



# National Association of Rocketry

## Standards & Testing Committee Motor Testing Manual

Version 1.5

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Acknowledgement: The format of this document is based on the Motor Certification Committee Manual written by Mike Dennett for the Canadian Association of Rocketry in an attempt to unify the testing and certification procedures used by NAR, CAR and TRA.

Effective March 1, 2008 this document, *NAR Standards & Testing Committee Motor Testing Manual*, supersedes all previous editions of this manual and all previously-published test and certification standards of the NAR Standards and Testing Committee. All motor tests conducted and certifications granted after this effective date will be governed by this manual. Motor certifications granted prior to this date using previous procedures shall remain in effect.

## **Section 1 – Committee Organization & Policy**

### **1.1 Manual Purpose**

The purpose of this manual is to establish the operating policies, testing, and certification procedures of the National Association of Rocketry (NAR) Standards and Testing Committee (S&T), supplementing and interpreting the requirements of National Fire Protection Association (NFPA) Code 1125, Code for the Manufacture of Model Rocket and High Power Rocket Motors. Where there is a conflict between this Manual and NFPA 1125, the NFPA Code shall be the governing directive.

### **1.2 Committee Purpose**

The NAR Standards and Testing Committee is a volunteer technical committee of the NAR, established by the NAR By-Laws. Its primary purpose is to test and evaluate commercial model rocket motors and commercial high power rocket motors in order to verify function, safety, and performance using the testing and certification standards specified in Chapter 8 of NFPA Code 1125. Motors that successfully pass S&T testing and evaluation procedures are declared to be certified by the NAR, in its capacity as a “recognized testing organization acceptable to the authority having jurisdiction” under NFPA 1125, for use on NAR rocket ranges and for sale to U.S. consumers.

### **1.3 Committee Structure**

The S&T will consist of the Committee Chairperson plus a sufficient number of committee members to carry out the work of the Committee within the policies and procedures established in this manual.

Committee members will be selected by the S&T Chairperson. Selection of Regional Subcommittee Chairpersons, if any, also requires the approval of the NAR President. Candidates for S&T membership must possess suitable technical skills and abilities to perform committee functions, must have no personal economic interest, business relationship, or formal affiliation with any company manufacturing sport rocket motors, must agree to comply with the policies and procedures established by this manual, and must be members of the National Association of Rocketry.

A complete and current list of committee members shall be kept publicly posted by the S&T Chairperson.

### **1.4 Committee Officers**

#### **1.4.1 Chairperson**

The Committee Chairperson will be appointed by the NAR President with the consent of the NAR Board of Trustees. The Committee Chairperson shall be responsible for ensuring that the Committee and its members operate in accordance with the policy and procedures in this Manual and any supplementary guidance provided by the NAR President and Board, and that certification testing is conducted in accordance with the standards of NFPA 1125.

#### **1.4.2 Secretary**

The S&T Secretary shall assist the Chairperson in maintaining paths of communications among Committee members, and with the NAR Board and the NAR membership, by the maintenance of records and the preparation of official S&T announcements for publications in NAR publications and website postings.

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## **1.4.3 Webmaster**

The S&T webmaster shall maintain the committee's webpages on <http://www.nar.org>

## **1.4.4 Technology Officer**

The S&T Technology Officer shall assess and implement advancements in technology to maintain and improve the performance and accuracy of the S&T procedures, techniques, and methods.

## **1.5 Test Sites**

The Committee Chairperson and the NAR President may at their discretion establish multiple testing sites around the country, with one site operating under the direction of the Committee Chairperson, and any additional sites each operating under the direction of a Regional Subcommittee Chairperson. The number and location of regional test sites shall be based on overall testing capacity demand and on availability of suitable test equipment and personnel. Until and unless satisfactory and accurate procedures are developed and documented in this manual for correcting results from tests at other altitudes to sea level conditions as required by NFPA 1125, all test sites must be at an altitude that is within 500 feet of mean sea level (MSL).

