Hybrid competitions.

Hand held fire extinguishers are not permitted to be mounted on or in the car.

(A) Minimum Requirements

Each team must have at least two (2) 2.3 kg (5 lb.) dry chemical (Min. 3-A:40-B:C) Fire extinguishers

Extinguishers of larger capacity (higher numerical ratings) are acceptable.

All extinguishers must be equipped with a manufacturer installed pressure/charge gauge.

As a team option, commercially available on-board fire systems are encouraged as an alternative to any equivalent extinguisher that must accompany the vehicle.

(B) Special Requirements

Teams must identify any fire hazards specific to their vehicle's components and if fire extinguisher/fire extinguisher material other than those required in section 3.4.11.2 (A) are needed to suppress such fires, then at least two (2) additional extinguishers/material (at least 5 lb or equivalent) of the required type must be procured and accompany the car at all times.

During technical inspection teams must specifically identify all such hazards and present the extinguishers or extinguishing material for examination.

3.4.11.3 Chemical Spills

Teams must have chemical spill absorbent at hand, appropriate to their specific risks. This material must be presented at technical inspection.

3.4.12 Accessibility of Controls

All vehicle controls, including the shifter, must be operated from inside the cockpit without any part of the driver, e.g. hands, arms or elbows, being outside the planes of the Side Impact Structure defined in 3.3.8.

3.4.13 Seat

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

3.4.14 Driver's Leg Protection

To keep the driver's legs away from moving or sharp components, all moving suspension and steering components, and other sharp edges inside the cockpit between the front roll hoop and a vertical plane 100 mm (4 inches) rearward of the pedals, must be shielded with a shield made of a solid material. Moving components include, but are not limited to springs, shock absorbers, rocker arms, anti-roll/sway bars, steering racks and steering column CV joints.

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

3.5 Powertrain

3.5.1 Formula Hybrid Definitions

Hybrid is defined as a vehicle using a propulsion system which comprises both a 4-stroke Internal Combustion Engine (ICE) and electrical storage (accumulator) with electric motor drive.

Hybrid-in-Progress (HIP) is defined as a hybrid vehicle that is still in the development stage, which is charged from an external source and operated as electric-only.

3.5.2 Hybrid

A hybrid drive system may deploy the ICE and electric motor(s) in any configuration, including series and/or parallel. Coupling through the road surface is permitted.

To qualify as a hybrid, vehicles must be capable of completing a 75 meter acceleration run in electric-only mode in less than 15 seconds.

3.5.3 Hybrid-in-Progress

A vehicle may be entered as a Hybrid-in-Progress for only one year. These vehicles must still meet all Formula Hybrid rules.

A Hybrid may revert to Hybrid-in-Progress in the event of a systems failure after the event has started, even if the vehicle was entered in a previous year as a Hybrid-in-Progress.

3.5.4 Engine and Drivetrain

3.5.4.1 Engine Limitations

Engines must be Internal Combustion, four-stroke, with a maximum displacement of 250cc for spark ignition engines and 310cc for diesel engines and be either:

1. Modified or custom fabricated. (See section 3.5.7)

Or

2. Stock -- Any single or any twin from a motorcycle approved for licensed use on public roads, or any commercially available "industrial" I.C. engine meeting the above displacement limits. (If you are not sure whether or not your engine qualifies as stock, contact the organizers)

Permitted modifications to a stock engine are:

- Modification or removal of the clutch, primary drive and/or transmission.
- Changes to fuel mixture or timing settings.
- Replacement or modification of any exhaust system components.
- Replacement or modification of any intake system components; i.e., components upstream of (but NOT including) the cylinder head. The addition of forced induction will move the engine into the modified category.
- Modifications to the engine casings. (This does not include the cylinders or cylinder head.

3.5.4.2 Engine Inspection

The organizer will measure or tear down a substantial number of engines to confirm conformance to the rules. The initial measurement will be made externally with a measurement accuracy of one (1) percent. When installed to and coaxially with spark plug hole, the measurement tool has dimensions of 381 mm (15 inches) long and 30 mm (1.2 inches) diameter. Teams may choose to design in access space for this tool above each spark plug hole to reduce time should their vehicle be inspected.

3.5.4.3 Transmission and Drive

Any transmission and drivetrain may be used.

3.5.4.4 Drive Train Shields and Guards

Exposed high-speed equipment, such as torque converters, clutches, belt drives and clutch drives, must be fitted with scatter shields in case of failure. Scatter shields for chains or belts must not be made of perforated material.

1. **Chain drive** - Scatter shields for chains must be made of at least 2.66 mm (0.105 inch) steel (no alternatives are allowed), and have a minimum width equal to three (3) times the width of the chain.

2. **Belt drive** - Scatter shields for belts must be made from at least 3.0 mm (0.120 inch) Aluminum Alloy 6061-T6, and have a minimum width that is equal to the belt width plus 35% on each side of the belt (1.7 times the width of the belt).
3. **Attachment Fasteners** - All fasteners attaching scatter shields and guards must be a minimum 6mm grade M8.8 (1/4 inch SAE grade 5).
4. **Shields -** Attached shields and guards must be mounted so that they remain laterally aligned with the chain or belt under all conditions.
5. **Finger Guards** – Finger guards may be made of lighter material.

3.5.4.5 System Sealing

The engine and transmission must be sealed to prevent leakage.

Separate catch cans must be employed to retain fluids from any vents for the coolant system or the crankcase or engine lubrication system. Each catch-can must have a minimum volume of ten (10) percent of the fluid being contained or 0.9 liter (one U.S. quart) whichever is greater.

Catch cans must be capable of containing boiling water without deformation, and be located rearwards of the firewall below driver's shoulder level. They must have a vent with a minimum diameter of 3 mm (1/8 inch) with the vent pointing away from the driver.

Any crankcase or engine lubrication vent lines routed to the intake system must be connected upstream of the intake system restrictor.

3.5.4.6 Coolant Fluid Limitations

Water-cooled engines must only use plain water, or water with cooling system rust and corrosion inhibitor at no more than 0.015 liters per liter of plain water. Glycol-based antifreeze or water pump lubricants of any kind are strictly prohibited.

3.5.4.7 Starter

Each car must be equipped with an on-board starter or equivalent, and be able to move without any outside assistance at any time during the competition. Specifically, push starts are not permitted.

3.5.5 Fuels

The basic fuels available at competitions in the Formula Hybrid Series is unleaded gasoline with an octane rating of 93 (R+M)/2 (approximately 98 RON), Bio-Diesel (B100) and E85. Other fuels may be available at the discretion of the organizing body.

Unless otherwise announced by the individual organizing body, the fuel at competitions in the Formula Hybrid Series will be provided by the organizer.

During all performance events the cars must be operated with the fuels provided by the organizer at the competition.

Nothing may be added to the provided fuels. This prohibition includes nitrous oxide or any other oxidizing agent.

Teams are advised that gasoline supplied in the United States is subject to various federal and state regulations and may contain up to ten percent (10%) ethanol. The exact chemical composition and physical characteristics of the available fuel may not be known prior to the competition.

It is important that any team planning to use any fuel other than gasoline let the organizers know well in advance of the competition.

3.5.5.1 Fuel Temperature Changes – Prohibited

The temperature of fuel introduced into the fuel system may not be changed with the intent to improve calculated fuel economy.

3.5.5.2 Fuel Additives – Prohibited

No agents other than fuel (gasoline, B100 or E85), and air may be induced into the combustion chamber. Non-adherence to this rule will be reason for disqualification. Officials have the right to inspect the oil.

3.5.6 Fuel System

3.5.6.1 Fuel Tank

The fuel tank must hold a minimum of 5 liters (1.32 Gallons).

The fuel system must have a drain fitting for emptying the fuel tank. The drain must be at the lowest point of the tank and be accessible from under the vehicle. It must not protrude below the lowest plane of the vehicle frame, and must have provision for safety wiring.

3.5.6.2 Filler Neck & Sight Tube

All filler caps and necks must have provision for a seal to be attached such that the filler cap may not be removed without the removal of the seal. This should consist of two 1/8" holes, one on the neck and one on the cap. When the fuel cap is secured, these holes should be located within ¼ inch of each other.

3.5.6.3 Tank Filling Requirement

The tank must be capable of being filled to capacity without manipulating the tank or vehicle in any way (shaking vehicle, etc.).

3.5.6.4 Spillage Prevention

The fuel system must be designed such that the spillage during refueling cannot contact the driver position, exhaust system, hot engine parts, or the ignition system. Belly pans must be vented to prevent accumulation of fuel.

3.5.6.5 Venting Systems

The fuel tank and carburetor venting systems must be designed such that fuel cannot spill during hard cornering or acceleration. This is a concern since motorcycle carburetors normally are not designed for lateral accelerations.

All fuel vent lines must be equipped with a check valve to prevent fuel leakage when the tank is inverted. All fuel vent lines must exit outside the bodywork.

3.5.6.5.1 Tilt Test-Fuel and Fluids

During technical inspection, the car must be capable of being tilted to a 45 degree (45°) angle without leaking fuel or fluid of any type.

The tilt test will be conducted with the vehicle containing the maximum amount of fluids it will carry during any test or event.

3.5.6.6 Fuel Lines, Line Attachment and Protection

Plastic fuel lines between the fuel tank and the engine (supply and return) are prohibited.

If rubber fuel line or hose is used, the components over which the hose is clamped must have annular bulb or barbed fittings to retain the hose. Also, clamps specifically designed for fuel lines must be used. These clamps have three (3) important features, (i) a full 360 degree (360°) wrap, (ii) a nut and bolt system for tightening, and (iii) rolled edges to prevent the clamp cutting into the hose. Worm-gear type hose clamps are not approved for use on any fuel line.

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

3.5.6.7 Fuel Injection System Requirement

The following requirements apply to fuel injection systems.

A. Fuel Lines – Flexible fuel lines must be either (i) metal braided hose with either crimped-on or reusable, threaded fittings, or (ii) reinforced rubber hose with some form of abrasion resistant protection with fuel line clamps per 3.5.3.7. Note: Hose clamps over metal braided hose will not be accepted.

B. Fuel Rail – If a fuel rail is used it must be securely attached to the engine cylinder block, cylinder head, or intake manifold with brackets and mechanical fasteners. This precludes the use of hose clamps, plastic ties, or safety wire.

C. Intake Manifold – If an intake manifold is used, it must be securely attached to the engine crankcase, cylinder, or cylinder head with brackets and mechanical fasteners. This precludes the use of hose clamps, plastic ties, or safety wires. Original equipment rubber parts that bolt or clamp to the cylinder head and to the throttle body or carburetor are acceptable. These rubber parts are referred to by various names by the engine

manufacturers; e.g., “insulators” by Honda, “joints” by Yamaha, and “holders” by Kawasaki. Other than such original equipment parts the use of rubber hose is not considered a structural attachment.

D. Air boxes and filters - Large air boxes shall be securely mounted to the frame or engine and connections between the air box and throttle shall be flexible. Small air cleaners designed for mounting to the carburetor or throttle body may be cantilevered from the throttle body.

3.5.6.8 Air Intake and Fuel System Location Requirements

All parts of the fuel storage and supply system, and all parts of the engine air and fuel control systems (including the throttle or carburetor, and the complete air intake system, including the air cleaner and any air boxes) must lie within the surface defined by the top of the roll bar and the outside edge of the four tires (see figure 8).

