



Canadian Association of Rocketry

CAR Motor Certification Committee Motor Testing Manual

Written by Mike Dennet

January 25, 2002 - Rev. 3.1



Table of Contents

Section 1 - Overview.....	3
Section 2 – Purpose and Structure.....	5
Section 3 – Application for Testing.....	7
Section 4 – Submission Quantities.....	9
Section 5 – General Design and Submission Requirements.....	11
Section 6 – Test Fees and Expenses.....	13
Section 7 – Certification Terms and Expiration.....	15
Section 8 – Test Scheduling.....	18
Section 9 – Official Listing.....	19
Section 10 – Right of Refusal.....	19
Section 11 – Test Procedures.....	20
Section 12 – Data Reduction Procedures and Standards.....	24
Section 13 – Solid Motor Design Requirements.....	26
Section 14 – Hybrid Motor Design Requirements.....	27
Section 15 – Official CAR Certified Motor Listing.....	28

Section 1 - Overview

The Canadian Association of Rocketry has been in existence for over 35 years, and in that time has seen many changes in the sport of model rocketry (MR). Perhaps the most significant change of late has been the development and growth of high power rocketry (HPR) in Canada as a separate but closely related facet of the sport.

With high power rocketry gaining popularity as it has in the US, Canada and abroad, various new motor manufacturers have come into existence, some to serve only the HPR market, others to serve both the MR and HPR sectors. Some have come and gone, others exist to this day, others are yet to be.

In the earlier days of high power rocketry, only one association existed to provide member services to the HPR sport - the Tripoli Rocketry Association. These early days marked the transition from localized experimental launches to a nationwide recreational activity. Originally, the association made no requirements of motor manufacturers, in other words any manufacturer, "legitimate" or not, was free to transport motors to a Tripoli sanctioned launch and offer them for sale. This had both positive and negative results. On the positive side, manufacturers continually brought new and interesting products to the market. One unique facet of early TRA launches was the ability to show up at a launch and be surprised by motor manufacturers offering new products, even "specials" made in limited quantities and "one-offs" for specific customers. Generally, this system was not problematic and was a point of interest of the activity for many. It became evident, however, that certain manufacturers were misrepresenting the performance and/or reliability of their products, either wittingly or in some due to a lack of technical expertise and test capability.

It was perhaps inevitable that the TRA needed to gain some form of control over the situation in order to foster and maintain credibility with federal authorities and insurance underwriters. The National Association of Rocketry (NAR) had required certification testing of model rocket motors for many years at this point. Thus, the TRA instituted the Tripoli Motor Testing and Listing Committee with the purpose of evaluating and testing any products destined for use at TRA sanctioned launches. This system has helped to weed out products that were unsafe, inconsistent or unreliable. In time, the NAR made a decision to embrace HPR within its organization, and subsequently the two organizations formed a reciprocal agreement whereby motors certified for use by one organization were allowed to be used at sanctioned launches of the other.

The CAR, like the NAR, originally existed solely to oversee MR activity. As is inevitable, interest in HPR within Canada grew, with the result that early HPR activity in Canada began when rocket enthusiasts returned from US launches with HPR motor products and launched in a clandestine fashion. Over time, the CAR embraced high power rocketry and sanctioned launches have become a regular occurrence.

In Canada, for any explosive article to be sold, possessed, and used it must not only be classified for shipping purposes, but also must receive explosives classification and be authorized per the Explosives Act and Regulations. An explosive is only "authorized" after the Explosives Regulatory Division (ERD) of National Resources Canada (NRCan) has reviewed test data and technical specifications, deemed the product safe and suitable for sale and use, assigned an explosives classification and placed that

product on the authorized explosives list.

Because of this requirement, it may seem that this authorization procedure would be sufficient scrutiny for the CAR to endorse use of authorized products. This is true to a point, but several problems recently have come to light. One is that the Canadian Explosives Research Laboratory (CERL) is limited in static test capability, as they have only required the ability to test up to G class model rocket motors until recently, and good quality load cells are very expensive especially considering their infrequent usage for this purpose. Secondly, CERL generally has a backlog of other tests in line resulting in extended waiting periods. Additionally, the HPR market in Canada is relatively limited, and the cost of testing has to date been prohibitive to manufacturers, resulting in very little HPR product being authorized. One final twist is that there are now and may be more in the future, hybrid rocket motor systems that utilize no explosive ingredients whatsoever and this plus other design features exempts them from jurisdiction by NRCan. However, CAR and Transport Canada must have reliable test data in order to provide launch authorizations where these products are involved.

It was thus proposed that the CAR institute a Motor Test Committee of its own, and endorse a requirement that motors used at CAR sanctioned launches must be certified. An integral part of this proposal is the goal to put a reciprocal agreement in place with the Tripoli Rocketry Association and perhaps also the NAR, so that motors certified by one organization are thereby certified for use by the others. While the CAR is a national organization, Tripoli is an international organization, and it is feasible that Canadian manufacturers may develop products destined only for Canadian consumers and/or for foreign (non-US) consumers flying under Tripoli. However, without such an agreement in place, motors destined for these markets would need to be first classified for shipping by the US DOT, and then certified in the US which would greatly impede the process of bringing new products to those markets by domestic manufacturers. Thus both manufacturers and CAR or TRA rocketry enthusiasts in Canada and abroad can benefit from CAR motor testing and reciprocity with Tripoli.