## **1.6 Treatment of Motor Manufacturers**

The Committee shall serve motor manufacturers in a fair, impartial and expedient manner. Two primary considerations shall govern their treatment by the Committee: the right of the association and its members to be accurately informed about the performance and reliability of products that are certified by the NAR for consumer use; and the right of manufacturers to maintain confidentiality of proprietary details of motor design and manufacture and/or corporate business plans and arrangements.

## **Section 2 – Application for Certification Testing**

### **2.1 Application Submission**

Commercial rocket motor manufacturers who wish to have motors tested for NAR certification must make written application to the S&T Chairperson by mail, courier, fax or e-mail or other means. The application must include the following information and any other that may be deemed appropriate:

**2.1.1** Full business name and address of the manufacturer of the motor.

**2.1.2** Name of applicant. Applicant must be an authorized representative of the manufacturer; motors may not be submitted for certification testing by other parties, except per 2.1.3 below.

**2.1.3** In the case of foreign manufacturers wishing to have motors tested for NAR certification to support consumer sale in the U.S., 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 manufacturer indicating approval of the application being made on their behalf.

**2.1.4** A complete list and description 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 thrust, burn time, and delay time must be included and must be of reasonable accuracy in order to assess test equipment compatibility. If a manufacturer is not able to provide basic information on the delivered performance of a motor system offered for testing, S&T may refuse testing until this information is provided. Otherwise, S&T test equipment may be subjected to unknown stresses and damage, and test personnel may be put at risk

**2.1.5** 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. Supply of or cost of any special provisions required for S&T testing is the responsibility of the manufacturer unless otherwise decided by the S&T Chairperson.

**2.1.6** Written proof as required by NFPA 1125 that any pyrotechnic or low explosive materials in the motors to be tested have been manufactured or imported in compliance with the licensing requirements of the Bureau of Alcohol, Tobacco, Firearms, and Explosives (BATFE), and that the motors themselves or the appropriate materials in them have been classified for transportation by the US Department of Transportation (DOT) as UN

1.3 or 1.4 explosives or 4.1 flammable solids. This information may include but is not limited to the following: a copy of a BATFE license for explosives manufacture; and either proof of DOT-approved UN classification of the compositions or devices, or if this classification is still pending a letter of permission issued by the DOT for the purposes of one-time transport for testing of new devices.

### **2.2 Motors for International Competition**

NAR S&T, upon the request of the NAR President, may certify motors of domestic or foreign manufacture that lack some elements of the required proof in paragraph 2.1.6. against the motor certification standards of the Federation Aeronautique Internationale (FAI) in order to provide the required “National Aero Club certification” of such motors to the FAI to support their use by U.S. Spacemodeling Teams in international competitions. This does not constitute full certification for U.S. consumer use under NFPA 1125.

### **2.3 Scheduling Test Sessions**

Upon receipt and approval of a written application for testing, the S&T Chairperson will, in cooperation with the manufacturer and committee members, assign a testing location and schedule a test session of sufficient duration at the earliest possible date. The S&T Chairperson will advise the manufacturer in writing of the following:

- Fees associated with the certification testing
- The quantity of each motor type required
- The address for shipment of the test articles
- Proposed test date and location

### **2.4 Shipping of Motors for Testing**

Motors must be legally shipped to the designated test site in a manner that will ensure arrival a minimum of seven days before the scheduled test date. Exceptions for later arrival may be made by agreement with the S&T Chairperson. Upon receipt of the test motor shipment the supervisor of the receiving test site (S&T Chairperson or Regional Subcommittee Chairperson, as appropriate) 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.

### **2.5 Packaging of Motors for Testing**

Motors to be tested must be packaged in the form in which they are to be offered to consumers, including instructions for use, igniters, etc. in order for the S&T to assess the suitability of the product for general consumer use. Exceptions to this rule may be made at the discretion of the S&T chairperson, for example if only a draft copy of the instructions is available as of the testing date.

### **2.6 Reservation of Right of Refusal**

The S&T Chairperson 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 NAR.