All fuel tanks must be shielded from side impact collisions. Any fuel tank which is located outside the Side Impact Structure required by 3.3.8, must be shielded by structure built to 3.3.8. A firewall must also be incorporated, per section 3.4.11.1.

Any portion of the air intake system that is less than 350 mm (13.8 inches) above the ground must be shielded by structure built to 3.3.8.

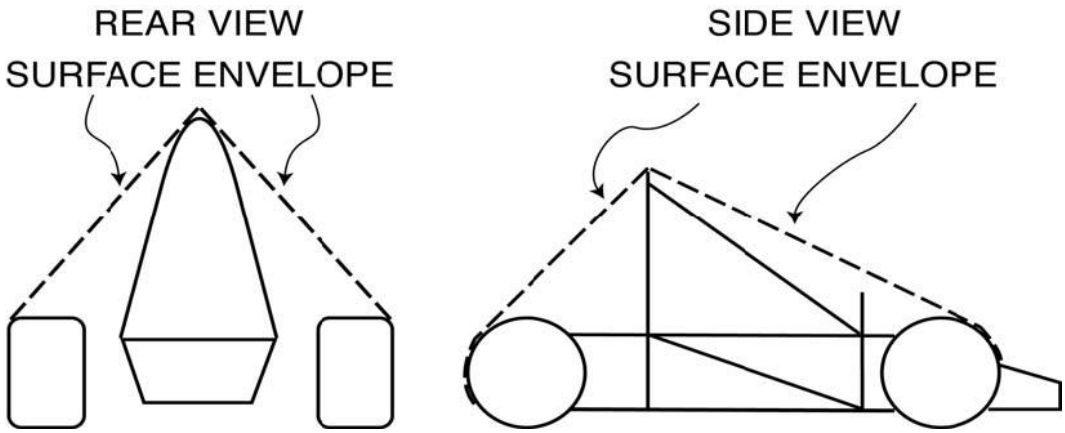


FIGURE 8

3.5.7 Throttle, Throttle Actuation and Intake Restrictor

Note: Section 3.5.7 applies only to those engines that are not on the approved stock engine list, or that have been modified beyond the limits specified in section 3.5.4.1.

Non-stock engines (See section 3.5.4.1**)** must be fitted with an air inlet restrictor as listed below. All the air entering the engine must pass through the restrictor which must be located downstream of any engine throttling device.

The restrictor must be located in such a way that its diameter may be easily measured during technical inspection.

The restrictor must be circular with a maximum diameter of:

Gasoline fueled cars - 12.9 mm (0.508 inch)

E-85 fueled cars - 12.3 mm (0.483 inch)

Biodiesel fueled cars – no inlet restrictor required

3.5.7.1 Carburetor/Throttle Body for Spark Ignition Engines – Required

All spark ignition engines must be equipped with a carburetor or throttle body. The carburetor or throttle body may be of any size or design.

3.5.7.2 Throttle Actuation

The throttling device may be actuated either mechanically or electrically; i.e. electrical throttle control or "throttle by wire" is acceptable.

3.5.7.2.1 Mechanical Throttle Actuation

If mechanical throttle actuation is used the throttle cable or rod must have smooth operation, and must not have the possibility of binding or sticking.

The throttle actuation system must use at least two (2) return springs located at the throttle body, so that the failure of any component of the throttle system will not prevent the throttle returning to the closed position. **Note:** Springs in Throttle Position Sensors (TPS) are NOT acceptable as return springs.

Throttle cables must be at least 50.8 mm (2 inches) from any exhaust system component and out of the exhaust stream.

A positive pedal stop must be incorporated on the throttle pedal to prevent over stressing the throttle cable or actuation system.

The use of a push-pull type throttle cable with a throttle pedal that is capable of forcing the throttle closed (e.g. toe strap) is recommended.

3.5.7.2.2 Electrical Throttle Actuation

If electrical throttle actuation is used, the throttle actuation system must be of a fail-safe design to assure that any single failure in the mechanical or electrical components of the throttle actuation system will result in a closed throttle. Teams are strongly encouraged to use commercially available electrical throttle actuation systems.

3.5.7.3 Turbochargers and Superchargers

Turbochargers or superchargers are permitted. The compressor must be located downstream of the inlet restrictor. The addition of a Turbo or Supercharger will move the engine into the Modified category.

3.5.8 Muffler and Exhaust System

3.5.8.1 Muffler

The car must be equipped with a muffler in the exhaust system to reduce the noise to an acceptable level.

3.5.8.2 Exhaust Outlet

The exhaust must be routed so that the driver is not subjected to fumes at any speed considering the draft of the car.

The exhaust outlet(s) must not extend more than 60 cm (23.6 inches) behind the centerline of the rear axle, and shall be no more than 60 cm (23.6 inches) above the ground.

Any exhaust components (headers, mufflers, etc.) that protrude from the side of the body in front of the main roll hoop must be shielded to prevent contact by persons approaching the car or a driver exiting the car.

3.5.8.3 Noise

3.5.8.3.1 Sound Measuring Procedure

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

Vehicles that do not have manual throttle control must provide some means for running the engine at the test RPM.

3.5.8.3.2 Test Speeds

The test speed for a given engine will be the engine speed that corresponds to an average piston speed of 914.4 m/min (3,000 ft/min) for automotive or motorcycle engines, and 731.5 m/min (2,400 ft/min) for Diesels. The calculated speed will be rounded to the nearest 500 rpm. The test speeds for typical engines will be published by the organizers.

Vehicles not equipped with engine tachometers must provide some external means for measuring RPM, such as a hand-held meter.

3.5.8.3.3 Maximum Sound Level

The maximum permitted sound level is 110 dBA, fast weighting.

3.5.8.3.4 Sound Level Re-testing

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

3.6 Vehicle Identification

3.6.1 Car Number

Each car will be assigned a number at the time of its entry into a competition.

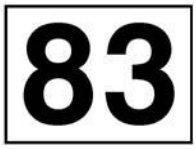
Car numbers must appear on the vehicle as follows:

a) Locations: In three (3) locations: the front and both sides;
b) Height: At least 15.24 cm (6 inch) high;
c) Font: Block numbers (i.e. sans-serif characters). Italic, outline, serif, shadow, or cursive numbers are prohibited.
d) Stroke Width and Spacing between Numbers: At least 2.0 cm (3/4 inch).
e) Color: Either white numbers on a black background or black numbers on a white background. No other color combinations will be approved.
f) Background shape: The number background must be one of the following: round, oval, square or rectangular. There must be at least 2.5 cm (1 inch) between the edge of the numbers and the edge of the background.
g) Clear: The numbers must not be obscured by parts of the car, e.g. wheels, side pods, exhaust system, etc.

Car numbers for teams registered for Formula Hybrid can be found on the “Registered Teams” section of the SAE Collegiate Design Series website.

Comment: Car numbers must be quickly read by course marshals when your car is moving at speed. Make your numbers easy to see and easy to read.

Example:



3.6.2 School Name

Each car must clearly display the school name (or initials – if unique and generally recognized) in roman characters at least 5.08cm, (2 inch) high on both sides of the vehicle. The characters must be placed on a high contrast background in an easily visible location.

The school name may also appear in non-roman characters, but the roman character version must be uppermost on the sides.

3.6.3 SAE & IEEE Logos

SAE and IEEE logos must be prominently displayed on the front and/or both sides of the vehicle. SAE and IEEE logos will be provided to the teams on-site or may be requested ahead of time by emailing the organizers.

3.6.4 Technical Inspection Sticker Space

Technical inspection stickers will be placed on the upper nose of the vehicle. Cars must have a clear and unobstructed area at least 25.4 cm wide x 20.3cm high (10” x 8”) on the upper front surface of the nose along the vehicle centerline.

3.7 General

3.7.1 Aero Dynamics and Ground Effects

All aerodynamic devices must satisfy the following requirements:

3.7.1.1 Location

In plan view, no part of any aerodynamic device, wing, undertray or splitter can be further forward than 460 mm (18 inches) forward of the fronts of the front tires, and no further rearward than the rear of the rear tires. No part of any such device can be wider than the outside of the front tires measured at the height of the front hubs.

3.7.1.2 Driver Egress Requirements

Egress from the vehicle within the time set in section 3.4.8 “Driver Egress,” must not require any movement of the wing or wings or their mountings. The wing or wings must be mounted in such positions, and sturdily enough, that any accident is unlikely to deform the wings or their mountings in such a way to block the driver’s egress.

3.7.1.3 Wing Edges - Minimum Radii

All wing leading edges must have a minimum radius 12.7 mm (0.5 inch). Wing leading edges must be as blunt or blunter than the required radii for an arc of plus or minus 45 degrees (± 45°) centered on a plane parallel to the ground or similar reference plane for all incidence angles which lie within the range of adjustment of the wing or wing element. If leading edge slats or

slots are used, both the fronts of the slats or slots and of the main body of the wings must meet the minimum radius rules.

3.7.1.4 Other Edge Radii Limitations

All wing edges, end plates, Gurney flaps, wicker bills, splitters undertrays and any other wing accessories must have minimum edge radii of at least 3 mm (1/8 inch) i.e., this means at least a 6 mm (1/4 inch) thick edge.

3.7.1.5 Wing Edge Restrictions

No small radius edges may be included anywhere on the wings in such a way that would violate the intent of these rules (e.g. vortex generators with thin edges, sharp square corners on end plates, etc.).

3.7.1.6 Ground Effect Devices – Prohibited

No power device may be used to move or remove air from under the vehicle except fans designed exclusively for cooling. Power ground effects are prohibited.

3.7.2 Fasteners

3.7.2.1 Grade Requirements

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

3.7.2.2 Securing Fasteners

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

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

Note: Lock washers and thread locking compounds, e.g. Loctite™, DO NOT meet the positive locking requirement.

There must be a minimum of two (2) full threads projecting from any lock nut.

All spherical rod ends and spherical bearings on the steering or suspension must be in double shear or captured by having a screw/bolt head or washer with an O.D. that is larger than spherical bearing housing I.D.

Adjustable tie-rod ends must be constrained with a jam nut to prevent loosening.

3.7.3 Modifications and Repairs

(A) Once the vehicle has been presented for judging in the Design Events, or submitted for Technical Inspection, and until the vehicle is approved to compete in the dynamic events, i.e. all the inspection stickers are awarded, the only modifications permitted to the vehicle are those directed by the Inspector(s) and noted on the Inspection Form.

(B) Once the vehicle is approved to compete in the dynamic events, the ONLY modifications permitted to the vehicle are:

a) Adjustment of belts and chains
b) Adjustment of brake bias
c) Adjustment of the driver restraint system, head restraint, seat and pedal assembly
d) Adjustment to engine operating parameters, e.g. fuel mixture and ignition timing
e) Adjustment of mirrors
f) Adjustment of the suspension where no part substitution is required, (except that springs, sway bars and shims may be changed)
g) Adjustment of tire pressure
h) Adjustment of wing angle
i) Replenishment of fluids
j) Replacement of worn tires or brake pads
k) The changing of wheels and tires for "wet" or "damp" conditions as allowed by 6.2.1.

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

(C) Once the vehicle is approved for competition, any damage to the vehicle that requires repair, e.g. crash damage, electrical or mechanical damage, will void the Inspection Approval whether or not the inspection sticker has been removed. Upon the completion of the repair and before re-entering into any dynamic competition, the vehicle MUST be re-submitted to Technical Inspection for re-approval.