Section 2 – Purpose and Structure

The RI Level 1 is certified to inspect simple, motor ejection rockets of H through L impulse inclusive, and is qualified to supervise RI Level 1 apprentices.

2.1 Purpose

The Canadian Association of Rocketry (CAR) Motor Certification Committee (MCC) is a division of the CAR. It's primary purpose is to test and evaluate model and high power rocket motors in order to verify function, safety, and performance. Motors that successfully pass this testing and evaluation procedure will be declared to be certified by the CAR, and suitable for use by members of that organization.

2.2 Committee Structure

The MCC will consist of the Committee Chairperson, plus a sufficient number of committee members to satisfy and enforce these policies and procedures. It is suggested that a minimum of four committee members be assigned within each test region. A test region is the area located within a practical distance to a CAR motor test facility. Committee member candidates will be selected by both the MCC Chairperson and the CAR Executive Committee. Candidates will be located within a practical distance from the regional test facility, and shall possess suitable skills and abilities to perform committee functions. CAR members wishing to be considered for MCC duties should advise the CAR Executive and MCC Chairperson in writing of their willingness and ability to serve on the committee. All suitable candidates who do so apply will be duly considered for posting on the committee when the need for additional members arises. Selection from available candidates is solely at the discretion of the MCC chairperson and CAR Executive.

A complete list of committee members shall be maintained at CAR Headquarters, and shall be updated and amended as required by the MCC Chairperson.

2.3 Committee Chairperson

The Committee Chairperson will be selected by the CAR Executive from the CAR membership and preferably from MCC members. The Committee Chairperson shall stand in position until either replaced by decision of the CAR Executive or voluntary resignation of his/her duties.

2.4 Test Sites

2.4.1 The number and location of regional test sites shall be decided by the CAR executive and based on overall need and availability of suitable test equipment and personnel.

2.4.2 Each regional test site shall have one MCC member appointed by the MCC Chairperson as regional test supervisor. This may be the same person where the Committee Chairperson is located in a test region.

2.5 Treatment of Motor Manufacturers

The CAR MCC shall strive to serve motor manufacturers in a fair, impartial and expedient manner. Of primary consideration are the necessity and right of the association and it's members to be suitably informed about the products they use in pursuit of the sport.

2.6 Publishing of Data

Data gathered from successfully tested and certified products will be published in a format practical and useful to CAR members. This may include posting to the CAR website and shall include publication of a certified motor list. All forms of information posted shall be updated at minimum on a quarterly basis and as expediently as possible when new data becomes available.

2.7 Certified Motor and Sanctioned Launches

Effective _____, only motors certified by the Canadian Association of Rocketry, the Tripoli Rocketry Association or the National Association of Rocketry shall be permitted to be used at CAR sanctioned launches. Motors without certification in good standing by any of these organizations will be considered experimental, and those CAR members launching them will not be subject to CAR member benefits including insurance coverage. This policy does not preclude any future policies by the CAR to include experimental activity, however at the time of this writing no such policy exists.

Section 3 – Application for Testing

3.1 Application Submission

Manufacturers wishing to have motors tested for CAR certification will make written application to the MCC chairperson by mail, courier, fax or e-mail or other means. The application should include the following information and any other that may be deemed appropriate:

3.1.1 Full business name and address of the Manufacturer,

3.1.2 Name of applicant. Applicant must be a representative of the manufacturer, motors may not be submitted for certification testing by other parties, except per 3.1.3 below,

3.1.3 In the case of foreign manufacturers wishing to have motors tested for certification, the applicant may be an agent of the manufacturer such as an importer or dealer, in which case the application must include a letter of permission from the manufacture indicating approval of the application being made on their behalf. See **3.2** below,

3.1.4 A complete list of the motors to be tested, including all delay times or other variations requiring separate test. Physical configuration such as length and diameter must be included to ensure that compatible test fixtures are available for static firing. Performance data including (at minimum) total impulse, maximum impulse, and burn time are required and must be of reasonable accuracy in order to assess test equipment compatibility,

3.1.4.1 It is not the intention of the MCC to replace testing by the manufacturer. If a manufacturer is not able to provide evidence of basic knowledge of the delivered performance of a motor system, the MCC may refuse testing until this information is provided. Otherwise, MCC test equipment may be subjected to unknown variables and be damaged, and test personnel put at undue risk,

3.1.5 If the motors to be tested require any special provisions, such as proprietary ground support equipment or vertical test fixtures, a complete description of the equipment and other provisions required to complete the tests,

3.2 Motors of Foreign Manufacture

Motors of foreign manufacture may be considered for CAR certification testing only where no CAR, Tripoli, NAR or other reciprocal association certification test facility exists in the country of manufacture.

3.3 Pyrotechnic Materials

If the motors to be tested contain any pyrotechnic materials whatsoever as packaged and offered for sale, including compositions or devices made by other manufacturers:

3.3.1 The manufacturer shall include with the application written proof to the MCC Chairperson that the motors to be tested have been manufactured or imported in compliance with the Explosives Act and Regulations CRC 599 as administered by National Resources Canada (NRCan), Explosives Regulatory Division (ERD). The CAR MCC reserves the right to verify any such information with NRCan.

This information will serve to verify legal manufacture of the motors, and may include one or more of the following as required: a copy of a factory license for explosives manufacture, proof of UN classification of the compositions or devices, or a letter of permission issued for the purposes of transport for testing of new devices, or a letter from NRCan ERD indicating that the motors to be tested are not under the jurisdiction of the Explosives Act and Regulations.