### **Section 3 – Submission Quantities**

#### **3.1 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. The S&T Chairperson has sole discretion as to whether motor type variants require separate testing or not.

#### **3.2 Model Rocket Motors**

**3.2.1** Motors meeting the definition of a model rocket motor by NFPA 1122 and NFPA 1125 shall be submitted and tested in the following quantities: a minimum of three (3) of each delay time with a minimum of eleven (11) motors in total.

**3.2.2** If the manufacturer elects to offer a new delay option to a motor currently certified, 3 samples of the new configuration must be supplied for testing. Following successful testing, the new motor configuration will be added to the existing certification and be subject to the recertification dates of the original motor group.

**3.2.3** For re-certification of model rocket motors originally certified as per 3.2.1 above, the following quantities shall be submitted and tested: a minimum of two (2) of each delay time with a minimum of six (6) motors in total.

#### **3.3 High Power Rocket Motors**

**3.3.1** Motors meeting the definition of a high power motor by NFPA 1127 and 1125 but having less than or equal to 5120 Newton-seconds total impulse shall be submitted and tested in the following quantities: three (3) of each delay time.

**3.3.2** If the manufacturer elects to offer a new delay option to a motor currently certified, 3 samples of the new configuration must be supplied for testing. Following successful testing, the new motor configuration will be added to the existing certification and be subject to the recertification dates of the original motor group.

**3.3.3** For re-certification of high power rocket motors originally certified as per 3.3.1 above, the following quantities shall be submitted and tested: two (2) of each delay time

**3.3.4** Motors of greater than 5120 Newton-seconds total impulse shall be submitted and tested in the following quantities: two (2) of each delay time.

**3.3.5** For re-certification of high power rocket motors originally certified as per **3.3.3** above, the following quantities shall be submitted and tested: one (1) of each delay time

**3.3.6** See Section 12.3 of this document for the quantities required for motors with User Adjustable Delays.

### **3.4 Hybrid Rocket Motors**

Hybrid rocket motors will be tested in quantities in accordance with their total impulse as per **Sections 3.1, 3.2 and 3.3** above. Distinction between different hybrid motor "types" for purpose of testing is at the discretion of the S&T 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.

### **3.5 Motor Hardware**

**3.5.1** S&T facilities to which re-loadable solid propellant rocket motors are submitted will be provided by the manufacturer submitting the motors for testing with a minimum of two sets of hardware for each reload. Where components are shared between motor types, such as nozzle retainers for cases of different lengths, a minimum of two of each unique component shall be submitted. Hardware supplied by the manufacturer will be retained for use during future motor testing, or until the manufacturer requests return of the items. Shipping costs for return of the hardware are the responsibility of the manufacturer.

**3.5.2** S&T facilities to which hybrid motors are submitted for testing shall be provided with a minimum of two sets of any reloadable or other flight hardware and accessories (except ground support equipment, see 3.5.3 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, a minimum of two of each unique component shall be submitted. This hardware will be retained by S&T for future test sessions, unless specifically otherwise requested by the manufacturer, in which case S&T 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.

**3.5.3** S&T 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 S&T, 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 S&T Chairperson or Regional Subcommittee Chairperson (as appropriate) in cooperation with the motor manufacturer.

**3.5.4** Manufacturers shall supply, or cover the cost of, any additional components or modifications to S&T test equipment required to accommodate the testing of motors which are not compatible with standardized test fixtures. S&T 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.

**3.5.5** Any hardware that becomes damaged or shows signs of wear deemed by the S&T 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 test site supervisor may elect to discontinue further testing until the manufacturer rectifies the problem.