3.7.4 Compressed Gas Cylinders and Lines

Any system on the vehicle that uses a compressed gas as an actuating medium must comply with the following requirements:

a) Working Gas-The working gas must be nonflammable, e.g. air, nitrogen, carbon dioxide.
b) Cylinder Certification- The gas cylinder/tank must be of proprietary manufacture, designed and built for the pressure being used, certified by an accredited testing laboratory in the country of its origin, and labeled or stamped appropriately.
c) Pressure Regulation-The pressure regulator must be mounted directly onto the gas cylinder/tank.
d) Cylinder Location- The gas cylinder/tank and the pressure regulator must be located within the structural portion of the Frame, but not in the cockpit or in a non-structural side pod.

e) Cylinder Mounting- The gas cylinder/tank must be securely mounted to the Frame, engine or transmission.
f) Cylinder Axis- The axis of the gas cylinder/tank must not point at the driver.
g) Insulation- The gas cylinder/tank must be insulated from any heat sources, e.g. the exhaust system.
h) Lines and Fittings- The gas lines and fittings must be appropriate for the maximum possible operating pressure of the system.
i) Protection- The gas cylinder/tank and lines must be protected from damage resulting from the failure of rotating equipment.

3.8 Transponders

3.8.1 Transponders

Transponders will be used as part of the timing system for the dynamic events at the Formula Hybrid competitions

Each team is responsible for having a functional, properly mounted transponder of the specified type on their vehicle. Vehicles without a specified transponder will not be allowed to compete in any event for which a transponder is used for timing and scoring.

3.8.2 Transponder Requirement

All vehicles must be equipped with at least one AMB TranX260 Rechargeable or AMB TranX260 Direct Power transponder.

3.8.3 Transponder mounting

The transponder mounting requirements are:

(a) Orientation – The transponder must be mounted vertically and orientated so the number can be read “right-side up”.

(b) Location – The transponder must be mounted on the driver's right side of the car forward of the front roll hoop. The transponder must be no more than 60 cm (24 in) above the track.

(c) Obstructions – There must be an open, unobstructed line between the antenna on the bottom of the transponder and the ground. Metal and carbon fiber may interrupt the transponder signal. The signal will normally transmit through fiberglass and plastic. If the signal will be obstructed by metal or carbon fiber, a 10.2 cm (4 in) diameter opening can be cut, the transponder mounted flush with the opening, and the opening covered with a material transparent to the signal.

(d) Protection – Mount the transponder where it will be protected from obstacles.

4 ELECTRICAL RULES

***Note**: It is strongly recommended that SAE Standard J1673 "High Voltage Automotive Assembly Wiring Design" be complied with wherever possible. Disregarding these engineering and construction practices can cost a team design points.*

Where there are differences between SAE J1673 and the Formula Hybrid rules, the Formula Hybrid rules will take precedence.

4.1 High-Voltage (HV) Isolation

High Voltage is defined as any system (individually or in series) containing or producing a voltage greater than 30V.

There must be no connection between the frame of the vehicle (or any other conductive surface that might be inadvertently touched by a crew member or spectator), and any part of any HV circuits.

HV and low-voltage circuits must be physically segregated:

- Not run through the same conduit.
- Where both are present within an enclosure, separated by insulating barriers such as Nomex, Formex, or other moisture resistant, UL recognized insulating materials.
- If both are on the same circuit board, they must be on separate, clearly defined areas of the board.

4.1.1 Ground Fault Detectors

All vehicles shall be equipped with an on-board Ground Fault detector. This must be a Bender IR486, IR475LY[3] or equivalent if approved by the organizers. The output relay of this device must be wired in series with the shutdown buttons such that a ground fault will cause an immediate shutdown of all electrical systems.

The ground fault detector should be accessible, or have a remote LED indicator to show when it has tripped

4.1.2 Ground Fault Detector Test

The ground fault detector will be tested during tech. inspection, by connecting, a 40,000 Ω resistor between multiple points on the HV circuit and the grounded frame with the HV systems at full charge. (See Figure 2). This must cause the Ground Fault detector to trip, and the vehicle electrical systems to shut down.

[3] Bender Corporation is a Formula Hybrid team sponsor. See the Formula Hybrid website for more information.

This test may be repeated by the electrical inspectors at any time during the competition.

Once the Ground fault test has been satisfactorily completed, the scruitineers will seal the High Voltage enclosures. If the seals are broken, the vehicle may not participate in any dynamic events until the Ground Fault test has been satisfactorily re-done. (If a repair is simple, and done in the presence of an Electrical Inspector, the Chief Electrical Inspector may choose to waive the re-testing requirement.)

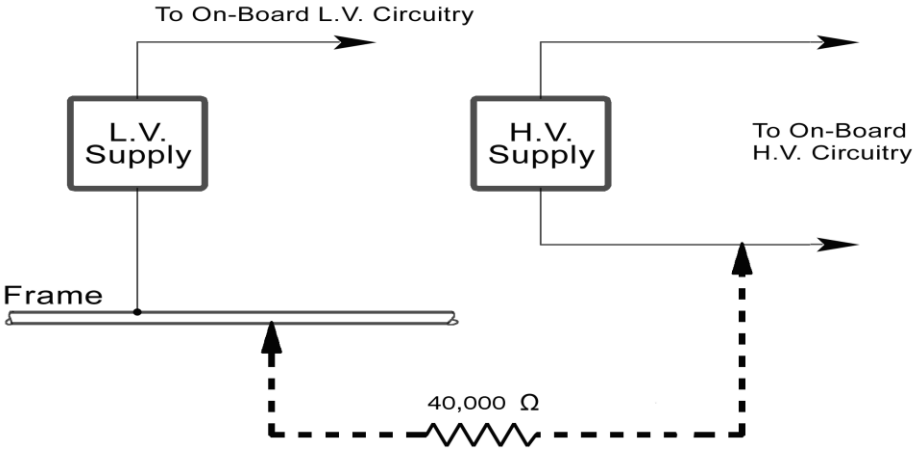


Figure 2

4.1.3 Rain Certification

A vehicle may not be operated in wet conditions unless Rain Certified.

To become Rain Certified, a vehicle must first pass the Ground Fault test outlined in **4.1.2.** It must then survive a 30 second water spray[4] with all systems energized without tripping the Ground Fault Detector.

4.2 No Exposed Connections

No HV connections may be exposed. Non-conductive covers must prevent inadvertent human contact. This would include crew members working on or inside the vehicle.

HV systems and containers must be protected from moisture in the form of rain or puddles for any car that is certified to run rain or wet conditions. (See section 4.1.3)

[4] The water spray will be directed from the top, front and sides of the vehicle. The spray is intended to simulate rain and will typically have drops ranging in size between 0.1 to 5 mm in diameter. A strong stream of water will not be directed at the vehicle.

There will be no HV connections behind the instrument panel or any cockpit switch or control panels. All controls, indicators and data acquisition connections must be isolated using optical isolation, transformers or the equivalent.

4.3 HV Insulation, Wiring and Conduit

All insulation materials used in HV systems must be rated for the maximum temperatures expected. Insulated wires must be commercially marked with a wire gauge, temperature rating and insulation voltage rating. Other insulation materials must be documented.

All HV wiring must be done to professional standards with appropriately sized conductors and terminals, and with adequate strain relief and protection from loosening due to vibration etc.

All HV wiring that runs outside of electrical enclosures must be enclosed in orange non-conductive conduit, such as Electri-flex LNMP or equivalent[5]. The conduit must be securely anchored at least at each end, and must be located out of the way of possible snagging or damage.

All external heat sinks must be securely grounded.

4.4 Fusing

All electrical systems (both low and high voltage) must be appropriately fused. Any wiring protected by a fuse must be adequately sized and rated for current equal to the fuse rating (See wire requirements in 4.3)

4.5 Accumulator Type and Size

Total accumulator voltage may not exceed 400V.

Accumulator capacity may not exceed 7,250 Wh.

Teams must state, as accurately as possible, their accumulator capacity. There is a $6,000.00 limit on the "standardized" cost of the accumulator system. An equivalency table will be published.

Energy accumulators must be of an approved type. At this time only batteries and capacitors are permitted.

[5] Graybar Electric stocks orange conduit and is a Formula Hybrid team sponsor. See the Formula Hybrid website for more information.

4.6 Energy Storage Container Electrical Configuration

All energy storage must be in closed containers containing normally open isolation relays[6] wired in such a way that when an incoming "energize" signal is interrupted no voltages will be present outside of the containers. The boxes must also include an appropriately rated fuse or circuit breaker. The relays must be rated to interrupt the rated fuse current at the maximum expected voltage.

Contactors and relays containing mercury are not permitted.

Multiple energy storage containers connected in series may be isolated by a total of two relays, provided that interconnects between the containers are protected by non-conductive conduit (See Section 4.3) anchored solidly to the containers.

All voltages outside the energy storage container must decay to below 30 V within ten seconds of when the relays are disconnected. For example, filter capacitors must have bleeder resistors across them.

The energy storage containers must have closable access ports allowing a 6" electrical probe[7] to make contact with each extreme of the HV system. These will be used to permit testing the isolation stipulated in section 4.1.2. Optionally, access to the same electrical nodes may be provided at another point.

Each energy storage container must have a prominent indicator, such as an LED that will illuminate whenever that container contains a voltage greater than (at a maximum) 30V. This must be clearly visible in direct sunlight. As an alternative, the battery container may contain an "embedded" analog meter clearly visible from the outside.

4.7 Energy Storage Container Mechanical Configuration

The energy storage container and mounting system must be sturdy, considering forces encountered during on-course competition and the possibility of a rollover accident.

The materials used to construct the container should ideally be electrically insulating, mechanically robust, fireproof, and transparent to allow easy inspection. Not all of these properties are available in a single material, but the following are required:

- At least one layer of fireproof material between the driver and the energy storage container.
- Mechanically robust, fireproof insulating material (e.g., Nomex) between live electrical parts and any conductive portions of the container.
- Adequate structural robustness for the weight of the accumulator.

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[6] Such as Tyco EV200 (http://relays.tycoelectronics.com/datasheets/ev200.pdf)

[7] The probes used during the technical inspection will be Fluke TL238 or equivalent.

There must be no unintentional electrical conduction paths through any of the walls of the container. (Metal screws, rivets, etc.)

The container must be prominently labeled with high voltage signs, at least 30 in^2, with a red (or white on red) lightning bolt and the text "High Voltage" or "Danger High Voltage".

Systems capable of venting H_2 gas (batteries) must have an active ventilation system that is active whenever the system is charging, whether from on-board or off-board sources.

4.8 Low-Voltage Circuits

Low-voltage (< 30 V) circuits must be grounded to the frame of the car. (This ensures that, in the event of a fault in the isolation of the HV circuit, no HV will be present between controls or anything else that personnel might touch and the frame.)

If the low-voltage circuits are powered by a battery or other source that is not inherently current limited, proper fusing must be used.

Low-voltage and HV circuits must be segregated and isolated as described in Section 4.1

The capacity of the Low Voltage battery need not be included in the overall vehicle accumulator capacity calculations.

4.9 Charging Equipment

All charging equipment must be maintained in safe working condition. High Voltage chargers and/or power supplies must be marked with appropriate High Voltage stickers. If any voltage remains outside the charger after the power is turned off then any open connections must be securely covered.

All chargers must be UL (Underwriters Laboratories) listed.

The vehicle must be de-energized while charging from external sources (as much as possible while still allowing charging), and no other activities (including any mechanical or electrical work) shall be allowed.