3.4 UN Classifications

Only motors allowed to ship as UN 1.3 or 1.4 explosives, or 4.1 flammable solids will be considered for testing, i.e. no class 1.1 or 1.2 devices will be considered for testing.

3.5 Scheduling Test Sessions

Upon receipt and approval of a written application for CAR MCC testing, the MCC Chairperson will, in cooperation with the manufacturer and committee members, assign a testing location and date, and schedule a test session of sufficient duration. The MCC Chairperson will endeavor to expedite testing whenever possible. The MCC Chairperson will advise the manufacturer in writing of the following:

- The quantity of each motor type required
- The address for shipment of the test articles
- Proposed test date and duration (subject to change based on test committee personnel availability)
- Any special provisions required with regards to test equipment, and cost of such provisions if not supplied or otherwise implemented by the manufacturer. Supply of or cost of any special provisions required for test is the responsibility of the manufacturer unless otherwise decided by the CAR executive and CAR Motor Test Committee chairperson.

3.6 Shipping of Motors for Testing

Motors should be shipped to the Test Committee in a manner that will ensure arrival a minimum of seven days before the scheduled test date whenever possible. Exceptions may be made by agreement with the regional test supervisor or MCC Chairperson. Upon receipt of the test motor shipment the regional test supervisor will advise the manufacturer promptly. Any damage, losses or omissions will be reported immediately to the manufacturer for remedy. The manufacturer will include with the shipment a complete list of all items included, and will clearly label or mark all items for identification.

3.7 Packaging of Motors for Testing

Motors to be tested are required to be packaged in the form in which they are to offered to consumers, including instructions for use, igniters if included, etc. in order for the MCC to assess the suitability of the product for general use by CAR members. Exceptions to this rule may be made at the discretion of the MCC chairperson, for example if only a draft copy of the instructions is available.

Section 4 – Submission Quantities

4.1 Variants as Unique Motors

Any variant of a particular motor type such as delay time, propellant formulation, physical construction etc. is considered a unique motor type and requires separate testing. Examples of such variants could include a "J200" low smoke and "J200" smoky motor, or a "J200" single-use versus a "J200" reloadable motor, or a "J200" hybrid with 800 Ns average total impulse and a "J200" hybrid with a larger oxidizer tank and 1000 Ns total impulse. The MCC Chairperson has sole discretion as to whether motor type variants require separate testing or not.

4.2 Model Rocket Motors

4.2.1 Motors of less than or equal to 160 Newton-seconds total impulse and otherwise meeting the definition of a model rocket motor (Class 7.2.3) as defined in the Explosives Act and Regulations, shall be submitted and tested in the following quantities:

4.2.1.1 - Single-use motors: a minimum of three (3) of each delay time with a minimum of eleven (11) motors in total.

4.2.1.2 - Reloadable motors: a minimum of three (3) of each delay time with a minimum of eleven (11) motors in total.

4.2.2 For re-certification of model rocket motors originally certified as per **4.2.1** above, the following quantities shall be submitted and tested:

4.2.2.1 - Single-use motors: a minimum of two (2) of each delay time with a minimum of six (6) motors in total.

4.2.2.2 - Reloadable motors: a minimum of two (2) of each delay time with a minimum of six (6) motors in total.

4.3 High Power Rocket Motors

4.3.1 Rocket motors of greater than 160 Newton-seconds total impulse and less than or equal to 5120 Newton-seconds total impulse (Class 7.2.5), shall be submitted and tested in the following quantities:

4.3.1.1 – Three (3) of each delay time.

4.3.2 For re-certification of high power rocket motors originally certified as per **4.3.1** above, the following quantities shall be submitted and tested:

4.3.2.1 - Two (2) of each delay time

4.3.3 Rocket motors of greater than 5120 Newton-seconds total impulse and less than or equal to 40,960 Newton-seconds total impulse (Class 7.2.5), shall be submitted and tested in the following quantities:

4.3.3.1 - Two (2) of each delay time

4.3.4 For re-certification of high power rocket motors originally certified as per **4.3.3** above, the following quantities shall be submitted and tested:

4.3.4.1 - One (1) of each delay time

4.4 Hybrid Rocket Motors

Hybrid rocket motors will be tested in quantities in accordance with their total impulse as per **Sections 4.1, 4.2 and 4.3** above. Distinction between different hybrid motor "types" for purpose of testing is at the discretion of the MCC Chairperson, and may be made based on differing fuel grain compositions or polymers, nozzle configurations, orifice size, ignition scheme, etc. or any other variable that the chairperson feels may result in differences in performance.

4.5 Motor Hardware

4.5.1 MCC facilities to which re-loadable solid propellant rocket motors are submitted will be provided with two sets of hardware for each motor type. Where components are shared between motor types, such as nozzle retainers for cases of different lengths, two of each unique component shall be submitted. This hardware will be retained by MCC for future test sessions, unless specifically requested by the manufacturer, in which case MCC will retain one example for record of each piece of hardware and return the remainder to the manufacturer. Return of any motor hardware will be made at the manufacturer's expense.