**3.5.6** If a manufacturer withdraws from retail availability any type of motor hardware in possession of the S&T, the S&T will, upon request of the manufacturer, return all but one example of said hardware. The remaining example in possession of the S&T will be retained for a period of 5 years after the certification period has expired

## **Section 4 – General Submission Requirements**

### **4.1 Motor Construction**

All motors submitted for S&T initial-certification testing must be accompanied by manufacturer documentation of how they were designed and constructed as specified in NFPA 1125 such that:

**4.1.1** 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:

- 3m (10 feet) for motors under 30 Ns total impulse
- 6m (20 feet) for motors of 30Ns to 160 Ns total impulse
- For high power motors, the distances prescribed in NFPA 1125 Table 7.4.3

**4.1.2** For metal-casing reloadable motors, the casing rupture pressure is at least twice the peak pressure normally expected to be developed by the reloadable motor system to be tested in that casing.

### **4.2 Motor Instructions**

All motors submitted for S&T testing shall include complete instructions for assembly and use meeting the requirements of NFPA 1125. Motors will not be certified unless suitable and complete instructions for safe use are provided. Omissions or errors will be reported to the manufacturer for remedy prior to certification, and S&T will not be responsible for any failed tests or lost data caused by any problems related to the instructions provided.

### **4.3 Production Date Codes**

All motors submitted for testing and subsequently offered for sale must have date of manufacture or other equivalent coding imprinted on the casing and/or reload package as required by NFPA 1125.

### **4.4 Motor Igniters**

All motors submitted for testing must include the igniter that will be 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. If igniters are supplied with the motors, a minimum of one extra igniter per test group must be included to address instances where there is an igniter or motor ignition failure occurs.

**4.4.1** 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 S&T for the cost of acquiring them as per the recommendation of the manufacturer. In cases where the manufacturer does not supply a suitable igniter with the product, S&T 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 5 – Test Fees and Expenses**

### **5.1 Test Fees**

**5.1.1** Testing fees are payable to the **National Association of Rocketry**

**5.1.2** Test fees shall be submitted by check, cash, money order or bank draft in US dollars to the NAR S&T Chairman.

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

**5.1.4** Certification will not be issued until all fees, and all expenses or damages incurred by S&T on behalf of the manufacturer are paid in full.

### **5.2 Fee Schedules (Subject to Discussion)**

All fees are in US Dollars.

#### **5.2.1 Model Rocket and High Power Rocket Motors to 160 Ns:**

Single Use:\$25.00 per motor type; Reloadable: \$40.00 per motor type.

#### **5.2.2 High Power Rocket Motors, 160.01 Ns to 5120 Ns:**

Single Use:\$25.00 per motor type; Reloadable: \$40.00 per motor type.

#### **5.2.3 High Power Rocket Motors, 5120.01 Ns to 40,960 Ns:**

Single Use:\$25.00 per motor type; Reloadable: \$40.00 per motor type.

### **5.3 Expenses Not Included in Fees**

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

**5.3.1** Igniters when not provided.

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

**5.3.3** Consumables such as nitrous oxide, oxygen, etc.

**5.3.4** Any other such items or materials required to complete testing and deemed to be the manufacturer's responsibility by the S&T Chairperson.

**5.3.5** Any shipping charges related to testing.

## **5.4 Damages**

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

**5.4.1** Catastrophic failure of a test motor.

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

**5.4.3** Other expenses the S&T Chairperson may determine to be the responsibility of the manufacturer.

## **5.5 Alterations or Upgrades**

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

## **5.5 Payment of Additional Expenses**

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

## **Section 6 – Certification Terms**

### **6.1 Granting of Certification**

A motor that has been submitted to S&T with a complete application package as specified in Section 6.1, full payment of fees as specified in Section 5, and that meets the certification standards specified by NFPA 1125 Chapter 8 as amplified by this Manual in testing conducted by S&T, shall be granted NAR certification effective on the day after completion of testing or of receipt of all required information from the manufacturer, whichever occurs later.

### **6.2 Certification Periods**

The period 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 five year term, will expire at the end of the first quarter of the fifth year after certification, i.e. March 31, 2007. Motors of all types will be certified for a period of **five** (5) years from the date of initial certification.

### **6.3 Scheduled Periodic Recertification**

**6.3.1** NAR S&T will notify manufactures of motor due for recertification testing a minimum of 120 days prior to the scheduled expiration of the certification term. Test motors may be submitted up to 90 days in advance of that time, but no later than 30 days prior to the end of the certification term. There will be no extensions of certification terms unless by written approval of the S&T Chairperson or the NAR President.