5 STATIC EVENTS

5.1 Static Events

The maximum possible scores in the static events are:

Technical Inspection	0 points
Presentation	100 points
Design	200 points
Total	300 points

5.2 Technical Inspection

5.2.1 Objective

The objective of technical inspection is to determine if the vehicle meets the FSAE rules requirements and restrictions and if, considered as a whole, it satisfies the intent of the Rules. For purposes of interpretation and inspection the violation of the intent of a rule is considered a violation of the rule itself.

5.2.2 Inspection & Testing Requirement

Each vehicle must pass all parts of technical inspection and testing, and bear the inspection stickers, before it is permitted to participate in any dynamic event or to run on the practice track. The exact procedures and instruments employed for inspection and testing are entirely at the discretion of the Chief Technical Inspector.

Technical inspection will examine all items included on the Inspection Form found on the Formula Hybrid website plus any other items the inspectors may wish to examine to ensure conformance with the Rules.

All items on the Inspection Form must be clearly visible to the technical inspectors. Visible access can be provided by removing body panels or by providing removable access panels.

Once a vehicle has passed inspection, except as specifically allowed under 3.7.3Modification and Repairs, it must remain in the “As-approved” condition throughout the competition and must not be modified.

Decisions of the inspectors and the Chief Scrutineer concerning vehicle compliance are final and are not permitted to be appealed.

Technical inspection is a non-scored activity.

Technical inspection is conducted only to determine if the vehicle complies with the requirements and restrictions of the Formula Hybrid rules.

Technical approval is valid only for the duration of the specific Formula Hybrid competition during which the inspection is conducted.

5.2.3 Inspection Condition

Vehicles must be presented for technical inspection in finished condition, i.e. fully assembled, complete and ready-to-run. Technical inspectors will not inspect any vehicle presented for inspection in an unfinished state.

Note: Cars may be presented for technical inspection even if final tuning and set-up has not been finished.

5.2.4 Inspection Process

Vehicle inspection will consist of four separate parts as follows:

Part 1 – Scrutineering - Mechanical

Each vehicle will be inspected to determine if it complies with the mechanical and structural requirements of the rules. This inspection will include examination of the driver's equipment (Rule 3.4.2) and a test of the driver egress time (Rule 3.4.8).

Part 2 – Scrutineering – Electrical

Each vehicle will be inspected for compliance with the electrical portions of the rules. This includes a test of the on-board Ground Fault Detector.

Note: In addition to the electrical rules contained in this document, the electrical inspectors will use SAE Standard J1673 "High Voltage Automotive Wiring Assembly Design" as the definitive reference for sound wiring practices.

Note: Parts 1 and 2 must be passed before a vehicle may apply for Part 3 or Part 4 inspection.

Part 3 – Tilt Table Tests

Each vehicle will be tested to insure it satisfies both the 45 degree (45°) fuel and fluid tilt requirement (Rule 3.5.6.5.1) and the 60 degree (60°) tilt table requirement (Rule 3.4.9.1).

Part 4 – Noise, Master Switch, and Brake Tests.

Noise will be tested by the specified method (Rule 3.5.8.3). If the vehicle passes the noise test then its master switches (Shutdown Buttons) will be tested (see Rule 3.4.10). If the vehicle passes both the noise and master switch tests then its brakes will be tested by the specified method (see Rule 3.2.5.1).

5.2.5 Correction and Re-inspection

If any part of a vehicle does not comply with the Rules, or is otherwise deemed to be a concern, then the team must correct the problem and have the car re-inspected.

The judges and inspectors have the right to re-inspect any vehicle at any time during the competition and require correction of non-compliance.

5.2.6 Inspection Stickers

Inspection stickers issued following the completion of any part of Technical Inspection will be placed on the upper nose of the vehicle as specified in 3.6.4 "Technical Inspection Sticker Space". Inspection stickers are issued contingent on the vehicle remaining in the required condition throughout the competition. Inspection stickers may be removed from vehicles that are not in compliance with the Rules or are required to be re-inspected.

5.3 Presentation Event

5.3.1 Presentation Event Objective – Business Case

The objective of the presentation event is to evaluate the team's ability to develop and deliver a **business case summary** that will convince the executives of a manufacturing firm that the team's design best meets the demands of the amateur, weekend, autocross/Sports Car Club of America (SCCA) Solo II racing market and that it can be profitably manufactured and marketed.

The judges should be treated as if they were executives of the manufacturing firm. Teams should **address the concerns of these** executives **(who may not be engineers)** but represent **key** areas of a corporate organization, including, **but not limited to, design,** production, marketing and finance.

Presentations will be evaluated on the contents, organization and visual aids as well as the presenters' delivery and the team's response to questions. The presentation must relate to the car entered into the competition although the actual quality of the prototype itself will not be considered as part of the presentation judging.

5.3.2 Presentation Schedule

Presentations will be made on the static events day. Presentation times will be scheduled by the organizers and either, or both, posted in advance on the competition website or released during on-site registration.

Teams that fail to make their presentation during their assigned time period will receive zero (0) points for the event.

5.3.3 Presentation Format

One or more team members will give the presentation to the judges. All team members who will give any part of the presentation, or who will respond to the judges' questions, must be in the podium area when the presentation starts and must be introduced to the judges. Team members who are part of this "presentation group" may answer the judge's questions even if they did not speak during the presentation itself.

Presentations are limited to a maximum of ten (10) minutes. The judges will stop any presentation exceeding ten minutes. The presentation itself will not be interrupted by questions. Immediately following the presentation there will be a question and answer session of up to five (5) minutes. Only judges may ask questions. Only team members who are part of the "presentation group" may answer the judges' questions.

5.3.3.1 Data Projection Equipment

Projection equipment is not provided by the organizers. Teams planning to use data projectors, or any type of projectors, as part of their presentation are responsible for bringing, or otherwise arranging for, their own projection equipment.

5.3.4 Evaluation Criteria

Presentations will be evaluated on content, organization, visual aids, delivery and the team's response to the judges' questions. The scoring criteria are detailed in Appendix E "Presentation Judging". The criteria are applied only to the team's presentation itself. The team that makes the best presentation, regardless of the quality of their car, will win the event.

5.3.5 Scoring Formula

The scoring of the event is based on the average of the presentation judging forms.

$$PRESENTATION\ SCORE = 100 \cdot \frac{Pyour}{Pmax}$$

Where:

"*Pmax*" is the highest score awarded to any team
"*Pyour*" is the score awarded to your team

It is intended that the scores will range from near zero (0) to one hundred (100) to provide good separation. The Presentation Event Captain may at his/her discretion; normalize the scores of different judging teams.

5.4 Design Event

5.4.1 Design Event Objective

The concept of the design event is to evaluate the engineering effort that went into the design of the car and how the engineering meets the intent of the market. The car that illustrates the best use of engineering to meet the design goals and the best understanding of the design by the team members will win the design event.

Comment: Teams are reminded that FSAE is an engineering design competition and that in the Design Event, teams are evaluated on their design. Components and systems that are incorporated into the design as finished items are not evaluated as a student designed unit, but are only assessed on the team's selection and application of that unit. For example, teams that design and fabricate their own shocks are evaluated on the shock design itself as well as the shock's application within the suspension system. Teams using commercially available shocks are evaluated only on selection and application within the suspension system.

5.4.2 Design Report and Design Spec Sheet – Submission Requirements

(a) Design Report - Judging will start with a Design Review before the event. The principal document submitted for the Design Review is a Design Report. This report must not exceed eight (8) pages, consisting of not more than four (4) pages of text, three (3) pages of drawings (see 5.4.2.1, "Vehicle Drawings") and one (1) optional page containing content to be defined by the team (photo's, graphs, etc…). This document should contain a brief description of the vehicle with a discussion of any important design features and vehicle concepts. Include a list of different analysis and testing techniques (FEA, dynamometer testing, etc.). Evidence of this analysis and back-up data should be brought to the competition and be available, on request, for review by the judges. These documents will be used by the judges to sort teams into the appropriate design groups based on the quality of their review.

Comment: Consider your Design Report to be the "resume of your car".

(b) Design Spec Sheet - In addition to the above document, a completed FH Design Spec Sheet must also be submitted. The FH Design Spec Sheet template can be found on the FH website at: http://www.formula-hybrid.org/FH-designspecs2009.xls. Do not alter or re-format the template prior to submission.

The design judges realize that final design refinements and vehicle development may cause the submitted figures to diverge slightly from those of the completed vehicle. For specifications that are subject to tuning, an anticipated range of values may be appropriate.

The Design Report and the Design Spec Sheet, while related documents, should stand alone and be considered two (2) separate submissions. Two separate file submissions are required.

5.4.2.1 Vehicle Drawings

The Design report must include all of the following drawings:

- One set of 3 view drawings showing the vehicle from the front, top, and side.
- A schematic of the high voltage wiring showing the wiring between the major components. (There is no need to detail the internals of the major components.)
- A wiring diagram superimposed on a top view of the vehicle showing the locations of all major high voltage components and the routing of high voltage wiring.

5.4.3 Design Report and Design Spec Sheet Formats

The Design Report must be submitted electronically in Adobe Acrobat™ Format (*.pdf file). This document must be a single file (text, drawings, and optional content all inclusive). The Design Report file must be named as follows: carnumber_schoolname.pdf using the SAE assigned car number and the complete school name, e.g. **999_University of SAE.pdf**

Design Spec Sheets must be submitted electronically in Microsoft Excel™ Format (*.xls file). The format of the Spec Sheet MUST NOT be altered. Similar to the Design Report, the Design Spec Sheet file must be named as follows: carnumber_schoolname_SPECS.xls using the Formula Hybrid assigned car number and the complete school name, e.g. **999_University of SAE_SPECS.xls**

WARNING – Failure to exactly follow the above submission requirements may result in exclusion from the Design Event. If your files are not submitted in the required format or are not properly named then they cannot be included in the documents provided to the design judges and your team will be excluded from the event.

5.4.4 Excess Size Design Reports

If a team submits a Design Report that exceeds four (4) pages of text, three (3) pages of drawing and one (1) optional page, then only the first four pages of text, three pages of drawings and first optional page will be read and evaluated by the judges. **Note:** If included, cover sheets and tables of contents will count as text pages.

5.4.5 Submission Deadlines

The Design Report and the Design Spec Sheets must arrive at the specified e-mail address by the date shown in the Action Deadlines for the competition your team is entering. E-mail the Design Report and Design Spec Sheets to the address provided in the appendix. The two files must be e-mailed as separate files.

You will receive confirmation of receipt via email and/or the event website once report is reviewed for accuracy. Teams should have a printed copy of this reply available at the competition as proof of submission in the event of discrepancy.

5.4.6 Penalty for Late Submission or Non-Submission

Teams who do not submit a Design Report and a Design Spec Sheet by the specified deadline will not compete in the design event, and will receive zero (0) points for design.

5.4.7 Penalty for Unsatisfactory Submissions

At the discretion of the judges, teams that submit a Design Report or a Design Spec Sheet which is deemed to be unsatisfactory, will also not compete in the design event, but may receive between five (5) and twenty (20) points for their efforts.

5.4.8 Design Event – Vehicle Condition

Cars must be presented for design judging in finished condition, i.e. fully assembled, complete and ready-to-run. The judges will not evaluate any car that is presented at the design event in what they consider to be an unfinished state. Unfinished cars that are refused judging will receive zero (0) points for design. Point penalties may be assessed for cars with obvious preparation issues, e.g. notably loose or missing fasteners.

