2011 SAE Clean Snowmobile Challenge Rules

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INTRODUCTION

This introduction is intended to highlight some areas of the 2011 SAE Clean Snowmobile Challenge Rules that you may find of interest. Each year the CSC Rules Committee changes the rules to introduce a slightly different engineering challenge. CSC 2011 is very similar to CSC 2010 with only some minor changes

Caution: Neither this Introduction nor any Summary of the Rules is a substitute for thoroughly reading and understanding the CSC Rules. Read the Rules thoroughly and carefully.

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ARTICLE 1: CSC OVERVIEW AND COMPETITION

1.1 Event Description

The SAE International Clean Snowmobile Challenge is an engineering design competition for college and university student members of SAE International, organized and administered by SAE and Michigan Technological University. The modified snowmobiles will compete in a variety of events including emissions, noise, fuel economy/endurance, acceleration, handling, static display, cold start and design.

There are two categories in the SAE Clean Snowmobile Challenge, sleds driven by only one Internal Combustion (IC) engine and sleds driven by electrical power and thus have Zero Emissions (ZE). **No hybrid designs will be allowed to compete.** Teams wishing to compete in a hybrid vehicle competition are encouraged to consider the SAE Formula Hybrid competition.

Please read through the rules completely and designate someone from your team to monitor the CSC Forum on the SAE website for updates and changes. Your team is responsible for following all the rules. For information regarding past competitions there are several SAE papers available written by the competition organizers as well as participating teams. These papers are easily found by searching the SAE website www.sae.org or www.mtukrc.org

1.2 Competition Objective for IC Engines

The intent of the competition is to develop a snowmobile that is acceptable for use in environmentally sensitive areas such as our National Parks or other pristine areas. Snowmobiles in the competition must be “flex-fuel” capable. Gasoline fuels will have a “bio

content" of corn-based ethanol of anywhere from E20 to E29. Diesel fuels will have a "bio-content" of soybean based diesel ranging from B1 to B5. The modified snowmobiles are expected to be quiet, and emit significantly less unburned hydrocarbons and carbon monoxide than current production snowmobiles, without significantly increasing oxides of nitrogen emissions. The modified snowmobiles are also expected to be cost-effective and comfortable for the operator to drive. The intent of the competition is to design a touring snowmobile that will primarily be ridden on groomed snowmobile trails. The use of unreliable, expensive solutions is strongly discouraged! Modern snowmobiles are engineered to meet the current standards for noise and emissions. Teams are expected to add innovative solutions for improving on the performance of the base sled that they start with. Design judges (written and oral) will be looking for innovations and incorporating that into their scores.

An additional objective of the competition is to improve on fuel economy. In addition to the Endurance Event described later within this document, fuel economy will be evaluated in the In-Service and Lab Emissions Events. Additional weighting in the overall scoring is given to fuel economy in the competition.

The minimum performance expectations for a trail IC snowmobile are set by these rules as a sled that by design will go 100 miles without refueling and can attain a trail speed of 45 miles per hour on a smooth trail. Additionally they should be able to traverse 500 feet in 12 seconds or less. Designs that do not have a reasonable expectation of achieving these requirements will be disqualified.

1.3 Competition Objective for Zero Emissions Category

The Greenland Ice Cap acts like a sponge, absorbing atmospheric chemicals produced naturally, or via anthropogenic activities. Many of these chemicals are also photoactive in the lower troposphere and even in the upper layers of the snow. Research underway at Summit Station seeks to understand the processes involved, and how it might play into the global cycling of these agents. Some of the chemical constituents under study are measured in parts per billion. Emissions resulting from the burning of fossil fuels on site can hopelessly skew the research results. Due to the sensitive nature of much of the research being conducted at Summit Station, NSF seeks to find a "zero-emissions" vehicle for transporting researchers and support staff to and from research sites.

Electric snowmobiles or other forms of zero-emissions transportation have long been sought. Range and performance have always been extremely limiting factors that have precluded the successful development of commercially available models. Recent advancements in battery and motor technology have finally made it possible to realize vehicles with ranges adequate for some purposes. Zero-emissions personal transportation would allow the operation of more distant satellite camp facilities, and allow access to areas previously accessible only by foot. In short, this is a tool that the research community needs now.

Snowmobiles in this category must be zero-emissions by default. Therefore, no test or points will be given for emissions. Instead, range and draw bar performance will be measured. Innovation will also be judged in this category.

1.4 Regarding Hybrid Snowmobile Designs

Hybrid vehicle designs are becoming increasingly popular in the marketplace. It is inevitable that recreational vehicles manufacturers will someday consider hybrid designs as costs of these systems decrease. At the current time however energy storage technologies and hybrid

control electronics make for expensive solutions in the snowmobile market. It is unlikely that snowmobiles that are much more expensive will displace conventional IC designs in the near future, especially if those designs lack the performance expected in the recreational market.

Hybrid snowmobile designs are not be permitted in the competition. A hybrid snowmobile is defined as a snowmobile that can be propelled with two separate forms of energy, for example gasoline and/or electricity in any combination.

Future CSC competitions may include an extended range electric snowmobile category. The goal of this category would be to serve markets where zero emissions are desired but an on-board engine-generator would acceptable to provide emergency power and/or extended range.

ARTICLE 2: COMPETITION ELIGIBILITY AND RULES

2.1 Team Eligibility

Registration for the Clean Snowmobile Challenge is limited to teams of undergraduate and graduate students from accredited universities. High school teams are prohibited.

2.2 Team Member Eligibility

Undergraduate participation is strongly encouraged. Graduate student participation is allowed, but limited to no more than 25% of the undergraduate participation on any individual team.

2.3 University Collaboration

Collaboration between schools will be accepted if both schools meet all requirements stated in these rules.

2.4 Entries per University

Registration for the Clean Snowmobile challenge is limited to one vehicle per university in each of the two categories, IC engine and zero-emissions.

2.5 Registration Limit – 25 Vehicles

Registration for the Clean Snowmobile Challenge is limited to 25 vehicles.

2.6 Registration Deadline – December 20, 2010

Registrations will be accepted in the order in which they are received starting at 10:00 am EDT October 4, 2010 and ending at midnight, Eastern Standard Time, Monday, December 20, 2010 **or** when 25 teams have registered, whichever occurs first.

The registration fee must be paid on-line by credit card at the time of registration. Registration fees may not be paid by any other means.

There is **no** late registration and there are **no exceptions** to this registration policy. Registration fees are not refundable.

To complete the registration process, teams must submit the mandatory required information below after completing online process.

1. Team Program Information

   Team program information will be uploaded to http://www.mtukrc.org/send.htm at the time of registration. The following is required:

   - Name of Faculty Advisor(s)
   - Name(s) of Team Leader(s)
   - Names of Team Members
   - Fuel choice (Flex-fuel ethanol or flex-fuel diesel)

2. Current Team Photo (optional)

   The photograph will be printed in the program on a page measuring 5.5 by 8.5 inches. The photograph will typically be 4 to 4.5 inches wide by 2 or 3 inches tall. The required resolution is 300 pixels per inch when printed on paper. If no photo is provided the organizers will decide what will be on the team page.

   NOTE: Pictures that look good on computer screens look different on paper. When in doubt, use the highest resolution the camera or scanner will allow.

2.7 Individual Participant Requirements

Individual members of teams participating in this competition must satisfy the following requirements:

A. Student Status: Team members must be enrolled as degree seeking undergraduate or graduate students. Team members who have graduated during the seven (7) month period prior to the competition remain eligible to participate.

B. SAE Membership: Team members must be members of SAE. Proof of SAE membership is required at the event. Students may join SAE online at: www.sae.org/students.

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

D. 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.

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

All student participants and faculty advisors MUST present proof of medical insurance coverage that is valid in United States.

2.8 Liability Waiver

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

2.9 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 snowmobile.

2.10 United States Visas

Teams requiring visas to enter to the United States are advised to apply at least sixty (60) 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.

2.11 International Participation – Vehicle Shipping/US Customs

SAE & the Clean Snowmobile Challenge organizers strongly recommend that international teams ship their vehicle(s) early to allow enough time to compensate for any delays that may occur in clearing U.S. Customs. Please check with the United States Customs Service concerning the regulations governing the temporary importation of vehicles. You may want to

consider using the services of a freight forwarder who is familiar with the international shipping of vehicles.

SAE staff and the Clean Snowmobile Challenge Event organizers are not permitted to provide advice on U.S. Customs matters.

2.12 Rules Authority

The SAE Clean Snowmobile Challenge Rules are the responsibility of the SAE Clean Snowmobile Rules Committee and are issued under the authority of the SAE University Programs Committee. Official announcements from SAE and/or the organizers shall be considered a 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 SAE Clean Snowmobile Rules Committee, SAE or by the competition organizer as appropriate.

2.13 Rules Validity

The SAE Clean Snowmobile Challenge Rules posted in the SAE website and dated for the calendar year of the competition are the rules in effect for the competition. Rules sets dated for the other years are invalid.

2.14 Rules Compliance

By entering the Clean Snowmobile Challenge 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 Clean Snowmobile Challenge Rule 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.

2.15 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.

2.16 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 on-site until they depart at the conclusion of the Clean Snowmobile Challenge or otherwise withdraw from the event.

2.17 Violations of Intent

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

2.18 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.

2.19 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.

2.20 SAE Technical Standards Access

A cooperative program of SAE's Education Board and Technical Standards Board is making some of SAE's Technical Standards available to teams registered for any North American Collegiate Design competition at no cost. The Technical Standards referenced in the Collegiate Design Series rules, along with other standards with reference value, will be accessible online to registered teams, team members and faculty advisors. To access the standards (1) your team must be registered for a competition in North America and (2) the individual team member or faculty advisor wanting access must linked to the team in SAE's system.

Access Procedure - Once your team has registered there will be a link to the technical standards titled "Design Standards" on the main registration screen where all the required onsite insurance information is added. On the technical standards webpage you will have the ability to search standards either by J-number assigned or topic of interest such as brake light.

A list of the accessible SAE Technical Standards can be found in Appendix S.

ARTICLE 3: INDIVIDUAL REGISTRATION REQUIREMENTS – ACTION REQUIRED

3.1 All students and faculty, both domestic and international, if you have an SAE International membership, make sure you are affiliated to your respective school/ college/ university on the SAE website under your "MySAE". If you have problems affiliating yourself online; please contact CollegiateCompetitions@sae.org.

3.2 If you are not a member of SAE International or other approved societies, you will need to join SAE International online at www.sae.org. Select the "Join SAE / Membership Renewal" link under "Quick links", and then select the "Join SAE" link under "Join SAE International". Students will need to select the "Student Membership" link and then follow the series of the questions that are asked. Faculty that wishes to be SAE members should choose the "Professional Membership" link and proceed to the series of questions. **Please note all student participants must be SAE International members to participate in the event.** It is not mandatory for faculty to join.

3.3 All international student participants (or unaffiliated faculty advisors) who are not SAE International members are required to complete the International Student Registration form for the entire team found in the specific event registration webpage. Upon completion, email the form to CollegiateCompetitions@sae.org stating which event and university name.

3.4 **Online registration information is required!** Every participant, including advisors must affiliate themselves and complete the following information on under the team's registration page 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 "Registration" page under the specific event the team is registered and then click on the "Register Your Team / Update Team Information" link. At this point, if you are properly affiliated to the school/college/university, a link will appear with your team name to select. Once you have selected the link, the registration page will appear. Selecting the "Add New Member" button will allow individuals to include themselves with the rest of the team. This can also be completed by team captain and faculty advisor for all team members.

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

All students, both domestic and international, must affiliate themselves online or submit the International Student Registration form by February 25, 2011. For additional assistance, please contact CollegiateCompetitions@sae.org.

ARTICLE 4: SNOWMOBILE MODIFICATION

4.1 Baseline Snowmobile

Teams are expected to provide their own snowmobile for modification. The baseline snowmobile must be a stock qualified snowmobile, defined as a model that was produced in a quantity of at least 500 units. **The model year of the base snowmobile must be from the model years 2005 to 2011 inclusive.**

The intent of the competition is for student teams to modify an existing snowmobile to improve emissions and noise characteristics. Teams choosing to ignore this intent by entering a snowmobile made clean and quiet by a manufacturer or aftermarket supplier will be disqualified. Competition organizers will be responsible for making this subjective determination, if necessary.

4.2 Engine

4.2.1 Permitted Modifications

Modifications to the engine, including substitution of a different engine are allowed.

Two-stroke, four-stroke, and rotary engines are allowed. There is no displacement limit ***however*** *the engine is limited to peak of 130 horsepower as measured in the power curve during the Lab Emissions Event. Sleds that exceed this horsepower limit will be disqualified from the Challenge.*

4.2.2 Permitted Fuels/Additives

Snowmobiles must be "flex-fuel" designs accepting ethanol fuel blends ranging from E20 to E29. The actual content of the ethanol content will not be revealed until after the competition is over (at the awards banquet). The ethanol content will not vary from event to event.

Diesel powered engines must be flex-fueled with bio-diesel fuel ranging from B1 (1% bio-based) to B5 (5% bio-based).

All fuels will be supplied at the competition including fuels for emissions testing.

4.2.3 Permitted Lubricating Oils

Any type of oil may be used in the modified snowmobiles as long as the oil does not contain any oxygenates or other power boosting additives.

4.2.4 Turbochargers/Superchargers

The use of turbochargers and superchargers is allowed. All superchargers must have a restraint system to prevent them from being blown free of the engine; this includes a flexible blanket shield. Snowmobiles with an unshielded supercharger will not be allowed to compete.

4.2.5 Exhaust Systems

The exhaust system may be modified. The exhaust system emissions pipe must not protrude more than three (3) inches beyond the chassis or hood configuration.

4.2.6 Throttle Requirements

An adequate return spring on the throttle is required. The throttle must remain on the right side. The throttle will be operated with a direct mechanical operated thumb mechanism

located on the handlebar to the rear of the machine (no twist grips). Fly-by-wire throttle systems are allowed.

4.3 Block Heaters

Block heaters, coolant heaters, or oil heaters are prohibited for any part of the Challenge.

4.4 Drive

4.4.1 Chain Drive Oil Bath Requirement

Solutions that utilize a chain to drive the primary clutch from the engine are permitted. However, this design solution has historically created excessive temperatures and has been prone to failure. Therefore, if this type of drive system is selected, the chain must be enclosed in a case with a constant oil bath.

4.4.2 Transmission

IC engine snowmobiles must be propelled with a variable ratio belt transmission. This requirement will be waived for electric drive designs.

4.4.3 Brake Performance Requirement

All brake modifications are subject to retaining the braking performance of the original snowmobile. This will be tested during the technical inspection before snowmobiles are allowed to compete in the competition.

The master cylinder, caliper and rotor assembly must be commercially available.

The "commercially available" stipulation can be accomplished two ways. Other brake systems, for example motorcycle, small tractors, and other off-road vehicles may use smaller diameter brakes. The concern is mainly one of material specifications for the parts. Commercially available systems will most likely satisfy some quality standard for the caliper and rotor assembly regarding the durability of the parts.