**6.2.3** If the total impulse of a single recertification motor varies by more than 13.1% from the mean measured total impulse in the original motor certification, full recertification retesting as a new motor type will be required for the current production motors.

#### **6.4 Timing of Recertification**

A manufacturer that fails to supply the specified recertification motors within the time window specified in Section 6.3.1 will cause the assignment of a certification expiration date by NAR S&T. Once this occurs, new certification fees, quantities, and testing requirements will be imposed prior to reinstatement of the motor to certified status.

#### **6.5 Unscheduled Mandated Recertification**

Motors registering a significant number of failures in the field as judged by the S&T Chairman based on the circumstance that MESS reports received on that type of motor were 20% or more of all MESS reports received during a 12 month period, will be reported to the manufacturer by the S&T Chairman, and may be recalled for retesting by the S&T Chairman if the manufacturer does not provide a satisfactory explanation as to why the reporting data was anomalous or how the reliability problem has been recognized and corrected. The manufacturer will be required to submit a quantity equal to that required for new certification.

**6.5.1** Motors that fail catastrophically during mandated retesting will be immediately decertified. The manufacturer will be advised of the failure, and the manufacturer may be required to submit a technical report to the S&T 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 S&T Chairperson deems appropriate, the motors will be approved for retesting.

**6.5.2** Manufacturers will be responsible for all shipping costs associated with retesting.

#### **6.6 Motors Testing Outside their Total Impulse Class**

**6.6.1** If the total impulse of any certification tests or recertification 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.

**6.6.2** If the discrepancy exceeds 1% 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 resubmit 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.

**6.6.3** The S&T Chairperson may elect to waive action regarding the discrepancy if conditions at time and location of firing 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.

### **6.7 Uncertified or Decertified Motors**

Motors that have valid certification and that are no longer available from the manufacturer or whose manufacturer has gone out of business will remain certified until the end of their certification term. The S&T Chairperson, with approval of the NAR President, may extend this certification period by up to five years if the product is still in use and exhibits no problems in use, in order that fliers and retailers are given the opportunity to use remaining inventory.

### **6.8 Submission for Testing after Decertification, Extended Certification or Expiration**

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

### **6.9 Submission for Testing After Design Changes**

When a manufacturer reports to S&T, as required by NFPA 1125, a change to the physical design or chemical composition of a certified motor, or if S&T determines that such a change has been made but not reported, the S&T Chairperson will determine if this change requires that the motor be resubmitted for certification testing due to the likelihood of a resulting change in the certified performance values of the motor. If the S&T Chairperson makes the determination that such testing is required, and the manufacturer fails to submit the motor for such testing within the period of time specified by the Chairperson, certification of that motor shall be withdrawn.

### **6.10 Approval for Use in NAR Competition**

Model rocket motors which are granted NAR certification will also be listed by S&T in official NAR motor certification lists as “approved for use in NAR competition”, if the motor is available to dealers and/or consumers from the manufacturer and is therefore available for purchase by any consumer in the U.S.

**6.10.1** The approval for competition must be made effective by S&T no less than 60 days after the date of publication of the notice of certification of that motor by S&T.

The approval for certification must be withdrawn by S&T effective the day after the end of the next National Association of Rocketry Annual Meet (NARAM) after the date upon which the manufacturer advises S&T that the motor is no longer being produced and that his stocks and those of any major national wholesale distributors of it are exhausted.

## **Section 7 – Reporting Results of Testing and Certification**

### **7.1 Letter of Certification**

Manufacturers will be presented with a Letter of Certification for each motor type that is successfully certified, marked with the official logo of the National Association of Rocketry **and signed by the S&T Chairperson**, within 30 days of completion of testing. If a motor is decertified for any reason other than the cessation of the business, the manufacturer shall be presented with a Letter of Decertification within 7 days of the decision. Copies of these letters shall be retained permanently by the S&T Chairperson and by NAR Headquarters.