Note: Cars can be presented for design judging without having passed technical inspection, even if final tuning and setup is in progress.

5.4.9 Judging Criteria

The design judges will evaluate the engineering effort based upon the team's Design Report, Spec Sheet, responses to questions and an inspection of the car. The design judges will inspect the car to determine if the design concepts are adequate and appropriate for the application (relative to the objectives set forth in the rules). It is the responsibility of the judges to deduct points on the design judging form, as given in Appendix F, if the team cannot adequately explain the engineering and construction of the car.

5.4.10 Judging Sequence

The actual format of the design event may change from competition to competition and year to year as determined by the organizing body. At Formula Hybrid and Formula Hybrid West, Design Judging will normally involve three parts:

Initial judging of all vehicles

Final judging ranking the top 2 to 4 vehicles.

At other competitions in the Formula Hybrid Series Design Judging may be in one or two parts.

5.4.11 Scoring

Scoring will be from 0 to 200 points at the judges discretion.

5.4.12 Support Materials

Teams may bring with them to the Design Event any photographs, drawings, plans, charts, example components or other materials that they believe are needed to support the presentation of the vehicle and the discussion of the their development process.

6 DYNAMIC EVENTS

6.1 Dynamic Events

The maximum scores in the dynamic events are:

Acceleration	150 Points
Autocross	150 Points
Endurance/Efficiency	400 Points
Total	**700 Points**

6.1.1 Vehicle Integrity and Disqualification

During the Dynamic Events, the mechanical integrity of the vehicle must be maintained. Any vehicle condition that could compromise vehicle integrity, e.g. damaged suspension, brakes or steering components, or could compromise the track surface, e.g. fluid leaks or dragging bodywork, will be a valid reason for exclusion by the officials until the problem is rectified.

Note: If this happens during the Endurance Event, it means disqualification from the heat.

6.2 Weather Conditions

The organizer reserves the right to alter the conduct and scoring of the competition based on weather conditions.

6.2.1 Running in Rain

A vehicle may not be operated in wet conditions unless Rain Certified. (See section 4.1.3)

6.2.1.1 Operating Conditions

The following operating conditions will be recognized at Formula Hybrid:

Dry – Overall the track surface is dry.

Damp – Significant sections of the track surface are damp.

Wet – The entire track surface is wet and there may be puddles of water.

Weather Delay/Cancellation – Any situation in which all, or part, of an event is delayed, rescheduled or canceled in response to weather conditions.

6.2.1.2 Decision on Operating Conditions

The operating condition in effect at any time during the competition will be decided by the competition officials.

6.2.1.3 Notification

If the competition officials declare the track(s) to be "Damp" or "Wet",

i. This decision will be announced over the public address system, and

ii. A sign with either "Damp" or "Wet" will be prominently displayed at both the starting line(s) and the start-finish line of the event(s), and the entry gate to the "hot" area.

6.2.1.4 Tire Requirements

The operating conditions will determine the type of tires a car may run as follows: Dry – Cars must run their Dry Tires, except as covered in 6.2.1.8. Damp – Cars may run either their Dry Tires or Rain Tires, at each team's option. Wet – Cars must run their Rain Tires.

6.2.1.5 Event Rules

All event rules remain in effect.

6.2.1.6 Penalties

All penalties remain in effect.

6.2.1.7 Scoring

No adjustments will be made to teams' times for running in "Damp" or "Wet" conditions. The minimum performance levels to score points may be adjusted if deemed appropriate by the officials.

6.2.1.8 Tire Changing

(A) During the Acceleration, Skid-Pad or Autocross Events:

Within the provisions of 6.2.1.4 above, teams may change from Dry Tires to Rain Tires or vice versa at any time during those events at their own discretion.

(B) During the Endurance Event: Teams may change from Dry to Rain Tires or vice versa at any time while their car is in the staging area inside the "hot" area.

All tire changes after a car has received the "green flag" to start the Endurance Event shall take place in the Driver Change Area.

(i) If the track was "Dry" and is declared "Damp":

- Teams may start on either Dry or Rain Tires at their option.
- Teams that are on the track when it is declared "Damp", may elect, at their option, to pit in the Driver Change Area and change to Rain Tires under the terms spelled out below in "Tire Changes in the Driver Change Area".

(ii) If the track is declared "Wet":

- A Red Flag will be shown at the Start/Finish Line and all cars will enter the Driver Change Area.
- Those cars that are already fitted with "Rain" tires will be allowed restart without delay subject to the discretion of the Event Captain/Clerk of the Course.
- Those cars without "Rain" tires will be required to fit them under the terms spelled out below in "Tire Changes in the Driver Change Area". They will then be allowed to re-start at the discretion of the Event Captain/Clerk of the Course.

(iii) If the track is declared "Dry" after being "Damp" or "Wet":

- The teams will NOT be required to change back to “Dry” tires.

(iv) Tire Changes at Team's Option:

- Within the provisions of 6.2.1.4above and 6.2.1.8 below, a team will be permitted to change tires at their option.
- If a team elects to change from “Dry” to “Rain” tires, the time to make the change will NOT be included in the team’s total time.
- If a team elects to change from “Rain” tires back to “Dry” tires, the time taken to make the change WILL be included in the team’s total time for the event, i.e. it will not be subtracted from the total elapsed time. However, a change from “Rain” tires back to “Dry” tires will not be permitted during the driver change.
- To make such a change, the following procedure must be followed:
  - Team makes the decision,
  - Team has tires and equipment ready near Driver Change Area,
  - The team informs the Event Captain/Clerk of the Course they wish their car to be brought in for a tire change,
  - Officials inform the driver by means of a sign or flag at the checker flag station,
  - Driver exits the track and enters the Driver Change Area in the normal manner.

(v) Tire Changes in the Driver Change Area:

- Per Rule 6.6.6, no more than three people for each team may be present in the Driver Change Area during any tire change, e.g. a driver and two crew or two drivers and one crew member.
- No other work may be performed on the cars during a tire change.
- Teams changing from "Dry" to "Rain" tires will be allowed a maximum of ten (10) minutes to make the change.
- If a team elects to change from "Dry" to "Rain" tires during their scheduled driver change, they may do so, and the total allowed time in the Driver Change Area will be thirteen (13) minutes.
- The time spent in the driver change area of less than 10 minutes without driver change, or 13 minutes with driver change, will not be counted in the team's total time for the

event. Any time in excess of these times will be counted in the team's total time for the event.

6.3 Driver Limitations

An individual team member may not drive in more than two (2) events.

An individual may not drive in both heats of any event. It is the team's option to participate in any event. The team may forfeit their second heat in any performance event.

Note: A minimum of three (3) drivers is required to participate in all heats of the dynamic events

In order to drive in the endurance event, a driver must have attended the mandatory drivers meeting and walked the entire track with an official.

The time and location of the meeting and walk-arounds will be announced at the event.

6.4 Acceleration Event

6.4.1 Acceleration Objective

The acceleration event evaluates the car's acceleration in a straight line on flat pavement.

6.4.2 Acceleration Procedure

The cars will accelerate from a standing start over a distance of 75 m (82 yards) on a flat surface. The foremost part of the car will be staged at 0.30 m (11.8 inches) behind the starting line. A green flag will be used to indicate the approval to begin, however, time starts only after the vehicle crosses the start line. There will be no particular order of the cars in each heat. A driver has the option to take a second run immediately after the first.

6.4.3 Acceleration Heats

There will be a minimum of 2 acceleration runs. One must be run electric-only, with the engine shut off. (See also Section 3.5.2) The second run may be done in any configuration the team chooses. Teams have the option of making up to two additional runs in each category (electric-only and unrestricted) for a total of up to 6 runs. The fastest run in each category will be the recorded acceleration time. It is permissible for one driver to make all the acceleration runs.

The two acceleration categories (electric only and unrestricted) will be scored separately for 75 points each.

6.4.4 Tire Traction – Limitations

Special agents that increase traction may not be added to the tires or track surface and "burnouts" are not allowed.

6.4.5 Acceleration Scoring

The acceleration score is based upon the corrected elapsed time. Elapsed time will be measured from the time the car crosses the starting line until it crosses the finish line.

6.4.5.1 Cones Down Or Out (DOO)

A two (2) second penalty will be added for each DOO (including entry and exit gate cones) that occurred on that particular run to give the corrected elapsed time.

6.4.5.2 Off Course

An Off Course (OC) will result in a DNF for that run.

Cars that have not run by the end of the event (determined by the organizer) will receive a Did Not Finish (DNF).

6.4.6 Acceleration Scoring Formula

The score for the acceleration event is spread between zero (0) and seventy-five (75) based upon the elapsed time. The following equation is used to determine the scores for the event:

$$ACCELERATION\ SCORE = 71.5 \times \frac{\left(\frac{15}{Tyour}\right) - 1}{\left(\frac{15}{Tmin}\right) - 1} + 3.5$$

Where: *Tyour* is the best corrected elapsed time for the team including penalties. *Tmin* is the elapsed time of the fastest car.

The maximum acceptable acceleration time is 15 seconds corresponding to an average speed of 18.0 km/hr. Negative "performance" points will not be given. However, 3.5 points will be given for a car that completes a run, even if *Tyour* exceeds 15 seconds.

In the above equation, the first term on the right hand side is "performance" points", while the second term represents "completion points," or the minimum score for having successfully completed the event.

DNF = zero (0) points

6.5 Autocross Event

6.5.1 Autocross Objective

The objective of the autocross event is to evaluate the car's maneuverability and handling qualities on a tight course without the hindrance of competing cars. The autocross course will combine the performance features of acceleration, braking, and cornering into one event.

6.5.2 Autocross Procedure

There will be two (2) Autocross-style heats, with each heat having a different driver. Two (2) timed laps will be run (weather and time permitting) by each driver and the best lap time will stand as the time for that heat.

The car will be staged such that the front wheels are 6 m (19.7 feet) behind the starting line. The timer starts only after the car crosses the start line.

There will be no particular order of the cars to run each heat but a driver has the option to take a second run immediately after the first.

The organizer will determine the allowable windows for each heat and retains the right to adjust for weather or technical delays. Cars that have not run by the end of the heat will be disqualified for that heat.

6.5.3 Autocross Course Specifications & Speeds

The following specifications will suggest the maximum speeds that will be encountered on the course. Average speeds should be 40 km/hr (25 mph) to 48 km/hr (30 mph).

Straights: No longer than 60 m (200 feet) with hairpins at both ends (or) no longer than 45 m (150 feet) with wide turns on the ends.

Constant Turns: 23 m (75 feet) to 45 m (148 feet) diameter.

Hairpin Turns: Minimum of 9 m (29.5 feet) outside diameter (of the turn).

Slaloms: Cones in a straight line with 7.62 m (25 feet) to 12.19 m (40 feet) spacing.

Miscellaneous: Chicanes, multiple turns, decreasing radius turns, etc. The minimum track width will be 3.5 m (11.5 feet).

The length of each run will be approximately 0.805 km (1/2 mile) and the driver will complete a specified number of runs.

6.5.4 Autocross Penalties

The cars are judged on elapsed time plus penalties. The following penalties will be added to the elapsed time:

6.5.4.1 Cone Down or Out (DOO)

Two (2) seconds per cone, including any after the finish line.

6.5.4.2 Off Course

Driver must re-enter the track at or prior to the missed gate or a twenty (20) second penalty will be assessed. Penalties will not be assessed for accident avoidance or other reasons deemed sufficient by the track officials.