The second way is to reduce the rotor diameter of a commercially available system. At least then you have started with parts that again satisfy some material standard. In stopping snowmobiles, usually the brakes lock up and the snowmobile slides on the snow, so there is plenty of clamping force available. A fifteen percent (15%) reduction in surface area will probably not change this.

Brake rotor on drive axle track shaft must be at least seven (7) inches minimum diameter. If the secondary brake is on the track shaft, the rotor may be smaller than seven (7) inches. Additional brake assemblies may be added. Axle shaft may be lengthened to accommodate additional brakes.

Moving the brake to the track drive axle is allowed. The brake components must be commercially available and the pad contact area cannot be reduced by more than fifteen percent (15%).

Replacement brake rotor of aluminum or carbon fiber is not allowed.

4.4.4 Brake Control Handle

The brake control handle must remain in the OEM location (front left side). Brakes must be operative at all times.

4.4.5 Brake Rotor Shield
If the brake system is standard as supplied by the manufacturer, no additional brake rotor shield is required. If the brake system is modified, the brake rotor must be covered with a shield capable of retaining an accidental explosion.

4.4.6 Rotor Contact Area
The rotor pad contact surface area may not be reduced more than fifteen percent (15%) of the original pad contact surface area.

4.4.7 Clutch Cover
Clutch cover must be separate of the cowl configuration and cover both clutches down to the center of the bolts or below. It must be made of 0.090 inch 6061 T6 aluminum or equivalent and be covered with six (6) inch belting. Belting refers to woven nylon or Kevlar belting that is used as supplemental explosion containment on drag racing cars and various other vehicles. Similar material is also used for such things as automobile tow straps. A thinner, single ply version is also used for automobile seat belts.

Carbon fiber clutch covers are not permitted. Snowmobiles with removable side panels may bolt clutch cover guard to side panel to meet this requirement.

4.4.8 Moving Parts Isolation
Chains, pulleys, and exposed moving parts will be isolated from the driver and other competitors by shields capable of retaining all accidental explosions and component impacts. No holes may be drilled in protective shields.

Chains that drive the primary clutch from the engine must be enclosed in a case with a constant oil bath per Rule 4.4.1.

4.5 Skis and Ski Suspension

4.5.1 Ski Requirements
Skis must be commercially available.

4.5.2 Ski and Ski Suspension Modification
The snowmobile's skis and ski suspension may be modified. However, the snowmobile must remain ski-steered.

4.5.3 Ski Runners
Carbide ski runners are allowed.

4.5.4 Ski Suspension Requirements
The following measurement procedure will be used to verify ski suspension travel. A measuring stick will be placed at the front nose of the snowmobile. The snowmobile will be lifted to the point of the full extension of the ski suspension. This point on the measuring stick will be noted as "Point A." Weight will be added to the snowmobile to push the ski suspension down to full compression of the suspension. This point will be noted on the measuring stick as "Point B." The total travel is the distance form "Point A" to "Point B."

The total travel must be equal to or greater than six (6) inches.

The heaviest driver will then sit on the sled. With the heaviest driver sitting on the sled in the normal driving position there must be a minimum of two (2) inches of travel downward to reach "Point B."

If this condition is not met, the team must modify the snowmobile to meet this requirement.

4.6 Track, Track Suspension, and Traction

4.6.1 Track and Track Suspension Modification

The snowmobile's track may be replaced with a different track. The track must be a commercially available, one piece, molded rubber snowmobile track. The selected, commercially available track may not be modified except for traction studs. The same track design must be used for all events.

4.6.2 Track Suspension Requirements

The following measurement procedure will be used to verify track suspension travel. A measuring stick will be placed at the rear of the snowmobile. The snowmobile will be lifted to the point of the full extension of the track suspension. This point on the measuring stick will be noted as "Point C." Weight will be added to the snowmobile to push the ski suspension down to full compression of the track suspension. This point will be noted on the measuring stick as "Point D." The total travel is the distance form "Point C" to "Point D."

The total travel must be equal to or greater than six (6) inches.

The heaviest driver will then sit on the sled. With the heaviest driver sitting on the sled in the normal driving position there must be a minimum of two (2) inches of travel downward to reach "Point D."

If this condition is not met, the team must modify the snowmobile to meet this requirement.

4.6.3 Traction Control Devices

The use of traction control devices such as ice grousers, grass hooks, or paddles is not allowed.

The use of track studs is allowed.

Regardless of track length or width, the snowmobile is limited to two (2) commercially available studs per bar, 60 degree unsharpened, unmodified single point studs (see example picture below).

All components of the traction devices must be located in the center of the track between the inside edges of the two slide runners and a minimum of 3.75 inches from the edge of the track.

The stud may not protrude more than .375 inch above the highest point on the track.

Stud backing plate maximum size is 2 inches x 2.25 inches.

Backing plates may not extend beyond the height of the rib and must rest against the rib. Sharpening (vertically or horizontally) of the backing plate is not allowed.

4.6.4 International Engineering, Inc. (Woody's) is the official supplier for traction studs for CSC and they are available for technical assistance in track stud installation. Teams choosing to use track studs must contact Woody's prior to the Challenge to ensure proper track stud selection and installation. The contact at Woody's is Mark Musselman mark@wiem.com (989) 689-4911ext. 108

4.6.5 Slide Runner
Slide runners may be drilled. OEM type slide runners may be used as a replacement. Inserts may be added to the slide runner. The slide rail lubrication system (ice scratchers) will be allowed this year. Slidekick ice scratchers will be provided by the organizers upon request. Only ice scratchers that do not have to be stowed when in reverse like the Slidekick will be allowed.

4.6.6 Maximum Track Lug Height
The maximum height of track lugs is two (2) inches.

4.7 Frame and Body

4.7.1 Rear Snow Flap
Rear snow flaps will be provided by the organizers in CSC 2011. Check the forum for information of how to obtain one. If you choose to use your own snow flap the following rules apply.

A rear snow flap of sufficient material to restrain traction components if thrown from the track will be installed in a permanent manner and shall be held down so as to contain all mud, snow, rocks, water, etc., at all speeds. The snow flap must overlap from outside of tunnel to outside of tunnel, one half inch (.5 inch) outside the widest part of the rear tunnel opening on both sides. The snow flap must be in contact with the course surface when the rider is on the sled. **This will be checked during technical inspection with the lightest driver.**

Please note that most stock snow flaps do not meet this requirement and are not acceptable in this competition. Snowmobiles not meeting this condition during events after technical inspection may be penalized.

The procedure for checking this will be:

a. The rear opening of the tunnel will be measured "Dimension A"
b. The snow flap width will be measured "Dimension B"
c. The snow flap width "Dimension B" must exceed "Dimension A" by one (1) inch.
d. A visual inspection will be performed to make sure the snow flap is centered and that it is not possible to look down the tunnel when viewing directly from the rear on each side of the snow flap.

4.7.2 Snow Flaps: Fastening
The use of springs and/or elastic material for holding down and fastening snow flaps is not acceptable.

4.7.3 Foot Stirrups/Pegs

Foot stirrups/foot pegs constructed of rigid materials may be installed.

4.7.4 Seat

All sleds will be equipped with an upholstered, padded seat with a minimum thickness of one (1) inch, a length of twenty-four (24) inches, and a width of the tunnel.

4.7.5 Body Modification
The snowmobile body may be modified. The hood must have top and side cowling and must contain at least one thousand three (1300) square inches.

4.7.6 Front Bumper Requirement
All snowmobiles must have a front bumper strong enough to support the snowmobile while suspended in mid-air (for ease of lifting).

4.7.7 Decal Space Requirement
Two hundred (200) square inches of space must be left free on the hood/tunnel of the snowmobile for sponsorship decals to be placed upon arrival to the competition.

4.7.8 Team Number
The team number must appear in at least four (4) places on the snowmobile: Both sides of the hood and both sides of the tunnel. (A) The numbers on the hood sides must be six (6) inches high, ¾ inches wide. (B) The numbers on both sides of tunnel, minimum of four (4) inches high.

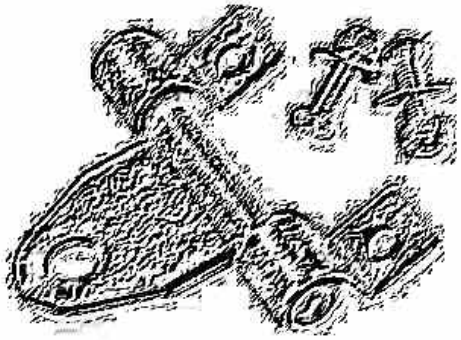
All numbers must be in contrasting colors and easy to read.

Team numbers will be assigned by SAE upon registration according to SAE policy.

4.7.9 Chassis Modification
The snowmobile chassis (bulkhead and tunnel) must be from a stock qualified snowmobile (a snowmobile that was produced in a quantity of at least 500 units). Teams are not permitted to build their own chassis from the ground up. No modifications may be made to the snowmobile chassis that will reduce structural integrity.

If a team makes modifications to the snowmobile chassis, they will be required to explain to the Technical Inspector what steps (including computer modeling and analysis) were taken to ensure structural integrity and durability.

4.7.10 Rear Hitch Requirement
Both IC and ZE sleds must have a rear hitch capable of a 0.375 inch pin connection (must have clearance for a 3/8 inch pin) providing at least +45 to -45 degrees of yaw rotation about the pin. The hitch must have flap or pitch rotation of +45 to -45 degrees of rotation. Roll degree of freedom is not required. The hitch must be rigid in fore-aft tension and compression and be capable of withstanding 800 pounds draw bar pull force. Pictured below is an example of a snowmobile hitch. These may be fabricated or purchased.



4.8 Ignition and Electrical

4.8.1 Disconnect Tether

All machines must be equipped with a disconnect tether that is operable at all times. Disconnect tethers must be used and attached to the operator whenever the engine is running. The tether must be connected around the operator's wrist (not to his glove or jacket). No alligator clips are allowed. Maximum tether cord length will be five (5) feet. Verification of the tether cord length will be determined at tether cord's fully extended length. The tether switch will be securely mounted in a location on the snowmobile other than on the handlebars. Battery operated electric fuel pumps must be connected to the tether switch. This includes electrically controlled fuel injection systems.

4.8.2 Kill Switch

All snowmobiles must have a handlebar mounted button (on/off) kill switch on the right side within thumb reach (in addition to the tether switch). The kill switch must be programmed so pushing down on the switch will kill the power to the sled. In other words, up equals "on" and down equals "off." Battery operated electric fuel pumps must be connected to the kill switch. This includes electrically controlled fuel injection systems.

4.8.3 User Selection Switches

Non-standard user selectable switches must identified and be labeled in English with their function. This function must be demonstrated to the inspection judges. The switch must remain in the same position throughout the competition. If the switch is not in the same position at any point during the competition, the team may be penalized or disqualified at the discretion of the judges.

4.8.4 Battery Fuel Pumps

Battery operated electric fuel pumps must be connected to the disconnect tether and the kill switch. This includes electrically controlled fuel injection systems.

4.8.5 Battery Box Requirements

All batteries, regardless of type, must be fully enclosed and sealed in a vented, non-conductive box. The purpose of this box is two-fold. First, for unsealed batteries, the box will prevent an acid spill in the event of an accident or "unusual attitude". And second, for all batteries, the non-conductive box will prevent the positive and negative terminals of the battery from contacting conductive material and/or sparking and starting a fire (in case of an accident).

NOTE: Venting typically consists of a 1/8" rubber line vented out the bottom of the snowmobile. Battery boxes may be lined with non-conductive material, but the lining must be secure enough to serve its purpose in an accident and/or unusual attitude. Positive terminal must be shielded. Battery box must be securely held in place.

The stock battery box is acceptable if and only if it is modified to meet the above requirements.

There are no exceptions to this requirement. If the technical inspectors are not satisfied that this modification has been made properly, the sled will not compete.

4.8.6 Head, Tail, and Brake Light Requirement

All snowmobiles are required to have functional head, tail, and brake lights. Head lights should provide adequate lighting to allow safe operation in complete darkness at speeds up to

45 miles per hour. Snowmobiles that do not meet these criteria can be penalized and/or ruled ineligible for any events conducted at night.

4.9 Component Deletion

No changes are allowed that would nullify compliance with federal, state, or provincial safety regulations.

4.10 Special Electrical Rules For Zero Emissions Snowmobiles

See Appendix F for special rules for Zero Emissions sleds.

ARTICLE 5: RULE QUESTIONS, DISCUSSION, AND COMMUNICATION

5.1 Question Submission

All rule questions must be submitted via the Rule Questions folder in the SAE Clean Snowmobile Challenge Public Discussion Forum on the SAE Website. Questions must include the appropriate rule number. Organizers will answer questions in the CSC Forum as soon as the Rules Committee agrees upon an answer. It is the responsibility of all participants to monitor this forum to keep up to date on competition questions. Answers will not be distributed individually to teams.
(http://forums.sae.org/access/dispatch.cgi/CLEAN_SNOWMOBILE)

The organizers will only respond to questions submitted to the Forum and answers to questions will only be posted on the Forum for all to see.

5.2 Loopholes and Problems

Any perceived loopholes in or potential problems with the rules should be provided to organizers via the Rules Questions folder in the SAE Clean Snowmobile Challenge Public Discussion Forum on the SAE Website. Suggestions for rule changes must reference the appropriate SAE CSC2010 rule number, state the current wording of the rule, and contain a suggestion of how the rule should be changed.
(http://forums.sae.org/access/dispatch.cgi/CLEAN_SNOWMOBILE)

5.3 Engineering Ethics

The SAE Clean Snowmobile Challenge is an engineering design competition that requires performance demonstration of snowmobiles. It is **NOT** a race. Engineering ethics will apply. In all events violation of the intent of the rule will be considered a violation of the rule.

5.4 Participants' Discussion

A Participants' Discussion folder has been provided in the SAE Clean Snowmobile Challenge Public Discussion Forum on the SAE Website. Participants are encouraged to use this folder to ask questions of and share information with other teams.
(http://forums.sae.org/access/dispatch.cgi/CLEAN_SNOWMOBILE)

5.5 Competition Information

Miscellaneous information regarding competition logistics and administration will periodically be posted in the Competition Information folder in the SAE Clean Snowmobile Challenge Public Discussion Forum on the SAE Website and also on the Clean Snowmobile Challenge Website. It is the responsibility of all participants to monitor both the forum and website and have the most recent competition information.
(http://forums.sae.org/access/dispatch.cgi/CLEAN_SNOWMOBILE)
(http://www.sae.org/students/snow.htm)

ARTICLE 6: CONDUCT OF THE EVENT

6.1 Snowmobile Operating Requirements

6.1.1 Technical Inspection

A Technical inspection of each snowmobile will be performed after it arrives to the competition to determine if it complies with the requirements and restrictions of the rules. If any noncompliance is found, the team will be promptly notified. The team must correct all noncompliance before the snowmobile is permitted to compete in any event.

Technical inspections will not be performed on Tuesday, March 8, 2011. Any team that does not pass technical inspection on Monday, March 7, 2011, will not compete in the Endurance Run on March 8, 2011 and will forfeit their 100 point no-maintenance bonus (item 6.3 below). See the schedule on the SAE CSC Forum for open Technical Inspection times.

It is the responsibility of participating teams to arrive at the competition prepared for the inspection. Teams will fill out and sign their own technical inspection forms indicating that they have checked all items prior to entering the Technical Inspection process.

