

2018 SAE CLEAN SNOWMOBILE CHALLENGE

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2018 SAE CLEAN SNOWMOBILE CHALLENGE

INTRODUCTION

This introduction is intended to highlight some revisions to the 2018 SAE Clean Snowmobile Internal Combustion (IC) Challenge Rules. Each year the CSC Rules Committee changes the rules to introduce a slightly different engineering challenge. This set of CSC Rules applies only to the IC categories including both spark ignited and diesel engine categories.

The Zero Emissions/Electric Category of CSC has been discontinued.

These highlights touch on only part of the revised text and do not replace or change the Rules. This summary, is a not a substitute for reading and understanding the Rules. We cannot stress it too strongly – read the Rules thoroughly and repeatedly.

2018 Changes

1. Requirement for a Speedometer Section 8.11
2. Design to Prevent Thermal Events 8.12
3. Regarding Diesel Fuel Lines 8.13
4. Change in format and content in the Engineering Design Report Section 10.4
5. Change in format and content of the Oral Design Presentation Section 10.7

2018 SAE Clean Snowmobile Challenge

ARTICLE 1: SAE CSC OVERVIEW AND OBJECTIVE

1.1 Event Description

The SAE International Clean Snowmobile Challenge (CSC) 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 CSC, sleds driven by only one **Internal Combustion (IC)** spark ignited engine and sleds driven by internal combustion compression ignition, **Diesel Utility Class (DUC)**

1.2.1 Competition Objective for Spark Ignited IC Engine Powered Snowmobiles

- 1.2.2 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 and to design a snowmobile that will primarily be ridden on groomed snowmobile trails

Snowmobiles in the competition must be “flex-fuel” capable. Gasoline fuels will have a “bio content” of corn-based ethanol of anywhere from 0% to 85%. Octane values could be 87 to 92. 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 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.

- 1.2.2 An additional objective of the competition is to improve on fuel economy. In addition to the Endurance Event described later within this document, fuel consumption 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.

1.2.3 Minimum Performance Requirements

Snowmobiles competing in CSC IC spark ignited must have the following minimum performance:

- Range – 100 miles without refueling
- IC Trail Speed – 45 miles per hour on a smooth trail
- IC Acceleration – Traverse 500 feet within 10 seconds from a standing start
- Designs that do not, in the sole opinion of the officials, have a responsible expectation of satisfying the minimum performance requirements will not be allowed to compete.

1.2.4 NO ECONOMY/PERFORMANCE MODES THIS YEAR.

Only one mode is allowed in CSC 2018. In keeping with the spirit of the CSC origins, teams are encouraged to design their snowmobile to be both fuel efficient and low emissions to the Yellowstone National Park standard of an E-Score of 175 or higher.

1.3 Competition Objective for the Compression Ignition Diesel Utility Class (DUC)

- 1.3.1. The intent of the Diesel Utility Class competition is to develop a snowmobile that is acceptable for use in environmentally sensitive areas such as our National Parks or other pristine areas using diesel technology rather than gasoline.

Diesel engines have higher torque capability and lower operating speeds which makes them less desirable for the higher powered and more traditional trail snowmobiles, but we want to overcome that battle in this competition. Due to clutch problems and heavier engines this class will NOT have an acceleration event. During, Endurance/Fuel economy event and the In-Service Emissions Event, the DUC sleds will be expected to maintain trail speeds of 35 mph.

- 1.3.2. The Diesel Utility Class (DUC) will still have the clean and quiet priorities of the CSC. EPA emissions requirements for off-road vehicles are fuel-neutral. Since higher, more noticeable emission particles (soot) are also a characteristic of diesel engines, there will be an additional emissions requirement for controlling soot.
- 1.3.3. The noise test will be the steady state test consistent with SAE J1161 with a speed of 35 mph.
- 1.3.4. Each of the four major snowmobile manufacturers (Arctic Cat, BRP, Polaris, and Yamaha) has a snowmobile in the Utility category, none of them offer a diesel option. It is a requirement that the starting point for the DUC be a snowmobile from one of these four manufacturers, that is no more than five years old and that the chassis is used in the Utility category for that manufacturer. The gasoline engine must be replaced by a diesel engine. The horsepower rating of the replacement engine must not exceed 130 hp, consistent with the traditional trail sled class.
- 1.3.5. The only fuel that will be allowed is diesel or bio-diesel up to 9%. No power boosters or on-board reformers will be allowed.
- 1.3.6. Minimum Performance Requirements
Snowmobiles competing in the DUC must have the following minimum performance:
- Range – 100 miles without refueling
 - Trail Speed – 35 miles per hour on a smooth trail
 - Acceleration – There is no acceleration requirement
 - Designs that do not, in the sole opinion of the officials, have a responsible expectation of satisfying the minimum performance requirements will not be allowed to compete.
- 1.3.7. NO ECONOMY/PERFORMANCE MODES THIS YEAR.
Only one mode is allowed in CSC 2018. In keeping with the spirit of the Clean Snowmobile Challenge origins, teams are encouraged to design their snowmobile to be both fuel efficient and low emissions to the Yellowstone National Park standard of an E-Score of 175 or higher.

ARTICLE 2: SAE CSC RULES AND ORGANIZER AUTHORITY

2.1 Rules Authority

The SAE Clean Snowmobile Challenge Rules are the responsibility of the SAE Clean Snowmobile Challenge Rules Committee and are issued under the authority of the SAE Education Board. Official announcements from the SAE or the organizers shall be considered part of, and shall have the same validity as these rules.

- 2.1.1 Ambiguities or questions concerning the meaning or intent of these rules will be resolved by the SAE Clean Snowmobile Challenge Rules Committee, SAE staff or by the individual competition organizers as appropriate.
- 2.2 Rules Validity**
The SAE Clean Snowmobile Challenge Rules posted on the SAE website and dated for the calendar year of the competition are the rules in effect for the competition. Rule sets dated for other years are invalid.
- 2.3 Rules Compliance**
By entering a SAE 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 SAE Clean Snowmobile Challenge Rules Committee, and the other organizing bodies.
- All team members, faculty advisors and other university representatives are required to cooperate with, and follow all instructions from, competition organizers, officials, and judges.
- 2.4 Understanding the Rules**
Teams 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.
- 2.5 Participating in the Competition**
Teams, team members as individuals, faculty advisors and other representatives of a registered university who are present on-site at a competition are considered to be “participating in the competition” from the time they arrive on-site until they depart at the conclusion of the competition or earlier by withdrawing.
- 2.6 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.
- 2.7 Right to Impound**
SAE and other competition organizing bodies reserve the right to impound any onsite registered vehicles at any time during a competition for inspection and examination by the organizers, officials and technical inspectors.
- 2.8 General Authority**
SAE and the competition organizing bodies reserve the right to revise the schedule of any competition and/or interpret or modify the competition rules at any time and in any manner, that is, in their sole judgment, required for the efficient operation of the event.
- 2.9 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 Series 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 be 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 on-site registration 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 G.

ARTICLE 3: INDIVIDUAL PARTICIPATION REQUIREMENTS

3.1 Eligibility Limits

Eligibility is limited to undergraduate and graduate students to ensure that this is an engineering design competition. High school students are prohibited.

3.2 Student Status

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

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.

3.3 University Collaboration

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

Teams which are formed with members from two or more Universities are treated as a single team. A student at any University making up the team may compete at any event where the team participates. The multiple Universities are in effect treated as one University and all eligibility requirements (one car per competition class, one registration slot, etc.) are enforced

3.4 Age

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

3.5 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.

3.6 Medical Insurance

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

3.7 Liability Waiver

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



3.8 SAE Membership

Team members must be members of SAE. Proof of SAE membership is required at the event. Information on SAE Student membership can be found on SAE's website:

www.sae.org/students

3.9 Individual Registration Requirements for North American Competitions – ACTION REQUIRED

3.9.1 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".

3.9.2 If you are not a member of SAE International, you will need to join SAE International online at www.sae.org.

- Select the "Join /Renew/Upgrade" link under the Membership tab, and then select "Professional or Student".
- 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.

3.9.3 All unaffiliated faculty advisors who are not SAE International members are required to create a free customer account profile on www.sae.org. Upon completion, please email CollegiateCompetitions@sae.org their assigned customer number also stating which event and university name.

3.10.1 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 www.sae.org:

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

If you need assistance in registering your team or affiliating yourself to the team registration page please visit the Frequently Asked Questions located online at <http://students.sae.org/cds/snowmobile/faq/>

Note: All students must affiliate themselves online by January 31 of the year of the competition. For additional assistance, please contact CollegiateCompetitions@sae.org.

3.11 On-site Registration Requirement

ON-SITE REGISTRATON IS REQUIRED OF ALL TEAM MEMBERS AND FACULTY ADVISORS.

- Bring your
 - (1) Government issued driver's license or passport
 - (2) your medical insurance card or documentation

ARTICLE 4: FACULTY ADVISOR

4.1 Status

Each team is expected to have a Faculty Advisor appointed by the respective 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.

4.2 Responsibilities

Faculty Advisors may advise their teams on general engineering and engineering project management theory.

4.3 Limitations

- The faculty advisor may not:
 - design any part of the vehicle
 - directly participate in the development of any documentation or presentation.
 - may not fabricate nor assemble any components
 - assist in the preparation, maintenance, testing or operation of the vehicle

ARTICLE 5: COMPETITION REGISTRATION

5.1 Registration

- Registration for SAE CSC must be completed online.
- Teams are required to select which class they will be participating in.
- Online registration must be done by either
 - a) an SAE member
 - b) the official faculty advisor connected with the registering university and recorded as such in the SAE record system.

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

5.2 Entries per University

Registration for the SAE Clean Snowmobile Challenge is limited to one vehicle per university in each category: Internal Combustion – ignition spark, Diesel Utility Class.

