



Requirements for Launching High Power Rockets in Canada

1. General

The *Aeronautics Act* confers upon the Minister of Transport regulatory oversight of rocket launches in Canada. Sections 602.43, 602.44 and 602.45 of the Canadian Aviation Regulations (CARs) require the Minister to authorize all rocket launches, excepting those classified as models or those used in fireworks displays. The Canadian Launch Safety Office (CLSO) is the functional office that fulfills this obligation.

602.43 Rockets

No person shall launch a rocket, other than a model rocket or a rocket of a type used in a fireworks display, except in accordance with an authorization issued by the Minister pursuant to Section 602.44.

602.44 Authorization by the Minister

The Minister may issue an authorization referred to in Section 602.42 or 602.43 where the release of the balloon or the launch of the rocket is in the public interest and is not likely to affect aviation safety.

602.45 Model Aircraft, Kites and Model Rockets

No person shall fly a model aircraft or a kite or launch a model rocket or a rocket of a type used in a fireworks display into cloud or in a manner that is or is likely to be hazardous to aviation safety.

2. Scope

2.1. These requirements apply to the conduct of all launch operations for

high power rocket vehicles in Canada as defined in Section 3.

2.2. These requirements are set out to provide a guideline to launch proponents for the safe conduct of high power rocket launch operations to ensure the safety of aviation and the public.

2.3. These requirements are based on Canadian regulatory requirements pertaining to aviation and explosive materials; applicable industry standards, such as NFPA 1127; and accepted safety requirements set out by rocketry associations, such as the Canadian Association of Rocketry, Tripoli Rocketry Association (US) and the National Association of Rocketry (US).

3. Acronyms and Definitions

The following definitions apply to the terms expressed in this document.

Authorized High Power Rocket Motors: High power rocket motors that have been authorized for use by Transport Canada (CLSO) Natural Resources Canada Explosives Regulatory Division (NRCAN) or covered under a General Importation Permit issued by NRCAN.

Authorization to Launch: An approval issued by the CLSO on behalf of the Minister of Transport for the launch of a rocket or series of rockets of similar type.



Bodily Injury: Any physical injury, sickness, disease, disability, shock or mental injury sustained by a person including death.

Canadian Launch Safety Office (CLSO): Transport Canada office delegated with safety and regulatory oversight of all rocket launch activities in Canada.

Casualty: A person suffering death or serious injury as the result of an accident associated with authorized launch activities. For third party liability purposes the cost of a casualty is estimated as \$1 million.

Certified User: A person who has met the requirements of Natural Resources Canada - Explosives Division and is capable of all the requirements set out in this document.

CLSO: Canadian Launch Safety Office

Combustion Chamber: The part of a rocket engine in which propellants are burned to produce combustion gases to provide thrust for the vehicle.

Damage: Means loss of life, personal injury or other impairment of health; or loss of or damage to property.

Defined Cleared Area: A defined area of land/sea which has been cleared of all persons and third party properties which could be damaged by components of a launch vehicle impacting in the area.

Defined Safety Envelope: A defined three dimensional space extending upward from the surface of the earth to an

altitude above which a launch vehicle and/or payload would achieve, and includes any space required for re-entry and recovery. The limits of the space are established such that no vehicle, or any component thereof, can violate the envelope whether performing nominally, non-nominally or terminated.

Deviation: A hardware or procedural noncompliance which is recognized but where the intended requirement can be met by an alternative means without any increase in risk. Deviations can be approved by Range Safety Officer but they must be justified, documented, signed indicating approval and made available to CLSO for review upon request.

Government Personnel: Employees of the Government of Canada, its agencies, and its contractors and subcontractors, involved in launch activities.

Hazardous Operation:

Any activity, process or procedure that, because of the nature of the equipment, facilities, personnel, or environment involved, or function performed, may result in bodily injury or damage.

High Power Rocket: A launch vehicle:

- (a) equipped with one or more rocket engines/motors contributing to an installed total impulse greater than 160 newton-seconds but less than or equal to 40,960 newton-seconds,
- (b) that weighs more than 1.5 kg (3.3 pounds),



- (c) equipped with a parachute or other device capable of retarding its descent, and
- (d) whose primary uses are for purposes of education and/or recreation.

High Power Rocket Motor: A rocket motor having a total impulse greater than 160 newton-seconds but less than or equal to 40,960 newton-seconds and that meets the requirements set out in this document.

Hybrid Rocket Motor: A rocket motor in which the fuel is in a different physical state than the oxidizer and that derives its force or thrust from the reaction thereof.