4.5.2 MCC facilities to which hybrid motors are submitted for testing shall be provided with two sets of any reloadable or other flight hardware and accessories (except ground support equipment, see **4.5.3** below) required for each motor type submitted, including flight tanks, injector bells, orifices, casings, nozzle retainers etc. Where components are shared between motor types, such as nozzle retainers for cases of different lengths, two of each unique component shall be submitted. This hardware will be retained by MCC for future test sessions, unless specifically requested by the manufacturer, in which case MCC will retain one example for record of each piece of hardware and return the remainder to the manufacturer. Return of any motor hardware will be made at the manufacturer's expense.

4.5.3 MCC facilities to which hybrid motors are submitted for testing must be provided with any filling apparatus, launch control or other ground support hardware required to fill and fire the motor as per the manufacturer's instructions. Where the filling apparatus is compatible with industry standard nitrous oxide, oxygen or other pressurized gas/liquid cylinders these may be provided by MCC, with the understanding that the manufacturer is responsible for the cost of any such materials required for testing. Decisions regarding who supplies gas cylinders, etc. are made at the discretion of the MCC Chairperson and regional test supervisor in cooperation with the motor manufacturer.

4.5.4 Manufacturers shall supply, or cover the cost of, any additional components or modifications to MCC test equipment required to accommodate the testing of motors which are not compatible with standardized test fixtures. MCC will provide test fixtures capable of accommodating industry standard diameter motors of cylindrical configuration and equipped with delays and ejection charges. The diameters considered industry standard at the time of this writing are: 13, 18, 24, 29, 38, 54, 75, and 98mm.

4.5.5 Any hardware that becomes damaged or shows signs of wear deemed by the MCC to be unsafe for further use shall be replaced by the manufacturer. Where these components became damaged or unreasonably worn during nominal operation of the motor during testing, the MCC chairperson may elect to discontinue further testing until the manufacturer rectifies the problem.

4.5.6 If a manufacturer withdraws from retail availability any type of motor hardware in possession of

the MCC, the MCC will, upon request of the manufacturer, return all but one example of said hardware. The remaining example in possession of the MCC will be retained for record while the product is still in use and certification is still valid. This remaining hardware may be returned upon request after expiration or withdrawal of certification. If the manufacturer requests all hardware to be returned at any time, then any motor type utilizing said hardware shall be immediately de-certified.

Section 5 – General Design and Submission Requirements

5.1 Motor Construction

All motors submitted for MCC testing will be designed and constructed in such a manner that in the event of a catastrophic failure, motor fragments will be projected predominantly in a longitudinal direction relative to the motor, and that no fragments will project further than:

5.1.1 3m (10 feet) for motors under 30Ns of total impulse.

5.1.2 6m (20 feet) for motors of 30Ns to 160 Ns total impulse.

5.1.3 For high power motors, not more than half the separation distance prescribed by the CAR Safety Code for the total impulse of the motor.

5.2 Motor Casing Temperatures

All motors submitted for MCC testing shall be designed and constructed in such a manner that the motor casing temperature will not exceed 200°C (392°F) at any point during or after the test. Isolated spots, such as the nozzle exit may exceed this if the bulk of the motor exterior adheres to this requirement.

5.3 Motor Instructions

All motors submitted for MCC testing shall include complete instructions for assembly and use. Motors will not be certified unless suitable and complete instructions for safe use are provided. Omissions or errors will be reported to the manufacture for remedy prior to certification, and MCC will not be responsible for any failed tests or lost data caused by any problems related to the instructions provided. Instructions will include but not be limited to directions for the following as applicable:

- Proper assembly of the motor for flight,
- Adherence to all Federal, Provincial and local laws and regulations, including the CAR Safety Code,
- Adjustment of delay time or ejection charge weight including safe disposal of any live residues generated from these procedures,
- Safe disposal of the motor if damaged, stale-dated or otherwise not to be used,
- Installation of the igniter,
- Disassembly, cleaning and maintenance of the motor after firing,
- Suitable precautions regarding toxicity of any compositions or combustion products.

5.4 Motor Specifications

All motors submitted for testing by the MCC will include as a minimum the manufacturer's rated total impulse, maximum thrust, and burn time. This information is required to select the appropriate load cell for impulse measurements during testing. In the event the information is erroneous, the manufacturer will be responsible for any damage incurred by the test equipment as a result of overloading. In addition, MCC will not be responsible for lost data if performance data is grossly misrepresented, and the manufacturer will be required to provide additional test samples before certification testing can be completed.

5.5 Production Date Stamps

All motors submitted for testing and subsequently offered for sale are required to have date of manufacture or other production date code imprinted on the casing and/or reload package.

5.6 Motor Igniters

All motors submitted for testing must include the igniter offered by the manufacturer for said motor type if any. If packaged separately from the motors or reload kits, the manufacturer must clearly identify which igniter is to be used with a particular motor type.

5.6.1 In the event that the motors are to be offered for sale without a corresponding igniter included in the motor package or offered separately by the manufacturer, the manufacturer must either supply suitable igniters for the test session, or reimburse the MCC for the cost of acquiring and/or assembling suitable igniters as per the recommendation of the manufacturer. In cases where the manufacturer does not supply a suitable igniter with the product, MCC assumes no responsibility for delays in testing, test data deviation, loss of test data or any other anomaly caused by problems associated with motor ignition.