5.3 Registration Limit – 25 vehicles

Registration for the SAE Clean Snowmobile Challenge is limited to 25 snowmobiles.

5.4 Registration Dates

Registration for the competition will open at the date and time posted on the competition website. Registration for the competition will close at the date and time posted on the competition website. There are no exceptions to this registration policy.

5.5 Registration Fee

Payment for registration fee must be initiated within 48 business hours of team registration.

Registration fees are NOT refundable, nor deferrable to future competitions.



5.6 Team Member Affiliation

See Rule 3.9

5.7 Withdrawals

Registered teams for the competition that find that they will not be able to attend the competition are required to officially withdraw notifying CDS Staff at collegiatecompetitions@sae.org prior to the competition.

5.8 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.

Don't wait – apply early for your visa.

SAE staff nor any competition organizers are permitted to give advice on visas, customs regulations or vehicle shipping regulations concerning the United States or any other country.

5.9 Visa Requests

Affiliated CDS Student Team Members will have the ability to print out a Registration Confirmation Letter for the individual event(s) that they are attending. They will have the opportunity to print out their personalized letter with the following information: Student's Name, School's Name, the CDS Event Name, Official Dates and Location(s).

Note: Please be advised that SAE International cannot intervene with by calling or sending personal letters to the State Departments, Embassies or Consulates of the United States or other governments on behalf of any meeting or event participant.

5.10 International Participation - Vehicle Shipping/US Customs

- 5.10.1 SAE and the 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 competition organizers are not permitted to provide advice on U.S. Custom matters.

- 5.10.2 Vehicle shipments by commercial carrier must comply with the laws and regulations of the nations from which, and to which, the snowmobile is being sent. Teams are advised to consult with their shipping company or freight forwarder to be sure that their shipment fully complies with all relevant customs, import/export and aviation shipping requirements.

5.11 On-site Registration

All team members and faculty advisors must complete the on-site registration procedures immediately after they arrive at the competition site.

On-site registration must be completed and any credentials and/or other identification issued by the organizers properly worn before the car can be unloaded, uncrated or worked upon in any manner.

ARTICLE 6: REQUIRED DOCUMENTATION, DEADLINES AND PENALTIES

6.1 Team Program Information

Team program information including the picture will be taken from the 2017 event. New teams that have never competed or teams needing to provide updates should contact the organizer and provide a team picture.

6.2 Design Paper and MSRP Due on February 19, 2018

The final Engineering Design Paper, describing the modifications made to the snowmobile, and the final MSRP are due on February 19, 2018.

6.2.1 Engineering Design Paper

Teams must submit two (2) copies of their paper;

- one (1) copy in font 12 point following SAE Paper template
- one (1) copy in large font 16 point.
- Failure to submit both files will result in an incomplete submission.
- The reports must be uploaded to <http://saecleansnowmobile.com/>.

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 font document. Confirmation of successful submission is indicated by the submission box turning green.

6.2.1.1 File Format for Engineering Design Paper

Both copies of the Engineering Design Paper must be submitted in Adobe Acrobat PDF file format. No other file type will be accepted.

6.2.1.2 Naming Convention for Engineering Design Paper

Teams must include their team number and 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".

NOTE: Be sure when uploading files online you submit to correct submission areas.

6.2.2 Manufacturer's Suggestion Retail Price

- MSRP Assessments need to be uploaded to <http://saecleansnowmobile.com/>.
- 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.

NOTE: Late MSRP submissions 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. Confirmation of successful submission is indicated by the submission box turning green.

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.

6.2.2.1 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).

6.2.2.2 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".

6.3 Account Signup for Online Submission

Account creation for online document submission requires the following steps:

- Visit <http://saecleansnowmobile.com/>
- Follow the account signup instructions on the website. Select "Your Affiliation" as either "Team Captain/Team Advisor" or "Team Member (non-captain)"
- Your "authentication number" for online signup is the SAE confirmation number that was issued when your team registered.
- Once your team captain has created an account it will remain valid until your team becomes dormant or no longer registers to compete.

NOTE - There may be a delay of up to three (3) business days between the time your team registers for a competition and the saecleansnowmobile.com site recognizes the validity of your authentication number and the team captain may create an account.

6.3.1 Responsibilities and Restrictions

- Team Captain Role – Each team must have at least one person identified online as the Team Captain. The Team Captain(s) has unique responsibilities on the site including accepting other team members for site access. Until the captain accepts a member's signup that person cannot upload or view team documents. Team captains automatically have the same roles and privileges as their team members.
- Team Member Restrictions – Team members must be approved by the Team Captain or the Faculty Advisor before being able to view or upload team documents.
- Uploading Documents – All team members and the team captain have equal authority to upload and/or replace documents in the name of the team.
- Document Access – Uploaded documents can only be viewed by (1) members of the submitting team, (2) authorized judges, technical inspectors and officials and (3) CDS staff.

Note: Anything your team uploads to the site is considered to be an official action by your team.

6.3.2 Transfer of Team Captain Responsibility

If your captain is leaving the team, through graduation or otherwise, it is important that the departing captain "pass the baton" by designating one, or more, new captains on the saecleansnowmobile.com website. Only your team captain(s) has the authority to add team member

Note: your team can designate more than one captain. But before you do so, remember that all your captains will have equivalent authority on the saecleansnowmobile.com website.

SAE.org Website Actions	saecleansnowmobile.com Website Actions
<ol style="list-style-type: none"> 1. Register for competition 2. Update Team Website & Social Media 3. Pay Your Team Invoice 4. Affiliate all members through Team Profile 5. Reprint your Team Invoice 6. Print Registration Confirmation Letter 7. Print Participation Certificate 8. Print Fast Track Roster 	<ol style="list-style-type: none"> 1. Affiliate those Submitting Documents 2. Affiliate those Asking Rules Questions 3. Ask Rules Questions 4. Submit Required Documents

ARTICLE 7: QUESTIONS & GENERAL INFORMATION

7.1 Official Communications

Teams are required to read the published announcements by SAE and the other organizing bodies and to be familiar with all official announcements concerning the competitions and rules interpretations released by the SAE Clean Snowmobile Challenge Rules Committee.

Miscellaneous information on competition logistics and administration will be posted online any of the four forms of media below.

7.1.1 SAE Clean Snowmobile Challenge News

- News will be provided to students in all four forms of media:
- Emails to registered student members online www.sae.org
- Press releases published online at <http://students.sae.org/cds/snowmobile/news/>
- Rules updates published online at <http://saecleansnowmobile.com/>
- Challenge Public Discussion Forum on the SAE Website <http://forums.saecleansnowmobile.com/>.

7.2 Question Submission

Rules Questions are to be submitted online www.saecleansnowmobile.com.

7.3 Question Publication

By submitting a question to the SAE Clean Snowmobile Challenge Committee or the competition's organizer you and your team agree that both your question and the official answer can be reproduced and distributed by SAE, in both complete and edited versions, in any medium or format anywhere in the world.

7.4 Loopholes and Problems

Any perceived loopholes in or potential problems with the rules should be provided to organizers via the designated folder in the SAE Clean Snowmobile Challenge Public Discussion Forum on the SAE Website <http://forums.saecleansnowmobile.com/>. Suggestions for rule changes must reference the appropriate SAE CSC rule number, state the current wording of the rule, and contain a suggestion of how the rule should be changed.

7.5 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.

7.6 Participants' Discussion

A Participants' Discussion folder has been provided in the SAE Clean Snowmobile Challenge Public Discussion Forum on the SAE Website <http://forums.saecleansnowmobile.com/>. Participants are encouraged to use this folder to ask questions of and share information with other teams.

ARTICLE 8: SNOWMOBILE MODIFICATION

8.1 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 300 units.

- The model year of the base snowmobile must be from the model years 2014 to 2018 inclusive from one of the four major snowmobile manufacturers (Arctic Cat, BRP (Ski Doo), Polaris, or Yamaha).

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 of the competition 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.

8.2 Engine

8.2.1 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.

8.2.2 Permitted Fuels/Additives

Snowmobiles must be "flex-fuel" designs accepting ethanol fuel blends ranging from 0% to 85%. The actual content will not be revealed until after the competition is over. The content may vary from event to event. Octane values could range from 87 to 92.

Diesel powered engines must be flex-fueled with bio-diesel fuel ranging from B00 (0% bio-based) to B9 (9% bio-based).

All fuels will be supplied at the competition including fuels for emissions testing. **Gage Products** is the official fuel supplier for CSC and is offering to sell ethanol prior the competition for testing purposes. Contact Robert Patzelt at bpatzelt@gageproducts.com for price and delivery.

8.2.3 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.

8.2.4 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.

8.2.5 Exhaust Systems

The exhaust system may be modified. Any exhaust component that is exposed to human contact must be shielded (excluding the outlet end of the piping). Shields should protect the operator and bystanders from injury due to contact with piping.

The exhaust system, piping, and shields must NOT protrude more than 3 inches beyond the “outer envelope” of the snowmobile. The “outer envelope” is defined for this rule as the outer surfaces of the hood, bellypan, side panels, running boards, and bumpers.

8.2.6 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.

8.2.7 Fluid Containment

Containers chosen for use as reservoirs, overflow containers or as fluid plumbing of any kind must be of professional quality and meet the design requirements for material compatibility, temperature, and pressure.

Food or beverage containers are NOT suitable or acceptable for this purpose.

8.3 Block Heaters

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

8.4 Drive

8.4.1 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.

8.4.2 Transmission

IC engine snowmobiles must be propelled with a variable ratio belt transmission.

8.4.3 Brake Performance Requirement

All brake modifications are subject to retaining the braking performance of the original snowmobile and 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.

8.4.4 Brake Control Handle

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

8.4.5 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.

8.4.6 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.