### **7.2 Reporting and Disclosure of Test and Motor Data**

Data reduction for an initial certification or mandated recertification shall be completed and the summary data shall be provided to the manufacturer within 14 days after completion of testing. Summary data from periodic recertification testing shall be provided within 30 days. Manufacturers may, at their request, be provided the full results of each separate test of each motor that they submitted for testing. No information concerning test events or results, data from such tests except the officially-published public summary data and certification report from successful tests, or data or business information submitted by a manufacturer in support of testing and certification may be disclosed to any person except the manufacturer and members of the NAR S&T Committee without prior approval of the S&T Chairman.

### **7.3 Publication of Certification Data and Status**

Summary data gathered from tests that lead to NAR certification of a motor, and an official notification of the certification of the motor including the date of effectiveness of that certification, will be published to the NAR membership in a format useful to NAR members and public safety officials within 30 days of successful completion of testing, without regard to the commercial availability of the motor. This publication will include posting to the NAR website. Where any motor is decertified for any reason, notification to the manufacturer and to NAR members shall be issued within 7 days of the decision.

### **7.4 Publication of Certified Motor Lists**

S&T will produce and release a comprehensive list of all model rocket and high power rocket motors certified by the NAR no less often than once every six months, and shall cause this list to be posted on the NAR website within 7 days of release, and to be submitted to the editor of the NAR's official magazine for publication therein. This list will include as a minimum motor manufacturer and type, certified total impulse, propellant mass, and a notation as to whether the motor is approved for use in NAR competition.

## **Section 8 – Test Procedures**

### **8.1 Test Personnel**

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

**8.1.2** Regional Subcommittee Chairmen (if any) will be responsible for managing all aspects of testing at the site which they supervise, and for promptly reporting results of and any issues resulting from such testing to the S&T Chairperson.

**8.1.3** Test sessions require a minimum of three officially-approved members of the S&T Committee present, including the S&T Chairman or a Regional Subcommittee Chairman. If the appropriate Chairman is not present at a test session at the testing site for which they are responsible, they must designate in advance another qualified member of the S&T Committee to be the person in charge of that test session. The NAR S&T person in charge of a specific test session will be referred to hereafter as the “test supervisor”.

**8.1.4** Additional personnel may be recruited for assistance with test sessions by the test supervisor, and need not be members of the NAR S&T or even NAR if the supervisor and/or S&T Chairperson feels that their abilities will be of benefit to the test session. Such personnel must agree to the non-disclosure policy in **Section 7.2** as a condition of participation.

**8.1.5** Representatives of the motor manufacturer whose products are undergoing test may attend that test session; however they may not be directly involved in the conduct of testing and must not be present if and when motors of other manufacturers are tested at that same session. These representatives may under no circumstances be involved in any function where test data or impartial assessment of any facet of the product is involved. Representatives failing or unwilling to comply with these requirements during the test session will be required to leave before testing is conducted. This decision is solely at the discretion of the test supervisor.

### **8.2 Receiving Motors for Test**

**8.2.1** The Chairman in charge of the receiving test site shall, upon receipt of motors for testing, verify that all contents of the shipment are in safe and undamaged condition and match the inventory and description provided in advance of testing in accordance with **Section 2.1.4**, and shall promptly notify the manufacturer and the S&T Chairperson of any discrepancies.

**8.2.2** Motors received for testing shall be stored in accordance with any applicable requirements of the NFPA Codes and of the BATFE and/or local jurisdictions until the test session. If the manufacturer advises that the motors have specific requirements for storage in controlled environmental conditions prior to the day of testing, these conditions will be provided or the manufacturer will be notified that this is not feasible.

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

**8.2.4.1** Manufacturer's name

**8.2.4.2** Manufacturer's motor designation

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**8.2.4.3** Date codes and/or lot numbers

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

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

**8.2.5.1** Test sequence number

**8.2.5.2** Test date

**8.2.5.3** Test conditions

**8.2.5.4** Comments

**8.2.6** 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 8.2.5** above at the time of firing. Otherwise, the test supervisor will assign and record sequential code numbers prior to testing.

