CAR High Power Rocket

Level 4 Certification Process

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1. Introduction

The Canadian Association of Rocketry was created in 1965 as an advocate of the model rocketry hobby. Over the past three decades the hobby has grown to encompass rocket motor types and performance unavailable to the modeler at the CAR's inception. In response to this growth CAR offers a certification process which permits individuals to purchase and use rocket motors whose physical constraints and performance exceed traditional model rocket motor boundaries. Rocket motors which exceed model rocketry motor definitions and the models that use these motors are collectively referred to as high power rocketry.

Certification for high power rocketry consists of four progressive levels:

- Level 1 allows the purchase and use of H impulse class motors.
- Level 2 allows the purchase and use of I impulse class solid motors and hybrid rocket motors.
- Level 3 allows the purchase and use of J,K and L impulse class rocket motors and hybrid rocket motors.

The procedures for Level 1, 2 and Level 3 certification are covered in the **CAR High Power Rocket Level 1, 2, and 3 Certification Process** document.

- Level 4 certification requires in-process reviews of the certification vehicle design and construction prior to flight, in additional to a demonstration flight. The Level 4 certification process is significantly more involved than the Level 1, 2, and 3 certification process.

Please note that the CAR High Power Certification is only one consideration when purchasing and using high power rocket motors. Compliance with local, NRCan (Natural Resources Canada) and TC (Transport Canada) federal regulations is also required.

High power certification is intended to provide a measure of the rocket flyer's competence to avoid gross violations of common-sense construction standards and safe rocket operation. The program is not foolproof. A single demonstration of a rocket flyer's skills does not guarantee consistent safe performance. The certification program does not replace the application of safe handling practices and common sense.

2. Level 4 Certification Overview

A Level 4 Certification allows a member to purchase and fly rockets with, M, N and 0 impulse motors. Level 4 Certification is a serious proposition and not taken lightly by the Canadian Association of Rocketry or by Transport Canada. Level 4 projects are typically large, heavy and complex. The procedures are quite formal, and while a brief overview of the certification process is presented here, please refer to section 4, Certification Procedure for additional details.

A member must first document their Proposed Level 4 Project, and then send the document to two members of the L4CC for their approval. Contact the CAR Provincial Representative for help in identifying L4CC members. The L4CC members review the project and sign off IF THEY APPROVE. At least one L4CC member must physically inspect the project in a nearly complete state before being approved for flight. After the two members of the L4CC have signed off the project, the member can then attempt their Level 4 flight. When attempting a Level 4 flight, the documentation submitted to L4CC should be made available to the Launch Event Chief RSO. The RSO has final say as to whether the Level 4 flight can occur at their launch. The flight must be witnessed by a member of L4CC and only a L4CC member can sign off on the flight granting level 4 certification status. It is the MEMBERS responsibility to send the signed required documentation to CAR Headquarters.

3. Minimum Requirements

3.1 Flyer Requirements

The flyer seeking Level 4 Certification must meet these minimum requirements:

1. **18 years old** - The individual seeking high power certification must be a minimum of 18 years old at the time of certification. A driver's license or a birth certificate is an acceptable proof of age.

2. **CAR Member** - The individual must be a member in good standing with the Canadian Association of Rocketry

(CAR) at the time of certification. Evidence of CAR membership will be requested prior to the certification attempt. Acceptable evidence of membership includes the CAR membership card, a canceled check indicating payment of membership fees, or participation in a CAR event where membership status is verified and indicated on the event materials.

3. **Level 3 Certified** - Any individual attempting CAR Level 4 Certification must have already attained Level 3 (5120 N-s) Certification prior to their Level 4 Flight.

4. **Two Previous Flights with Electronic Recovery** - Any individual attempting CAR Level 4 Certification must show proof of at least 2 flights at Level 3 impulses (640.01 to 5120.00 Ns) that incorporate electronic recovery. See the Electronics Endorsement documentation and process.

3.2 Rocket Requirements

The rocket used for the Level 4 flight must meet certain minimum requirements:

1. **Flyer-Built** - The certification rocket must be substantially built by the certifying flyer. Individuals using rockets with substantial "prefabricated" components will be required to demonstrate suitable construction knowledge to the satisfaction of the L4 Certification Committee. Only the builder of the rocket may use that rocket for a certification attempt. Rockets built by other than the certifying flyer are specifically disallowed. Certification rockets may be built from commercially available kits and may contain components built to the specifications of the certifying flyer but fabricated by others. Team projects for certification attempts are specifically disallowed.