Installed Total Impulse: The sum of the total impulses of all rocket motors installed in a rocket and intended to be ignited during the launching and flight of that rocket.

Launch Activities: Activities beginning with the arrival of a particular vehicle, or any component thereof, payload, or associated personnel on the launch site in preparation for launch. These activities end when the launch vehicle and any associated payload return to Earth, or when the launch vehicle and payload have been recovered, and associated personnel have left the site at the end of the mission, whichever occurs later.

Launch Area: An area designated by the Range Safety Officer in which high power rockets are launched.

Launch Site: An area authorized and used for high power rocket launch

activities. This includes all areas required for preparation, launch, recovery, public viewing and parking.

Launch Vehicle: See definition of rocket.

Liability: A legal obligation to pay claims for bodily injury, death or property damage resulting from authorized launch activities.

Liquid Propellant Rocket Engine: A rocket engine in which the propellant is in liquid form and that generates thrust by the combustion, decomposition, change of state or other process thereof.

Model Rocket: (Per Exemption from Section 602.43 of the Canadian Aviation Regulations Letter dated September 28th, 1998) a rocket:

- (a) equipped with model rocket engines that will not generate a total impulse exceeding 160 newton-seconds,
- (b) of a gross weight, including engines, not exceeding 1500g (3.3 pounds), and
- (c) equipped with a parachute or other device capable of retarding its descent.

Motor Reloading Kit: A package designed and produced by a commercial manufacturer that contains all the components and parts necessary to reload and reuse a non-expendable rocket motor casing specifically designed and manufactured to use these components and parts. These components and parts normally include propellant modules, a new rocket motor nozzle, new insulation components, prepackaged delay and ejection charges, an electrical igniter



and the parts necessary to seal the casing during operation.

NFPA 1127: National Fire Protection Association (US) Safety Code. Elements of this code apply to the design, construction, propellant, power, reliability and launch of high power rocket motors and components.

NRCan: Natural Resources Canada - Explosives Regulatory Division

Predicted Flight Safety Envelope: A pre-determined three dimensional area that provides for the safe launch and flight of a high power rocket.

Prevailing Visibility: The greatest distance that can be seen throughout at least half the horizon circle, not necessarily continuous; the visibility that is continuous; the visibility that is considered representative of visibility at the station.

Production Lot: A quantity of solid propellant rocket motors, reloading kits or hybrid fuel grains produced during a single work shift, with the same manufacturing equipment, using the same batch of propellant.

Propellant: Any substance or combination of substances which constitute a mass to be expelled at high velocity to produce a propulsive reaction force or thrust. Propellants can be classified according to their physical state as solid, liquid or gaseous.

Propellant Grain: Solid rocket propellant or fuel grains for hybrid rockets.

Property Damage: For third parties, means partial or total destruction, impairment or loss of tangible property, real or personal. The cost of damage is calculated when possible based on the replacement value of the property.

Range Safety Officer: A certified user of high power rocket motors whose responsibility and duty during launch activities are to ensure the conduct of safe launch operations, oversee public and participant safety, and confirm compliance with the requirements set out in this document and Transport Canada's Authorization to Launch.

Reloadable Rocket Motor: A rocket motor that has been designed and manufactured so that the user can load, re-load, and reuse the pressure containing body or casing using the components of a motor reloading kit specifically designed, manufactured and intended for use with that rocket motor casing by the manufacturer.

Rocket: A vehicle propelled by a rocket engine or motor.

Rocket Engine: A propulsive device in which liquid propellants are burnt in a combustion chamber to provide a reaction force to propel a vehicle. Although the terms engine and motor are generally interchangeable, it is customary for propulsive devices using liquid propellants to be called engines and those using solid propellants to be called motors. A typical liquid rocket engine consists of: a propellant delivery and injection system of tanks, pipes,



pumps, or pressurization tanks; an ignition system; a combustion chamber; a control subsystem; and an exhaust nozzle.

Rocket Motor: A propulsive device in which solid propellants are burnt to provide a reaction force, or thrust, to propel a vehicle. Also called a Solid Rocket Motor (SRM). A typical solid rocket motor comprises a motor case which contains the propellant grain, a surrounding insulating blanket or propellant liner and an exhaust nozzle. The motor case serves as both the propellant tank and the combustion chamber.

Shall: Indicates a mandatory requirement.

Should: Indicates a recommendation or that which is advised but not mandatory.

Solid Propellant Rocket Motor: See definition of rocket motor.