### **8.3 Motor Testing Process**

Motors will be tested in accordance with Chapter 8 of NFPA 1125. Further clarifications are outlined below.

**8.3.1** Test equipment shall be set up and calibrated in accordance with the procedures associated with the hardware and data acquisition software. All equipment, software, calibration methods and operational procedures shall be approved by the S&T Chairperson.

**8.3.2** 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. This requirement is meant to ensure that the product is fairly assessed as to the quality and completeness of the assembly and operating instructions.

**8.3.3** Motors, fuel grains, oxidizer tanks etc. shall be kept within the environmental conditions specified by NFPA 1125 for testing. For motors, these conditions are a temperature of  $20\text{oC} + 5\text{oC}$ . If local conditions are outside of this temperature range during the test session, motors shall be thermally conditioned after assembly and prior to test to ensure that they are within this temperature range at the moment of firing.

**8.3.4** 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.

**8.3.5** 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 the launch separation distance in the NAR Safety Code for the class of motor that is being fired. Where a bunker, earth berm or other substantial protective barrier protects test personnel, these distances may be shortened as deemed safe by the test supervisor.

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**8.3.6** 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, testing 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.

**8.3.7** Motors will be weighed to the nearest gram or better before and after firing. 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 tabulate pre- firing and post-firing weights as accurately as possible.

**8.3.8** Each static test firing will be videotaped. Video records of successful firings may be over written if necessary. Any video record of unsuccessful or questionable firings must be kept for a minimum of 3 months to permit viewing by the motor manufacturer if requested.

**8.3.9** Still photography shall be available to make photographic record of any problems, failures etc. that may occur. These records shall be maintained for 5 years after the general use certification period has expired.

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

**8.3.11** NAR Safety Code procedures, where applicable, shall be observed during test sessions. Clear audible countdowns will be given, and all participants and observers must be situated at safe distances and locations.

**8.3.12** 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 afterburn, debris landing, etc. has ended. Once cleared by the test supervisor, test personnel shall assess the test equipment and motor hardware for damages.

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

**8.3.14** The test supervisor shall fill out an incident report for each and every catastrophic failure, containing as much information and all observations that may be relevant and useful. One copy shall be forwarded to the S&T Chairperson, one copy shall be given to the manufacturer, and one copy shall be retained in the test site's records. Care should be taken to record all damages to S&T equipment in detail.

**8.3.15** Motor failures and/or performance anomalies shall be recorded in the motor database file.

**8.3.16** 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 S&T for damages is obtained from the manufacturer and is to the satisfaction of the S&T Chairperson.

**8.3.17** Testing of products that have exhibited catastrophic failure on the test stand may be suspended until the S&T Chairperson is satisfied that the manufacturer has taken steps to remedy the reason for the failures. The S&T 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 S&T Chairperson.

#### **8.4 Post-Firing Process**

**8.4.1** All data shall be copied on high-density floppy disk, USB jump drive, 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. The suggested file naming format is:YYMMDD(test location letter code)(daily test sequence), 070217W01 would indicate a the first test performed on February 17, 2007 at the West Coast location. 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.

**8.4.2** One copy of all data shall be sent to the S&T Chairperson for final data reduction within 48 hours of completion of the test session. The S&T Chairperson will provide a copy of the collected test data and reports to the S&T Secretary for archiving on an annual basis.

#### **8.5 Test Stand Requirements**

A test stand used for NAR motor certification testing must be approved for such use by the S&T Chairperson, and must as a minimum consist of:

**8.5.1** A load cell calibrated with a NIST traceable weight standard such as an Instron;

**8.5.2** A data collection system where the least significant bit(LSB) has a value that is value is less than 0.33% percent of the average thrust of the motor under test. The sample rate for data collection must be 1000 samples per second or greater for motors with a burn time of less than 1 second, and at least 500samples per second for all other motors.