Section 6 – Test Fees and Expenses

6.1 Test Fees

6.1.1 Test fees are payable to the **Canadian Association of Rocketry**

6.1.2 Test fees shall be submitted by check, cash, money order or bank draft in Canadian dollars to:

CAR Headquarters
71 Bermuda Close NW
Calgary, Alberta, Canada
T3K 1G4

6.1.3 Testing will not commence until testing fees are paid in full.

6.1.4 Certification will not be issued until all fees, and all expenses or damages incurred by MCC on behalf of the manufacturer are paid in full. The MCC reserves the right to withdraw **ALL** certification granted to a manufacturer where test fees or other expenses remain in arrears.

6.2 Fee Schedules

All fees are in Canadian Dollars.

6.2.1 Model Rocket Motors to **160 Ns**;

6.2.1.1 – Certification: \$25.00 per motor type.

6.2.1.2 – Re-certification: \$20.00 per motor type.

6.2.2 High Power Rocket Motors, **160.01 Ns** to **5120 Ns**;

6.2.2.1 – Certification: \$30.00 per motor type.

6.2.2.2 – Re-certification: \$25.00 per motor type.

6.2.3 High Power Rocket Motors, **5120.01 Ns** to **40,960 Ns**;

6.2.3.1 – Certification or Re-Certification: \$50.00 per motor type.

6.3 Expenses Not Included in Fees

Testing fees listed above do not include expenses incurred for any of the following:

6.3.1 Igniters when not provided.

6.3.1 Modifications or additions to test equipment required by non-standard motor diameters or other unusual configurations.

6.3.3 Consumables such as nitrous oxide, oxygen, carbon dioxide, etc.

6.3.4 Any other such items or materials required to complete testing and deemed to be the manufacturer's responsibility by the MCC Chairperson.

6.3.5 Any shipping charges related to testing.

6.4 Damages

Manufacturers are responsible for any and all damages incurred to testing equipment as a result of, but not limited to, the following:

6.4.1 Catastrophic failure of a test motor.

6.4.2 Misrepresentation of performance parameters or irregular performance resulting in overload or other damage of test equipment.

6.4.3 Other expenses the MCC Chairperson may determine to be the responsibility of the manufacturer.

6.5 Alterations or Upgrades

Costs of any alterations or upgrades to MCC test equipment are non-refundable and any such material or equipment shall remain the property of the MCC.

6.5 Payment of Additional Expenses

All expenses additional to the basic testing fees are payable within 30 days of receipt of invoice from MCC. MCC reserves the rights to withdraw any or all certifications from any manufacturer in arrears with the MCC until such fees or expenses are paid.

Section 7 – Certification Terms and Expiration

7.1 Certifications and Calendar Quarters

Terms of certification will be based on the nearest quarter of the calendar year., i.e. a motor type certified on February 15, 2002 and that is certified for a three year term, will expire at the end of the first quarter of the third year after certification, i.e. March 31, 2005.

7.2 Certification Periods

7.2.1 Motors of up to **5120 Ns** total impulse (class L) will be certified for a period of **three (3)** years from the date of certification.

7.2.1 Motors of over **5120 Ns** and up to **40,960 Ns** total impulse (class M through O) will be certified for a period of **five (5)** years from the date of certification.

7.3 Re-certification

Motors must be submitted for re-certification prior to expiration of the certification term, and may be submitted up to 90 days in advance of that time. There will be no extensions of certification terms unless by written approval of the CAR Executive.

7.4 Timing of Re-certification

Manufacturers must apply for re-certification testing of a motor type no more than 120 days in advance of expiration, and no less than 30 days in advance of expiration. Where a manufacturer has applied for re-certification testing within this time frame, the MCC chairperson may extend the certification period for up to one quarter year past expiration in order to accommodate scheduling of the test committee. Where a manufacturer is late in making application for re-testing, new certification fees and quantities shall apply.

7.5 Re-certification

Motors registering a significant number of failures in the field as judged by the MCC and/or CAR Executive based on field reports, may be called for re-testing by the MCC. The manufacturer will be required to submit a quantity equal to that required for new certification.

7.5.1 Motors that fail catastrophically during re-testing will be immediately de-certified. The manufacturer will be advised of the failure, and the manufacturer may be required to submit a technical report to the MCC indicating the means by which the design or manufacturing defect will be repaired. Upon approval of the report, which will be required to contain any information the MCC Chairperson deems appropriate, the motors will be approved for re-testing.

7.5.2 Manufacturers will be responsible for all shipping and test fees associated with re-testing as required by **Section 7.5** above. These fees will be equal to the original certification fees for that motor type.

7.6 Motors Testing Outside their Total Impulse Class

7.6.1 If the total impulse of all certification tests or re-certification tests of a motor type averages to a value placing the motor class either above or below the manufacturer's designation, the manufacturer will be advised of the discrepancy promptly. Manufacturer's designations will be allowed a total impulse class discrepancy of 2% of the upper or lower thresholds of the class for a single term of certification only. In other words, a motor designated a "G50" may have an average total impulse as tested as low as 78.4 Ns or as high as 163.2 Ns. If the average total impulse of the motor does not fall completely within the total impulse class at time of next (re-certification) testing, the designation must be changed by the manufacturer, or the deviation corrected and the motor retested as for re-certification. Otherwise, certification will be withdrawn at the end of the next quarter year period, i.e. three months from expiration of the previous term.