Solid Rocket Motor (SRM): See definition of rocket motor.

Structural Parts: The load bearing parts of a rocket, specifically the nose cone, body tube and fins.

Third Party: Applies to any person not involved with an authorized launch. The term includes on-site government and government contractor employees, personnel of other commercial launch firms not involved in the activities under consideration, and any other persons or entities that are not private party participants, including contractors and sub-contractors, in the authorized activities.

Third Party Claims: Claims by a third party for death, bodily injury, or loss or damage to property resulting from activities carried out in connection with any particular launch.

Thrust: A force produced by any propulsion system. The product of the mass of gas ejected per unit time and the exhaust velocity.

Thrust Augmentor: A device for increasing the force or motive power of a rocket motor by imparting a portion of the momentum of the rocket motor's exhaust jet to the surrounding environment medium; it is considered to be a part of the rocket engine/motor when and where it is used.

Waiver: A hardware or procedural noncompliance, discovered after operations or the launch authorization process has begun, requires a waiver. Requests for waivers must provide a justification for the issuance of a waiver and an analysis of any increase in risk associated with the change. Waivers must be approved by the Range Safety Officer and the Manager, CLSO. Granting of a waiver by the CLSO applies only to a single instance or event.

4. High Power Rockets

4.1. A high power rocket is:

4.1.1. equipped with one or more authorized (by TC or NRCan or covered under a General



Importation Permit issued by NRCan) rocket engines or motors having a total impulse of more than 160 Newton-seconds but not exceeding 40,960 Newton-seconds and/or of a gross weight over 1.5kg.,

- 4.1.2. equipped with a parachute or other device capable of retarding its descent so that it does not create a hazard to persons or property,
 - 4.1.3. constructed of lightweight materials capable of withstanding the stresses anticipated during ignition and flight.
- 4.2. High power rocket motors are classified based on the total impulse generated. *Table 1* indicates the motor types and their related total impulses.

Motor Type	Total Impulse Newton-Seconds NS
H	>160-320
I	>320-640
J	>640-1280
K	>1280-2560
L	>2560-5120
M	>5120-10240
N	>10240-20480
O	>20480-40960

Table 1
High Power Rocket Classification

- 4.3. All high power rocket motors using solid propellants and all pyrotechnic substances used in high power rockets must be authorized by NRCan, or be covered under a General Import Permit issued by NRCan. All other rocket motors

shall be authorized by Transport Canada.

- 4.4. As a minimum the testing and qualification for approval of high power rocket motors shall include:
- 4.4.1. for solid propellant motors, that the case temperature during firing shall not exceed 200°C;
 - 4.4.2. verification that any overpressure resulting in structural failure of the case will not project case fragments beyond a radial distance of one half the minimum safe distance specified for the motor/rocket;
 - 4.4.3. for solid propellant motors, that the primary failure mode is along its longitudinal axis, i.e. nozzle or bulkhead expelled;
 - 4.4.4. for solid propellant motors, the motors shall be incapable of spontaneous ignition due to interaction with air or water, or as a result of physical shock;
 - 4.4.5. that rocket motor casings be of adequate strength to prevent rupture, bulging or burn through during functioning;
 - 4.4.6. that the solid propellant maintains adhesion to the inhibitor, casing or supporting components, as appropriate, throughout ambient temperatures ranging from -30 degrees Celsius to +30 degrees Celsius;
 - 4.4.7. that the solid propellant not have or develop cracks or voids in normal shipping, handling and storage, nor in temperature fluctuations from -30 degrees Celsius to +30 degrees Celsius;



4.4.8. that motors function as intended within the design limits of burn time and impulse; and

4.4.9. that the motor reliably ejects and deploys the recovery system.

4.5. High power rocket motors shall use only proven or approved igniters. High power rocket ignition methods must reliably ignite the motors upon actuation of the firing circuit.

5. Requirements for Individuals Launching High Power Rockets

5.1. All persons launching high power rockets in Canada shall do so in compliance with all federal, provincial, municipal and local laws, rules, regulations, statutes and ordinances.

5.2. All persons launching high power rockets in Canada shall do so in accordance with the certification and/or qualification requirements for the rockets to be launched.

5.3. All persons launching high power rockets in Canada shall make available to Transport Canada representatives, upon request, proof of such qualification and/or certification.

5.4. All persons launching high power rockets in Canada shall do so only under the terms of an Authorization to Launch issued by Transport Canada's Canadian Launch Safety Office.