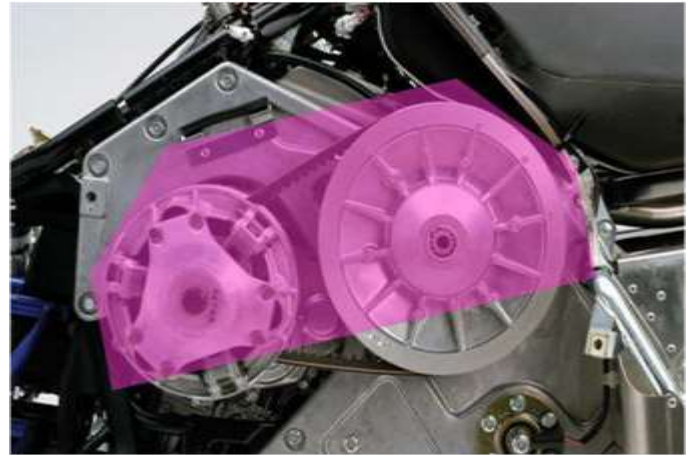
8.4.7 Belt Guard/Clutch Cover

The stock belt guard is acceptable provided that both of the following conditions are met:

- The engine has NOT been modified to exceed the manufacturer's recommended top rotational speed or horsepower.
- The clutches and parts (excluding weights, springs, and or ramps/helixes) are Original Equipment Manufacturer specific to the engine.

In all other cases, the stock belt guard must be replaced with a clutch cover. Fabricated clutch covers must be made of 0.090 inch 6061 T6 aluminum or equivalent. The clutch cover must be separate of the cowl configuration and be removable. The clutch cover must shield the operator (including knees, shins and feet) and bystanders from flying debris related to a belt/clutch failure. Specifically, straight-line paths (in the rotating plane of the CVT assembly) to the operator must be interrupted by the combination of the clutch cover and the foot rest/stirrup. The clutch cover must also extend below the mounting bolts of the clutch sheaves on the outboard side of the machine. There shall be no open areas wider than 0.5" or longer than 1.0" on the clutch cover or footrest. Stock footrests may require modification to meet this requirement.

Some examples of proper clutch coverage areas on several common chassis are shown:



Please submit any questions to the SAE Forum with regard to your specific engine/chassis application.

8.4.8 Moving Parts Isolation

Except for the Belt Guard and Clutch Cover mentioned in 4.4.7, 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.

8.5 Skis and Ski Suspension

8.5.1 Ski Requirements

Skis must be commercially available.

8.5.2 Ski and Ski Suspension Modification

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

8.5.3 Ski Runners

Carbide ski runners are allowed.

8.5.4 Ski Suspension Requirements

The following measurement procedure will be used to verify ski suspension travel:

- With the driver in the seated position, a measuring stick will be placed at the front bumper of the snowmobile. This point on the measuring stick will be noted as "Point A."
- With the driver still on the snowmobile, weight will be added to the snowmobile until the ski suspension is fully compressed. This point will be noted on the measuring stick as "Point B."
- The ski suspension travel is the distance from "Point A" to "Point B." The ski suspension travel must be equal to or greater than three (3) inches.
- Adjustments to the ski suspension (spring and damping) are allowed, provided the minimum ski suspension travel of 3 inches is maintained. There will be no loss of the 100 points "No Maintenance Rule" for ski suspension adjustments.

8.6 Track, Track Suspension, and Traction

8.6.1 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.

Commercially available pre-studded tracks from Camso are allowed. If used, Rule 8.6.3 does not apply.

Tracks specially modified by Camso will be allowed provided the part number and serial number from Camso are provided for verification at the competition. Tracks modified by any other individual or company will not be allowed.

8.6.2 Track Suspension Requirements

The following measurement procedure will be used to verify track suspension travel:

- With the driver in the seated position, a measuring stick will be placed at the rear bumper of the snowmobile. This point on the measuring stick will be noted as "Point C."
- With the driver still on the snowmobile, weight will be added to the snowmobile until the track suspension is fully compressed. This point will be noted on the measuring stick as "Point D."
- The track suspension travel is the distance from "Point C" to "Point D." The track suspension travel must be equal to or greater than three (3) inches.
- Adjustments to the track suspension (spring and damping) are allowed, provided the minimum track suspension travel of 3 inches is maintained.
- There will be no loss of the 100 points "No Maintenance Rule" for track suspension adjustments.

8.6.3 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.

8.6.4 International Engineering, Inc. (Woody's) official supplier for traction studs for CSC 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) 689-4911 ext. 108

8.6.5 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.

Only ice scratchers that do not have to be stowed when in reverse like the Slidekick design will be allowed.

8.6.6 Maximum Track Lug Height

The maximum height of track lugs is two (2) inches.

8.7 Frame and Body

8.7.1 Rear Snow Flap

A Rear snow flap is required.

If a team's base sled is a "touring" sled designed to travel on groomed snowmobile trails then the stock rear snow flap as provided by the manufacturer is acceptable. Off road or "mountain" sleds typically have rear snow flaps designed for that purpose and are much higher off the ground and are not acceptable. The rear snow flap design could affect the noise of the snowmobile. For this reason, we encourage innovation in this area.

Here are some guidelines to follow should your team decide to design your own rear snow flap.

- Be securely fastened to the tunnel or chassis (a snow flap that falls off or is inadequately held on to the snowmobile during competition will incur penalties for safety and repair).
- Be wider than the track of the snowmobile. Tapered or shaped snow flaps are allowable provided that the narrowest point is wider than the track.
- Be in close proximity (one inch or less) to the ground when the lightest operator is on the machine.
- Be adequately rigid (or massive) to remain in close proximity with the ground during high-speed operation.
- Be adequately supported so that the flap does not get drawn into the track during reverse maneuvers (if so equipped).

Snow flaps in question will be dynamically tested. Snow flaps that are deemed to not meet the above criteria will not be allowed.

Snow flaps from prior year competition do not necessarily meet the above requirements and are not "grandfathered in".

8.7.2 Foot Stirrups/Pegs

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

8.7.3 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.

8.7.4 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.

8.7.5 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).

8.7.6 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.

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

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.

The numbers on the hood sides must be six (6) inches high, $\frac{3}{4}$ inches wide.

The numbers on both sides of tunnel, minimum of four (4) inches high.

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

8.7.8 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 300 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.

8.7.9 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 $\frac{3}{8}$ -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.



8.8 Ignition and Electrical

8.8.1 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.

8.8.2 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.

Note: The reason for this type of kill switch is to provide a common safety feature for judges and organizers on all the competing sleds. In the event of an emergency, drivers as well as judges and organizers should all know how to disable a snowmobile.

Below are examples of available Kill Switches that meet the requirements:

(A) 01-171 Ski-Doo kill switch available at

<http://www.mfgsupply.com/m/c/01-171.html?id=UxSI4Vzn>



(B) Aftermarket WPS#27-0152 or 27-0124

<http://www.parkeryamaha.com/index.asp?PageAction=PRODSEARCH&txtSearch=27-0152&Page=1>



(C) A Stock Polaris # 4110106



8.8.3 User Selection Switches

Non-standard user selection switches must be identified.

8.8.4 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.

8.8.5 Battery Box Requirements

All batteries will be of a sealed, maintenance-free, design. Appropriate batteries include Valve-Regulated Lead Acid (VRLA) technology, such as gel or absorbed glass mat (AGM) types. Flooded/wet-cell batteries are NOT allowable. If there is a question about the battery, teams will be required to present the data sheet and MSDS for their battery upon judge's request.

A single wire (4AWG or smaller) is the only connection allowed to each battery terminal. Any power distribution that is required must be done downstream of the battery using a shielded/insulated terminal strip, connector, or fuse block. The single wire connecting to the positive terminal of the battery must be fused upstream of the aforementioned power distribution. Fusing must be sized according the wire gage used. Circuit breakers or auto-resetting circuit protection are not allowable.

Both terminals of the battery and connected wiring must be shielded/insulated with a non-conductive boot. The negative terminal of the battery must be grounded to the chassis.

The battery must be securely held in place so that the battery does not shift or become dislodged in the event of an accident. The battery may be contained in a box if desired, provided that it is vented and non-conductive. Battery boxes do not, by themselves, satisfy the requirements of securing the battery and shielding/insulating the battery terminals.

8.8.6 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.

8.9 Component Deletion

No changes are allowed that would nullify compliance with federal, state, or provincial safety regulations. This includes removal or bypassing emissions components/systems required by the EPA.

8.10 Fire Extinguishers

Each team must have two (2) 0.9 kg (2 lb.) ABC dry chemical/dry powder or 1.75 liters Aqueous Film Forming Foam (AFFF), fire extinguishers.

One must be mounted on the rear of the sled and be easily accessible by course workers. This mount must be securely fastened to the vehicle frame and it must resist shaking loose over rough terrain, while allowing the course workers to remove it easily if necessary. If the fire extinguisher falls off the snowmobile during an event a 50-point penalty will be charged to the team.

The second must be brought to technical inspection with mounting accessories; it will be used as a replacement if needed.

All fire extinguishers must be equipped with a manufacturer installed dial pressure gauge. The gauge must be readable and indicate a full charge. Extinguishers of larger capacity are acceptable.

Except for the initial inspection, one extinguisher must readily be available in the team's paddock area, and the second must accompany the vehicle wherever the vehicle is moved. Both extinguishers must be presented with the vehicle at Technical Inspection. Fire extinguishers must be labeled with school name and vehicle number.

8.11 Speedometer Requirements

- a. GPS-based
- b. Readout in Miles per Hour (MPH)
- c. Minimum size on the readout (0.25" numeral height or larger).
- d. Powered by the sled (not batteries)
- e. Securely mounted in an area visible to the driver (no tape or velcro)

8.12 Design to Prevent Thermal Events

Any material added to the sled in a high temperature area, such as under the hood, near the engine, exhaust, or near the catalytic converter, must be verified to withstand the temperatures without melting, changing dimensions during the competition, or catching on fire. Material added must be verified through submission of a Material Safety Data Sheet (MSDS) and thermal data taken near the area where the material was added.