7.6.2 If the discrepancy exceeds the 2% threshold noted in **Section 7.6.1** above, and is not explainable by conditions at time and location of testing, then the manufacturer will be given the choice of amending their designation to truly reflect the power class of the motor tested, or to re-submit the motor for certification. Motors will not be considered certified if labeled incorrectly with regards to total impulse class, both to prevent misrepresentation of the commercial value of the motor and to ensure that the motor is flown by persons certified to the appropriate level for that class of motor. Motors may be provisionally certified after testing, if the manufacturer agrees to change the motor designation and provides adequate proof to that effect within 30 days of certification testing.

7.6.3 The MCC Chairperson may elect to waive action regarding the discrepancy if conditions at time and location of firing (such as test site elevation or temperature conditioning problems, etc.) are consistent with the nature and magnitude of the discrepancy. In such a case the test data may be either adjusted to standard test conditions when possible, or a notation made on the certification report to indicate the reason for the discrepancy.

7.7 Uncertified or De-certified Motors

7.7.1 Motors that have been de-certified due to expiration may be flown at CAR sanctioned launches for a period of 12 months following expiration.

7.7.2 Motors that have valid certification and that are no longer available to due either to being withdrawn from production by the manufacturer or the manufacturer going out of business, will remain certified until the end of their certification term. The MCC Chairperson may extend this term for one year past expiration if the product is still in use and exhibits no problems in use, in order that fliers are given the opportunity to use remaining inventory.

7.7.3 Motors that have been de-certified for any other reason than described in **Sections 7.7.1** and **7.7.2** above may not be flown at CAR launches at any time.

7.7.4 Manufacturers may not sell or otherwise offer to CAR or other rocketry association members any motors whose certification is not current and valid. This includes motors whose certification has expired but that are still allowed to be flown per **Section 7.7.1** above.

7.8 Submission for Testing after De-certification or Expiration

Any motor submitted for testing after expiration of a certification term, or after decertification for any reason, will be treated as a new certification and the appropriate test fees and quantities shall apply.

7.9 Deviation of Total Impulse from Prior Certification

Motors deviating by more than 15% in total impulse or more than 25% in average impulse from the prior term of certification will be de-certified, and will require either complete re-submission as for new certification, or (solely upon agreement of the MCC Chairperson) the manufacturer may provide additional samples and test fees to bring the total number of samples tested and the total fees paid equal to new certification levels.

Section 8 – Test Scheduling

8.1 Scheduling Test Sessions

Test sessions for new certification and re-certification will be scheduled as soon as possible and practical for committee members in the region where testing is to be held, and in no case later than 60 days after new application or re-certification application made within the time frame allowed in **Section 7** above.

8.2 Data Reduction

Data reduction shall be completed within a reasonable time period after completion of testing, and it is recommended that this be completed within 14 days of completion of testing.

8.3 Test Data Provision to Manufacturer

Test data will be provided to the manufacturer when data reduction is completed. In the case of failure of a motor during testing, the manufacturer shall be notified as quickly as possible.

8.4 Testing Results to CAR HQ

Results of certification testing or re-certification testing shall be posted and otherwise reported by the CAR within 30 days of completion of data reduction. Where any motor is de-certified for any reason, notification shall be issued within 7 days of the decision.

Section 9 – Official Listing

9.1 CAR Officially Certified Motors

Only listings of certified motors published by the CAR will be considered official.

9.2 Letter of Certification

Manufacturers will be presented with a Letter of Certification for each motor type successfully certified or re-certified, marked with the official seal of the Canadian Association of Rocketry [*do we have one?] and signed by the MCC Chairperson or member of the CAR Executive.

9.3 Publication of Certified Motors

As soon as practical, the list of certified motors on CARweb, the CAR website, will be amended to reflect additional and/or new motor certifications or de-certifications. [* who gets the list of certified motors?]

Section 10 – Right of Refusal

10.1 Reservation of Right of Refusal

The MCC Chairperson or regional test supervisor reserves the right to refuse for certification testing any motor that, in the opinion of the chairperson or regional test director is flawed, damaged, of obvious poor design, or is otherwise unsafe or unsuitable for testing and that could present unreasonable hazard to the test committee personnel and equipment or to the membership of the CAR.

Section 11 – Test Procedures

11.1 Test Personnel

11.1.1 The MCC Chairperson will be responsible for overseeing all aspects of operation of the MCC test program, including acting as primary contact point for motor manufacturers for issues regarding any aspect of testing.

11.1.2 The regional test supervisor will be responsible for managing all aspects of testing within their test region, and will act as liaison to the MCC Chairperson for regional committee members, manufacturers present at test sessions or for any other issues of regional nature.

11.1.3 Test sessions will require a minimum of three MCC members, of which at least two must have no business association or direct relation to any motor manufacturer or its representatives or employees.

11.1.4 Additional personnel may be recruited for assistance with test sessions by the regional test supervisor, and need not be members of the CAR MCC or even CAR if the supervisor and/or MCC chairperson feels that their abilities will be of benefit to the test session.

11.1.5 Representatives of the motor manufacturer whose products are undergoing test are welcome to attend the test session, however they may not be directly involved in the test session except to assist in impartial duties such as test equipment setup, transport etc. These representatives under no circumstances may be involved in motor assembly, interpretation of instructions, test stand calibration, or any other function where test data or impartial assessment of any facet of the product is involved. The regional test supervisor will be responsible and accountable for ensuring that test sessions are conducted in a fair, impartial, and professional manner.

11.1.6 Representatives failing or unwilling to comply with the preceding requirements during the test session may be required to leave. This decision is solely at the discretion of the regional test supervisor and/or MCC Chairperson.