2. **Single Stage** - Multiple stage rockets are specifically disallowed for Level 4 Certification flights.

3. **Redundant Deployment Mechanism** - The rocket must contain a redundant mechanism for performing the initial recovery event. This means that they must not share any component parts such as battery, pyrotechnic device, wiring or altimeter. For single event recovery, the main parachute must have redundant mechanisms for ejection. For drogue-main recovery systems, the drogue parachute must have multiple mechanisms for ensuring drogue deployment. Motor ejection charges may be used as a redundant ejection mechanism, but rockets depending primarily on motor ejection for any recovery event are specifically disallowed.

4. **Disarm Pyrotechnic Devices** - The capability must exist to externally disarm all pyrotechnic devices in the rocket. In this context, "disarm" means the ability to physically break the connection between a pyrotechnic device and the power source of its igniter and short the pyrotechnic device. Simply turning off the device controlling the pyrotechnic(s) is not sufficient.

5. **Car High Power Safety Code -** The rocket must conform in all respects to any restrictions imposed by the CAR High Power Safety Code and Transport Canada.

6. **Certified Motor -** Motors used for certification attempts must be currently certified by the CAR MCI, National Association of Rocketry (NAR) or Tripoli Motor Testing and be accepted by NRCan or covered under a general importation permit issued by NRCan. Hybrid motors used shall be approved by TC. Manufacturer's designations, not certification test data, will be used to identify suitability for the certification level being attempted (e.g. an H128 is an H, a G75 is a G).

7. **Impulse for Certification Flight** - The certification flight will have a motor with a minimum of 5120.01Ns. While it is possible to use an N or 0 motor for a certification flight, it is suggested that the flyer build around and use an M impulse class motor for their certification flight.

3.3 Documentation Requirements

The rocket used for the Level 4 flight must meet certain minimum requirements:

1. **CAR Level 4 Certification Application Form** - This form is used by the builder and the L4CC to ensure that all the certification procedures are followed.

2. **Documentation Package** - A documentation package must be prepared that consists of at least drawings, materials lists, performance predictions, CG and CP predictions, at least one photograph of the builder working on the project. More information on the documentation package requirements is available later in this document.

3. **Recovery Systems Package** - This document can be included in the Documentation Package.

4. **L4 Data Capture Form** - An L4 Data Capture Form will be filled out and provided the to L4CC for review not less than 30 days prior to the flight attempt.

5. **Flight Data Card** - A flight data card will be filled out and give to the LCO prior to the flight attempt.

6. **HPR Certification Affidavit** - the form is forwarded to CAR HQ for processing the certification. At least one member of the flyer's L4CC team must sign as a witness to the flight.

4. Certification Procedure

There are 11 specific steps to the Level 4 Certification process. The intent of this process is to ensure that the builder has the confidence that his or her design and construction will work as a result of having the design and construction reviewed by experienced rocketeers of the L4 Certification Committee (L4CC).

4.1 L4 Certification Application Form

The builder will fill out the L4 Certification Form. This form captures the key information and provides a map for the rest of the L4 Certification process.

4.2 Prepare L4 Documentation

This documentation package will introduce the L4CC to the builder's design, intended construction methods and anticipated performance. The L4CC will review the package and, the L4 Certification Form. The information required in this form will be covered in the L4 documentation Package Outline section.

4.3 Contact L4 Certification Committee (L4CC)

Once the L4 Documentation Package is ready, the builder should either contact two members of the L4CC to have them review the project, or contact their CAR Provincial Representative to have two members of the L4CC assigned to review the project. These two L4CC members will become the builder's L4CC Team. The builder will then provide the L4CC Team a copy of the L4 Documentation Package and L4 Certification Form. If required, the builder will include a self-addressed envelope with sufficient postage for the return of the L4 Certification Form (and Documentation Package if desired).

4.4 L4CC Design Approval

The L4CC Team will review the L4 Documentation Package and, if necessary, contact the builder for clarification. Once the L4CC Team is satisfied they will approve the design by signing the Design Approved section of the L4 Certification Form.

4.5 Construction

With the design approved, the builder can begin construction. It's important that at a few points during construction, there must be photos taken of the builder actually constructing parts of the rocket. During the construction' process, the L4CC Team must at some point inspect the rocket before it's complete. The purpose of the inspection is to verify, to the satisfaction of the L4CC Team, that the rocket is being constructed in a manner suitable for the stresses encountered in an L4 flight. The inspection can be done in one of two manners:

1. **Physical Inspection** - the builder may present the rocket for physical inspection to one member of the L4CC Team prior to it's final assembly.
2.
3. **Construction Package** - the builder may prepare a construction packet with detailed descriptions of the construction techniques, including photos and diagrams as appropriate. If a Construction Package is used, it should be included in the L4 Documentation Package. Specific information on the content required in this document can be found in the L4 Documentation Page outline section.