Decisions of the Chief Technical Inspector concerning compliance or non-compliance with the CSC Rules are final and may not be appealed.

Both a static and a dynamic inspection will be performed on each sled. Sample forms used for the static and dynamic inspections are provided in the appendix.

Passing the Technical inspection does not, in any way; imply that SAE, the CSC organizers, or any individuals acting on their behalf certify that the snowmobile is safe for use. It is the sole responsibility of participating teams to ensure that their snowmobiles are safe for entry in the competition.

6.1.2 Disconnect Tether and Kill Switch

Each snowmobile must be equipped with a disconnect tether and a separate kill switch as described in Rules 4.9.1 and 4.9.2. Twenty-five (25) penalty points will be assessed each time the tether is not properly utilized when the engine is on.

6.1.3 Moving Snowmobiles

When snowmobiles are driven anywhere but in practice areas, snowmobile trails, or roadways they must be driven at a walking pace. During the performance events when the excitement is high, it is particularly important that the snowmobile is driven at a very slow pace. The walking rule will be enforced and point penalties will be assessed for violations of this rule.

6.1.4 Support Snowmobiles

Team support snowmobiles may be allowed during certain events. The equipment listed in Rules 6.2 to 6.3 must be worn at all times any team member is on any snowmobile that is in motion. The same penalties described in Rule 6.2.4 will be applied to team support snowmobiles. Keweenaw Research Center Test Course guidelines (available upon request) apply to all support snowmobiles.

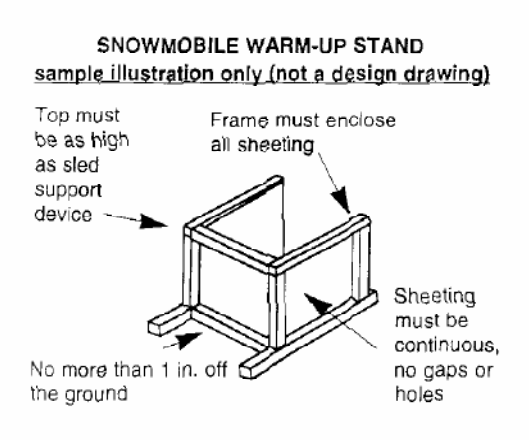
6.1.5 Warm-Up Stands

Snowmobiles may be warmed up before competing in events. However, this warm-up must take place with the snowmobile mounted in a snowmobile stand (you MAY NOT warm up the snowmobile by manually holding the track off of the snow). Twenty-five (25) penalty points will be assessed each time this rule is violated.

The warm-up stand must be designed to catch and retain track, track cleats, traction components and other items that might be thrown by the track. The stand must be no more than six (6) inches from the rear of the tunnel opening and no more than twelve (12) inches from the track. The warm-up stand will be constructed of metal equivalent to 6061T6 aluminum, 1/8 inch thick. Side panels are mandatory and they must extend at least to the center of the rear axle. The sides and back must be secured inside the framework. Vertical coverage must be no more than one (1) inch off the ice and as high as the snowmobile support device. Coverage must be continuous (no lightening holes). A plywood liner is recommended to help absorb impact. The warm-up stand must maintain sufficient height to prevent track coming into contact with ground/ice surface. The stand must be used whenever the rear of a machine is raised to clean out the engine or track, and during warm-up.

Teams may not run their snowmobile engine in the KRC shop/pit area unless directed to do so by an organizer or judge.

A sample illustration of a snowmobile warm-up stand is provided below (courtesy of the International Snowmobile Racing Association).



6.2 Driver Protective Equipment

6.2.1 Helmet Requirement

Full coverage helmets (Snell 2000 or newer) are mandatory. Note: Snell 2000 helmets expire January 1, 2012 so the newer Snell 2005 is preferred and will be required for CSC 2012. Helmets not meeting this requirement may be impounded for the duration of the competition. The helmet must be securely fastened at all times. Eye protection is required.

6.2.2 Clothing and Boots

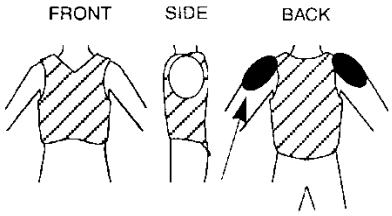
Gloves and clothing, along with boots (must be, at least, above the ankle) are mandatory. The driver's jacket and pants must have of an outer layer that is water and wind resistant, such as nylon, ballistic nylon, Gore-Tex laminates, etc. **Cotton pants, blue jeans, and other**

absorptive fabrics are prohibited. The purpose of this rule is to protect the driver from the cold and moisture that he or she will be exposed to for potentially long times outside during events. Proper apparel must be worn by all drivers throughout the events.

6.2.3 Jacket/Vest

A jacket or vest that conforms to International Snowmobile Racing guidelines as well as shin and knee guards made of an impenetrable material must be worn by drivers during all competition events. A sample illustration of approved upper body protection is provided below (courtesy of the International Snowmobile Racing Association).

UPPER BODY PROTECTION



6.2.4 Penalties

Twenty-five (25) penalty points will be assessed for each individual not wearing appropriate driver's gear each time the individual is observed to be in violation of the rule by a competition official. Appropriate driver's gear must be worn any time a snowmobile is in motion.

6.3 On Site Modifications (Bonus Points and Penalties)

One hundred (100) bonus points will be awarded to teams who come prepared and do not need to repair or service their sled during the competition. If any parts of the snowmobile burn, fall off, or become missing after the Technical inspection through the completion of the final event, the team will not receive the 100 extra point bonus.

Hoods will be sealed and engine calibrations will be frozen after technical inspection with a "serial-numbered" strap. Teams must make appropriate modifications to their hood to accommodate sealing with two (2) 7 inch long 1/4-inch wide tie straps. Accidental breakage of the seal must be reported immediately.

No telemetry will be allowed. Teams are not allowed to remotely alter calibrations during events.

No non-standard user input (other than power, ignition, starter and kill switches) is allowed to the powertrain (includes engine intake, base engine, engine exhaust, or drivetrain).

Twenty-five (25) penalty points will be assessed if the hood seal is broken by anyone other than a liaison or a competition official. Once the hood seal is broken, the liaison or competition official will log the reason for the opening and supervise the modification. New hood seals will be installed and the serial number of the new seals will be recorded.
Breaking of the seals will be supervised by competition officials at two specific times during the competition without penalty to inspect for rules compliance. Teams must wait for a competition official before breaking the seals to avoid penalty. These inspection times will be:

1. At the conclusion of the Endurance/Fuel Economy Event
2. At the beginning of the Emission Test for each sled

Additional hood openings may be requested to inspect the engine area, however making changes will result in loss of the one hundred (100) point bonus. No changes or modifications to snowmobiles will be allowed after Technical inspection except for:

1. Those required to fix compliance issues, in which case the one hundred (100) point bonus is forfeited but no additional penalties will be assessed.
2. Those required to return the snowmobiles to operating condition after a breakdown, in which case the one hundred (100) point bonus is forfeited and additional penalties may apply.
3. Those considered standard maintenance items as described in Rule 6.4, in which case the one hundred (100) point bonus will be forfeited but no additional penalties will be assessed.

If any of the above modifications are to be made, the snowmobile must be serviced in the designated work area. The team may not return the snowmobile to its trailer to perform above maintenance items. Any team that violates this policy will be considered withdrawn from the competition.

In the event that a snowmobile design strategy is "changed" during repairs made after emission testing, the team may continue to compete in events. However, the team will not be eligible to receive any awards for events won after the strategy change.

6.4 Permitted Maintenance Items

The following maintenance items will be allowed throughout the competition without penalty. Teams must notify and obtain permission from competition officials before any permitted maintenance is performed.

NOTE: Even though these modifications can be made without penalty, making these modifications will result in automatic loss of the one hundred (100) point No-Maintenance bonus. This includes modifications made at the inspection times listed in section 6.3 above.

- Addition of any fluid – same fluid must be used throughout competition (**NOTE**: adding significant amounts of coolant will not be considered standard maintenance)
- Suspension adjustment
- Track alignment and tension adjustment
- Drive belt/chain tension adjustment
- Headlight bulbs, taillight bulbs, brake light bulb replacement
- Tightening of loose bolts: suspension mounting, suspension front limiter strap, ski saddle, and spindle.
- Lubrication of snowmobile parts.
- Tightening of rear idler wheel bolts and idler adjusting bolt jam nuts.
- Replacement of spark plugs (same plugs must be used as before…two (2) changes without penalty…then five (5) point penalty per plug).
- Replacement of fuel injectors (same injectors must be used as before or design strategy will be considered to be "changed"…two (2) changes without penalty…then five (5) point penalty per injector).

- Oil/fuel filter replacement
- Changing of the track is **not** in the list of permitted maintenance items. In other words, the average snowmobiler would **not** consider changing of the track a standard maintenance procedure.
- Adding or removing traction studs after the initial technical inspection is **not** permitted.

NOTE: The intent of this rule is to allow 1000-mile maintenance items to be performed throughout the competition without penalty. Organizers reserve the right to modify and add to this list as conditions demand.

6.5 Fuel at Competition

Teams are required to power their snowmobile with the "flex-fuel" provided throughout the competition by Gage Products, Inc. Teams are required to use the provided fuel for all events.

6.6 Lubricating Oil at Competition

Competing teams are responsible for providing their own lubrication oil (two-stroke or four-stroke). Teams will not be allowed to switch the type of lubrication oil they are using once the competition has begun. Doing so without approval from a competition official will result in disqualification. Oil must be added in the presence of an official and must come from a factory sealed container.

6.7 Drafting Prohibited

Drafting of other snowmobiles will not be allowed during the Fuel Economy & Endurance event. Drafting is defined as following another vehicle closer than three (3) snowmobile lengths at cruising speeds for sustained periods of time. Infractions of this rule may be reported by other competitors or by competition officials. Twenty-five (25) points per occurrence will be deducted for drafting during the Fuel Economy & Endurance event.

6.8 Unsportsmanlike Conduct

Unsportsmanlike conduct will not be tolerated. Any driver, crew member, faculty advisor, or spectator who, by their conduct, detracts from the character of the event, or who abuses, threatens, or uses profane language to an official may be assessed a warning or penalty for unsportsmanlike conduct. A second violation may result in expulsion of the team from the competition. Warnings and penalties may be given by any official and will become record with the approval/concurrence of the organizers.

6.9 Drug and Alcohol Policy

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.

Drinking alcoholic beverages anywhere on the Keweenaw Research Center site including buildings, property, or test course is prohibited. There will be a zero-tolerance policy regarding the violation of this rule. Any participant, guest, or advisor violating this rule will cause the immediate disqualification of their team. Volunteers or event staff violating this rule will be dismissed.

There is also a zero-tolerance policy regarding the use of illegal drugs. Any participant, guest, or advisor observed using illegal drugs will cause the immediate disqualification of their team. Volunteers or event staff violating this rule will be dismissed.

6.10 Protests and Problems

Any problems that arise during the competition will be resolved through the organizers and the decision will be final. All protests must be in writing. Protests must be filed within one (1) hour after scores are posted. The decision of the judges and organizers is final.

6.11 Event Appearance and Forfeits

It is the responsibility of the teams to be in the right place at the right time. If a snowmobile is not ready to compete at the scheduled time, then the team forfeits the run of the event and will not be offered a late make-up. The driver for an event will be disqualified if they do not attend the driver meeting for the event.

ARTICLE 7: DEADLINES

7.1 Registration Opens on October 4, 2010

Student teams may begin to register online on October 4, 2010, at 10am EDT online CSC website http://www.sae.org/students/snow.htm.

At the time of registration, each team must provide fuel choice (electricity, diesel or ethanol-based), team program information, and a team photo to be printed in the event program. Teams will receive a confirmation upload once their information is received by the event organizers.

7.1.1 Team Program Information per Rule 2.6

7.1.2 Team Photo per Rule 2.6

7.2 Registration Closes on December 20, 2010

Registration closes at 11:59 p.m. on Monday, December 20, 2010, or when twenty-five (25) teams have registered; whichever comes first. Entries later than December 20, 2010 will be admitted at the discretion of the organizers.

7.3 Design Paper and MSRP Due on February 25, 2011

The final Engineering Design paper, describing the modifications made to the snowmobile, and the final MSRP are due February 25, 2011.

7.3.1 Engineering Design Paper

Teams must submit two (2) copies of their paper; one (1) copy in normal SAE paper print size and one (1) copy in large print (16 point). Both copies of the paper must be in Adobe Acrobat PDF format. The large print file is necessary for one of the judges who cannot read small print files. Failure to send a large print format file will be the same as not sending the file. The reports must be uploaded to http://www.mtukrc.org/send.htm .

The paper must be received no later than 5:00 p.m. **your local University time zone** on February 25, 2011.

NOTE: Late engineering design papers will accrue ten (10) penalty points for each day that they are late, up to a maximum penalty equal to the team's score for this event. This includes delivery of the large print format file. Teams are encouraged to send the files sooner than February 25, 2011 in case of Internet problems. Confirmation of receipt will be provided electronically on the upload site.

7.3.1.1 File Format for Engineering Design Paper

The Engineering Design Paper must be submitted in Adobe Acrobat PDF format. No other file type will be accepted.

7.3.1.2 Naming Convention for Engineering Design Paper

Teams must include their team number and the name of their University in the PDF file name. For example, "01_uw-madison_design_paper.pdf" and "01_uw-madison_design_paper_large_format.pdf" to avoid confusion for the organizers.

7.3.2 Manufacturer's Suggested Retail Price

One (1) electronic copy of the Manufacturer's Suggested Retail Price Assessment (MSRP) is due. A copy of all supporting documentation should be brought to the competition. The MSRP judges will ask to see supporting documentation for the MSRP during the competition in a 20 minute presentation and explanation of the MSRP. The file should be received no later than 5:00 p.m. **your local University time zone** on February 25, 2011. The MSRP information must be uploaded to http://www.mtukrc.org/send.htm.

A penalty of ten (10) points per day will be assessed until the MSRP has been received up to a maximum penalty equal to the team's score for this event. A confirmation e-mail will be returned.

NOTE: All teams will be required to update their MSRP at the start of the competition and have their snowmobile inspected to verify that their MSRP is complete and accurate. Teams not submitting a complete and accurate MSRP will be ineligible to receive the awards for Most Practical Solution and Best Value.

7.3.2.1 File Format for Manufacturer's Suggested Retail Price

The Manufacturer's Suggested Retail Price document must be presented in Microsoft Office Excel 2007 format (.xlsx).

7.3.2.2 Naming Convention for Manufacturer's Suggested Retail Price

Teams must include their team number and the name of their University in the Microsoft Office Excel 2007 file name. For example, "01_uw-madison_msrp_.xlsx" to avoid confusion for the organizers.