5.5. Changes subsequent to issuance of the Rocket (High Power) Launch Authorization, require CLSO approval.

6. Launch Site Requirements

6.1. The launch site shall be an open, outdoor area where overhead hazards such as trees, power lines and buildings will not impact the safety of the launch operation.

6.2. The launch site shall be in an area where launch operations will not generate hazards to persons, property, and/or land, water or air traffic.

6.3. Permission of the owner(s) or lessee(s) of the land to be used for the launch and recovery of high power rockets is required for all launch operations.

6.4. The launch site shall include sufficient area for the launch and recovery of all high power rockets to be launched.

6.5. The minimum dimensions of the launch site shall be established in accordance with the specifications set out in *Table 3*. For circular sites the minimum site dimension is the diameter of the circle, for rectangular sites the minimum site dimension is the length of the shortest side.

Expected Altitude (feet)	Minimum Dimension (km)
0-3000	500 m
3001-6000	1
6001-10000	2
10001-12000	3
12,001-over	TBD



Table 3

Launch Site Dimensions

(Rockets expecting to achieve an altitude of 12,001 feet or more will be evaluated on a case by case basis)

- 6.6. In no case shall the minimum dimension of the launch site be less than one half the estimated maximum altitude of the high power rocket.
- 6.7. In no case shall the launch site have a dimension less than 500m.

7. Launcher Requirements

- 7.1. The launcher shall be positioned so as to ensure that recovery of the rocket is within the area authorized for the launch site.
- 7.2. The launcher shall be located more than 500m from any occupied building or public roadway on which traffic density exceeds 10 vehicles per hour.
- 7.3. The launcher shall be located in an area, with a radius of at least 5m, that is cleared of all loose objects and flammable materials, such as dead grass.
- 7.4. The launcher shall provide rigid guidance for the rocket on launch to ensure the rocket attains flight within its predicted flight safety envelope.
- 7.5. The launcher shall incorporate a blast deflector or alternative means of preventing rocket motor exhaust from directly striking the ground or any flammable materials.
- 7.6. The launcher shall restrict the launch angle to within 20 degrees of vertical.
- 7.7. To minimize the risk of injury to persons, the launch rod or rail should be raised above eye level or have a shield placed over the end of the rod between launches.

8. Launch Site Safety Requirements

- 8.1. No person shall be closer to the launch of a high power rocket than the person launching the rocket unless authorized by the Range Safety Officer.
- 8.2. No person shall be closer to the launch of a high power rocket than the minimum safe distances specified in *Table 4*.

Motor Type	Total Impulse (NS)	Minimum Distance (m)	Minimum Distance Complex Rocket ¹ (m)
H	>160-320	30	60
I	>320-640	60	100
J	>640-1280	60	100
K	>1280-2560	60	100
L	>2560-5120	100	150
M	>5120-10240	200	300
N	>10240-20480	300	500
O	>20480-40960	300	500

Table 4

Minimum Safe Distances

¹ A complex high power rocket is a multi-staged vehicle or one propelled by a cluster of motors.

- 8.3. All spectators shall remain in an area determined to be safe and designated for public viewing by the Range Safety Officer.

9. Launch Requirements and Restrictions

- 9.1. All persons launching high power rockets in Canada shall use only commercially manufactured high power rocket motors, motor reloading kits or components authorized by NRCAN and/or CLSO, except by deviation approval.
- 9.2. No person shall launch a high power rocket unless it has been inspected and approved for operation



- immediately prior to flight by an authorized Range Safety Officer.
- 9.3. No person shall launch a high power rocket unless its stability for flight is determined before launch. Documentation regarding the location of centre of pressure and centre of gravity shall be made available, upon request, to the Range Safety Officer and/or Transport Canada representatives.
 - 9.4. No person shall launch a high power rocket if the gross weight of the high power rocket at launch exceeds the maximum liftoff weight of the rocket motor(s) specified by the manufacturer. Documentation regarding compliance with this requirement shall be made available, upon request, to the Range Safety Officer and/or Transport Canada representatives.
 - 9.5. No person shall launch a high power rocket with an installed total impulse of more than 40,960 Newton-seconds of total impulse.
 - 9.6. No person shall launch a high power rocket unless the rocket contains a system that will retard its descent back to the ground effectively.
 - 9.7. No person shall launch a high power rocket while another high power rocket is in flight, unless the high power rocket in flight has safely deployed its recovery system and the RSO has determined that the remainder of the flight presents no hazard to persons or property.
 - 9.8. No person shall launch a high power rocket into cloud.
 - 9.9. No person shall launch a high power rocket if the prevailing visibility is less than 5km.