If a paved road edged by grass or dirt is being used as the track, e.g. a go kart track, four (4) wheels off the paved surface shall count as an "off course". Two (2) wheels off will not incur an immediate penalty; however, consistent driving of this type may be penalized at the discretion of the event officials.

6.5.4.3 Missed Slalom

Missing one or more gates of a given slalom will be counted as one "off-course" per occurrence. Each occurrence will incur a twenty (20) second penalty.

6.5.5 Stalled & Disabled Vehicles

If a car stalls and cannot restart without external assistance, the car will be deemed disabled. Cars deemed disabled will be cleared from the track by the track workers. At the direction of the track officials team members may be instructed to retrieve the vehicle. Vehicle recovery may only be done under the control of the track officials.

6.5.6 Corrected Elapsed Time

The elapsed time plus any penalties from that specific run will be used as the corrected elapsed time. Cars that are unable to complete the course with an average speed of 80% of the fastest car will not be awarded “performance” points. This means that any autocross time in excess of 125% of the fastest time will receive no “performance” points.

6.5.7 Best Run Scored

The time required to complete each run will be recorded and the team’s best corrected elapsed time will be used to determine the score.

6.5.8 Autocross Scoring Formula

In the equation below, the first term on the right hand side represents “performance” points, while the second term, or “completion” points represents the minimum score for having successfully completed the event. The following equation is used to determine the autocross score:

$$AUTOCROSS\ SCORE = 142.5 \times \frac{\left(\frac{Tmax}{Tyour}\right) - 1}{\left(\frac{Tmax}{Tmin}\right) - 1} + 7.5$$

Where: *Tmin* is the lowest corrected elapsed time recorded for any competitor in either heat *Tmax* is 125% of *Tmin Tyour* is the lowest corrected elapsed time in either heat for the team being scored.

Negative "performance" points will not be given. However, 7.5 points will be given for a car that completes a run, even it *Tyour* exceeds 125% of the fastest time (*Tmin*)

6.6 Endurance Event

Prior to the beginning of the endurance event, the vehicle fuel tank (and if fitted, carburetor float bowls) will be drained. The tank will then be filled by the organizers and the filler will be sealed. (See section 3.5.6.1)

The amount of fuel allotted to each team will be 80% of the average fuel consumption for the Previous year's Michigan FSAE Endurance event, adjusted downward by an amount equal to the stated energy content of the vehicles accumulators. (It is assumed that the vehicle will start the dynamic events with fully charged accumulators) The fuel/accumulator energy conversion will be based on a 27% fuel-to-mechanical engine efficiency. (See Appendix B)

2009 Formula Hybrid Fuel Allocation: 3.756 liters (0.992 Gals.)

There will be no extra points awarded for fuel remaining at the end of the dynamic events.

Hybrids-in-progress (see section3.5.3) may use the allotted fuel to power a portable generator which may be used to charge the accumulators. The generator must comply with the fuel tank drain and filler cap seal requirements, and must be located in a prominent area i.e. not inside of a trailer or other structure.

Hybrids-in-progress may recharge their accumulators during the Endurance driver change (Not to exceed 30 minutes)

NOTE: Once the endurance event has begun, hybrids-in-progress may *only* charge from portable, fuel-powered generators. (Multiple generators are permissible, but must share the team's fuel allotment.)

Prior to the beginning of the endurance event, all competitors may charge from any power source they wish.

6.6.1 Right to Change Procedure

The following are general guidelines for conducting the endurance event. The organizers reserve the right to establish procedures specific to the conduct of the event at the site. All such procedures will be made known to the teams through newsletters or the Formula Hybrid website.

6.6.2 Endurance Objective

The endurance event is designed to evaluate the vehicle's overall performance, reliability and efficiency. Unlike fuel economy tests that result in vehicles going as slow as possible in order to use the least amount of fuel, Formula Hybrid rewards the team that can cover a designated distance on a fixed amount of energy in the least amount of time.

6.6.3 Endurance Course Specifications & Speeds

Course speeds can be estimated by the following course specifications. Average speed should be 48 km/hr (29.8 mph) to 57 km/hr (35.4 mph) with top speeds of approximately 105 km/hr (65.2 mph).

Straights: No longer than 77.0 m (252.6 feet) with hairpins at both ends (or) no longer than 61.0 m (200.1 feet) with wide turns on the ends. There will be passing zones at several locations.

Constant Turns: 30.0 m (98.4 feet) to 54.0 m (177.2 feet) diameter.

Hairpin Turns: Minimum of 9.0 m (29.5 feet) outside diameter (of the turn).

Slaloms: Cones in a straight line with 9.0 m (29.5 feet) to 15.0 m (49.2 feet) spacing.

Miscellaneous: Chicanes, multiple turns, decreasing radius turns, etc. The minimum track width will be 4.5 m (14.76 feet).

6.6.4 Endurance General Procedure

The team completing the required number of laps in the shortest time will earn the maximum points available for this event. If no teams complete the allotted laps, the required laps will be adjusted downward until there is a winner. The remaining finishing positions will be filled out by "fastest cars for *n* laps", followed by "fastest cars for *n*-1 laps", then "fastest cars for *n*-2 laps", etc.

Wheel to wheel racing is prohibited. Passing another vehicle may only be done in an established passing zone or under the control of a course marshal.

The endurance distance is 22km (13.7 Miles).

6.6.5 Endurance Vehicle Starting/ Restarting

The vehicle must be capable of starting / restarting without external assistance at all times once the vehicle has begun the heat. If a vehicle stalls out on the track, it will be allowed one (1) lap by the car that is following it (approximately one (1) minute) to restart. If a vehicle has a restart problem at the end of Driver Change, it will be allowed a further two (2) minutes to restart the engine. If restarts are not accomplished within the above times, the car will be deemed disabled and scored DNF for the heat.

6.6.6 Endurance Driver Change Procedure

There must be two drivers for the endurance event. The first driver will complete 11 kilometers and then the second driver must take over.

The clock will be stopped during the driver change. The car must come to a complete stop in the driver change area with all drive and electrical systems shut down. The drivers may then switch. The second driver must indicate to the course marshal when she/he is ready to reenter the track, whereupon the course marshal will confirm proper seat belt and helmet buckling. The course marshal will then allow the car to reenter the track.

The vehicle may be stopped during the driver change for up to 30 minutes without penalty. (See section 6.6.13.6)

6.6.7 Entering the Track

Teams must push their vehicle to the staging area at the start. All vehicle movement in the staging area must be done under control of the course marshal.

Cars will be allowed to enter the track based on traffic conditions.

6.6.8 Endurance Run Order

Endurance run order will be determined by the team's score in the autocross. Teams with the best autocross score will run first. If a team did not finish the autocross, run order will then continue based on acceleration times, followed by any vehicles that may not have completed either previous event. Endurance run order will be published at least one hour before the endurance event is run.

6.6.9 Breakdowns & Stalls

If a vehicle breaks down it will be removed from the course and will not be allowed to re-enter the course. If a vehicle stalls, or ingests a cone, etc., it will be allowed to restart and re-enter the course where it went off, but no work may be performed on the vehicle. If a car stalls and cannot be restarted without external assistance, the track workers will push the car clear of the track. At the discretion of event officials, two (2) team members may retrieve the car under direction of the track workers.

6.6.10 Endurance Minimum Speed Requirement

The allotted number of laps must be completed in sixty (60) minutes or less. Cars that are unable to complete 22 kilometers within 60 minutes will be flagged off the course and their actual completed laps will be tallied.

6.6.11 Exiting the Course

Timing will stop when the car crosses the finish line.

Teams may elect to shut down and coast after crossing the finish line, but must fully enter the shut-down area before coming to a stop. There will be no “cool down” laps.

The speed limit when entering the shut-down area is 15MPH. Excessive speed will be penalized.

6.6.12 Endurance Lap Timing

Each lap of the endurance event will be individually timed either by electronic means, or by hand. The time for an individual heat will be determined by subtracting the extra long lap for the driver change from the total time and adding any penalty points.

6.6.13 Endurance Penalties

Penalties will not be assessed for accident avoidance or other reason deemed sufficient by the track official.

Additional driving rules will be found in other sections including 6.7 “Flags” and 6.11 “Driving Rules”

The following penalties will be assessed:

6.6.13.1 Cones

Cone down or out (DOO) - two (2) seconds per cone. This includes cones before the start line and after the finish line.

6.6.13.2 Off Course (OC)

For an OC, the driver must re-enter the track at or prior to the missed gate or a twenty (20) second penalty will be assessed.

If a paved road edged by grass or dirt is being used as the track, e.g. a go kart track, four (4) wheels off the paved surface shall count as an "off course". Two (2) wheels off will not incur an immediate penalty.

However, consistent driving of this type may be penalized at the discretion of the event officials.

6.6.13.3 Missed Slalom

Missing one or more gates of a given slalom will incur a twenty (20) second penalty.

6.6.13.4 Penalties for Moving Violations

The following are penalties and assessed times or disqualifications for moving violations:

a) Failure to obey a flag: 1 minute
b) Over Driving (After a closed black flag): 1 Minute
c) Vehicle to Vehicle contact: DISQUALIFIED

6.6.13.5 Out of Order

Running out of order – two (2) minute penalty.

6.6.13.6 Mechanical Problem

Repairs may be made during the event, but this must be done in the designated repair area. The clock will not be stopped during this time, and the 60-minute total time allowance (Section 6.6.10) will still be in effect.

Repairs will be allowed during the driver change, but may not exceed the thirty (30) minute shutdown time. There will be no penalty for repairs made during the driver change, however if the vehicle is stopped for longer than 30 minutes the clock will be restarted.

Hybrids-in-progress may recharge during the shutdown time.

6.6.13.7 Reckless or Aggressive Driving

Any reckless or aggressive driving behavior (such as forcing another car off the track, refusal to allow passing, or close driving that would cause the likelihood of car contact) will result in a black flag for that driver. When a driver receives a black flag signal, he/she must proceed to the penalty box to listen to a reprimand for his driving behavior. The amount of time spent in the penalty box will vary from one (1) to four (4) minutes depending upon the severity of the offense.

If it is impossible to impose a penalty by a stop under a black flag, e.g. not enough laps left, the event officials may add an appropriate time penalty to the team's elapsed time.

6.6.13.8 Inexperienced Driver

The Chief Marshall/Director of Operations may disqualify a driver if the driver is too slow, too aggressive, or driving in a manner that, in the sole opinion of the event officials, demonstrates an inability to properly control their car resulting in a DNF.

6.6.14 Endurance Scoring Formula

The times for the endurance event will be based upon the sum of the times of each driver in the heat plus penalties.

The following equation is used to determine the time scores for the event:

If *Tyour* is < or = to 60:

$$ENDURANCE\ SCORE = (Pmax - Pmin)\frac{\left(\frac{60}{Tyour}\right) - 1}{\left(\frac{60}{Tmin}\right) - 1} + Pmin$$

If a team completes all of the allotted laps, then *Pmax* = 400 and *Pmin* = 300.

If a team does not complete the allotted laps, then *Pmax* and *Pmin* will be based linearly on the number of laps completed. See Appendix C for an example.

Tmin will be the lowest corrected time of the fastest team for each of the number of laps completed.

Tyour will be the combined corrected times of the drivers in your heat.

6.6.15 Post Event Engine Check

The organizer reserves the right to impound any vehicle immediately after the event to check engine displacement (method to be determined by the organizer) and restrictor size.