11.2 Receiving Motors for Test

11.2.1 The regional test supervisor shall, upon receipt of motors for testing, verify that all contents of the shipment are in accordance with Section [*3.3.1 regarding compliance with the Explosives Act and Regulations. Any items or materials apparently in discrepancy with this requirement shall be reported immediately to the MCC Chairperson. Shipments may be impounded, refused, reported or otherwise dealt with where non-compliance is apparent. In no way shall MCC personnel or the CAR be held liable or accountable for any legal aspect of the manufacture or shipment of articles for test.

11.2.2 Motors received for test shall be stored in controlled environmental conditions of 60 - 80° F and 30 - 50% relative humidity before and during test.

11.2.3 The regional test supervisor will advise both the manufacturer and the MCC Chairperson upon

receipt of a motor shipment for test, including any damages, omissions or other discrepancies.

11.2.4 Motors and associated equipment, accessories etc. will be organized and sorted for testing. The regional test supervisor will generate either an electronic or printed database of each motor received for testing, including the following information:

11.2.4.1 Manufacturer's name

11.2.4.2 Manufacturer's motor designation

11.2.4.3 Date codes and/or lot numbers

11.2.4.4 Any observations regarding condition of product, i.e. shipping damage, visible defects, etc.

11.2.5 The database will include additional fields for the following information and any other deemed necessary:

11.2.5.1 Test sequence number

11.2.5.2 Test date

11.2.5.3 Test conditions

11.2.5.4 Comments

11.2.6 If the data acquisition software to be used has the capability of assigning and recording with the test data a sequential code number for each test firing, then that code number will be recorded with the information from **Section 11.2.5** above at the time of firing. Otherwise, the test supervisor will assign and record sequential code numbers prior to testing.

11.2.7 Code numbers shall use the format MMDDYY##, where ## is sequential and represents the order of firing in the test series.

11.3 Motor Testing Process

11.3.1 Test equipment shall be setup and calibrated in accordance with the procedures associated with the hardware and data acquisition software. All equipment, software, calibration methods and operational procedures are to be approved by the MCC Chairperson.

11.3.2 Motors shall be unpackaged, assembled, mounted, have igniters installed and otherwise be handled in strict accordance with the manufacturer's instructions. At no time shall manufacturer's representatives be allowed to assist physically or verbally during product assembly, except at the discretion of the regional test supervisor. This requirement is meant to ensure that the product is fairly assessed as to the quality and completeness of the assembly and operating instructions.

11.3.3 Motors, fuel grains, oxidizer tanks etc. shall be kept within the environmental conditions specified for storage at all times during testing. If necessary, these items shall be conditioned after assembly and prior to test.

11.3.4 Motor cases, reload packages, or other method of containment shall be clearly marked at time

of testing (or prior) with the test sequence number, in such a manner that spent articles can be easily associated with test records at a later time.

11.3.5 Safe separation distances shall be maintained at all times during static testing. Where the test equipment and personnel are relatively unprotected such as on open ground, separation distance shall be equal to or greater than one half of the launch separation distance in the CAR Safety Code for the class of motor being fired. At no time shall this distance be less than 15m (30 feet). Where a bunker, earth berm or other substantial protective barrier protects test personnel, these distances may be shortened as deemed safe by the regional test supervisor.

11.3.6 Test firing shall be conducted in accordance with the manufacturer's operational instructions in coordination with the operational procedures for the test hardware and software. In all cases, test procedures will be conducted in a manner as consistent as possible with actual launch conditions, as an example the delay time between hybrid oxidizer tank fill completion and firing shall be similar for static test and standard launch procedures. In all cases, where procedures could impact on test results, procedures will duplicate operational conditions and maintain storage environmental conditions as closely as possible.

11.3.7 Motors will be weighed before and after firing, preferably to the nearest gram or better. In the case of hybrid motors or other situations where this is not entirely practical, sub-components such as hybrid fuel grains will be weighed before firing and other weights made by calculation or reference. In all cases, test personnel will endeavor to tabulate pre-firing and post-firing weights as accurately as possible.

11.3.8 Each static test firing will be videotaped. Video record of successful firings may be over written if necessary, but preferably are kept on record (tapes are cheap). Any video record of unsuccessful or questionable firings must be kept permanently.

11.3.9 Still photography shall be available to make photographic record of any problems, failures etc. that may occur. These records shall be maintained permanently.

11.3.10 The test supervisor will make note of, photograph, and otherwise record in the test database any pertinent observations regarding each and every firing.

11.3.11 CAR Safety Code procedures, where applicable, shall be observed during test sessions. For example, igniters may not be installed except when the motor is securely fastened to the test fixture and test personnel are situated appropriately for safety. Clear audible countdowns will be given, and all participants and observers must be situated at safe distances and locations.

11.3.12 In the event of a catastrophic failure on the test stand, the test supervisor will ensure all personnel remain situated at a safe distance until all possibility of further action, i.e. propellant after-burn, debris landing, etc. has ended. Once cleared by the test supervisor, test personnel may assess the test equipment and motor hardware for damages.

11.3.13 The test crew will make a complete photographic record of the test hardware and effects of any catastrophic failure.

11.3.14 The test supervisor shall fill out an incident report for each and every failure, containing as much information and all observations that may be relevant and useful. One copy shall be forwarded to the MCC Chairperson, one copy shall be given to the manufacturer, and one copy shall be retained in the regional test supervisor's records. Care should be taken to record all damages to MCC equipment in detail.