The organizers reserve the right to question any potentially suspect design and request documentation that the design is properly engineered.

8.13 Regarding Diesel Fuel Lines

SUPPLY SIDE

- If the engine being used has high pressure (HP) fuel lines this must be revealed to the organizers at the time of registration or as soon as the decision has been made by the team to use an engine with high pressure fuel lines but no later than January 1, 2018.
- Teams must submit an explanation of how they will maintain the integrity of the high-pressure fuel line. Where possible, only production high pressure fuel lines along with their clamps and dampers should be used.
- HP lines on engine must have shield/guard to prevent cracked line from allowing fuel direct line of sight to students/competitors
- All student lines should have vibration modal analysis performed on them to understand

line natural frequency

- Clamping/dampers should be used to keep line vibration below 150-micron displacement

RETURN SIDE

- Fuel line used on return side must be metal or rubber line with SAE/ISO certification for 150C minimum

ARTICLE 9: CONDUCT OF THE EVENT

9.1 Snowmobile Operating Requirements

9.1.1 Technical Inspection

A Technical inspection of each snowmobile will be performed on Monday, March 5, 2018 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.

Teams that do not show up with their snowmobile and register on Monday, March 5, 2018 will not be allowed to compete the remainder of the week.

Any team that does not pass technical inspection on Monday, March 5, 2018, will not compete in the Endurance Run on Tuesday, March 6, 2018 and will forfeit their 100 point no-maintenance bonus (Rule 9.3 below).

- Technical inspections will not be performed on Tuesday, March 6, 2018.
- Technical Inspections will re-open Wednesday morning.

Check in and technical inspection times for Monday for each team will be posted prior to the competition.

- Teams must show up at their scheduled time to register and be ready for tech inspection at that time.
- The penalty for not showing up on time will be 10 points per hour.
- After 4 hours (40 points) the team will not be eligible to compete in the Endurance Run on Tuesday, March 6, 2018.

Teams that fail to pass their first Technical Inspections by 4:00 pm Wednesday will be disqualified from the remaining events. Only re-inspections of snowmobiles which had previously passed their first technical inspection will be performed after 4:00pm Wednesday.

- 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. New this year is a formal Emission Test Preparation Inspection where teams will be checked for proper fuel and coolant connectors along with exhaust sample probe configuration.

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 outside of the competition. It is the sole responsibility of participating teams to ensure that their snowmobiles are safe for entry in the competition.

9.1.2 Disconnect Tether and Kill Switch

Each snowmobile must be equipped with a disconnect tether and a separate kill switch as described in Rules 8.8.1 and 8.8.2. Twenty-five (25) penalty points will be assessed each time the tether is not properly utilized when the engine is on.

9.1.3 Moving Snowmobiles and Test Drives/Practice

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.

Test drives may only be made

- after the sled has passed technical inspections
- during scheduled practice periods
- in practice areas designated by the organizers.
- Teams operating their sled outside the hours and areas designated by the organizers will be disqualified from the competition.

9.1.4 Support Snowmobiles

Team support snowmobiles may be allowed during certain events. The equipment listed in Rules 9.2 to 9.3 must be worn at all times any team member is on any snowmobile that is in motion.

The same penalties described in Rule 9.2.4 will be applied to team support snowmobiles.

Keweenaw Research Center Test Course guidelines (available upon request) apply to all support snowmobiles.

9.1.5 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.

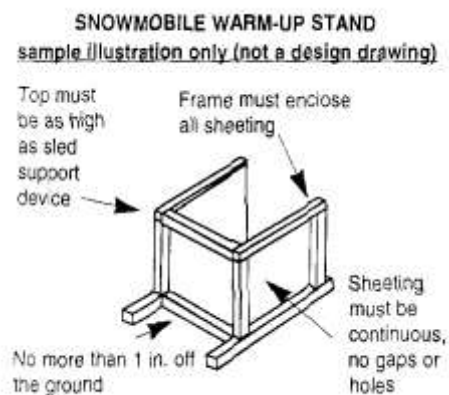
The warm-up stand must be designed to catch and retain track, track cleats, traction components and other items that might be thrown by the track.

- 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).



9.2 Driver Protective Equipment

9.2.1 Helmet Requirement

Full coverage helmets that meet Snell 2005 or ECE Regulation 22, Rev. 4 (or newer) are mandatory.

- Helmet modifications (custom paint, decals, Mohawks, POV cameras, etc.) are not allowed.
- Helmets not meeting requirements may be impounded for the duration of the competition.
- The helmet must be worn and securely fastened by all drivers whenever operating a snowmobile.
- Eye protection is required
- Helmets may be equipped with a chin or full-face guard that pivots or flips up for the rider's convenience.
- These structures are considered integral parts of the helmet and helmets equipped with them must always be used in their downward locked position, or in accordance with the instructions from the manufacturer.

9.2.2 Clothing and Boots

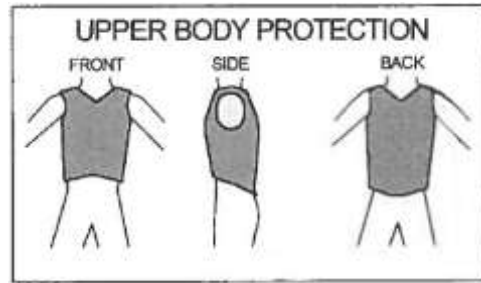
Gloves and clothing, along with boots (above the ankle) are mandatory.

- 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.
- The above apparel must be worn by all drivers whenever operating a snowmobile.
- Shin/knee guards are mandatory and must be worn on both legs.

- Shin /knee guards must extend from the top of the boot to above the kneecap, and be constructed of an impenetrable material.

9.2.3 Jacket/Vest

A jacket or vest that conforms to International Snowmobile Racing guidelines must be worn by drivers during all competition events to protect the upper body. A sample illustration of approved upper body protection is provided below (courtesy of the International Snowmobile Racing Association):



Typical motocross/ATV chest protectors do NOT satisfy this requirement.

9.2.4 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.

9.3 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:

- At the conclusion of the Endurance/Fuel Economy Event
- 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:

- Those required to fix compliance issues, in which case the one hundred (100) point bonus is forfeited but no additional penalties will be assessed.
- 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.
- Those considered standard maintenance items as described in Rule 9.4, 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. The team will not be eligible to receive any awards for events won after the strategy change.

9.4 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.

Changes in suspension to accommodate rider weight will be allowed without losing the 100-point bonus pertaining all requirements are met in Rule 8.5.4 and 8.6.2.

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 9.3 above.

- Addition of any fluid – same fluid must be used throughout competition
(NOTE: adding significant amounts of coolant will not be considered standard maintenance)
- 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.
- 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.

Engine swaps: We will allow engine parts to be replaced during the competition. The penalty points for replacing engine parts is as follows providing the design of the engine compared to that which was presented at technical inspection is not changed:

Example list:

- Spark Plugs: 5 points per plug
- Fuel Injectors: 5 points per injector
- Piston: 10 points per piston
- Crankshaft: 50 points
- Crankcase: 50 points
- Connecting Rods: 10 points
- Cylinder: 50 points
- Head Gasket: 5 points
- Turbo Charger: 50 points
- Total engine: 200 points

Items not listed will be individually evaluated.

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.

9.5 Fuel at Competition

Teams are required to power their snowmobile with the fuel provided throughout the competition by Gage Products, Inc. Teams are required to use the provided fuel for all events. Teams are not allowed to drain their tanks prior to or after any event. Organizers may decide to top off snowmobile fuel tanks before an event.

9.6 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.

9.7 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.

9.8 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.

9.9 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.

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.

9.10 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.

9.11 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 10: SCORING

10.1 Overall Score

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

Internal Combustion Class Spark Ignited Event	Minimum Points for Minimum Performance	Maximum Points for Relative Performance in Event
Engineering Design Paper	5	100
Manufacturer's Suggested Retail Price (MSRP)	2.5	50
Lab Emissions	10	300
Brake Specific Fuel Consumption	0	50
In-Service Emission	2.5	50
In-Service Fuel Economy	0	50
Oral Presentation	5	100
Fuel Economy & Endurance	5	200
Weight (no points in CSC2016)	0	0
Acceleration	2.5	50
Objective Handling	2.5	50
Subjective Handling	2.5	50
Cold Start	2.5	50
Static Display	0	50
Objective Noise	3.75	150
Subjective Noise		150
No-Maintenance Bonus		100
Total Points	43.75	1550

Diesel Utility Class Event	Minimum Points for Minimum Performance	Maximum Points for Relative Performance in Event
Engineering Design Paper	5	100
Manufacturer's Suggested Retail Price (MSRP)	2.5	50
Lab Emissions	10	300
Brake Specific Fuel Consumption	0	50
In-Service Emission	2.5	50
In-Service Fuel Economy	0	50
Oral Presentation	5	100
Fuel Economy & Endurance	5	200
Draw Bar Pull (new)	5	100
Acceleration plus Load	5	100
Cold Start	2.5	50
Static Display	0	50
Objective Noise	3.75	150
Subjective Noise		150
No-Maintenance Bonus		100
Total Points	46.25	1600

10.2 Event Points

The team having the best score in each of the events will be awarded points as described in each event below. Teams finishing behind those leaders will be awarded proportionally fewer points according to a linear scale.

No negative points other than as a result of penalties will be awarded.

Points will be granted to teams that meet the minimum requirements of an event. The minimum requirements are outlined in each event that follows.

10.3 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.

10.4 Engineering Design Paper

10.4.1 Engineering Design Paper Description

- **Introduction** – this part of the report has traditionally included rhetoric regarding the controversy over snowmobiles in Yellowstone. Despite some rumors to the contrary,

snowmobiles were never banned from Yellowstone National Park. For the SAE CSC Design Report, no Introduction section is required. If incorrect or unsubstantiated statements are made in the design report, points will be deducted.