6.7 Flags

The flag signals convey the commands described below, and shall be obeyed immediately and without question.

There are two kinds of flags for the competition: Command flags and Informational flags. Command flags are just that, flags that send a message to the competitor that the competitor must obey without question. Informational flags, on the other hand, require no action from the driver, but should be used as added information to help him or her to maximize performance. What follows is a brief description of the flags used at the competitions in North America and what each flag means.

Note: Not all of these flags are used at all competitions and some alternate designs are occasionally displayed. Any variations from this list will be explained at the drivers meetings.

6.7.1 Command Flags

BLACK FLAG - Pull into the penalty box for discussion with the Director of Operations or other official concerning an incident. A time penalty may be assessed for such incident.

BLACK FLAG With Orange Dot – ("Meatball") Pull into the penalty box for a mechanical inspection of your car, 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 hand signals at the end of the passing zone to merge into competition.

CHECKER FLAG - Your session has been completed. Exit the course at the first opportunity.

GREEN FLAG - Your session has started, enter the course under direction of the starter. (NOTE: If you stall the vehicle, please restart and await another green flag as the opening in traffic may have closed.)

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.

6.7.2 Informational Flags

RED AND YELLOW STRIPED FLAG - Something is on the racing surface that should not be there. Be prepared for evasive maneuvers to avoid the situation. (Corner workers may be able to point out what and where it is located, but do not expect it.)

WHITE FLAG - There is a slow moving vehicle on the course that is much slower than you are. Be prepared to approach it at a cautious rate.

6.8 Rules of Conduct

6.8.1 Competition Objective – A Reminder

The Formula Hybrid event is a design engineering competition that requires performance demonstration of vehicles and is NOT a race. Engineering ethics will apply. It is recognized that hundreds of hours of labor have gone into fielding an entry into Formula Hybrid. It is also recognized that this event is an "engineering educational experience" but that it often times becomes confused with a high stakes race. In the heat of competition, emotions peak and disputes arise. Our officials are trained volunteers and maximum human effort will be made to settle problems in an equitable, professional manner.

6.8.2 Unsportsmanlike Conduct

In the event of unsportsmanlike conduct, the team will receive a warning from an official. A second violation will result in expulsion of the team from the competition.

6.8.3 Official Instructions

Failure of a team member to follow an instruction or command directed specifically to that team or team member will result in a twenty five (25) point penalty.

Note: This penalty can be individually applied to all members of a team.

6.8.4 Arguments with Officials

Argument with, or disobedience to, any official may result in the team being eliminated from the competition. All members of the team may be immediately escorted from the grounds.

6.8.5 Alcohol and Illegal Material

Alcohol, illegal drugs, weapons or other illegal material are prohibited on the event site during the competition. This rule will be in effect during the entire competition. Any violation of this rule by a team member will cause the expulsion of the entire team. This applies to both team members and faculty advisors. Any use of drugs, or the use of alcohol by an underage individual, will be reported to the local authorities for prosecution.

6.8.6 Parties

Disruptive parties either on or off-site should be prevented by the Faculty Advisor.

6.8.7 Trash Clean-up

Cleanup of trash and debris is the responsibility of the teams. The team's work area should be kept uncluttered. At the end of the day, each team must clean all debris from their area and help with maintaining a clean paddock.

Teams are required to remove all of their material and trash when leaving the site at the end of the competition. Teams that abandon furniture, or that leave a paddock that requires special cleaning, will be billed for removal and/or cleanup costs.

6.9 General Rules

6.9.1 Dynamometer Usage

If a dynamometer is available, it may be used by any competing team. Vehicles to be dynamometer tested must have passed all parts of technical inspection.

Fuel, ignition and drivetrain tuning will be permitted while testing on the dynamometer.

6.9.2 Problem Resolution

Any problems that arise during the competition will be resolved through the Operations Center and the decision will be final.

6.9.3 Protests

(A) Required Review - Any team that intends to protest a rule, score, judge's decision or any other aspect of the competition, must present the issue to SAE staff for discussion, and possible resolution before the protest is filed.

(**B) Cause for Protest** - A team may protest any rule interpretation, score or official action (unless specifically excluded from protest) which they feel has caused some actual, non-trivial, harm to their team, or has had a substantive effect on their score. Teams may not protest rule interpretations or actions that have not caused them any substantive damage.

(C) Protest Period - Protests must be filed within one-hour (½) after the action being protested has occurred or the scores for the activity involving the protest subject are posted.

(D) Protest Format - Protests must be in writing and submitted to designated organizer or SAE staff.

(E) Protest Bond - The protesting team must post a twenty-five (25) point bond to be deducted from their score if the protest is denied.

(F) Decision - The decision of the officials regarding any protest is final.

6.9.4 Forfeit for Non-Appearance

It is the responsibility of teams to be in the right place at the right time. If a team is not present and ready to compete at the scheduled time they forfeit their attempt at that event. There are no make-ups for missed appearances.

6.9.5 Safety Class – Attendance Required

A safety class is required for all team members. The format and requirements will be posted on the Formula Hybrid website.

6.9.6 Drivers Meetings – Attendance Required

All drivers for an event are required to attend the pre-event drivers meeting(s). The driver for an event will be disqualified if he/she does not attend the driver meeting for the event.

6.9.7 Personal Vehicles

Personal cars and trailers must be parked in designated areas only. Only FSAE competition vehicles will be allowed in the track areas.

6.9.8 Motorcycles, Bicycles, Rollerblades, etc.—Prohibited

The use of motorcycles, quads, bicycles, scooters, skateboards, rollerblades or similar person-carrying devices by team members and spectators in any part of the competition area, including the paddocks, is prohibited.

6.9.9 Self-propelled Pit Carts, Tool Boxes, etc. - Prohibited

The use of self-propelled pit carts, tool boxes, tire carriers or similar motorized devices in any part of the competition site, including the paddocks, is prohibited.

6.10 Pit Rules

6.10.1 Vehicle Movement

Vehicles may not move under their own power anywhere but on the practice or competition tracks. Off track vehicles must be pushed at a normal walking pace by means of a “Push Bar”, with all four (4) wheels on the ground, a team member sitting in the cockpit to steer and brake and with another team member walking beside the car. Cars with wings are required to have two team members walking on either side of the vehicle whenever the vehicle is being pushed. During performance events when the excitement is high, it is particularly important that the car be moved at a slow pace in the pits. The walking rule will be enforced and a point penalty of twenty five (25) points will be assessed for each violation.

6.10.2 Push Bar

Each car must have a removable device that attaches to the rear of the car that allows two (2) people, standing erect behind the vehicle, to push the car around the event site. This device must also be capable of decelerating, i.e. slowing and stopping the forward motion of the vehicle and pulling it rearwards. It must be presented with the car at Technical Inspection.

6.10.3 Smoking – Prohibited

Smoking is prohibited in all competition areas.

6.10.4 Fueling and Refueling

Officials must conduct all fueling and refueling. The vehicle must be de-energized when refueling, and no other activities (including any mechanical or electrical work) shall be allowed while refueling.

6.10.5 Engine Running in the Paddock

Engines may be run in the paddock provided the car has passed technical inspection and the following conditions are satisfied:

(A) The car is on an adequate stand, and

(B) The drive wheels are at least 10.2 cm (4 in) off the ground, or the drive wheels have been removed.

6.11 Driving Rules

6.11.1 Driving Under Power

Cars may only be driven under power

a) When running in an event,
b) When on the practice track
c) During the brake test
d) During any powered vehicle movement specified and authorized by the organizers.

For all other movements cars must be pushed at a normal walking pace using a push bar.

Violation of this rule will result in a two hundred (200) point penalty for the first violation and expulsion of the team for a second violation.

6.11.2 Driving Off-Site -- Prohibited

Driving off-site is absolutely prohibited. Teams found to have driven their vehicle at an off-site location during the period of the competition will be excluded from the competition.

6.11.3 Practice Track

A practice track for testing and tuning cars may be available at the discretion of the organizers.

The practice area will be controlled and may only be used during the scheduled practice times.

Practice or testing at any location other than the practice track is absolutely forbidden. Driving a vehicle outside of scheduled events or scheduled practice will result in a minimum two hundred (200) point penalty or disqualification at the organizer's discretion.

Cars using the practice track must have passed all parts of the technical inspection.

6.11.4 Situational Awareness

Drivers must maintain a high state of situational awareness at all times and be ready to respond to the track conditions and incidents. Flag signals and hand signals from course marshals and officials must be immediately obeyed.

6.11.5 Endurance Event – Driving

During Endurance when multiple cars are running on the course it is paramount that the drivers strictly follow all of the rules and driving requirements. Aggressive driving, failing to obey signals, not yielding for passing, etc will result in a black flag and a discussion in the penalty box with course officials. The amount of time spent in the penalty box is at the discretion of the

officials and is included in the run time. Penalty box time serves as a reprimand as well as informing the driver of what he/she did wrong. Drivers should be aware that contact between open wheel racers is especially dangerous because tires touching can throw one car into the air.

Endurance is a timed event in which drivers compete only against the clock not against other cars. Aggressive driving is unnecessary.

6.11.6 Endurance Event – Passing

Passing during Endurance may only be done in the designated passing zones and under the control of the track officials. Passing zones have two parallel lanes – a slow lane for the cars that are being passed and a fast lane for the cars that are making a pass. On approaching a passing zone a slower leading car will be blue flagged and must shift into the slow lane and decelerate. The following faster car will continue in the fast lane and make the pass. The car that had been passed may reenter traffic only under the control of the passing zone exit flagman. Passing, i.e. slow, lanes may be either to the left or right of the fast lane depending on the design of the specific course.

These passing rules do not apply to cars that are passing disabled cars on the course or cars that have spun out and are not moving. When passing a disabled or off-track car it is critical to slow down, drive cautiously and be aware of all the vehicles and track workers in the area.

Under normal driving conditions when not being passed all cars use the fast lane.

6.11.7 Endurance Event – Driver's Course Walk

The endurance course will be available for walk by drivers prior to the event. All endurance drivers are required to walk the course before the event starts.

6.12 Definitions

DOO - A cone is "Down or Out"—if the cone has been knocked over or the entire base of the cone lies outside the box marked around the cone in its undisturbed position.

DNF- Did Not Finish

Gate - The path between two cones through which the car must pass. Two cones, one on each side of the course define a gate: Two sequential cones in a slalom define a gate.

Entry Gate -The path marked by cones which establishes the required path the vehicle must take to enter the course.

Exit Gate - The path marked by cones which establishes the required path the vehicle must take to exit the course.

Staging Area - An area prior to the entry to an event for the purpose of gathering those cars that are about to start.

OC - A car is Off Course if it does not pass through a gate in the required direction.

7 REQUIRED EQUIPMENT

Each team must have the following at the event. It is recommended that this equipment be purchased well in advance and kept with the car during development and testing.

All required special equipment must be presented at tech inspection.

- Insulated cable cutters, rated for at least the voltage in the HV system. (Not simply unrated plastic handles). Long fiberglass-handle cutters, e.g., Bahco 2520S8, are recommended. These must be capable of cutting live HV cables in the event of a serious malfunction.
- Insulated gloves, rated for at least the voltage in the HV system.
- Materials Safety Data Sheets (MSDS) for the accumulator.
- Any special safety equipment called for in the MSDS, for example correct gloves recommended for handling any electrolyte material in the accumulator.
- Safety glasses. These must be worn when working on the vehicle and at all times while in the pit area.