ARTICLE 8: AWARDS

8.1 Award Criteria

Overall Winners:	Presented to the top five (5) teams in terms of total points.
Best Performance:	Presented to the team receiving the highest total score in the Acceleration, and Handling events that also passed the Noise, Acceleration, and Emissions event.
Best Emissions:	Presented to the team receiving the best score in the emissions event.
Best Design:	Presented to the team receiving the highest total score in the Engineering Design Paper, Oral Design Presentation, and Static Display events that also received passing scores in the Emissions, Noise, and Acceleration events.
Best Fuel Economy:	Presented to the team receiving the most points in the Fuel Economy & Endurance event.
Quietest Snowmobile:	Presented to the team receiving the most points in the Noise events
Best Acceleration:	Presented to the team receiving the most points in the Acceleration event.
Most Practical Solution:	Presented to team with the best balance between cost and measured noise and emissions reduction. Winner will be the team with the highest score according to the following formula: (Noise points + Emissions points) * MSRP Points.
Best Value:	Presented to team with the best balance between cost, fuel economy, and performance. Winner will be the team with the highest (Fuel Economy points + Acceleration points + Handling points + Cold Start points) * MSRP Points.
Founder's Trophy:	Trophy awarded to the team recognized by other participants as being the most sportsmanlike.
Best Ride:	Presented to the team with the best combined score in the Handling and Drivability and Subjective Ride events.
Best Zero Emissions:	Presented to the team with the highest point total in the ZE category.
Endurance Award:	Presented to teams that complete the Endurance Event.
Cold Start Award:	Presented to teams passing the Cold Start Event
Best Handling:	Presented to team winning the Objective Handling event.
Lowest "In-Service" Emissions:	Presented to the team that has the lowest "In Service" emissions.
Range Event:	Presented to the team that travels the farthest distance on a single charge.

Draw Bar Pull Award:	Presented to the team that wins the Draw Bar Pull event.
Innovation:	Presented to the team who in the opinion of the organizers has the most innovative solution.
Design Simulation:	Presented to the team who in the opinion of the organizers demonstrates a successful simulation of their design.
Safety Award:	Presented to the team who in the opinion of the organizer demonstrates the best safe practices.
Most Improved Snowmobile:	Presented to the team who in the opinion of the organizers has improved the most since last year.

Note: Although not guaranteed, some awards will include a cash award dependant on sponsorship. These and other awards will be detailed in the event program available at the on-site competition registration booth.

8.2 Participation Plaque

Each school will receive a plaque commemorating its participation in the competition.

ARTICLE 9: SCORING

9.1 Overall Score

Overall scores will be determined based on maximum points according to the following schedule:

Internal Combustion Class Event	Points for Passing Event	Maximum Additional Points for Relative Performance in Event
Engineering Design Paper	N/A	100
Manufacturer's Suggested Retail Price (MSRP)	N/A	50
Lab Emissions	100	200
Brake Specific Fuel Consumption	N/A	50
In-Service Emission	N/A	50
In-Service Fuel Economy	N/A	50
Oral Presentation	N/A	100
Fuel Economy & Endurance	100	100
Weight (no points in CSC2010)	N/A	0
Acceleration (points reduced in CSC2010)	0	50
Objective Handling and Drivability (points reduced in CSC2010)	N/A	50
Subjective Handling	N/A	50
Cold Start	50	N/A
Static Display	50	N/A
Objective Noise	75	75
Subjective Noise	0	150
No-Maintenance Bonus		100
Subtotals	375	1175
Maximum Total for IC Category (both columns)		1550 points

Zero Emissions Class Event	Points for Passing Event	Maximum Additional Points for Relative Performance in Event
Engineering Design Paper	N/A	100
Manufacturer's Suggested Retail Price (MSRP)	N/A	50
Oral Presentation	N/A	100
Weight	N/A	100
Range	N/A	100
Draw Bar Pull	N/A	100
Acceleration + Load Event	N/A	50
Objective Handling and Drivability	N/A	50
Subjective Handling	N/A	50
Cold Start	50	N/A
Static Display	50	N/A
Objective Noise	N/A	75
Subjective Noise	N/A	75
No-Maintenance Bonus		100
Subtotals	100	950
Maximum Total for ZE Category (both columns)		1050 points

9.2 Event Points

With the exception of the all "pass or fail" events, the team having the best score in each of the events will be awarded the maximum possible points (if they have also passed the event). Teams finishing behind those leaders will be awarded proportionally fewer points according to the scoring schemes that appear at the end of the following items. No negative points other than as a result of penalties will be awarded.

9.3 Penalties

Penalties will result from violating competition rules, performing prohibited maintenance on snowmobiles at any time after emissions testing, drafting during the Fuel economy/endurance event, or failing to meet competition deadlines.

A summary of possible penalties are detailed in the appendix.

9.4 Engineering Design Paper

9.4.1 Engineering Design Paper Description

This event requires the team to submit an engineering design paper describing the snowmobile conversion concept, design, and implementation. The paper should explain why modifications were performed and the results of testing and development. The paper must address the durability, practicality, and increased cost of any modifications. An absolute limit of **fifteen (15) pages** will be strictly enforced, except as noted below for papers submitted in alternative accessible formats.

Late engineering design papers will receive ten (10) penalty points for each day that they are late, up to a maximum penalty equal to the team's score for this event. Hand written papers will not be accepted.

Papers must conform to the current standard format for SAE technical papers. The format for SAE technical papers is available on-line through the SAE website at: www.sae.org

9.4.2 Engineering Design Paper Scoring

The team with the highest average judges' score will receive one hundred (100) points. All other teams will receive points based on the following equation:

$$TeamScore = 100 * \left[\frac{\left(\frac{Pteam}{P\min} \right)^2 - 1}{\left(\frac{P\max}{P\min} \right)^2 - 1} \right]$$

Where P = the average judges' score

Engineering design paper judges will have a technical background. A sample engineering design paper judging form is located in the Rules Appendix.

Zero Emissions sleds will be judged along with IC engine snowmobiles.

9.5 Manufacturer's Suggested Retail Price (MSRP)

9.5.1 The intent of the Manufacturer's Suggested Retail Price (MSRP) portion of the CSC is for the teams to determine and defend what they believe a reasonable MSRP would be for their sled. The teams are considered the actual manufacturer of the snowmobile they designed and the MSRP they place on the entry is to be for minimum manufacturing quantities of 5000 units/year. Sleds presented at competition are considered prototype units for demonstration of concepts. This exercise is about estimating the final value of the product to the consumer. This is a real exercise that you as graduates will be expected to perform upon entry into professional careers as engineers. The intended purpose of the MSRP is to make a reasonable estimate of what this sled would sell for in today's market. The MSRP in industry is not based on an exact formula, rather an estimate of what the unit can be sold for factoring in manufacturing cost, features offered, and perceived value in the market place. Consequentially any features added to a sled that would improve customer's perceived value must increase the MSRP. No entry with a value less than its equivalent base MSRP will be permitted as it is expected the teams are adding value and features to the snowmobile to

improve emissions, fuel economy, and/or reduce emitted noise. Sled modifications for reasons other than emissions, fuel economy, and noise are permitted and must be included in the MSRP calculation. Teams will be given 20 minutes to present and defend their final MSRP submission to the judges.

9.5.2 Rules

9.5.2.1 Base sled for starting point of MSRP must be 2010 Model Year regardless of the model year of the sled.

9.5.2.2 MSRP must reflect engine choice first

9.5.2.3 When base engine is modified, closest current manufacturer offering must be used. This is to make sure that ECU upgrades which include injector drivers, sensors, are captured in MSRP costing.

9.5.2.4 MSRP must reflect all factory options included on competition sled (Electric Start, Reverse, etc)

9.5.2.5 Electric & Diesel powered sleds using IC engine chassis should attempt to obtain a reasonable cost of the chassis without engine. If unable to determine reasonable cost of the chassis, teams can reduce initial MSRP by 40% to reflect removal of original power pack (2010 base sled * 60% will be used to calculate base MSRP for electric and diesel powered sleds only).

9.5.3 All MSRPs must include the following additions to meet competition goals:

9.5.3.1 Catalyst (if used)

9.5.3.2 Sound treatment

9.5.3.3 Mufflers more than stock, or stock muffler that is significantly more complex than original production unit.

9.5.3.4 Studs

9.5.3.5 Additional coolers, intercoolers

9.5.3.6 Secondary air pumps, plumbing

9.5.3.7 Motor controllers for Electric sleds

9.5.3.8 Electric motors/Diesel engines added to sleds

9.5.4 All base sled modifications must be listed (may or may not add to base MSRP). Examples include:

9.5.4.1 Ski changes

9.5.4.2 Suspension changes

9.5.4.3 Track substitution

9.5.4.4 Fuel tank modification, replacements

9.5.4.5 Battery boxes

9.5.4.6 Miscellaneous changes for lights, hand warmers, aesthetics, etc.

9.5.4.7 Fuel pumps, regulators, injectors for ethanol fuels

9.5.4.8 Engine calibration hardware and software

9.5.4.9 Engine mounting brackets, hardware.

9.5.5 Value of each modification on MSRP must be estimated.

9.5.5.1 Modifications to prototype sled can be considered to add zero value if the items in question would obviously be included in production version.

9.5.5.2 Modifications to prototype sled to reduce weight, increase performance, or otherwise add features/value from base sled must be reflected in an MSRP that is higher than initial value.

9.5.6 All data used to estimate MSRP is to be included in spreadsheet form. This spreadsheet will be available in digital form on the CSC Forum webpage.

9.5.7 Estimated increase in MSRP must be based on one or more of the following:

9.5.7.1 Manufacturing quotes plus 50%

9.5.7.2 Wholesale plus 50%

9.5.7.3 Retail price for added component, feature or difference between substituted components.

9.5.7.4 A justified estimate of manufacturing cost differences between components plus 50% mark up for increased value to customer.

9.5.8 Judging will be conducted by a panel of industry representatives. If the values presented in the MSRP calculation are not supported with data, the Judges will meet once with the team(s) during the CSC and ask for clarifications or justification. Teams will have the opportunity to adjust the value of their MSRP up or down based on this meeting. One correction of the MSRP will be allowed based on the meeting with the Judges.

9.5.8.1 Teams that do not correct the MSRP to the Judges satisfaction will have the MSRP adjusted upward to what the Judging panel deems a reasonable cost.

9.5.8.2 Teams that are advised during the meeting with Judges that their MSRP is too high but do not adjust the value downward accordingly (or correctly) will have the MSRP value left as presented. The Judging panel will not adjust MSRPs downward, nor assess a penalty, as the higher proposed cost is believe to be a sufficient penalty.

Documentation Required
A spreadsheet tab for documentation will be added. Teams will be required to paste justification documents into the spreadsheet to support cost claims over $25 dollars (.pdf or .jpeg format)

Part Changes
For part changes from the stock sled, the new price will be calculated by determining production part cost, replacement part cost and determining the more expensive unit. The more expensive price will have 50% premium added to it and this cost will be added to the MSRP. The reason for this change is to end the practice of significantly upgrading sleds with aftermarket parts that list for the same price or in some cases cost less and then request credit off the MSRP. This is in affect improving the customer value without additional cost to the product which is not a real world scenario. Reviewing manufactures websites the same sled/chassis/engine combination can vary by more than $1,500.00 when higher performance sleds are ordered with premium suspension components and upgrades.

9.5.9 MSRP Scoring **New for CSC 2011!**
Twenty (20) points will be awarded to the winner (the team with the lowest MSRP) of this event. Other scores will be determined by the following:

$$TeamScore = 50 * \left[\frac{\left(\frac{M\ \max}{Mteam} \right)^2 - 1}{\left(\frac{M\ \max}{M\ \min} \right)^2 - 1} \right]$$

Where M = MSRP

In addition, subjective points will be awarded by the judges for the following items associated with determining the MSRP for their sled.

- 10 subjective points for the choice of the base sled used as their MSRP starting point
- 10 subjective points for justifying the reason for their component adds
- 10 subjective points for the quality of their research in determining price

MSRP points will also be used to determine the winners of the Most Practical Solution and Best Value awards. Teams that do not submit a complete an accurate MSRP will be ineligible to receive the awards for Most Practical Solution and Best Value.

9.6 Emissions Event – IC Engine Snowmobiles

9.6.1 Purpose of Emissions Event

The purpose of this event is to determine the emissions levels generated by each snowmobile at predetermined operating conditions following guidelines currently issued by the EPA. Electric driven snowmobiles will not be tested for emissions.

9.6.2 Emissions Event Description

Before being allowed to undergo emissions testing, snowmobiles will pass the technical inspection. Teams that arrive unprepared or run into problems and are unable to complete the Fuel Economy & Endurance event will lose their right to emissions testing. Emissions of these teams may be tested, after all other teams that met competition deadlines, if and only if time permits.

For the competition, the Fuel Economy & Endurance event will be held before the emissions testing, therefore eliminating the need for a separate "catalyst break-in" event. If a team does not complete at least one hundred (100) miles during the endurance event they will be required to make up the difference on a closed course at KRC before moving on to the emissions event, regardless if whether or not the sled design includes a catalytic converter.

Teams must provide the following information to event organizers before being permitted to participate in emissions testing: (1) The engine's rpm for their snowmobile at maximum steady engine speed in snowmobile operation (will be considered as 100% speed) and (2) The snowmobile engine's maximum torque observed at 100% speed.

Brake-specific (g/Kw-hr) emissions will be measured using laboratory-grade instrumentation and a Land & Sea DYNO-mite direct coupled dynamometer. The DYNO-mite mounts directly to the engine primary clutch shaft. Provisions for mounting the DYNO-mite direct coupled dynamometer must be provided or the team will not be tested and will receive zero points for the event. The testing will follow a five-mode test procedure approved by EPA for snowmobile emissions measurement. Teams shall be prepared to test up to all five modes of the proposed test emissions test cycle. More information on the emissions testing process can be found by reviewing the methods proposed in SAE Paper No. 982017 and EPA 40 CFR Parts 89, 90 and 91.

9.6.2.1 Emissions Event Equipment Requirements

In addition to passing the inspection and completing the endurance event, special preparations are required in order to compete in the Emissions event. The following requirements must be met before a machine will be considered ready for an emissions test.

1. DYNO-mite Dynamometer must be able to be installed. Teams will be responsible for pulling their clutches. The test facility will provide and install the DYNO-mite. Teams will be responsible for adapters if unconventional designs, shaft diameters, or tapers are used.

2. Exhaust Gas Sampling. A correct probe must be provided as described below. The exhaust system will be checked for leaks that could influence the emissions measurements. Leaks must be repaired prior to test.

3. Fuel Pressure and Pressure Regulation. Teams will be required to supply their own external high pressure fuel pumps and pressure regulators that are capable of mating to the facility fuel measurement system. The test facility will supply fuel at 3-5 psi and will have a cooler and vapor separator for the return line.

4. Supplemental Cooling. The facility will have a 50-50 ethylene glycol cooling system available that provides 115°F coolant, gravity fed through a one (1) inch diameter hose, back to the engine. This is an open loop system that will not allow pressure to build up. Teams are required to furnish their own cooling systems if this system is not adequate. Teams are required to furnish their own supplemental cooling for intercoolers.

9.6.2.2 Exhaust Gas Sampling Probe:

Each sled in the competition is required to be fitted with an exhaust gas-sampling probe in accordance with the following probe design and installation specifications:

1. The sample probe shall be a straight, closed end, stainless steel, multi-hole probe made from 1/4 inch OD stainless steel tubing. The wall thickness of the probe shall not be greater than 0.10 cm.