In either case, the L4CC Team member inspecting the construction will sign the Construction Inspection section of the L4 Certification Form.

4.6 Recovery Systems Package

Prior to the certification flight, the builder will provide the L4CC Team with a Recovery Systems Package. The content required can and should be included in the L4 Certification Document. The specific information required is covered in the L4P. An L4CC Team member, after reviewing the Recovery Systems Package with the builder will complete and

sign the Recovery Systems Approval section of the L4 Certification Form.

4.7 Complete Construction

The builder can now complete construction of the rocket.

4.8 Completed L4 Documentation Package to L4CC Team

With the rocket completed, the builder will now complete the L4 Documentation Package and prepare two copies for the L4CC Team. One member of the L4CC Team will review the package with the builder prior to the, Certification Flight. A copy of the L4 Documentation Package will also be made available to the Launch. Event Chief RSO prior to flight. One L4CC Team member will sign the Completed Documentation Package section of the L4 Certification from.

The builder now transitions to "flyer".

4.9 Pre-Flight Rocket Inspection

At least one member of the L4CC Team must physically inspect the completed flight-ready rocket before flight. In addition, the Launch Event Chief RSO will usually physically inspect the rocket and review the L4 Documentation Package as well. The Chief RSO has the final say as to whether or not the certification flight can take place at their launch.

Two signatures are required on the Pre-Flight Rocket Inspection section of the L4 Certification Form, one signature must be an L4CC Team member, but the other can be any CAR Level 3 or level 4 certified flyer. The persons signing the Pre-Flight Rocket Inspection section of the L4 Certification Form must have physically inspected the rocket before flight and will act as Flight Witnesses for the Certification Flight.

4.10 Certification Flight

Once the rocket has been cleared to fly, the flyer can then mount the rocket on the assigned pad. The flyer must ensure that the Flight Data Card is handed to the Duty LCO prior to heading to a pad. It is not necessary to have the rocket inspected by the Duty RI, simply show the Duty RI the signed L4 Certification Form.

The Certification Flight must meet all of the following requirements:

1. The rocket must have at least one motor with a total impulse greater than 5120Ns (M impulse),
2. The flight must be made while a valid Transport Canada Launch Authorization is in effect,
3. The rocket must make a stable, safe flight,
4. The rocket must fully deploy its recovery system,
5. The rocket must remain intact, with no separation of parts that do not deploy their own recovery system,
6. The rocket must be returned for post-flight inspection.

If the recovered rocket is plainly visible but not retrievable, (such as hung in high power lines or in an inaccessible location) the flyer may direct the Flight Witnesses to the location of the rocket for visual inspection at that location.

4.11 Complete L4 Certification Form

Once the flight is complete and the rocket has had it's post-flight inspection, the L4 Certification Form will be completed. The Flight witnesses will sign the Final Approval section of the L4 Certification Form certifying that the flight met the above requirements and that they have reviewed the L4 Documentation Package and to the best of their knowledge it is complete and acceptable. The Flight Witnesses will sign the Flight Witness section confirming a successful flight and recovery.

Either Flight Witness may disallow the certification attempt if, in their opinion:
the flight did not demonstrate the flyer's ability to successfully fly a Level 4 High Power Rocket; or, the rocket did not fully meet all of the flight requirements for Level 4 Certification.

With the L4 Certification Form completed, the flyer will forward to CAR Headquarters the following:

- L4 Certification Form, with all sections signed,
- L4 Data Capture Form,
- L4 Documentation Package,
- L4 Recovery Systems Package (can be included in the L4 Documentation Package),
- L4 Construction Package (can be included in the L4 Documentation Package).
- A processing fee of $5

The flyer can have multiple copies signed to keep as temporary proof of Level 4 Certification. The flyer will receive an updated CAR Membership card showing their new Level 4 Certification in the mail.

5. L4 Documentation Package Outline

Preparation of the L4 Documentation Package is a critical component of the L4 Certification Program. The documentation forces the builder to consider design and construction techniques appropriate to the thrust levels in Level 4 motors (M, N and 0 impulse). The documentation also allows the L4CC Team to review the builders' design and construction and be assured that. the builder is constructing a safe rocket that conforms to the CAR HPR Safety Code.