[8] The Bahco 2520S cutters are available from *www.builderdepot.com*

8 QUESTIONS ABOUT THE FORMULA HYBRID RULES

8.1 Frequently Asked Questions

Before submitting a question, check the Frequently Asked Questions sections of the Formula Hybrid website and the FSAE website

8.2 Question Format

All rules questions must include (1) the full name and email address of the student submitting the question, (2) the name of the university – no abbreviations – and (3) the number of the applicable rule.

The following limits apply to questions submitted to the rules committee (1) No photograph, drawing or other attachment may exceed 100 KB in size (2) the total size of any question, with all attachments, must not exceed 1MB.

8.3 Response Time

Please allow a minimum of two (2) weeks for a response. The Rules Committee will respond as quickly as possible, however responses to questions presenting new issues, or of unusual complexity, may take more than two weeks. Please do not resend questions.

8.4 Submission Addresses:

Send questions to: Wynne Washburn, Formula Hybrid Deputy Director
Email: wynne@formula-hybrid.org

9 IMPORTANT FORMS AND DOCUMENTS

The following forms and documents are available to download at http://formula-hybrid.org in Microsoft Word or Excel Format:

- Structural Equivalency Form – (see Rule 3.3.2 and Appendix D)
- Tech Sheet (see Section 5.2)
- Design Specification Sheet (see Rules 5.4.2)

Appendix A Accumulator Pricing

To avoid the distorting effect of different price breaks on the dollar value of accumulator devices, we will use the following technique to determine our official prices.

To find the price at some quantity q*x*, we use the published prices, p1 and p2, at the next lower and higher quantities, q1 and q2.

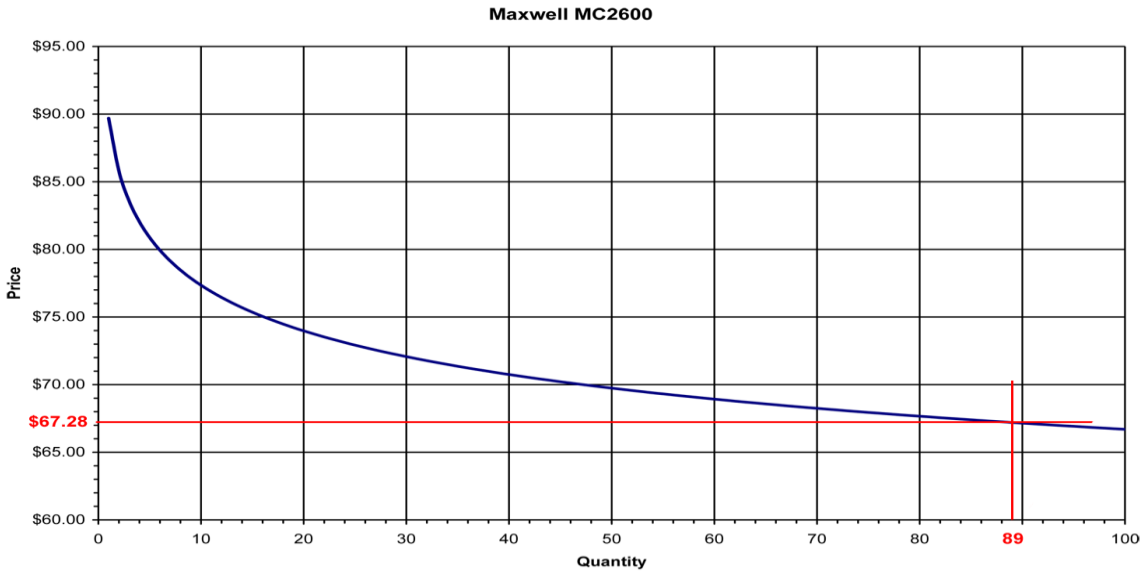
$$p_x = p_1\left(\frac{q_x}{q_1}\right)^a \qquad \text{where} \qquad a = \frac{\log\left(\frac{p_2}{p_1}\right)}{\log\left(\frac{q_2}{q_1}\right)}$$

(This formula has been shown to approximate many electronic device manufacturers pricing structures.)

For example, suppose the Maxwell MC2600 Ultracapacitor were priced at $89.70 in quantities from 1 to 99, and $66.70 for 100 to 999.

If we were to apply our $6,000.00 limit based strictly on this pricing structure, a team could use only 66 devices. However had we set a limit of $6,700.00 they could have used 100.

Using the above formula, the resultant price for the device would be $67.28, allowing the team to use 89 devices.



Typical Price vs. Quantity

Appendix B Fuel Equivalency

We will assign a fuel equivalency to each accumulator device based on the following:

(Note: C, V_{nom}, V_{peak} and Ah are device name-plate values.)

Batteries:

$$Energy(Wh) = (V_{nom})(Ah)(0.8)$$

Capacitors:

$$Energy(Wh) = \left(\frac{C(V_{peak}{}^2 - V_{\min}{}^2)}{2} \right) / 3600$$

where V_{min} is assumed to be 10% of Vpeak.

Gasoline:

$$Gasoline = 2{,}414 \frac{Wh}{l}$$

(Assuming a 27% mechanical efficiency);

For example, taking the Maxwell MC 2600 used in the example above, the fuel equivalency would be 2.606 Wh per device, or 231.9 Wh for a bank of 89, resulting in a 96cc reduction of gasoline.

Other Fuels:

Fuel Type	Wh / Liter (@ 27%)
Gasoline (regular)	2,414
Biodiesel (B100)	2,472
Ethanol (E85)	1,710

Appendix C Example determination of *Pmax* and *Pmin* based on a 22-lap endurance event.

Laps Completed	*Pmax*	*Pmin*
22	400	300
21	299	286
20	285	271
19	270	257
18	256	243
17	242	229
16	228	214
15	213	200
14	199	186
13	185	171
12	170	157
11	156	143
10	142	129
9	128	114
8	113	100
7	99	86
6	85	71
5	70	57
4	56	43
3	42	29
2	28	14
1	13	0

Appendix D Structural Equivalency Form

If required, this form must be completed and submitted no later than the date specified in the Action Deadlines. The FH Technical Committee will review all submissions which deviate from the FH rules. This form must also accompany the vehicle to Technical Inspection.

Structural Equivalency Forms (SEF) and supporting calculations must be submitted electronically in Adobe Acrobat Format (*.pdf). The submissions must be named as follows: **schoolname_SEF.pdf** using the complete school name. Please submit to the person indicated in the Action Deadlines for each event.

*In the event that the FH Technical Committee requests additional information or calculations, teams have one week from the date of the request to submit the requested information.

University Name_____
Team Contact_____ Telephone Number_____
E-mail Address_____ Faculty Advisor_____
Telephone Number_____ E-mail Address_____

Rule Deviated: (check all that apply) and provide summary of change on each line, such as "Eight 5/16 inch Bolts" or "1.00 x 0.065 Square". (Note that FH section numbers may differ from FSAE)

X	Rule No.	Rule Description	Design Description
	3.3.4.2	Main Roll Hoop	
	3.3.4.2.F	Main Roll Hoop Attachment to Monocoque	
	3.3.4.3	Front Roll Hoop Material	
	3.3.5.1	Main Roll Hoop Bracing	
	3.3.5.2	Front Roll Hoop Bracing	
	3.3.5.3	Monocoque Bracing Attachment	
	3.3.6.1	Front Bulkhead	
	3.3.6.1.D	Monocoque Front Bulkhead	
	3.3.6.2	Front Bulkhead Support	
	3.3.6.2.D	Monocoque Front Bulkhead Support	
	3.3.6.3	Impact Attenuator Attachment	
	3.3.8.1	Tube Frames Side Impact Structure	
	3.3.8.2	Composite Monocoque Side Impact Protection	
	3.3.8.3	Metal Monocoque Side Impact Protection	
	3.4.1E	Monocoque Safety Harness Attachment	

ATTACH PROOF OF EQUIVALENCY Please see "Structural Equivalency Guide" on FSAE website for details of proof of equivalency calculations and supporting documentation.

TECHNICAL COMMITTEE DECISION/COMMENTS

Approved by_____ Date_____

NOTE: THIS FORM AND THE APPROVED COPY OF THE SUBMISSION MUST BE PRESENTED AT TECHNICAL INSPECTION AT EVERY FORMULA HYBRID EVENT ENTERED

Appendix E Presentation Judging Form

SCHOOL_____CAR NUMBER_____

PRESENTATION JUDGING

Score the following categories on the basis of 0-10 points each according to the following scale (any number or fraction along this scale may be used).

0.0	Inadequate or no attempt
2.5	Attempted but below expectation
5.0	Average or expected
7.5	Above average but still lacking
10	Excellent, perfectly meets intent

CONTENT: Were the concepts presented appropriate and adequate to explain how the car meets the intent of the customer? Were enough technical details presented without being boring?

ORGANIZATION: Were the concepts presented in a logical order progressing from basic concept and showing how the engineering accomplished the concept? Was it clear to the audience what was to be presented and what was coming next? Were distinct introduction and overviews as well as summary and conclusions given?

VISUAL AIDS: Were visual aids used or clear visual references made to the car? Were the illustrations visible for all of the audience?

DELIVERY: Did the presenter speak in a clear voice? Did the presenter show enthusiasm and promote confidence in the technical aspects? Did he maintain eye contact?

QUESTIONS: Did the answer illustrate that the team fully understood the question? Is there doubt that the team understood the answer? Did the team promote complete confidence in their response to the questions?

TOTAL = PRESENTATION POINTS (50 points maximum)

COMMENTS:

Appendix F Design Judging Form

SCHOOL _____ CAR NUMBER _____

DESIGN JUDGING

AESTHETICS (0-5) - Does the vehicle look attractive? Does it have a high performance appearance?

MECHANICAL DESIGN (0-20) - Do components appear to have been sized properly for the load? Does form follow function? Do brackets serve more than one purpose?

CHASSIS DESIGN (0-30) - Does the suspension design consider kinematics, roll center placement or load transfer? How was vehicle handling designed for and developed? How was brake system designed? Was weight distribution and C.G. height optimized?

MANUFACTURABILITY (0-10) - Can 1000 units per year be economically produced? Was manufacturing and ease of assembly a major consideration?

SERVICEABILITY (0-15) - Is the engine easy to service or remove? Is the suspension easy to adjust?

INNOVATIVENESS (0-15) - Are any of the components or systems unique?

Do the innovations add to the product's functions?

ERGONOMICS/INTERIORS/SAFETY (0-20) - Is the vehicle designed to accommodate & function with a wide variety of body sizes? Are controls and instruments easy to use? Does the design consider occupant safety beyond the requirements?

POWERTRAIN (0-30) - Does the engine have significant modifications with respect to fuel injection, turbocharging, intake or exhaust? Was the drivetrain well done? Were throttle, drive controls designed well?

BUILD QUALITY (0-5) - Fit and finish, quality of materials, detail work, quality appearance.

MISCELLANEOUS (0 to -50) - If (a) this entry is a second year car and did not undergo significant improvements (not applicable in North America) or (b) if the team does not exhibit a good understanding of the car, then a penalty may be applied.

TOTAL = DESIGN POINTS (150 points maximum)

COMMENTS:

Appendix G Other Information

Formula Hybrid Competition and Document Submission Information on the dates, locations and document submission deadlines and addresses for the Formula Hybrid Competition are not included in the Rules. This information will be posted separately on the Formula Hybrid as it becomes available. Date, location and document submission information is typically released 6 to 8 months prior to the competition.