2. The probe shall have nine 1/16 in. holes. The spacing of the radial planes for each hole in the probe must be such that they cover approximately equal cross-sectional areas of the exhaust duct. The nine holes shall be drilled in a spiral pattern with an angular spacing between adjacent holes of approximately 120 degrees. This results in a spiral pattern with three triads of holes aligned along the length of the probe.

   Required probe fittings: Stainless steel tubing - 0.25 in. OD, Swagelok cap - PN SS-400-C, Swagelok thermocouple fitting - PN SS-400-1-2BT.

3. The probe is to be installed in the engine exhaust system, using the above fittings. A 1/4 in. diameter hole is to be drilled in the common exhaust pipe at the selected location (see requirements below). A 1/8 inch NPT internally-threaded close bushing is to be welded or brazed onto the exhaust pipe over the hole. The Swagelok thermocouple fitting is screwed into the bushing, and the probe is inserted through the thermocouple fitting so that it crosses the full diameter of the exhaust pipe, perpendicular to the direction of exhaust flow. The Swagelok cap compression fitting is installed at the end of the probe. For emissions sampling, the cap will be removed for connection of the heated sample line. The probe may be bent, as needed, to provide a straight-on connection for the heated sample line.

Probe location requirements:

1. For systems without after treatment, the probe must be placed after the point at which the exhaust from all cylinders is well mixed, a minimum of five pipe diameters downstream of the last "Y" connection.

2. For systems with air injection or after treatment, the probe must be placed a minimum of five (5) pipe diameters downstream of the converter outlet.

3. For all systems, the probe must be placed a minimum of 12 inches upstream of the end of the exhaust pipe.

The reason the exhaust probe needs to be at least 12 inches from the point in which the exhaust exits into the atmosphere is to prevent back pulses from reaching the sample probe. When the probe is located too close to the end of the exhaust, air pulses propagating back into the exhaust may actually reach the probe and dilute the sample. So, if the probe is located before or in the muffler there are no problems. As long as there is at least 12 inches of exhaust travel before it exits the system into the atmosphere, there will be no problems.

NOTE: if the probe is placed in the actual muffler the full exhaust stream must pass perpendicular to the probe. It may not be placed at a point where the exhaust stream has been separated into multiple streams for noise treatment purposes

In special cases, an exhaust system extension may be allowed at the discretion of the organizers, to meet this rule.

9.6.2.3 Fuel Flow Measurement

Accurate fuel flow data are required to make brake-specific emissions measurements. The emissions testers will supply the apparatus for measuring fuel used during the Emissions event. Teams will be responsible for setting up their fuel lines for quick disconnection from their on-board fuel system. Specifications for the connectors and connection diagrams will be provided at a later date.

9.6.2.4 Supplemental Engine Cooling System

Supplemental cooling will be required for snowmobile engine operation using the direct connect dynamometer described above. Fan-cooled engines will be tested with two cooling fans directed onto the engine with the cover open. For liquid-cooled engines, an external heat exchanger system consisting of a small automotive radiator with an electric fan will be provided. Liquid-cooled sleds are to be configured with cooling systems supply and return lines for connection to the external system. Specifications for the connectors and a connection diagram will be provided at a later date.

9.6.2.5 Fuel and lubricants

For CSC2010, each team must use the fuel supplied to fuel their snowmobile.

9.6.2.6 Pretest Inspection, Required Information

Prior to emissions testing, each sled will be inspected for proper installation of required equipment and fittings. Installations will be checked against provided specifications. Additionally, the engine, drivetrain, and related systems will be inspected. Sleds that have not passed the technical inspection prior to their scheduled emissions test forfeit their right to undergo emissions testing. If the team's sled does not complete the Fuel Economy & Endurance event, they will be given credit for the distance traveled. The remainder will be completed on a closed course to fulfill the requirements for the Emissions event. Their snowmobile will be rotated to the back of the schedule, and the next available sled will proceed with testing.

Teams need to provide the following pretest information to the emissions staff: the sled's maximum steady speed (engine rpm) at WOT and maximum steady engine torque at WOT. A pretest information form will be provided prior to the competition.

9.6.3 Emissions Testing

Teams should be prepared to test the complete 5-mode emissions test cycle currently under adopted by the EPA 40 CFR Part 1051 dated November 8, 2002 and discussed in SAE Paper No. 982017. This cycle is shown below for reference.

Mode	1	2	3	4	5
Speed, %	100	85	75	65	Idle
Torque, %	100	51	33	19	0
Wt. Factor, %	12	27	25	31	5

The emissions staff reserves the right to minimize the number of cycles run at the time of emissions testing, i.e., only three may be run but to be fair to all participants, the specific modes will not be identified until the time of emissions testing. Test modes will be run in order,

from highest to lowest speed. One hundred (100) percent engine speed is defined at the maximum steady engine speed in snowmobile operation. Torque values are specified as a percent of maximum wide open throttle torque observed at one hundred (100) percent speed in Mode 1.

If a sled develops a problem during emissions testing, a maximum of 20 minutes may be allowed for repairs. If a sled cannot be repaired in 20 minutes, the DYNO-Mite will be removed from the sled and installed on the next sled. No adjustments to the sled's calibration will be allowed after technical inspection or during maintenance or repairs. This repair allowance is not provided to allow re-engineering of a sled deficiency.

9.6.4 Emissions Testing

Snowmobile engines are operated at high power levels during emissions testing. Engines and powertrain systems must be sufficiently robust to be operated without failure at WOT-rated speed for as much as 15 minutes.

Teams should incorporate rev limiters in their design, but this is not a requirement.

Only the team captain or another single designated individual will be allowed to stand near the sled during testing. This individual will serve principally as a sled performance operation observer. This individual must be ready with a CSC supplied fire extinguisher at all times during the emission test. This individual must be willing to use the fire extinguisher when directed to do so.

Hazardous conditions may result in the immediate disqualification of the sled under test. This determination will be at the sole discretion of emissions testing staff. Examples of such conditions include:

- Broken motor mounts
- Fuel leak
- Fire or appearance of smoke
- Excessive vibration

This list provides a number of examples, but is by no means intended as an exhaustive or complete list of every possible ground for disqualification. In all such cases, sled operation will be immediately discontinued if the emissions staff feels a potentially hazardous operating condition is present. It is the responsibility of each team to design their sled and drivetrain with these requirements in mind. Questionable designs have no place in this competition.

Fuel Pumps: For the emission event, fuel consumption must be measured. The test facility will supply fuel at low pressure (< 10 psi). Teams are required to have their own external high pressure fuel pump if needed for the emission event. In-tank fuel pumps cannot be used during the emission event. Teams must supply their own power for electrical fuel pumps. Electric fuel pumps must be de-energized when the safety tether is pulled. Fuel should be able to circulate during a key ON/engine OFF condition so that existing fuel and entrapped air can be purged prior to the start of testing on the emission test fuel.

Per EPA regulations, attempts to modify operating conditions during the emission event will lead to disqualification. For example, activating a switch so that a different engine map is utilized during emission testing is prohibited. Suspected violators may be re-inspected and re-tested at any time.

The emission event consists of a Power Sweep to determine maximum power, 2-minutes at Mode 1, and 3-minutes at Modes 2, 3, 4, and 5. Failure to run steady for the full duration of Mode 1 will halt testing and lead to no score in the emission event.

Horsepower Limit
Engines that exceed 130 horsepower in the Power Sweep will be disqualified from the competition. See Rule 4.2.1

Soot Limit
Soot in the emissions stream can be measured just like any other constituent. The AVL 483 Micro Soot Sensor system can measure soot at each mode just like HC, CO, and Nox. The final soot number will be weighted just like the other constituents to come up with a weighted value in grams per kilowatt-hour. Reviewing vales in both the US EPA and Euro standards, we have settled on a weighted value of 100 mg/kw-hr as the upper limit for all engine types. Note: this is four times the current Euro standard for diesel engines. Engines that exceed this soot limit will be disqualified from the emissions event but not the BSFC event 9.6.6 below.

The right of the emissions testing staff to discontinue testing a sled at any time is absolute and may not be appealed.

NOTE: At the risk of overstating this point, if your sled has **any** weak points in its engine, they **will show up** in emissions testing. If you cannot complete emissions testing, you cannot win the competition. **Do not underestimate the difficulty of surviving this event.**

9.6.5 Emissions Event Scoring
Emissions scoring will be based on the standards for 2012. There will be no control snowmobile for emissions in the competition.

To score the minimum points for emissions, your engine emissions number must be greater than 100 according to the following formula:

$$E = \left[1 - \frac{(HC + NOx) - 15}{150}\right] * 100 + \left[1 - \left(\frac{CO}{400}\right)\right] * 100 \geq 100$$

Where E = the sled's emissions number

If E<100, the sled score is zero (0).

Emin is the lowest E number that meets the HC and CO requirements below.

HC+NOx must not exceed 90 g/Kw-hr and CO must not exceed 275 g/Kw-hr

NOTE: HC+NOx can be as high as 90 g/Kw-hr and CO can be as high as 275g/Kw-hr but not at the same time.

Refer to the US Environmental Protection Agency Final Ruling, 40 CFR, Part 1051 dated November 8, 2002.

100 points will be awarded for engines that satisfy the above equation. The final score will be calculated according to the following formula:

$$TeamScore = 100 + 200 * \left[\frac{\left(\frac{Eteam}{E\min}\right)^2 - 1}{\left(\frac{E\max}{E\min}\right)^2 - 1} \right]$$

Where E = the emissions number (derived from the equation above)

9.6.6 Brake Specific Fuel Consumption

Brake-specific fuel consumption (BSFC) will be calculated for each mode of the emission test in units of grams per kw-hour. The weighted average of BSFC (using the weighting factors for emissions) will be calculated for each team that completes the emission test. The team with the best (lowest) weighted BSFC will receive fifty (50) points and the team with the lowest BSFC will receive zero (0) points using the following formula:

$$TeamScore = 50 * \left[\frac{\left(\frac{B\max}{Bteam}\right)^2 - 1}{\left(\frac{B\max}{B\min}\right)^2 - 1} \right]$$

Where B= the weighted BSFC

9.7 Oral Design Presentation

9.7.1 Oral Design Presentation Description

A ten (10) minute oral presentation of the rationale and approach to the conversion is required, followed by a five (5) minute question and answer period. The presentation should state clearly how your modified snowmobile addresses the needs of snowmobilers (performance), environmentalists/land managers/regulatory agencies (noise and emissions), and snowmobile dealers/outfitters (cost, durability, resale value). Your presentation should focus on how your snowmobile will economically and practically reduce the impact that snowmobiles have on the environment. The presentation will be judged on content, format, and delivery. All statements must be backed up with test results and science. This is a marketing delivery that must be based on FACTS.

Each team is required to submit an electronic copy of their oral design presentation to competition organizers at the end of the presentation. Electronic copies may be submitted on a CD or data stick. Teams that fail to provide an electronic copy of their oral presentation will receive zero (0) points for this event. **This requirement will be strictly enforced!**

9.7.2 Oral Design Presentation Scoring

Oral design presentation judges will include snowmobilers, environmentalists, land managers, and engineers. A sample oral design presentation judging form is located in the Rules Appendix. The team that receives the highest average score from the judges will receive one hundred (100) points. Other teams will receive points based on the following equation:

$$TeamScore = 100 * \left[\frac{\left(\frac{Dteam}{D\min} \right)^2 - 1}{\left(\frac{D\max}{D\min} \right)^2 - 1} \right]$$

Where D = judges' average score

Zero Emissions sleds will be judged along with IC engine snowmobiles.

9.8 Fuel Economy & Endurance Event – IC Engines Snowmobiles

9.8.1 Purpose of Fuel Economy & Endurance Event

The purpose of this event is to evaluate the endurance and durability of the competition snowmobile in conjunction with its energy efficiency. A separate Range and Capacity test is described in Section 9.8.5 below for Electric and other Zero Emissions design snowmobiles.

9.8.2 Fuel Economy & Endurance Event Description

The snowmobiles will be filled with fuel and paired with a trail judge before being allowed to enter the trail section. The teams will travel approximately one hundred (100) miles (trail section dependent on snow conditions) to the finish point. Teams must plan for at least 100 miles of travel without refueling. At the final destination, the snowmobiles will be refilled with fuel and their fuel consumption will be recorded. After the previously arranged photo shoot and dinner, each team will be responsible for hauling its snowmobile back to KRC (road maps will be provided to the teams). The planned route can be anywhere from Twin Lakes to Copper Harbor. Trail conditions may result in a change to this plan on the day of the competition.

9.8.3 Fuel Economy & Endurance Rules

The fuel tanks will be filled to within three (3) inches of the top of the filler spout. The trail judge will maintain a speed consistent with trail conditions following all trail signs and rules. The snowmobile and driver's ability must be capable of safely driving at steady speeds up to 45 mph dependent on trail conditions in order to keep pace with the group. If a snowmobile cannot maintain progress with the trail judge they will fail the event. If the trail judge determines the snowmobile cannot maintain progress as a result of means other than mechanical failure, for example not enough power, veering off of trail, etc. the snowmobile will fail event. When this happens, the trail judge will tow or direct the snowmobile to the nearest road crossing and will then radio to a pick up trailer. The competition snowmobile will then be hauled to the event finish area or back to KRC.

9.8.4 Fuel Economy & Endurance Scoring

Teams that complete the endurance event will receive one hundred (100) "passing points". They will then receive additional "performance points" for their fuel economy compared to the rest of the field based on the following equation:

$$TeamScore = 100 * \left[\frac{\left(\frac{G\max}{Gteam} \right)^2 - 1}{\left(\frac{G\max}{G\min} \right)^2 - 1} \right]$$

Where G = number of gallons of fuel consumed.

9.8.5 Zero Emissions Range Test

Zero Emissions snowmobiles will be subjected to a range test. The entries will be run at a speed of 20 mph (or a lower speed set by the organizers based on conditions) on a closed test course until the snowmobile is unable to proceed. There will be no limit on the distance each sled can travel. The team who travels the furthest will receive one hundred (100) points. All other ZE teams that complete the event will receive points based on the following equation:

$$TeamScore = 100 * \left[\frac{\left(\frac{Rteam}{R\min} \right)^2 - 1}{\left(\frac{R\max}{G\min} \right)^2 - 1} \right]$$

Where R = distanced traveled

New for CSC 2011!

ZE Team exceeding 10 miles will receive additional points based on efficiency. This will be calculated by dividing the miles traveled by the amount of kilowatt hours used to recharge the battery pack. More details will be provided on the forum when the final instrumentation used for this measurement is defined.

9.8.6 Zero Emissions Draw Bar Pull Test

Zero Emissions snowmobiles will also be subjected to a Draw Bar Pull test. The snowmobile must pull a progressive resistance starting at 4 miles per hour until it can no longer proceed through loss of power or traction. Once the test has started the driver may not bounce the sled in an effort to increase traction. The maximum draw bar pull load will be measured. The sled that pulls the maximum load will be declared the winner. Points will be awarded according to the following formula:

$$TeamScore = 100 * \left[\frac{\left(\frac{Rteam}{R\min} \right)^2 - 1}{\left(\frac{R\max}{R\min} \right)^2 - 1} \right]$$

Where R = the draw bar pull load

9.9 Objective and Subjective Noise Events

9.9.1 Purpose of the Noise Event

The purpose of the objective noise event is to determine the peak A-weighted sound pressure level generated by each snowmobile during a maximum acceleration. In addition, the subjective noise performance (sound quality) of each snowmobile at a bystander location will be evaluated. Zero Emissions snowmobiles will be tested along with IC engine snowmobiles although they have different requirements and design goals.