There are five main sections that make a complete L4 Documentation Package:

1. L4 Certification Form, with all sections signed,
2. L4 Data Capture Form, I
3. L4 Documentation Package,
4. L4 Recovery Systems Package (can be included n the L4 Documentation Package),
5. L4 Construction package (can be included in the L4 Documentation Package).

The two L4 Forms can be downloaded from CARweb, or you can contact your CAR Provincial Representative for copies or write to:

CAR/ACF
71 Bermuda Close NW
Calgary, AB T3K 1G4

and request copies of the L4 Certification Form and the L4 Data Capture Form.

Note that the L4 Recovery Systems Package and the L4 Construction Package need not be separate documents, they can both be incorporated into a single L4 Documentation Package.

The remainder of this section will review the information required for each of the three builder written sections.

5.1 Documentation Package

At a minimum the Documentation Package will contain the following information:

- a scale drawing of the rocket design showing major dimensions, calculated Centre of Pressure, and the expected Centre of Gravity in Level 4 flight configuration,
- a description of the expected flight profile using the intended motor(s), showing, at a minimum, estimates for:
    - maximum expected altitude
    - maximum expected acceleration • maximum expected velocity
    - velocity as the rocket leaves the launch system
- a pre-launch checklist covering rocket and motor preparation and setup, as well as procedures for hangfire/misfire anomalies
- a post-recovery checklist for "safeing" the rocket in case of a failure, including steps required for disarming pyrotechnics, removal of unfired igniters, etc.

5.2 Recovery Systems Package

The Recovery Systems Package must be presented to the L4CC Team prior to the certification flight. At a minimum, this package must contain the following components:

- A description of the recovery system components, including the type of electronics, where redundancy is employed, the type and size of pyrotechnic devices and the sizes of parachutes and/or streamers being used;

- A schematic/wiring diagram of the ejection control system. This diagram should show the wiring between the ejection devices, disarming "switches" and the controlling electronics and/or power sources;

- Description of the expected descent rate with the main recovery device deployed and an explanation of how the descent rate was determined, or a description explaining why the main recovery device is suitably sized for the certification rocket, (such as manufacturer's recommendation, etc.);

- Documentation describing how the basic functioning of the recovery system has been demonstrated prior to the certification flight. The use of untested electronics is not permitted. This may be accomplished by either of two methods:
    - The builder may document a Level 3 test flight utilizing the recovery components intended for use in the

Level 4 Certification Flight, including the primary ejection electronics to be used in the Certification Flight; or
    - The builder may document the ground testing of the recovery electronics.

This document can either be a standalone document or incorporated in the L4 Documentation Package.

5.3 Construction Package

While the Construction Package is only mandatory in the case where the L4CC Team cannot physically inspect the rocket during the construction phase, the builder is strongly encouraged to complete a Construction Package as part of the L4 Documentation Package. This package should include at a minimum:

- descriptions of the construction techniques used, such as how bulkheads were constructed, tubes cut to length, etc.
- descriptions of the materials used for fins, airframes, couplers, bulkheads and motor tubes,
- descriptions of the adhesives used, and explanations for where they are used,
- descriptions of any reinforcements, such as fiberglass airframes,
- close-up photos of critical areas, such as the fin - airframe/motor tube attachments,
- photos of the builder working on the rocket.

This document can either be a standalone document or incorporated in the L4 Documentation Package.

6. Administrative Items

6.1 Tripoli and NAR Certification

CAR has a reciprocal agreement with the two major rocketry associations in the United States, Tripoli Rocketry Association (TRA) and the National Association of Rocketry (NAR). This agreement allows TRA and NAR HPR Certifications to be honored at CAR Launches. TRA and NAR members must show evidence of their Certification level and evidence of current membership prior to launching and they may fly to their current certification level, but not beyond.

Canadian Tripoli members wishing to grandfather into CAR must:

- Pay a CAR membership fee
- Give evidence of certification
- Complete the CAR certification exam

CAR members who are also members of TRA or NAR may have their Certification levels updated as a result of a successful CAR Level 4 Certification.

6.2 Failed Certification Attempts

Certification attempts and failures will not be tracked by individual, nor will failed certification attempts "count against" an individual. Forms sent to CAR on failed Level 4 certi21catin attempts will be used to track the effectiveness of the CAR Level 4 certification Program. They will also be used to track the frequency and type of failures. This information will be used to improve the certification procedures over time and help the L4CC members provide better guidance.