- 9.10. No person shall launch a high power rocket when the surface wind is greater than 30 km per hour.
- 9.11. No person shall launch a high power rocket horizontally, or at an angle that takes the rocket beyond the boundary of the launch site in the event of a recovery system failure resulting in “ballistic recovery”.
- 9.12. No person shall launch a high power rocket as a weapon at a surface or air target.
- 9.13. No person shall launch a high power rocket that creates a hazard to aircraft.
- 9.14. No person shall launch a high power rocket except under the oversight and with the approval of the Range Safety Officer or in accordance with the requirements specified in the Rocket (High Power) Launch Authorization.
- 9.15. No person shall launch a high power rocket containing explosive, incendiary or live vertebrate animal payloads.
- 9.16. Smoking or open flames shall not be permitted in the launch area, prepping area or within 10m of any high power rocket motor, motor reloading kit or pyrotechnic module.
- 9.17. A minimum of a five second countdown, audible to all persons in the launching, spectator and parking areas, shall be given prior to the launch of a high power rocket.
- 9.18. All high power rocket launches or motor ignitions shall be conducted by means of a remote controlled electrical firing system. The system shall include a firing switch that returns to the “OFF” position when released and a safety interlock to prevent accidental ignition.



- 9.19. The firing system shall be located no closer to the launch pad than the minimum distance specified in *Table 4*.
- 9.20. High power rocket motor ignition systems shall incorporate a method of disconnecting all power to the launch pad. The disconnection point shall be a minimum of 5m from the launch pad.
- 9.21. Ignition devices for high power rocket motors shall only be installed at the launch pad, or in an area designated by the Range Safety Officer, and in all cases as close to the time of intended launch as practical. The rocket shall be pointed in a safe direction during and after installation of the ignition device(s). This also applies to removal of ignition devices if the launch is aborted.
- 9.22. No person shall approach a high power rocket that has misfired until the safety interlock has been removed or the battery disconnected from the ignition system, 5 minutes have passed, and the Range Safety Officer has authorized only a single person to approach and inspect the rocket.
- 9.23. Upon completion of the inspection to the satisfaction of the Range Safety Officer, the rocket may (1) be fitted with a new ignition device for another launch attempt or (2) have the ignition device removed and the rocket removed from the launch area. The Range Safety Officer shall ensure only the minimum number of people required to perform the task are permitted to approach the rocket.
- 9.24. No person shall attempt to catch a high power rocket as it approaches the ground.

- 9.25. No person shall attempt to retrieve a high power rocket from a hazardous location, such as a power line, without approval of the appropriate authority.

10. Range Safety Officer Requirements

- 10.1. All persons performing the duties of a Range Safety Officer shall meet the qualification and certification requirements as acceptable to the Canadian Launch Safety Office.
- 10.2. Range Safety Officer responsibilities include:
 - 10.2.1. protecting people, property and the environment from safety risks that may arise during the pre-launch, launch, flight recovery of high power rockets;
 - 10.2.2. developing and implementing ground and flight safety rules for launches that are consistent with federal, provincial, municipal laws, requirements and accepted safe practices;
 - 10.2.3. reviewing and approving the schedule of launch operations;
 - 10.2.4. ensuring persons launching high power rockets are appropriately qualified and/or authorized;
 - 10.2.5. reviewing and approving launch operations and procedures;
 - 10.2.6. monitoring launch operations and controlling surveillance areas to minimize risks to all persons;
 - 10.2.7. monitoring countdowns and procedures for holds and misfires;



- 10.2.8. supervising and controlling the allocation of safety roles for other participating safety monitors;
- 10.2.9. developing, approving and/or verifying accident contingency plans; and
- 10.2.10. in the event of a mishap, securing the launch site and ensuring all relevant data and materials are impounded for investigation.

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11. Public Safety and Liability

- 11.1. Launches shall be conducted in an area and manner that will not create a hazard to persons or property.
- 11.2. In the event of an accident/incident any person launching or charged with safety oversight of the launch high power rockets could be held responsible and liable.
- 11.3. It is recommended that all persons launching or charged with safety oversight of high power rocket launches obtain third party liability insurance of \$1,000,000 or more to cover potential injury or damage claims.

12. Contact Information

Further information may be obtained from:

**Transport Canada
Canadian Launch Safety Office**

**P.O. Box 8550
344 Edmonton Street
Winnipeg, Manitoba
R3C 0P6**

Telephone: 204-984-7296/7286

Facsimile: 204-983-2005