9.9.2 Noise Event Description for IC Snowmobiles

The sound pressure created by the sled must pass the current standards set by the International Snowmobile Manufacturers Association (ISMA) which is 78dbA using SAE J192 Recommended Practice. The current standard allows +2dbA for measurement error due to environmental conditions; however, this +2 dbA allowance will NOT be used.

The snowmobile will be driven by a competition judge according to the published procedure SAE J192 Recommended Practice. In addition, the snowmobile must have a functioning speedometer, be capable of operating at a steady-state speed of 15 mph for 150 feet and be capable of accelerating from a steady state speed of 15 mph to 30 mph in less than 150 feet.

Every reasonable effort will be made to provide a test site that conforms to SAE J192 specifications, however this cannot be guaranteed due to changing weather conditions.

A binaural recording system will be placed on one side of the vehicle acceleration lane, also at a distance of 50 feet, for the recording of subjective noise playback files. The side on which the recording system is placed will be chosen by the event staff immediately before the noise event.

The vehicle throttle will be applied swiftly and smoothly by the operator when the vehicle reaches the start point of the acceleration lane. The amount of throttle opening used for the test will be determined by the operator to yield the maximum machine acceleration.

The vehicle throttle will be instantaneously and completely released when the vehicle reaches the end point of the acceleration lane. From this point, the vehicle will be allowed to coast back down to 15 mph. A portion of this coast-down may be included in the subjective noise recordings.

The 2dB tolerance over the sound limit for variance in test site, temperature, etc, will NOT be used for the objective noise event.

9.9.3 Noise Event Description for ZE Snowmobiles

Although a low noise signature for a zero-emissions snowmobile is important, it is not as important as in the IC Class where a high noise reading could result in lost sales. ZE sleds emit less noise and therefore the organizers have decided that the sound pressure created by the sleds will be graded on a relative scale for both the objective noise portion as well as the subjective noise portion of the test.

The snowmobile will be driven by a competition judge according to the published procedure SAE J1161. In addition, the snowmobile must have a functioning speedometer, be capable of operating at a steady-state speed of 15 mph for 150 feet, and be capable of traveling one (1)

mile to reach the noise test course while maintaining adequate power to achieve all other requirements.

Every reasonable effort will be made to provide a test site that conforms to SAE J1161 specifications, however this cannot be guaranteed due to changing weather conditions.

A binaural recording system will be placed on one side of the vehicle acceleration lane, also at a distance of 50 feet, for the recording of subjective noise playback files. The side on which the recording system is placed will be chosen by the event staff immediately before the noise event.

The vehicle throttle will be applied smoothly by the operator when the vehicle reaches the start point of the lane. The amount of throttle opening used for the test will be determined by the operator to yield the appropriate speed

The vehicle throttle will be instantaneously and completely released when the vehicle reaches the end point of the lane. From this point, the vehicle will be allowed to coast back down to 10 mph. A portion of this coast-down may be included in the subjective noise recordings.

9.9.4 Objective Noise Scoring for IC Sleds

IC sleds will receive seventy-five (75) points for having a sound pressure less than or equal to 78 dbA. If their sound pressure exceeds 78 dbA IC sleds will receive no points for objective noise.

ZE sleds do not have a threshold level for passing and will only receive points in relation to their sound pressure according to the equation below.

IC and ZE sleds will have the opportunity to receive up to seventy-five (75) additional points based on the following formula:

$$TeamScore = 75 * \left[\frac{\left(\frac{N\max}{Nteam} \right)^2 - 1}{\left(\frac{N\max}{N\min} \right)^2 - 1} \right]$$

Where N = sound pressure (dbA)

9.9.5 Subjective Noise Scoring

Data from the above Objective Noise Event will be recorded for playback to a "blind jury". The jury will consist of attendees to the Clean Snowmobile Challenge. Jury members will be screened to determine their ability to discern the noise playback files. Acceptable jury members will evaluate and grade the playback files. Jury members will not be given the team name of the sound file. Scoring will be based on the following equation:

$$TeamScore = M * \left[\frac{\left(\frac{N\max}{Nteam} \right)^2 - 1}{\left(\frac{N\max}{N\min} \right)^2 - 1} \right]$$

Where N = sound pressure (dbA)

M = Mulitplier: For IC Snowmobiles M = 150
For ZE Snowmobiles M = 75

9.10 Acceleration Testing Event

9.10.1 Purpose of the Acceleration Testing Event

The purpose of this event is to determine the acceleration performance of each snowmobile.

9.10.2 Acceleration Testing Event Description

Each snowmobile will be driven by a student participant during this event. The snowmobile will be accelerated from a standing stop to the maximum speed that it can achieve in 500 feet. The snowmobile will be timed from start to finish, the lower the time the better. This event will be completed two times and the best time will be the time used for scoring. To pass this event, the elapsed time must be equal to or less than 12 seconds. All drivers must wear the proper safety gear as specified earlier.

Zero Emissions snowmobiles will be tested for acceleration times pulling a load of approximately 500 pounds.

9.10.3 Acceleration Testing Event Scoring

The team with the least time to reach 500 feet (best of two runs) will receive fifty (50) points.

A team that passes the event by reaching 500 feet in 12 seconds or less will receive points according to the following formula:

$$TeamScore = 50 * \left[\frac{\left(\frac{T\max}{Tteam} \right)^2 - 1}{\left(\frac{T\max}{T\min} \right)^2 - 1} \right]$$

Where T = time

9.11 Objective Handling & Drivability Event – IC and ZE Snowmobiles

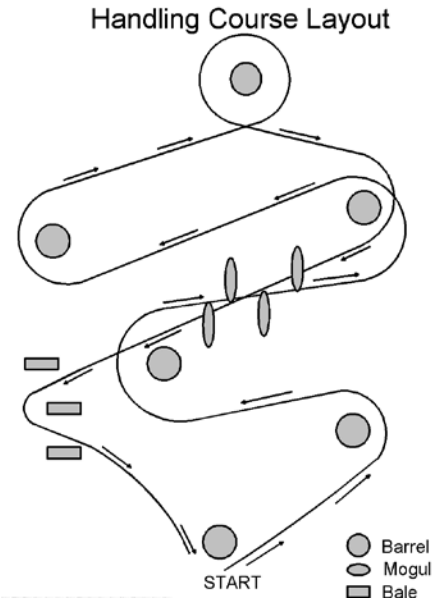
9.11.1 Purpose of Objective Handling & Drivability Event

The purpose of this event is to objectively evaluate the agility and maneuverability of each competition snowmobile.

9.11.2 Objective Handling & Drivability Event Description

A student driver from each team will be allowed to complete two (2) consecutive individually timed laps on a slalom style course (course example below). The fastest lap time will be recorded. No adjustments to the snowmobile will be allowed between laps. A one (1) second penalty will be assessed for each cone, barrel, or bale hit. Five (5) seconds will be assessed if the entire sled does not stop within the designated stopping area.

Zero Emissions sleds will be tested along with IC engine snowmobiles.



Example course example layout
Not to scale.

9.11.3 Objective Handling & Drivability Rules

The handling event will consist of a course designed to challenge the snowmobiles in the areas concerned with handling. The horsepower of the snowmobile will have very little influence on how well the snowmobile performs in this event. The snowmobiles will be driven by a student team member. This team member must wear the proper safety gear to be eligible for this event as specified earlier.

9.11.4 Objective Handling & Drivability Scoring
The scoring for the event will be a comparative ranking based on the equation below.

$$TeamScore = 50 * \left[\frac{\left(\frac{T\max}{Tteam} \right)^2 - 1}{\left(\frac{T\max}{T\min} \right)^2 - 1} \right]$$

Where T = lap time

9.12 Subjective Handling & Drivability Event

9.12.1 Purpose of Subjective Handling & Drivability Event
The purpose of this event is to subjectively evaluate the agility and maneuverability of the competition snowmobile.

9.12.2 Subjective Handling & Drivability Event Description
Professional snowmobile riders will drive each competition snowmobile through a course designed to evaluate handling and drivability. Lap times will not be recorded. Rather, the professional rider will evaluate ride quality based on criteria on the Subjective Handling and Drivability Event Judging Form (see Appendix).

Zero Emissions sleds will be tested along with IC engine snowmobiles.

9.12.3 Subjective Handling & Drivability Rules
The handling event will consist of a course designed to challenge the snowmobiles in the areas concerned with handling and overall drivability. The snowmobiles will be driven by a competition judge.

9.12.4 Subjective Handling & Drivability Scoring
The scoring for the event will be based on the judge's ranking of each snowmobile according to the Subjective Handling and Drivability Event Judging Form (see Appendix).

Fifty (50) points will be awarded to the winner of this event. Other scores will be determined by the following formula:

$$TeamScore = 50 * \left[\frac{\left(\frac{H\max}{Hteam} \right)^2 - 1}{\left(\frac{H\max}{H\min} \right)^2 - 1} \right]$$

Where H = driver's score

9.13 Cold Start Event

9.13.1 Cold Start Event Description

Snowmobiles will be cold-soaked overnight. Teams will have exactly twenty (20) seconds to start their snowmobile. The use of ether is not allowed. To pass the event, the snowmobile must start in 20 seconds and then move forward without stalling 100 feet within 120 seconds. If the engine stalls during the 100 feet movement the team will fail.

9.13.2 Cold Start Event Scoring

If a snowmobile does not start within twenty (20) seconds and move 100 feet in 120 seconds, the team will fail the Cold Start event and will receive zero (0) points. Snowmobiles that start within twenty (20) seconds and move 100 feet in 120 seconds will receive fifty (50) points.

Zero Emissions sleds will be tested along with IC engine snowmobiles.

9.15 Static Display Event/Networking with Industry

9.15.1 Static Display Event Description

Each school must place their snowmobile on display. An area of approximately 8 feet by 10 feet will be provided for your snowmobile and display. The display is intended to serve as a marketing and promotional display that will encourage snowmobilers and outfitters to purchase and use your snowmobile. Teams are encouraged to put up signs, hand out flyers, and use any other marketing techniques to attract attention to your prototype snowmobile.

Zero Emissions sleds will be judged along with IC engine snowmobiles.

9.15.2 Static Display Scoring

This is a mandatory event worth fifty (50) points. Teams must show up on time and not tear down their display until allowed told to do so by the competition organizer. This event will last approximately two (2) hours. Local dealers, snowmobile enthusiasts, and other professionals will tour the displays. Teams choosing not to attend the static display will receive zero (0) points.

9.17 Snowmobile Weight – Zero Emissions Snowmobiles

Each snowmobile will be weighed after fueling for the endurance event. The lowest ZE weight sled will receive one hundred (100) points and the highest ZE weight sled will receive zero (0) points.

Weight for the IC sleds will be recorded but will not be part of the scoring system.

The score for the ZE teams will be:

$$TeamScore = 100 * \left[\frac{\left(\frac{W\max}{Wteam} \right)^2 - 1}{\left(\frac{W\max}{W\min} \right)^2 - 1} \right]$$

Where W = weight

9.18 In Service Emission – IC Engine Snowmobiles

9.18.1 Event Description

The goal of this event is to determine the total gaseous emission emitted from the snowmobile on the trail. In service emissions measurements is fairly new technology and there are no regulations or legislations governing procedures as of this writing. The organizers have created this event based on available technology and will make every effort to make this a fair comparison between designs. Note that the event is designed to measure total emissions unlike the other emission event that measures a rate normalized to power.

9.18.2 Test Procedure

- The same exhaust pipe probe used for the lab emissions event will be used for this event
- Sled will be driven by competition organizers on a closed course
- Every effort will be made to drive the sleds in an identical and consistent matter to create a fair comparison of designs
- The course will be approximately 3 miles, in length, level, with speeds up to 45 mph. The actual course will be dependent upon current weather and trail conditions.
- Measured gases will include HC, CO, CO2, and NOx.
- The weighting of gases will be equal.

9.18.3 Scoring

- The team with the lowest total grams of emissions will receive 50 points.
- The team with the highest total grams of emission will receive zero points.
- A linear interpolation will determine the scores between zero and 50 for the remaining teams.
- Fuel Economy will also be measured in this event and scores between zero (0) and fifty (50) will be awarded according to the following formulas:
-

$$TeamScore = 50 * \frac{\left[\left(\frac{FE\max}{FEteam}\right)^2 - 1\right]}{\left[\left(\frac{FE\max}{FE\min}\right)^2 - 1\right]}$$

Where FE is the Fuel Economy measured in the event.

ARTICLE 10: ORGANIZER AUTHORITY

The organizers of the competition reserve the exclusive right to revise the schedule of the competition and/or to interpret the competition rules at any time and in any manner which is, in their sole judgment, required for efficient operation or safety of the competition.

APPENDIX A
Snowmobile Description Form

Please fill out the following form and return it to the registration desk. Answer all questions about your snowmobile as it is actually competing (not as it was intended to compete).

Team Name _____ Team Number:_____

Chassis-Year and Model_____

Engine
Engine Cycle (2-stroke, 4-stroke, rotary, or electric)_____Number Of cylinders_____

Engine Displacement (cc or electric motor size)_____

Engine Manufacturer_____

Engine Modifications (if any)_____

Compression Ratio_____

Turbocharged? or Supercharged? Yes or No – If Yes circle one

Engine Management System_____

Fuel Delivery -Carburetors, EFI, DI, SDI – (circle one)_____

Fuel Pump Pressure_____psi Fuel Type (circle one) gasoline diesel electric _____

Emission Control
Air/Fuel Ratio Chosen (lean, stoichometric?)_____

Catalyst? Type? _____

Secondary Air Injection? - Yes or No (circle one)

Exhaust Gas Recirculation? – Yes or No (circle one)
Other_____

Noise Control
Muffler Design_____

Noise Treatment_____

Cooling
Describe Strategy_____

_____

Other Unique Features of Your Snowmobile
Describe Strategy_____

APPENDIX B
SAE CSC 2011 Engineering Design Paper Judging Form IC Engine Sleds Only

University Team Name: _____

Score the following categories, giving each points ranging from 0 (very bad) to the maximum points available for the category (excellent). The maximum points available for each category are listed in parenthesis.

When evaluating the papers, please keep in mind that the papers should be high-quality, technical papers that meet the rigorous standards required for publication in scholarly journals.

_____ **PERFORMANCE (15):** Does the paper describe the challenges of maintaining/improving snowmobile performance (while reducing emissions and noise)? Does the paper describe the strategy the team selected to maintain/improve performance? Are adequate technical details given? Are adequate results given?

_____ **INNOVATION (20)** Does the paper describe significant design innovation and modifications to the base snowmobile to meet the objectives of a clean and quiet trail snowmobile.

_____ **EMISSIONS CONTROL (15):** Does the paper describe the challenges of improving snowmobile emissions? Does the paper describe the strategy team selected to improve emissions? Are adequate technical details given? Are adequate results given?