- **The first section of the report will be titled “Innovations.”** For returning teams, this section must include all the changes and innovations made to the snowmobile compared to the previous year’s entry. If the base snowmobile chassis or the engine is different, state this in this section. Also label and include any part of the snowmobile that includes an innovative design approach or part. This section will be used to collect information regarding awards that key in on innovation. If it is not mentioned in this section, it will not be considered for an innovation award. For first year teams, simply include innovative approaches and parts in your new entry.
- **The second section of the report will be titled “Team Organization and Time Management.”** In this section, describe how the team was formed, who is in charge and of what, and how timelines were set and monitored from start of the project to the first day of competition. Include Gantt charts and Organizational chart were appropriate. In addition to the actual project organization and timelines, include any outreach activities related to the team for fund raising, team building, or other educational purposes.
- **The third section** should include an accurate description of the build items of the competing snowmobile and should be in this order:
 - Chassis – Manufacturer, Model, year of production
 - Engine – Manufacturer, Fuel, (Gasoline or Diesel) Model, 2-stroke or 4-stroke, combustion volume in cubic centimeters, peak horsepower (note if horsepower is estimated from specifications or measured by the team).
 - Track – Manufacturer, style, supplier of traction studs if used
 - Muffler – Manufacturer or student designed
 - Catalytic Converter – Manufacturer, style
 - Skis – Stock or aftermarket
 - Other significant additions to the snowmobile

The remainder of the report should include discussions of the design content of the snowmobile to address the major design objectives of clean, quiet, and fuel efficient.

An absolute limit of **fifteen (15) pages** will be strictly enforced, except as noted below for papers submitted in alternative accessible formats.

Innovation is weighted more heavily in the scoring sheet than in past competitions. A maximum of 25 points can be awarded for innovation.

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 two column standard format for SAE technical papers. The format for SAE technical papers is available on-line through the SAE website at: www.sae.org

10.4.2 Engineering Design Paper Scoring

Engineering design paper judges will be a combination of professionals with a technical background in Engineering, land management, other fields related to the snowmobile industry. A sample engineering design paper judging form is located in the Rules Appendix. The weighting of points in each category is noted on the form.

The minimum requirement to receive points in this event will be to submit a paper according to the

rules. The average of the judges' score will be the points awarded in this event. In the event that the judges' average score is less than 5 points, the team will receive 5 points.

Penalty points for late design papers will appear in the penalty section of the score sheet and not reduce the team's design paper score.

10.5 Manufacturer's Suggested Retail Price (MSRP)

- 10.5.1 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.

- 10.5.2 Base sled for starting point of MSRP must be 2018 Model Year regardless of the model year of the sled.
- 10.5.3 MSRP must reflect engine choice first.
- 10.5.4 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.
- 10.5.5 MSRP must reflect all factory options included on competition sled (Electric Start, Reverse, etc.).
- 10.5.6 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 (2017 base sled * 60% will be used to calculate base MSRP for electric and diesel-powered sleds only).
- 10.5.7 All MSRPs must include the following additions to meet competition goals:
- Catalyst (if used)
 - Sound treatment
 - Mufflers more than stock or stock muffler that is significantly more complex than original production unit.
 - Studs
 - Additional coolers, intercoolers
 - Secondary air pumps, plumbing

- Diesel engines added to sleds

10.5.8 All base sled modifications must be listed (may or may not add to base MSRP).

Examples include:

- Ski changes
- Suspension changes
- Track substitution
- Fuel tank modification, replacements
- Battery boxes
- Miscellaneous changes for lights, hand warmers, aesthetics, etc.
- Fuel pumps, regulators, injectors for ethanol fuels
- Engine calibration hardware and software
- Engine mounting brackets, hardware.

10.5.9 Value of each modification on MSRP must be estimated.

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

10.5.9.2 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.

10.5.10 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.

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

- Manufacturing quotes plus 50%
- Wholesale plus 50%
- Retail price for added component, feature or difference between substituted components.
- A justified estimate of manufacturing cost differences between components plus 50% mark up for increased value to customer.

10.5.12 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.

10.5.12.1 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.

10.5.12.2 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 believed 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.

10.5.13 MSRP Scoring

Scoring for the MSRP will be based on a combination of objective and subjective methods.

The objective part will consist of twenty (20) points to the team with the lowest MSRP after review and correction by the judges. The other team scores will be determined by a linear fit from the lowest to the highest MSRP. The highest MSRP will receive zero points.

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

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

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 and accurate MSRP will be ineligible to receive the awards for Most Practical Solution and Best Value.

The minimum requirement for a score in this event is to submit a MSRP according to the rules. In the event that through the above evaluations the team's score is less than 2.5, the minimum score of 2.5 points will be awarded.

Penalties for late submission of the MSRP will appear in the penalty section of the score sheet and not reduce the team's MSRP score.

10.6 Lab Emissions Event

10.6.1 Purpose of Lab Emissions Event

The purpose of this event is to determine the exhaust emissions generated by each snowmobile at predetermined operating conditions following guidelines currently issued by the EPA. The Clean Snowmobile Challenge departs from EPA protocol for evaluating emission test results by requiring a more stringent test which includes NOx and Soot.

10.6.2 Lab Emissions Event Description

Brake-specific (g/Kw-hr) emissions will be measured using laboratory-grade instrumentation and a Land & Sea DYNO-mite dynamometer. Total hydrocarbons (THC), Carbon Monoxide (CO) and

Nitrogen Oxides (NO_x) will be measured to determine an “E-Score”. Soot will also be measured and scored.

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.

Important Note: The Ramped Modal Cycle (RMC) emission test was demonstrated in 2015 and used for the majority of tests in CSC 2016. This is an alternative EPA emission test procedure that requires a 20-minute continuous run. The Ramped Modal Cycle test procedure will be the Lab Emission test procedure. Only if an engine is unable to run the RMC will the 5-Mode test procedure be used. Historically, engines which are unable to run the RMC are not tuned well and have poor emissions.

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 the endurance event they will be required to make up the difference on a closed course at KRC before moving on to the emission events, regardless if the sled design includes a catalytic converter or not.

At Technical Inspection, teams must provide a filled-out Emission Data Sheet. A sample Emissions Inspection Form, which will be filled out by a Technical Inspector, can be found in the Appendix. A member of the emission testing team will be available to collect the forms and answer questions. The information on the Emission Data Sheet is used for setup and scheduling so the emissions testing can be conducted as efficiently as possible.

Teams will prep their sled for the Lab Emission Event and then turn it over to the Emission Test personnel. The Emission Test personnel will complete the fuel and coolant hookups, mount the dyno, and install instrumentation. Team members can observe and must be available to answer any questions, but team members will be hands-off unless specifically requested by the event coordinator. The EPA protocol for engine warm-up will be followed.

The power curve for the engine will be determined by the Lab Emissions test crew prior to the Lab Emission test. Developing a power curve requires wide open throttle (WOT). If a team does not want their engine to exceed a particular engine rotational speed in that test, they must program a rev limiter into their engine controls.

10.6.2.1 Lab 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) **Dynamometer.** A 9” DYNO-mite Dynamometer for snowmobiles must be able to be installed with the engine in the sled.

- 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 cannot be tested and will receive zero points for the event. 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. Note: A variety of shaft diameters and tapers are being used snowmobile manufacturers and the DYNO-mite does not properly fit all configurations. Teams must contact the event coordinator if there is any question about the mounting of the dyno.
- 2) **Exhaust Gas Sampling.** A correct sample probe and sample port 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.** Accurate fuel flow data are required to make brake-specific emissions measurements. A test facility fuel system will be used during the lab emission event.
 - a. The test facility fuel lines (supply and return) connect to the engine fuel system via -6 AN fittings. Only -6AN fittings will be allowed (not gender specific). Fuel line length must be sufficient that the -6AN fittings can be accessed outside the body of the snowmobile to prevent fuel spillage on or into the sled, especially around hot components.
 - b. The test facility can supply fuel at 3-60 psi and there is a return line. Teams will be required to supply their own external high-pressure fuel pump and pressure regulator if the facility system is insufficient for their engine. In-tank pumps and regulators cannot be used during the emission events because fuel consumption cannot be accurately measured. Electric fuel pumps must be de-energized when the safety tether is pulled.
 - c. Teams must be familiar with their fuel system so they can direct test personnel on where/how to regulate pressure. Teams must be able to explain how to purge any entrapped air after hookup and verify the system is at the correct operating pressure when on the facility fuel supply.
- 4) **Supplemental Cooling.** The lab emission event is conducted with the sled on a test stand and at ambient room temperature. Supplemental cooling is typically required to satisfy the cooling requirements normally provided while a sled is operating at speed in cold conditions. For the lab emission event, components susceptible to scorching or melting may be removed, i.e. seat, track, cowlings, fairings.
 - a. **Engine Cooling.** The facility will have a closed loop cooling system available for primary engine cooling. The system consists of a plate heat exchanger with one (1) inch diameter hoses which interface with the sled through -16 AN fittings. The system is set to provide a 50-50 ethylene glycol solution at 115°F returning to the engine. **This is the only coolant system available at the event. Teams with coolant needs other than 50-50 ethylene glycol solution will not be able to connect to this system.**
 - b. **Auxiliary Air Cooling.** Sleds undergoing a static test at room temperature may require an external air flow to keep parts cool which would normally occur during operation at speed in a cold environment. The emission test facility will have outside air directed to the front of the sled and a large hood at the rear of the sled, pulling across the sled.

NEW THIS YEAR: Teams are allowed to have one fixed electric (120V, 15-amp max) fan to blow on their engine. Team member held fans are no longer permitted. Oscillating fans are not permitted.