11.3.15 Motor failures shall be recorded in the motor database file.

11.3.16 Where a motor failure has damaged test equipment to the point where further testing is not possible or where in the judgment of the test supervisor further testing may be questionable, the test session may be suspended. Further testing will not be resumed until repairs have been affected, and written agreement to reimburse the MCC for damages is obtained from the manufacturer and is to the satisfaction of the MCC Chairperson.

11.3.17 Testing of products that have exhibited catastrophic failure on the test stand may be suspended until the MCC Chairperson is satisfied that the manufacturer has taken steps to remedy the reason for the failures. The MCC reserves the right to request any information deemed necessary to support the manufacturer's claims of remedy, and to refuse further testing if the situation is not resolved to the satisfaction of the MCC Chairperson.

11.4 Post-Firing Process

11.4.1 All data shall be recorded on high-density floppy disk or CD-R in duplicate. Data shall be sorted by manufacturer, date, motor type, etc. in such a manner as to provide clear and logical access to any test data file. Text files shall be added describing weather conditions for each day of each test session, as well as any other information the test supervisor may be relevant for future reference.

11.4.2 One copy shall be sent to the MCC Chairperson for final data reduction within 48 hours of completion of the test session.

11.4.3 All test data will remain in strict confidence until released by the MCC Chairperson. Until that time, access to test data will be restricted to the CAR MCC and CAR Executive.

11.5 Release of Test Data

Test data and reports will only be released for publication by express permission of the CAR Chairperson to the MCC Chairperson.

Section 12 – Data Reduction Procedures and Standards

12.1 Data Analysis

Each firing of each motor type will be analyzed, and for each firing the following will be calculated:

12.1.1 Burn time, expressed in seconds. Burn time start is hereby defined as that point at which the motor's instantaneous thrust is equal to or first greater than five percent of the peak recorded thrust for that firing. Burn time end is hereby defined as that point at which the motor's instantaneous thrust first drops below five percent of the motor's peak thrust for that firing.

12.1.2 Delay time (if applicable), expressed in seconds. Delay time is hereby defined as the time interval in seconds between burn time end and activation of the motor's ejection charge. In the case of motors with tracking delay but no ejection charge (and with no option of using an ejection charge), the tracking charge burn time is recorded from burn time end until visual indication of delay/tracking grain burn-out is observed. Delay times shall be rounded to the nearest 0.25 second.

12.1.3 Total impulse, expressed in Newton-seconds (Ns) and optionally in pounds force-seconds (lbf-s). Total impulse is hereby defined as the force-time integral calculated from burn time start to burn time end.

12.1.4 Average thrust, expressed in Newtons and optionally pounds force. Average thrust is hereby defined as total impulse divided by burn time.

12.1.5 Specific impulse, expressed in pounds force - seconds per pound mass (lbf-s/lbm) or simply as seconds. Specific impulse is hereby defined as total impulse divided by the change in motor mass (calculated from change in weight).

12.2 Averages for Data

Total impulse, average thrust, and delay time for all firings of a particular motor type will be averaged.

12.2.1 A motor type designation shall be assigned to the motor tested. The motor designation shall be in standard "model rocket" format of [letter class][average thrust in Newtons] - [delay time], e.g. H165-12. Each figure/term in this designation shall be derived from average figures calculated per [*11.5.2 above].

12.2.2 All thrust curves for the motor type tested shall be overlaid on a single graph.

12.2.3 The motor firing which most closely represents the averaged data should be used as the published example of the motor type wherever possible, and the time thrust curve for that firing should be used as a representative example of the motor type.

12.2.4 Where time-thrust curves and other data are notably dissimilar, the MCC will endeavor to generate a set of data and thrust curve which most accurately reflect the average performance of the motor type.

12.2.5 Where the averaged total impulse places the motor outside of the total impulse class in the manufacturer's designation, the polices in [*7.8 above shall be applied.

12.2.6 Once a representative set of data has been generated to the satisfaction of the MCC Chairperson and all relevant issues addressed, this data shall be recorded and added to the official list of CAR Certified Rocket Motors.

12.2.7 All test data will be maintained and kept on permanent record at CAR HQ.

12.2.8 Letters of Certification for all successfully certified motor types shall be printed in triplicate, signed, sealed, and distributed as follows:

12.2.8.1 One copy to the motor manufacturer.

12.2.8.2 One copy to CAR HQ.

12.2.8.3 One copy retained in MCC records.

12.2.9 The MCC Chairperson shall forward test data and Letters of Certification to NRCan ERD and/or Transport Canada as required.

12.2.10 The MCC Chairperson shall forward additional copies of the Letters of Certification to the responsible party of any rocketry association in reciprocal agreement with CAR regarding motor certification.

Section 13 – Solid Motor Design Requirements

13.1 [* Essentially ditto TMT

Section 14 – Hybrid Motor Design Requirements

14.1 [* Essentially ditto TMT

Section 15 – Official CAR Certified Motor Listing

15.1[* Essentially ditto TMT

nm

Current Revision: v3.1

Revision History:

Jan 25, 2002 – Mike Dennet, original 2002 document

Jul 27, 2005 – Ian Stephens, editing for format, no other changes

Jan 26, 2017 - David Buhler, address update

CAR_Motor_Testing_Manual_3.1

Copyright 2005 Canadian Association of Rocketry