_____ **NOISE (15):** Does the paper describe the challenges of reducing snowmobile noise? Does the paper describe the strategy team selected to reduce noise? Are adequate technical details given? Are adequate results given?

_____ **RESULTS/DATA – (10)** Does the paper contain valid numerical data? Are results described based upon testing?

_____ **USE OF GRAPHICS – TABLES/GRAPHS/PICTURES (10) -** Were graphics used in the paper? Were they clearly explained in the text? Were they legible? Were they effective?

_____ **ORGANIZATION (10)** Was the paper format logical and organized? Did it contain an introduction/overview as well as conclusion/summary? Did the paper conform to the SAE standard format for technical papers?

_____ **REFERENCES (5)** Were references cited whenever appropriate? Were the references from high-quality sources?

_____ **TOTAL = ENGINEERING DESIGN PAPER POINTS (100 Points maximum)**

COMMENTS:

APPENDIX C
SAE CSC 2011 Engineering Design Paper Judging Form Zero Emissions Sleds Only

University Team Name: _____

Score the following categories, giving each points ranging from 0 (very bad) to the maximum points available for the category (excellent). The maximum points available for each category are listed in parenthesis.

When evaluating the papers, please keep in mind that the papers should be high-quality, technical papers that meet the rigorous standards required for publication in scholarly journals.

_____ **CONTENT – OVERALL PERFORMANCE (15):** Does the paper describe the challenges of the zero-emissions snowmobile? Does the paper describe the strategy the team selected to achieve the required performance? Are adequate technical details given? Are adequate results given?

_____ **CONTENT – RANGE (15):** Does the paper describe the challenges meeting the 10 mile range requirement? Does the paper describe the strategy team selected to achieve this? Are adequate technical details given? Are adequate results given?

_____ **CONTENT – DRAW BAR PULL (15):** Does the paper describe the challenges of maximizing draw bar pull capabilities of their design? Does the paper describe the strategy team selected to achieve this? Are adequate technical details given? Are adequate results given?

_____ **CONTENT – MISCELLANEOUS (20)** Does the paper describe other features of the snowmobile? How will the modifications affect the cost of the snowmobile? Will the snowmobile be durable? Will the snowmobile be energy efficient? Will the snowmobile be safe to ride? Was rider comfort a major consideration?

_____ **RESULTS/DATA – (10)** Does the paper contain valid numerical data? Are results described based upon testing?

_____ **ORGANIZATION (10)** Is the paper format logical and organized? Did it contain an introduction/overview as well as conclusion/summary? Did the paper conform to the SAE standard format for technical papers?

_____ **USE OF GRAPHICS – TABLES/GRAPHS/PICTURES (10) -** Were graphics used in the paper? Were they clearly explained in the text? Were they legible? Were they effective?

_____ **REFERENCES (5)** Are references cited whenever appropriate? Were the references from high-quality sources?

_____ **TOTAL = ENGINEERING DESIGN PAPER POINTS (100 points maximum)**

COMMENTS:

APPENDIX D
SAE CSC 2011 Oral Presentation Judging Form for IC Sleds

University Team Name: _____

Score the following categories on the basis of 0-12.5 points each according to the following scale (any number or fraction along this scale may be used).

0 = inadequate or no attempt
2.5 = attempted but below expectation
5 = average or expected
7.5 = above average but still lacking
10 = excellent, meets intent
12.5 = extraordinary, far exceeds expectations

_____ **CONTENT (SNOWMOBILE OPERATOR PERSPECTIVE):** Does the presentation describe how the design will appeal to snowmobilers? Will the snowmobile maintain/improve performance and handling? Is enough detail given about how? How have ergonomics been taken into account?

_____ **CONTENT (SNOWMOBILE DEALER/OUTFITTER PERSPECTIVE):** Does the presentation describe how the design will meet the needs of snowmobile outfitters? Is the cost reasonable? Is the design durable and easy to maintain? Does the design allow operation by a novice snowmobiler? Is enough detail given about how these goals are met? Are there other factors that make this design more attractive to snowmobile dealers/outfitters? Was rider comfort a major consideration?

_____ **CONTENT (ENVIRONMENTAL PERSPECTIVE):** Does the presentation describe how the design will minimize the environmental impacts of the snowmobile? Are emissions reduced significantly? How much? Is the snowmobile quiet enough? How quiet? Is enough detail given about how these goals are met? Are there other factors that make this design more attractive from an environmental perspective?

_____ **CONTENT (TEST RESULTS/SCIENCE):** Are test results given for all of the "claims" made about the modified snowmobile? Is the presentation based on "good science" (as opposed to a slick sales job)? Is data provided to support all conclusions?

_____ **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? Was the text readable? Were illustrations, graphs, and tables clearly explained? Were the visual aids effective?

_____ **DELIVERY:** Did the presenter speak in a clear voice? Did the presenter show enthusiasm and promote confidence in the technical aspects? Did he/she 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 (100 points maximum)**

COMMENTS:

APPENDIX E
SAECSC2011 Oral Presentation judging form for ZE Sleds

University Team Name: _____

Score the following categories on the basis of 0-12.5 points each according to the following scale (any number or fraction along this scale may be used).

0 = inadequate or no attempt
2.5 = attempted but below expectation
5 = average or expected
7.5 = above average but still lacking
10 = excellent, meets intent
12.5 = extraordinary, far exceeds expectations

_____ **CONTENT (SNOWMOBILE OPERATOR PERSPECTIVE):** Does the presentation describe how the design will appeal to scientists working in the North and South Pole areas? Will the snowmobile have sufficient range and power? Is enough detail given about how? How have ergonomics been taken into account?

_____ **CONTENT (SNOWMOBILE DEALER/OUTFITTER PERSPECTIVE):** Does the presentation describe how the design will be serviced in the North and South Pole environment? Is the cost reasonable? Is the design durable and easy to maintain? Does the design allow operation by a novice snowmobiler? Is enough detail given about how these goals are met? Was rider comfort a major consideration?

_____ **CONTENT (ENVIRONMENTAL PERSPECTIVE):** Does the presentation describe how the design will minimize the environmental impacts of the snowmobile? How much? Is the snowmobile quiet enough? How quiet? Is enough detail given about how these goals are met? Are there other factors that make this design more attractive from an environmental perspective?

_____ **CONTENT (TEST RESULTS/SCIENCE):** Are test results given for all of the "claims" made about the modified snowmobile? Is the presentation based on "good science" (as opposed to a slick sales job)? Is data provided to support all conclusions?

_____ **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? Was the text readable? Were illustrations, graphs, and tables clearly explained? Were the visual aids effective?

_____ **DELIVERY:** Did the presenter speak in a clear voice? Did the presenter show enthusiasm and promote confidence in the technical aspects? Did he/she 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 (100 points maximum)**

COMMENTS:

Reviewer Name:

APPENDIX F
SAE CSC 2011 Handling Event Judging Form for IC and ZE Sleds

University Team Name: _____

Score the following categories, giving each points ranging from 0 (very bad) to the maximum points available for the category (excellent). The maximum points available for each category are listed in parenthesis.

_____ **CORNERING (5):** Does the sled have solid steering? Is handling responsive? Do you have confidence that the sled will go where you point it?

_____ **RIDE (5):** Does the sled impress you as rideable? Could you ride this sled all day and be comfortable? Is sled ride consistent and smooth?

_____ **ENGINE RESPONSE (7.5):** Is the engine response quick and sure? Do RPM's increase/decrease quickly and smoothly? Is there any hesitation to increase RPM?

_____ **CLUTCH/TRACTION (7.5):** Does the clutch engage smoothly? Does the drive train put power to the snow well?

_____ **BRAKING (7.5):** Do the brakes engage properly? Are you confident the brakes will perform in an emergency situation?

_____ **BALANCE (7.5):** Is the sled balanced front to back and side to side? Is the sled nose heavy? Does is torque to the side?

_____ **OVERALL PERFORMANCE (10):** Do all parts of the performance seem to fit together? Are the controls simple and easy to operate? Are the handlebars, seat, and footrest comfortable and well laid out?

_____ **TOTAL HANDLING EVENT POINTS (50 points maximum)**

COMMENTS:

_____

_____

_____

_____

_____

Judge Name_____

APPENDIX G
Electrical Rules for Zero Emission Sled[1]

It is strongly recommended that SAE Standard J1673 "High Voltage Automotive Assembly Wiring Design" be complied with wherever possible.

FH-2.1 High-Voltage (HV) Isolation

The Maximum voltage between any two electrical connections in the vehicle including ground shall not exceed 400V DC or AC RMS under all operating and non-operating conditions.

High voltage circuits (anything exceeding 30V) must be isolated at all times from all low voltage circuits. There must be no connection between the frame of the vehicle (or any other conductive surface that might be inadvertently touched by a rider, service person, or spectator), and any part of any HV circuits.

HV and low-voltage (chassis-grounded) circuits must be physically segregated:
• Not run through the same conduit.
• Where both HV and grounded circuits are present within an enclosure, they must be separated by insulating barriers (such as Nomex, Formex, or other moisture resistant, UL recognized insulating materials), or well-separated so that there is no risk of arcing due to dielectric breakdown or contact due to slight shifting of components during use.
• If both are on the same circuit board, they must be on separate, clearly defined areas of the board.

FH-2.1.1Ground Fault Detectors

All vehicles shall be equipped with an on-board Ground Fault detector. This must be a Bender IR125Y or IR475 (or equivalent if approved by the organizers). The output relay of this device must be wired such that the vehicle immediately stops providing power and all high voltage is disabled (contactors open) within 4 seconds. The system must be in operation at any time that the key is on.

FH-2.1.2 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 1**). This **must** cause the Ground Fault detector to trip, and the vehicle HV electrical systems to shut down.
This test may be repeated by the electrical inspectors at any time during the competition.

[1] *Copyright © 2007, The Trustees of Dartmouth College and the SAE Formula Hybrid Rules*

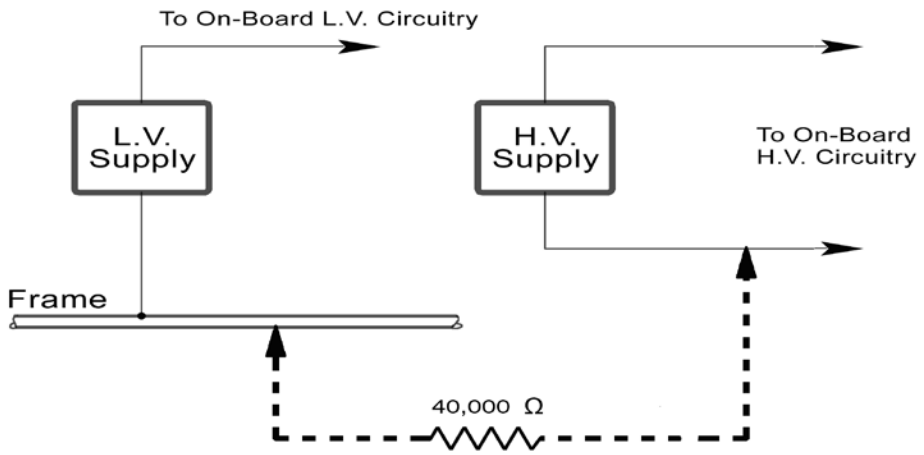


Figure 1
Ground Fault Test

FH-2.1.3 Rain Certification

A vehicle may not be operated in wet conditions unless Rain Certified. To become Rain Certified, a vehicle must pass a visual inspection that checks that all high and low voltage wiring and components are suitably protected from rain and water thrown up by the skis and track. At the judge's discretion, an additional test may be required that the vehicle survive a 60 second water spray, with all systems energized, without tripping the Ground Fault Detector.

FH-2.2 No Exposed Connections

No un-insulated HV surfaces may be exposed. Non-conductive covers must prevent inadvertent human contact. This would include crew members working on or inside the vehicle. The snowmobile hood, seat or other panels are not considered to be an adequate cover as they may be removed for service.

All HV enclosures must be finger–proof (it is impossible to touch an HV terminal with a finger), tool-proof (it is impossible to touch an HV terminal with a tool (screwdriver, wrench, etc), and drop-proof (small (e.g. #10) nut dropped on the enclosure cannot cause a short circuit, ground fault, or other hazardous condition).

HV systems and containers must be protected from moisture.

FH-2.2.1 HV Controls

Electronic controls carrying high voltage must be mounted away from the handlebars and actuated through a non-conductive or well-grounded mechanical linkage.

Dash gauges may be references to HV, but provided that the maximum voltage between any 2 wires or points inside the gauge must remain below 30V at all times. For example, a prescaler should be used inside the battery to reduce the measured voltage to be below 30V.

FH-2.3 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 or documentation from the manufacturer must be provided showing this 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 high-voltage connections must be secured using suitable vibration-resistant fasteners such as nylocks or lock washers. Poor contacts can lead excessive heat and loose contacts can lead to short circuits.
- Crimped HV connections should be crimped with a proper crimping tool for the style of connector and wire gauge used. Soldered connections may be substituted for crimped ones if permitted by the manufacturer.

All HV wiring that runs outside of the hood or under-seat area or through areas where rotating or moving components might cause abrasion must be enclosed in orange non-conductive conduit, such as Electri-flex LNMP or equivalent. The conduit must be securely anchored at least at each end, and must be located out of the way of possible snagging or damage.

Under hood and under-seat HV wiring that cannot possibly be subject to mechanical stress or abrasion may be protected with orange split-loom instead of non-conductive conduit. Wiring inside of battery enclosures is not required to be covered, but must be adequately secured and protected from abrasion and mechanical stress.

All external heat sinks or metal housings for HV components (i.e. motors, inverters, etc…) must be securely grounded.

Within an enclosure, exposed (un-insulated) HV terminals and conductors of opposing polarities must be spaced with an adequate air gap to prevent arcing due to dielectric breakdown. It is strongly recommended that the spacing is significantly larger than this to reduce the risk of accidental short circuit during service.

FH-2.4 Fusing

All electrical systems (both low and high voltage) must be appropriately fused. The continuous current rating of a fuse must not be greater than the continuous current rating of the smallest wire it protects. All fuses must be rated for the highest voltage in the systems they protect. Fuses used for DC must be rated for DC, and must carry a DC rating equal to or greater than the system voltage. Specification sheets for all high-voltage fuses must be provided to the electrical safety inspector. See Appendix G

If multiple parallel strings of batteries are used, then each string must be individually fused. If individual fuses are used this will provide a total fusing equal to the number of fuses multiplied by the fuses rating. Any wires conducting the entire pack current must be appropriately sized to this total fusing or an additional fuse used to protect the wiring.

Multiple parallel fuses in a single string are not permitted.

The fuse should be as located as close to the source (battery) as feasibly possible and must be prior to any external connectors (i.e. if a bulkhead connector is used on the battery housing, the fuse must be internal to the pack; if a pigtail is used, then it may be external but must be before the connector). Mid-string fuse positioning is recommended.

FH-2.5 Battery Type and Size

Teams must state, as accurately as possible, the energy storage capacity of their battery. Accumulator size is limited to 8Kw-hrs. At this time only batteries are permitted.