10.6.2.2 Exhaust Gas Sampling Probe and Port:

Each sled in the competition is required to have a removable exhaust gas-sampling probe and a permanent exhaust gas sample port. The same probe and port are used for both the lab and in-service emission events. The probe and port design and installation specifications include:

1. The probe will be a 3/8-inch OD stainless steel tube with 0.049-inch wall thickness (0.277-inch ID). One end of the sampling probe is cut on a 45-degree angle and the open portion of the tube will face upstream in the exhaust pipe. Both ends of the tube must have a standard 3/8 Nut-Ferrule set (Swagelok SS-600-NFSET).

The overall length and configuration (bends) of the probe is dependent on the engine/exhaust/sled. A heated sample line must connect to the end of the probe and its location and routing must be taken into consideration for the in-service event where the cowling is down and the heated sample line must run from the sleigh to the probe.

2. An adapter which mates with the exhaust probe must be welded to the exhaust pipe to create the sample port. Swagelok fitting SS-600-1-4BT shall be used as the sample port.



Swagelok Plug SS-600-P is used to cap the port when the probe is not installed. Alternatively, a short probe can be left in place and capped with a Swagelok SS-600-C.

The adapter (sample port) must be welded to the exhaust to provide a leak-free joint (do not use epoxy as shown in the photo).

Probe and sample port 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 or seven diameters, whichever is greater.

The reason the exhaust probe needs to be at least 12 inches or seven diameters 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 or seven diameters 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.

Exhaust Extensions. Rule 8.2.5 states the exhaust pipe must not protrude more than three (3) inches. In some cases, for the emission events an exhaust system extension is required to satisfy the 12 inches or seven diameters upstream requirement for the sampling location. If an exhaust extension is to be used only for the emissions event, then the exhaust pipe connections must be made with a Marman V-band clamp and flanges. The Marman style joint is a leak-free connection while providing the structural integrity required to withstand the conditions encountered during the in-service event. (One source for Marman clamps is Detroit Flexible Metal at www.hosenow.com).

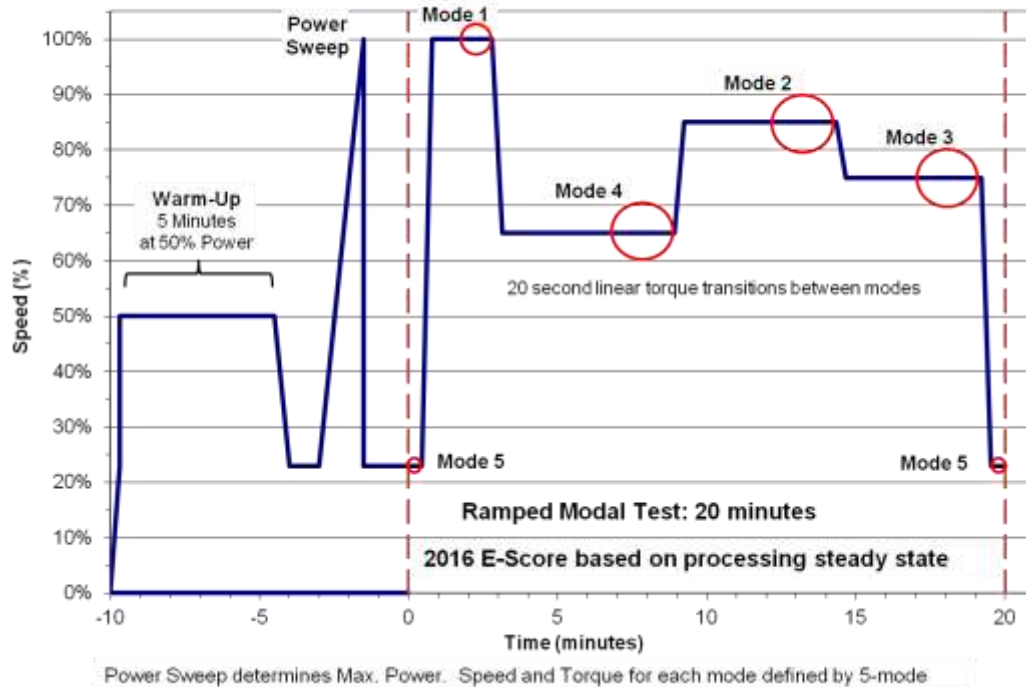


10.6.3 Lab Emissions Test

Teams should be prepared to test under the Ramped Modal Cycle currently adopted by the EPA 40 CFR Part 1051 dated November 8. This cycle is shown below for reference.

RAMPED MODAL CYCLE				
Sequence	Speed %	Torque %	Min. Time (seconds)	Mode
1a	Warm Idle	0	27	Mode 5
1b	Linear Transition	Linear Transition	20	
2a	100	100	121	Mode 1
2b	Linear Transition	Linear Transition	20	
3a	65	19	347	Mode 4
3b	Linear Transition	Linear Transition	20	
4a	85	51	305	Mode 2
4b	Linear Transition	Linear Transition	20	
5a	75	33	272	Mode 3
5b	Linear Transition	Linear Transition	20	
6	Warm Idle	0	28	Mode 5

CSC2016 LAB EMISSION TEST



The CSC Lab Emission measurement differs from EPA protocol. For the RMC the EPA processes data for the entire 20-minute test. CSC processes only a portion of the steady state conditions so that comparisons can be easily made to the discrete-mode test. The RMC duty cycle uses time as a weighting factor. With the CSC version of the RMC, the steady state measurements will be weighted in the same manner as the discrete-mode test. Engines that cannot run the full RMC will be retested under the discrete-mode conditions and will be penalized 50 points. The penalty occurs because teams have been informed well in advance of the testing they will need to undergo and they should prepare for this test during their engine development. Failure to complete the RMC occurs when an engine stops. The judges of the Laboratory Emissions Event may decide to run a steady state test at their discretion, without penalty to the team.

5-MODE DUTY DISCRETE CYCLE			
MODE	Speed %	Torque %	Weighting Factor
1	100	100	0.12
2	85	51	0.27
3	75	33	0.25
4	65	19	0.31
5	IDLE	0	0.05

The discrete-mode emission test 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.

The emissions staff reserves the right to reduce the number of modes run at the time of emissions testing if available testing time is limited, i.e., only three modes may be run but to be fair to all participants, the specific modes will not be identified until the first emissions test begins. Test modes will be run in order, from highest to lowest speed. One hundred (100%) percent engine speed and 100% torque are defined as the point at which maximum power occurs.

Per EPA regulations, attempts to modify operating conditions for or during the emission event will lead to disqualification. For example, activating a different engine map during emission testing is prohibited. Suspected violators may be re-inspected and re-tested at any time, which may include testing at points other than the five defined modes.

Horsepower Limit. Engines that exceed 130 horsepower in the Power Sweep will be disqualified from the competition. See Rule 8.2.1.

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. **NEW THIS YEAR** a weighted value of 50 mg/kw-hr as the upper limit for all engine types. Engines that exceed this soot limit will fail the emissions event but not the BSFC event.

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.

10.6.4 Lab Emission Test Considerations

Snowmobile engines are operated at high power levels during lab 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. The thermal issues associated with high power and a static, room temperature environment deserve careful consideration.

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

The operating conditions for a sled should be known and understood. Flow diagrams of both the fuel system and cooling system should be readily available in case issues arise when hooked up to the test facility systems. Test facility personnel will assist in diagnosing problems but the lack of information slows down the process and places teams in jeopardy of a no-test per the 20-minute repair rule stated above.

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.

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.

10.6.5 Lab Emissions Event Scoring

Lab emissions scoring will be modeled after the original EPA standards for 2016 snowmobiles that include NO_x in the calculation. The engine must pass the soot limit of 50 mg/KW-hr. Extra points will be given for passing a threshold of an E-Score of 175 or higher as shown in the graph below.

The minimum performance to receive points in the Lab Emission test is to generate power for which ten (10) points will be awarded. Additionally, if the engine completes the 5-mode test an additional 10 points will be awarded. If the engine passes the EPA set limit of (E-score = or >100) then instead of the minimum points, the points awarded will be based on the E-score.

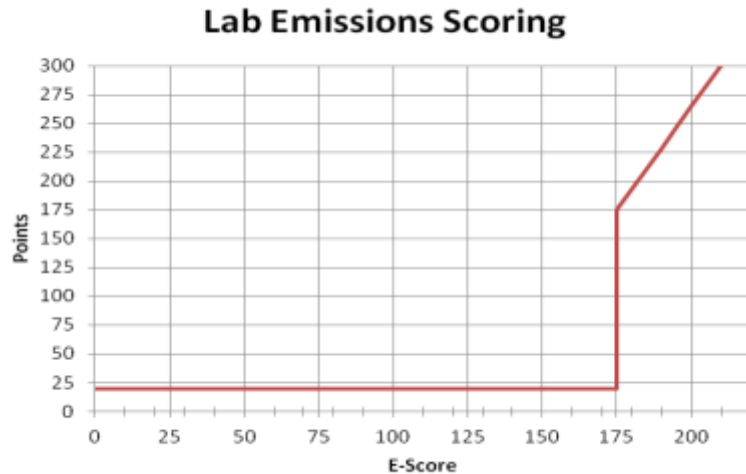
An E-Score is calculated according to the following formula:

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

Where: E = E-Score (theoretical maximum value is 210)
HC, NO_x, and CO is the calculated brake specific emissions in g/Kw-hr

Point calculation for Lab emission event:

	<u>Points</u>	<u>Comments</u>
Generate power on the dyno	10	Minimum points for competing
Complete Lab Emission test	10	Award for completing test but failing to achieve E Score of 100
Pass Soot <50mg/kw-hr	0	Required
Pass HC+NO _x <90 g/kw-hr	0	Required
Pass CO<275 g/kw-hr	0	Required
Fail RMC, pass discrete mode	-50	Penalty for unable to run RMC
Pass EPA test E score =175	175 to 210	E score = points
Pass E score >175	0 to 90	Additional points linear from E=175 to E=210



10.6.6 Brake Specific Fuel Consumption

Brake-specific fuel consumption (BSFC) will be calculated for each mode of the lab 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 worst (highest) BSFC will receive two and one-half (2.5) points.