FH-2.5.1 Battery Monitoring

A battery monitoring system appropriate for the battery type is required. The battery monitoring system must monitor the battery to prevent overcharging.
Depending on the battery type, thermal monitoring may also be required.

FH-2.6 Energy Storage Container Electrical Configuration

All energy storage must be in closed containers containing normally open isolation relays 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.

All energy storage systems must use a minimum of two contactors located at the most positive and most negative location of the circuit. These relays must be located in the same enclosure as the energy storage device and as close as is reasonable to the energy storage device. Multiple energy storage containers connected in series must have at least one relay per container, provided that interconnects between the containers are protected by non-conductive conduit 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 to make contact with each extreme of the HV system. These will be used to permit testing the isolation stipulated in section 2.1.2. Optionally, access to the same electrical nodes may be provided at another point.

Each energy storage container must have a label at least 30 in^2 with the text “High Voltage ALWAYS ENERGIZED”.

FH-2.7 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.
• Adequate impact resistance to contain a battery that explodes during charging

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.

FH-2.9. Low-Voltage Circuits
Low-voltage (< 30 V) circuits must be grounded to the frame of the sled. (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 **FH-2.1**.

FH-2.10. Charging Equipment
Any external equipment such as chargers that are to be electrically connected to high-voltage system of the vehicle must be maintained in safe working condition. High-voltage chargers and/or power supplies must be marked with appropriate high-voltage stickers.

Provisions for charging must follow the same rules as other high-voltage wiring: no exposed connections, proper strain relief, etc. The battery enclosure must remain closed during charging.

All chargers must be UL (Underwriters Laboratories) listed. Any waivers of this requirement require approval in advance, based on documentation of the safe design and construction of the system, including galvanic isolation between the input and output of the charger.

When the vehicle is charging from external sources:

- The vehicle must be de-energized as much as possible while still allowing charging.
- No other activities (including any mechanical or electrical work) shall be allowed on the vehicle while charging.
- At least one member of the team with knowledge of the vehicles electrical system and charging process must be present throughout the charging process.

FH-3 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 sled during development and testing.

- Insulated gloves, rated for at least the voltage in the HV system, including leather protective outer glove.

- 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.
- Fire Extinguishers. Teams must identify any fire hazards specific to their vehicle's components and have the appropriate fire extinguishers or fire extinguishing materials required to suppress such fires. During technical inspection teams must specifically identify all such hazards and present the extinguishers or extinguishing materials for examination.
- Chemical Spill cleanup. Teams must have chemical spill absorbent at hand, appropriate to their specific risks.

FH-4 Electrical Safety Inspector

Exceptions to these rules may be made on a case-by-case basis through submissions to the rules committee which must be documented in writing and with photos if necessary. Exceptions must be requested well in advance of the competition. The electrical safety inspector has **final** discretion as to whether a vehicle will be prohibited from being operated at competition or serviced on the CSC facilities at **any time**, regardless of whether it complies with the letter of the rules or not.

FH-4.1 Re-inspection

After any time the high-voltage system is serviced, the vehicle may not participate in any dynamic events until the Electrical Inspector has recertified the vehicle. This may require re-testing the ground fault monitor. If a repair is simple, and done in the presence of an Electrical Inspector, the Chief Electrical Inspector may choose to waive the requirement.

APPENDIX H
CSC 2011 INSPECTION FORMS

IC General Technical and Dynamic Tests
Page 1 of 1

University Name				
Team Captain Printed Name		email		
Team Captain Signature		Phone		
Rule Number	**Topic**	**Yes?**	**No?**	**Not applicable**
	Safety Glasses ok?			
	Fire Extinguishers ok?			
6.1	**Protective Equipment**			
6.1.5	Warm up stand ok?			
6.2.1	Driver helmet ok?			
6.2.2	Clothing and boots ok?			
6.2.3	Jacket/Vest ok?			
	DYNAMIC TESTS			
4.2.6	Throttle Return ok?			
4.5.2	Steering ok?			
4.8.1	Disconnect Tether ok?			
4.8.2	Kill Switch ok?			
4.8.3	User Selection switched ok?			
9.9.2	Speedometer ok?			
1.2	Attain 45 mph?			
1.2	500 feet in 12 seconds?			

Inspector Printed Name				
Inspector Signature				

APPENDIX H
CSC 2011 INSPECTION FORMS

IC General Technical and Dynamic Tests
Page 1 of 2

University Name				
Team Captain Printed Name		email		
Team Captain Signature		Phone		
Rule Number	**Topic**	**Yes?**	**No?**	**Not applicable**
4.1	Stock qualified and model years 2005 to 2010 inclusive?			
4.2	**Engine**			
4.2.1	Engine type 2-stroke, 4-stroke, rotary?			
4.2.2	Fuel type ethaol or diesel?			
4.2.3	2-stroke oil does not have boosting additives?			
4.2.4	Turbochargers/Superchargers meet design criteria?			
4.2.5	Exhaust systems outlet ok?			
4.2.6	Throttle design meets requirements?			
4.3	No block heaters?			
4.4.1	Meets chain drive oil bath requirement?			
4.4.2	Meets CVT requirement?			
4.4.3	Meets brake performance requirement?			
4.4.4	Meets brake control handle requirement?			
4.4.5	Meets brake rotor shield requirement			
4.4.6	Meets rotor contact area requirement?			
4.4.7	Clutch cover ok?			
4.4.8	Moving parts isolation okay			
4.5	**Skis and Ski Suspension**			
4.5.1	Meets ski requirements			
4.5.2	Ski and ski suspension modifications okay?			
4.5.4	Ski suspension requirements ok?			
4.6	**Track, Track Suspension, and Traction**			
4.6.1	Track and track suspension modifications ok?			
4.6.2	Track suspension requirements ok?			
4.6.3	Traction control devices ok?			

IC General Technical and Dynamic Tests Page 2 of 2				
4.6.5	Slide runners ok?			
4.6.6	Maximum track lug height ok?			
4.7	**Frame and Body**			
4.7.1	Rear snow flap ok?			
4.7.3	Foot Stirrups/Pegs ok?			
4.7.4	Seat ok?			
4.7.5	Body modification ok?			
4.7.6	Front bumper requirement met?			
4.7.7	Decal space requirement ok?			
4.7.8	Team number correct?			
4.7.9	Chassis Modification (requires explanation and analysis)			
4.8	**Ignition and Electrical**			
4.8.1	Disconnect tether ok?			
4.8.2	Kill Switch ok?			
4.8.3	User Selection Switches ok?			
4.8.4	Battery fuel pumps connected to tether and kill switch?			
4.8.5	Battery box requirements met?			
4.8.6	Head, tail, and brake lght requirement met?			
4.9	Component deletion requirement met?			

Inspector Printed Name				
Inspector Signature				

APPENDIX H
CSC 2011 INSPECTION FORMS

ZE General Technical and Dynamic Tests
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University Name				
Team Captain Printed Name		email		
Team Captain Signature		Phone		
Rule Number	**Topic**	**Yes?**	**No?**	**Not applicable**
FH-3	**Required Equipment**			
	Insulted Gloves?			
	MSDS for the batteries?			
	Special Equipment required in MSDS?			
	Safety Glasses?			
	Fire Extinguishers?			
	Required Chemical Spill Cleanup?			
6.1	**Protective Equipment**			
6.2.1	Driver helmet ok?			
6.2.2	Clothing and boots ok?			
6.2.3	Jacket/Vest ok?			
	DYNAMIC TESTS			
4.2.6	Throttle Return ok?			
4.5.2	Steering ok?			
4.8.1	Disconnect Tether ok?			
4.8.2	Kill Switch ok?			
4.8.3	User Selectable Switches ok?			
9.9.2	Speedometer ok?			

Inspector Printed Name				
Inspector Signature				

APPENDIX H
CSC 2011 INSPECTION FORMS

ZE General Technical and Dynamic Tests
Page 1 of 2

University Name				
Team Captain Printed Name		email		
Team Captain Signature		phone		
Rule Number	**Topic**	**Yes?**	**No?**	**Not applicable**
4.1	Stock qualified and model years 2005 to 2010 inclusive?			
2.1	**Electrical**			
2.1.1	High Voltage Isolation ok?			
2.1.2	Ground Fault Detectors ok?			
2.1.3	Ground Fault Detector Test ok?			
2.2	Rain Certification ok?			
2.2.1	No Exposed Connections ok?			
2.3	HV Controls ok?			
2.4	HV Insulation, Wiring, and Conduit ok?			
2.5	Fusing ok?			
2.5.1	Battery ok? Quantity/Votage/Amp-hours			
2.6	Battery Monitoring ok?			
2.7	Energy Storage Container Electrical ok?			
2.9	Energy Storage Container Mechanical ok?			
2.10.	Low Voltage Circuits ok?			
FH-3	Charging Equipment ok?			
4.4.3	Meets brake performance requirement?			
4.4.4	Meets brake control handle requirement?			
4.4.5	Meets brake rotor shield requirement			
4.4.6	Meets rotor contact area requirement?			
4.4.7	Clutch cover ok?			
4.4.8	Moving parts isolation okay			
4.5	**Skis and Ski Suspension**			
4.5.1	Meets ski requirements			

ZE General Technical and Dynamic Tests Page 2 of 2				
4.5.2	Ski and ski suspension modifications okay?			
4.5.4	Ski suspension requirements ok?			
4.6	**Track, Track Suspension, and Traction**			
4.6.1	Track and track suspension modifications ok?			
4.6.2	Track suspension requirements ok?			
4.6.3	Traction control devices ok?			
4.6.5	Slide runners ok?			
4.6.6	Maximum track lug height ok?			
4.7	**Frame and Body**			
4.7.1	Rear snow flap ok?			
4.7.3	Foot Stirrups/Pegs ok?			
4.7.4	Seat ok?			
4.7.5	Body modification ok?			
4.7.6	Front bumper requirement met?			
4.7.7	Decal space requirement ok?			
4.7.8	Team number correct?			
4.7.9	Chassis Modification (requires explanation and analysis)			
4.8	**Ignition and Electrical**			
4.8.1	Disconnect tether ok?			
4.8.2	Kill Switch ok?			
4.8.3	User Selection Switches ok?			
4.8.5	Battery box requirements met?			
4.8.6	Head, tail, and brake lght requirement met?			
4.9	Component deletion requirement met?			

Inspector Printed Name				
Inspector Signature				

APPENDIX S
SAE Technical Standards

The SAE Technical Standards Board (TSB) has made the following SAE Technical Standards available on line, **at no cost**, for use by Collegiate Design teams. Standards are important in all areas of engineering and we urge you to review these documents and to become familiar will their contents and use.

The technical documents listed below include both (1) standards that are identified in the rules and (2) standards that the TSB and the various rules committees believe are valuable references or which may be mentioned in future rule sets.

All Collegiate Design Series teams registered for competitions in North America have access to all the standards listed below - including standards not specific to your competition.

See Clean Snowmobile Challenge Rule A2.20 “Technical Standards Access” for the access procedure.

SAE Technical Standards included in the CDS Rules

Baja SAE
J586 - Stop Lamps for Use on Motor Vehicles Less Than 2032 mm in Overall Width
J759 - Lighting Identification Code
J994 - Alarm - Backup – Electric Laboratory Tests
J1741 - Discriminating Back-Up Alarm Standard

Clean Snowmobile Challenge
J192 - Maximum Exterior Sound Level for Snowmobiles
J1161 - Sound Measurement – Off-Road Self-Propelled Work Machines Operator-Work Cycle

Formula Hybrid
J1318 - Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance and Service Vehicles
J1673 - High Voltage Automotive Wiring Assembly Design

Formula SAE
SAE 4130 steel is referenced but no specific standard is identified
SAE Grade 5 bolts are required but no specific standard is identified

Supermileage
J586 - Stop Lamps for Use on Motor Vehicles Less Than 2032 mm in Overall Width

SAE Technical Standards for Supplemental Use

Standards Relevant to Baja SAE
J98 – Personal Protection for General Purpose Industrial Machines – Standard
J183 – Engine Oil Performance and Engine Service Classification - Standard
J306 – Automotive Gear Lubricant Viscosity Classification - Standard
J429 – Mechanical and Material Requirements for Externally Threaded Fasteners – Standard
J512 – Automotive Tube Fittings - Standard
J517 – Hydraulic Hose - Standard
J1166 – Sound Measurement – Off-Road Self-Propelled Work Machines Operator-Work Cycle
J1194 – Rollover Protective Structures (ROPS) for Wheeled Agricultural Tractors
J1362 – Graphical Symbols for Operator Controls and Displays on Off-Road Self-Propelled Work Machines - Standard
J1614 – Wiring Distribution Systems for Construction, Agricultural and Off-Road Work Machines

J1703 - Motor Vehicle Brake Fluid - Standard
J2030 – Heavy Duty Electrical Connector Performance Standard
J2402 – Road Vehicles – Symbols for Controls, Indicators and Tell-Tales - Standard

Standards Relevant to Clean Snowmobile Challenge
J44 – Service Brake System Performance Requirements – Snowmobiles - Recommended Practice
J45 – Brake System Test Procedure – Snowmobiles – Recommended Practice
J68 – Tests for Snowmobile Switching Devices and Components - Recommended Practice
J89 – Dynamic Cushioning Performance Criteria for Snowmobile Seats - Recommended Practice
J92 – Snowmobile Throttle Control Systems – Recommended Practice
J192 – Maximum Exterior Sound Level for Snowmobiles - Recommended Practice
J288 – Snowmobile Fuel Tanks - Recommended Practice
J1161 – Operational Sound Level Measurement Procedure for Snowmobiles - Recommended Practice
J1222 – Speed Control Assurance for Snowmobiles - Recommended Practice
J1279 – Snowmobile Drive Mechanisms - Recommended Practice
J1282 – Snowmobile Brake Control Systems - Recommended Practice
J2567 – Measurement of Exhaust Sound Levels of Stationary Snowmobiles - Recommended Practice

Standards Relevant to Formula SAE
J183 – Engine Oil Performance and Engine Service Classification - Standard
J306 – Automotive Gear Lubricant Viscosity Classification - Standard
J429 – Mechanical and Material Requirements for Externally Threaded Fasteners – Standard
J452 - General Information – Chemical Compositions, Mechanical and Physical Properties of SAE Aluminum Casting Alloys – Information Report
J512 – Automotive Tube Fittings - Standard
J517 – Hydraulic Hose - Standard
J637 – Automotive V-Belt Drives – Recommended Practice
J829 – Fuel Tank Filler Cap and Cap Retainer
J1153 - Hydraulic Cylinders for Motor Vehicle Brakes – Test Procedure
J1154 – Hydraulic Master Cylinders for Motor Vehicle Brakes - Performance Requirements - Standard
J1703 - Motor Vehicle Brake Fluid - Standard
J2045 – Performance Requirements for Fuel System Tubing Assemblies - Standard
J2053 – Brake Master Cylinder Plastic Reservoir Assembly for Road Vehicles - Standard

Standard Relevant to Formula Hybrid
J1772 – SAE Electric Vehicle and Plug in Hybrid Conductive Charge Coupler

Standard Relevant to all CDS Competitions
J1739 – Potential Failure Mode and Effects Analysis in Design (Design FMEA) Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA) and Potential Failure Mode and Effects Analysis for Machinery (Machinery FMEA)