The scores for the remaining teams will be a linear interpolation between the high and low scores.

They minimum requirement for points in this event is to complete all 5 modes of the emissions test for which 10 points will be awarded in the Lab Emission score.

10.7 Oral Design Presentation

10.7.1 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 major goal of the presentation is to demonstrate the team's ability to make a professional and technical presentation to the judges. Using the report as a general outline the topics of Innovation, Team management should be covered. Test results are critical to success and should be presented in a clear and concise manner. Lack of real data will result in loss of points. 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!**

10.7.2 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 average of the judges' scores for each team will equal the points awarded to that team on a 100-point scale weighted as described in the sample judging form.

The minimum performance level for this event is presenting the oral design presentation. If the average of the judges' presentation score is less than 5 points, the team will receive the minimum performance level score of 5 points.

10.8 Fuel Economy & Endurance Event

10.8.1 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.

10.8.2 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. The organizer will be responsible for hauling the snowmobiles back to KRC. 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.

The DUC sleds will run separately and slower than the IC gasoline class sleds and pull a load of about 250 pounds.

10.8.3 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 the 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.

Snowmobiles reaching the end of the event significantly behind the pack will also fail the event. During the Endurance Run, any failure of the snowmobile, parts falling off (including the fire extinguisher), fire or other significant thermal event will result in disqualification from the event.

10.8.4 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 a linear scale from 100 for the best fuel economy to zero based on the worst fuel economy. There will be a total of 200 points for this event. The minimum performance level on this event is traveling 500 feet. 5 points will be awarded for traveling 500 feet. No additional "performance points" for fuel economy will be awarded in this case.

10.9 Objective and Subjective Noise Events

10.9.1 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 steady state pass-by. In addition, the subjective noise performance (sound quality) of each snowmobile at a bystander location will be evaluated.

10.9.2 Noise Event Description

The sound pressure created by the sled for use in Yellowstone National Park is determined using the current standards set by the National Park Service Winter Ruling using SAE J1161 Recommended Practice. To pass the current J1161 standard the A-weighted, slow response, maximum overall level must be less than 67 dBA during a steady state pass by at a distance of 50ft. The standard allows +2dBA for measurement error due to environmental conditions (i.e. 69 dBA is still considered passing).

Environmental factors and snow pack conditions are known to greatly affect the results obtained using the sound pressure tests. As such a control sled will be used to determine the pass/fail sound pressure level. The control sled will be an unmodified production sled provided by an OEM and certified to pass the SAE J1161 Recommended Practice noise standard. The sound pressure level of the control sled measured on the day of testing will be the pass/fail level.

Each snowmobile will be driven by a competition judge according to the published procedure SAE J1611 Recommended Practice. In addition, the snowmobile must have a functioning speedometer, be capable of operating at a steady-state speed of 35 mph for 150 feet.

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.

Note: The SAE J1161 Noise Test is very dependent on environmental conditions including the condition of the snow and wind speed. Ideal conditions cannot be guaranteed on the day of the event. The organizers may reschedule the event or they may have to adjust the scoring limits based on the conditions available on the day of the test. Once the test is scheduled, all available participants must be tested in the time window of the event since there is no good way to compare sound pressures taken under different conditions.

10.9.3 Objective Noise Scoring for IC Sleds

IC sleds will receive a maximum of one hundred and fifty (150) points on an exponential scale consistent with sound pressure versus loudness. A 3dbA increase in sound pressure level will result in a reduction of points by one half. The maximum sound pressure allowable will be 1dBA less (rounded using J1161 rules) than the sound pressure measured on a control sled selected by the organizers. If their sound pressure is greater than or equal to the control sled sound pressure the minimum points for competing in the objective noise event (7.5 points) will be awarded. If the sled cannot compete in the noise test the team will receive zero points. If the sound pressure is higher than the control sled, the team will not be eligible for subjective noise points.

Here is an example if the minimum sound pressure was 70dbA and the control sled measured 78 dbA.

SPL	Score
70	150.00
71	119.06
72	94.49
73	75.00
74	59.53

75	47.25
76	37.50
77	29.76
78	7.5
79	7.5
80	7.5
81	7.5
82	7.5
83	7.5
84	7.5

10.9.4 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 a linear relationship from the worst to the best. The scale will be 150 points for IC teams.

10.9.5 Diesel Utility sleds will use the SAE 1161 Noise Test Standard with a speed of 35 mph. There will be no control sled. Other than these changes, scoring will be the same as for the spark ignited sleds.

10.10 Acceleration Testing Event

10.10.1 Purpose of the Acceleration Testing Event

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

10.10.2 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 10 seconds. All drivers must wear the proper safety gear as specified earlier.

10.10.3 Acceleration Testing Event Scoring

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

The minimum performance level will be to reach 500 feet in 10 seconds.

Any team that passes the event by reaching 500 feet in 10 seconds or less will receive the minimum performance level of 2.5 points.

The remaining sleds will receive additional points on a linear scale from the fastest measured time (50 points) to the slowest allowable time (10 seconds).

10.11 Objective Handling & Drivability Event

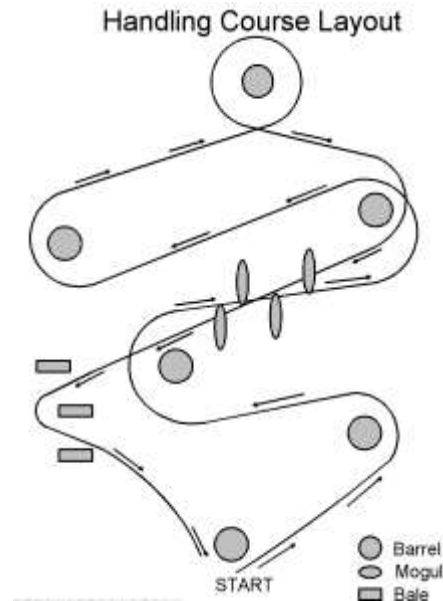
10.11.1 Purpose of Objective Handling & Drivability Event

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

10.11.2 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.



Example course example layout
Not to scale.

10.11.3 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.

10.11.4 Objective Handling & Drivability Scoring

The scoring for the event will be based on a linear scale from the fastest time (75 points) to the slowest time which will receive 3.75 points.

The minimum performance level will be to complete one lap of the course.

10.12 Subjective Handling & Drivability Event

10.12.1 Purpose of Subjective Handling & Drivability Event

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

10.12.2 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).

10.12.3 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.

10.12.4 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).

Points will be awarded based on the average of the judges' scores.

The minimum performance level is allowing the judges to evaluate the subjective ride of the sled.

In the event that the judges' scores average below 2.5, the team will receive 2.5 points.

10.13 Cold Start Event

10.13.1 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.

10.13.2 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.

The minimum performance level of the Cold Start Event is starting within 20 seconds.

Teams that start within 20 seconds but fail to move 100 feet in 120 seconds will receive the minimum performance level of 2.5 points.

10.14 Static Display Event/Networking with Industry

10.14.1 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.

10.14.2 Static Display Scoring

This is a mandatory event worth UP TO fifty (50) points. Teams must show up on time and not tear down their display until allowed 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 and judge the display. A sample judging form will be provided prior to the competition. Teams choosing not to attend the static display will receive zero (0) points.

A standardized chart, similar to a new vehicle window sticker, will be required for all snowmobiles. A finalized version of this chart will be provided at the competition. The chart will include basic

information about the snowmobile such as:

- chassis make and model
- engine size
- number of cylinders
- 2-stroke or 4-stroke
- MSRP
- design horsepower
- fuel economy.

10.15 Snowmobile Weight

Each snowmobile will be weighed after fueling for the endurance event. Weight for the IC sleds will be recorded but will not be part of the scoring system.

10.16 In-Service Emission

10.16.1 In-Service Emission Event Description

The goal of this event is to determine the total mass (grams) of gaseous emissions (pollutant) emitted from each snowmobile over a range of operating conditions, while operating on the snow. Carbon monoxide (CO), nitrogen oxide (NO), and total hydrocarbon (THC) emissions as well as fuel consumption will be measured while the snowmobile is operated by the event coordinator around a pre-defined test course. Speeds will vary from 20 mph to 45 mph to simulate actual vehicle operation on a snowmobile trail. If your snowmobile will not pull the sleigh at 45 mph (35 for DUC sleds), you will not get any points for this event. Figure 1 shows a typical installation of the in-service vehicle connected to a test snowmobile. The in-service vehicle weighs approximately 250 lb.



Figure 1. In-Service emissions analyzer being pulled by competition snowmobile

10.16.2 In-Service Emission Event Test Procedure

- The sled needs to tow a sleigh containing the emissions analyzer and fuel system
- Sled will be driven by a competition organizer on a closed course, roughly oval in shape
- Every effort will be made to drive the sleds in an identical and consistent manner to create a fair comparison of designs. No excessive acceleration, steering, or braking maneuvers will be conducted.
- The course is approximately 1.3 miles in length, level, with speeds up to 45 mph (35 mph for DUC sleds). The actual course will be dependent upon current weather and trail conditions.
 - A total of four laps will be completed during the testing of each competition snowmobile

- The first lap is to warm up the snowmobile and also to familiarize the driver with the operation of the snowmobile.
- Gaseous emissions and fuel consumption will be measured for laps 2, 3, and 4 (total distance of ~3.9 miles). The emissions components (CO, NO, and THC) will be converted to grams and summed for laps 2, 3, and 4 (not averaged). Total fuel consumption for the three laps will be recorded for determining the fuel economy (miles/gallon)
- The weighting of exhaust gases will be equal.

10.16.3 In-Service Emission Event Equipment Requirements

- Tow hitch: the sled **MUST** have a tow hitch per rule 8.7.9
- Emissions sample probe: the same exhaust pipe sample probe used for the lab emissions event will be used for this event. If an exhaust extension was required for the lab emission event, then it must also be used during the in-service event. The setup must be viable for trail riding, i.e. an exhaust extension with 2 inches of ground clearance is not viable.
- Fuel system connection: all competition snowmobiles **MUST** use Jiffy-tite 2000-series, fuel system couplers with fluorocarbon seals on supply and return lines (if equipped). The couplers **MUST** exit the chassis away from the exhaust system due to safety concerns. Removal of major components of the snowmobile, such as the seat, fuel tank, or exhaust system, to access the fuel lines is unacceptable and will require modification by the competing team, before they are allowed to participate in the in-service emissions event.



Figure 2. Jiffy-tite plug (left) and socket (right) fittings (for reference)

10.16.4 Scoring

- The team with the lowest total grams of emissions (CO+NO+THC) will receive 50 points.
- The team with the highest total grams of emissions (CO+NO+THC) will receive 2.5 points.
- A linear interpolation will determine the scores between 2.5 and 50 for the remaining teams.
- Fuel Economy (miles/gallon) scores between zero (0) and fifty (50) will be awarded according to a linear scale.
- The minimum performance level for this event will be to pull the sleigh at the required speed of the event. For this the team will receive 2.5 points.

10.17 Acceleration Plus Load Event

10.17.1 Purpose of the Acceleration Plus Load Event

The purpose of this event is to determine the ability of the snowmobile to pull a heavy load quickly.

10.17.2 Acceleration Plus Load 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. All drivers must wear the proper safety gear as specified earlier.

Diesel Utility Class snowmobiles will be tested for acceleration times pulling a load of approximately 500 pounds.

10.17.3 Acceleration Testing Event Scoring

The team with the least time to reach 500 feet pulling another snowmobile which will be riding on top of a plastic recue skid (best of two runs) will receive fifty (50) points.

Any team that passes the event by reaching 500 feet will receive the minimum performance level of 2.5 points.

The remaining sleds will receive additional points on a linear scale from the fastest measured time (50 points) to the slowest time.

10.18 DUC Draw Bar Pull Test

DUC 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 draw bar pull will be ranked based on an average of three pulls. The maximum average of the pulls will be the highest draw bar pull. Points will be awarded according to a linear scale from lowest draw bar pull (5 points) to the highest draw bar pull (100 points).

The minimum performance level for this event is pulling a load for which the team will receive 5 points.

ARTICLE 11: AWARDS

11.1 Award Criteria

Award Criteria	Award Description
Overall Winners:	Presented to the top three (3) teams in terms of total points who also passed the Emissions and Noise events. The top three teams must pass the Emissions and Noise events to be eligible to receive an award in the IC or DUC categories.
Best Performance:	Presented to the team receiving the highest total score in the Acceleration, and Objective 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 + Objective and Subjective Handling points + Cold Start points) * MSRP Points.
Founder's Trophy:	Trophy awarded to the team recognized by other participants as being the most sportsmanlike. This may be either an IC sled or a ZE sled.
Best Ride:	Presented to the team with the best combined score in the Handling and Drivability and Subjective Ride events.
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
Innovation:	Presented to the team who in the opinion of the organizers has the most innovative solution. This may be either an IC sled or a ZE sled.
Safety Award:	Presented to the team who in the opinion of the organizer demonstrates the best safe practices. This may be either an IC sled or a ZE sled.
Most Improved Snowmobile:	Presented to the team who in the opinion of the organizers has improved the most since last year. This may be either an IC sled or a ZE sled.

Note: Awards vary year to year based on Sponsorships and although not guaranteed, some awards will include a cash award dependent on sponsorship. These and other awards will be detailed in the event program available at the on-site competition registration booth.

11.2 Participation Plaque

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



ARTICLE 12: 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.

The Keweenaw Research Center (KRC) of Michigan Technological University is the host site for the SAE Clean Snowmobile Challenge. The University has a Safety Manual <http://www.admin.mtu.edu/fm/oshs/pdf/safetymanual.pdf> which applies to all operations at KRC. In addition to wearing safety glasses in the shop areas, safe practices are encouraged and expected at all times. Rules and operating procedures specific to the KRC shop will be reviewed upon arrival.



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, or rotary) _____ Number of cylinders _____

Engine Displacement (cc) _____

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 or Diesel

Emission Control

Air/Fuel Ratio Chosen (lean, stoichiometric?) _____

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

Engineering Design Paper Judging Form

University Team Name: _____

Score the following categories, giving each point 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 (10):** 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 (25)** 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

Oral Presentation Judging Form

University Team Name: _____ Judge 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 (Design Process):** Does the presentation describe how the team designed their snowmobile? Did the team have clear objectives as to the decisions they made in designing their snowmobile?

_____ **CONTENT (Innovation):** Did the team take an innovative approach in their design or were there any innovative features in their snowmobile compared to current snowmobiles on the market today.

_____ **CONTENT (Emissions, Noise, and Fuel Economy):** Did the team address the highest priority goals of the Challenge: Emissions, Noise, and Fuel Economy?

_____ **CONTENT (Test results):** 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 D

Handling Event Judging Form

University Team Name: _____

Score the following categories, giving each point 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 E Emission Test Form

Team Name _____ Team No. _____

Engine Description:

Manufacturer _____ Displacement (cc) _____
Cycle (2 or 4 stroke, diesel) _____ Cylinders _____

Engine Performance:

RPM Limit during Lab Emissions Power Sweep _____ rpm

Expected Maximum: _____ HP at _____ RPM and _____ ft-lb
Or _____ kW at _____ RPM and _____ N-m

Pre-Event Checkout (by Emission Test Engineers)

Couplers (checking for accessibility, orientation, location, and routing):

Fuel Supply _____
Fuel Return _____
Coolant _____

Fuel Choice: E-XX or B-XX

Required Fuel Pressure from external source _____ psi or _____ bar

Exhaust:

Is an Exhaust Extension required for emissions? YES / NO
Exit Location and Orientation _____
Sample Port Location _____
Sample Probe configuration correct YES / NO
Sample Probe Location (connection for analyzer) _____

DYNOMite Dynamometer Installation:

Prior Experience with installation in this sled: YES / NO
Do you have Clutch Pullers: YES / NO
Shaft Diameter and Taper: _____ 30 mm 3-4° _____ 32 mm 10:1 _____ Other
Is dyno shaft speed different from engine speed: YES / NO
Gear Ratio _____ Increasing or Decreasing

In-Service Emission Requirements:

Tow Hitch YES / NO
Accessibility to couplers and routing of fuel lines YES / NO
Accessibility to probe and routing of sample line YES / NO

NOTES/COMMENTS: _____

APPENDIX F 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?			
8.10	Fire Extinguishers ok?			
9.1	Protective Equipment			
9.1.5	Warm up stand ok?			
9.2.1	Driver helmet ok?			
9.2.2	Clothing and boots ok?			
9.2.3	Jacket/Vest ok?			
	DYNAMIC TESTS			
8.2.6	Throttle Return ok?			
8.5.2	Steering ok?			
8.8.1	Disconnect Tether ok?			
8.8.2	Kill Switch ok?			
8.8.3	User Selection switched ok?			
10.9.2	Speedometer ok?			
1.2.3 / 1.3.6	Attain 45 mph?			
1.2.3 / 1.3.6	500 feet in 12 seconds?			

Inspector Printed Name				
Inspector Signature				

APPENDIX F 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
8.1	Stock qualified and model years 2013 to 2017 inclusive?			
8.2	Engine			
8.2.1	Engine type 2-stroke, 4-stroke, rotary?			
8.2.2	Fuel type ethanol or diesel?			
8.2.3	2-stroke oil does not have boosting additives?			
8.2.4	Turbochargers/Superchargers meet design criteria?			
8.2.5	Exhaust systems outlet ok?			
8.2.6	Throttle design meets requirements?			
8.3	No block heaters?			
8.4.1	Meets chain drive oil bath requirement?			
8.4.2	Meets CVT requirement?			
8.4.3	Meets brake performance requirement?			
8.4.4	Meets brake control handle requirement?			
8.4.5	Meets brake rotor shield requirement			
8.4.6	Meets rotor contact area requirement?			
8.4.7	Clutch cover ok?			
8.4.8	Moving parts isolation okay			
8.5	Skis and Ski Suspension			
8.5.1	Meets ski requirements			
8.5.2	Ski and ski suspension modifications okay?			
8.5.4	Ski suspension requirements ok?			
8.6	Track, Track Suspension, and Traction			
8.6.1	Track and track suspension modifications ok?			
8.6.2	Track suspension requirements ok?			
8.6.3	Traction control devices ok?			

IC General Technical and Dynamic Tests

Page 2 of 2

8.6.5	Slide runners ok?			
8.6.6	Maximum track lug height ok?			
8.7	Frame and Body			
8.7.1	Rear snow flap ok?			
8.7.3	Foot Stirrups/Pegs ok?			
8.7.4	Seat ok?			
8.7.5	Body modification ok?			
8.7.6	Front bumper requirement met?			
8.7.7	Decal space requirement ok?			
8.7.8	Team number correct?			
8.7.9	Chassis Modification (requires explanation and analysis)			
8.8	Ignition and Electrical			
8.8.1	Disconnect tether ok?			
8.8.2	Kill Switch ok?			
8.8.3	User Selection Switches ok?			
8.8.4	Battery fuel pumps connected to tether and kill switch?			
8.8.5	Battery box requirements met?			
8.8.6	Head, tail, and brake light requirement met?			
8.9	Component deletion requirement met?			
Inspector Printed Name				
Inspector Signature				



APPENDIX G

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 with 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)