**8.5.3** A data acquisition system must have the capability to format and store the collected data into a general use data formats, such as a .txt, .csv, or .xls for archive storage. Evaluation for the collected data for NFPA 1125 compliance evaluation will be performed using John DeMar's Thrust Curve Tool Program, or comparable software tool.

**8.5.4** A load cell mechanical element whose first resonance is greater than 100 Hz, and whose motion under thrust is confined to either the horizontal or vertical axis depending on stand architecture. Residual thrust stand resonances should be removed from the output data by digital averaging.

**8.5.5** A capability for digitally recording the load cell trace from a time prior to motor ignition to beyond the ejection charge impulse to determine the delay time.

**8.5.6** In a vertical test stand configuration, the motor should be base preloaded to prevent the weight loss during burn from shifting the baseline. A mass flow correction based on the thrust curve will be applied to the data to account for the propellant burnoff.

## **8.6 Thermal Testing Requirements.**

The external casing temperature will be measured on at least one motor of a given type during initial certification testing, to ensure that this temperature does not exceed 200°C during or after firing, as required by NFPA 1125.

**8.6.1** Measurements will be made using a thermocouple sensor of low thermal mass, with an amplifier and readout system capable of delivering accuracy of 10°C or better and a thermal response time of 5 seconds or better less. Motor designs that have a history of motor casing temperatures well under 200C, the motor test supervisor can elect to perform the temperature evaluation using a 200C color indicating sensor.

**8.6.2** Thermocouples will be attached tightly and directly to the casing at two points along its length, one of which must be at the spot corresponding to where the propellant grain and the nozzle meet and the other at the point that is 75% of the motor casing length as measured from the nozzle end of the motor

**8.6.3** The casing temperature will be recorded from the moment of motor ignition until 60 seconds after the end of motor burn.

The temperatures of all the thermocouples in use will be averaged to derive the recorded external temperature for the test event. If this average value exceeds 200°C on the first test, two additional tests will be conducted, and the results of all three tests will be averaged to determine whether the motor failed this standard. If the average does not exceed the standard on the first test, additional tests are not required.

## **Section 9 – Data Reduction Procedures and Standards**

### **9.1 Data Analysis**

Each firing of each motor type during a certification or recertification test will be analyzed, and for each firing the following parameters will be determined using the protocols specified in NFPA 1125:

**9.1.1** Burn time, expressed in seconds.

**9.1.2** Delay time (if applicable), expressed in seconds.

**9.1.3** Total impulse, expressed in Newton-seconds

**9.1.4** Average thrust, expressed in Newtons.

### **9.2 Data Reporting**

Total impulse, average thrust, and delay time for all firings of a particular motor type will be averaged, and standard deviation values for each of these parameters will be calculated. Certification will be based on the specific standards for these quantities as described in NFPA 1125.

**9.2.1** A motor type designation shall be assigned to the motor tested. The motor designation shall be in standard NFPA 1125 format of [letter class][average thrust in Newtons] - [delay time]. Each figure/term in this designation shall be derived from average figures calculated per **9.1** above.

**9.2.2** Published certification reports, which are described in **Section 7.3**, shall include as a minimum the average measured values of the four performance parameters required by NFPA and listed in **Section 9.1**, the measured standard deviations of these parameters, and an example thrust-time curve.

**9.2.3** The motor time-thrust curve which most closely represents the averaged data should be used as the published example of the time-thrust curve for NAR published certification reports of that motor type. Where time-thrust curves are notably dissimilar, S&T will generate a thrust curve which most accurately reflects the measured average performance of the motor type.

**9.2.5** Where the averaged total impulse places the motor outside of the total impulse class in the manufacturer's designation, the policies in **Section 6.5** shall be applied.

## **Section 10 – Special Requirements**

### **10.1 User Adjustable Motor Delays**

User adjustable motor ejection delays are not addressed in NFPA 1125 so the S&T operational and testing requirements are listed below:

**10.1.1** The manufacturer of a motor with a user adjustable delay must provide a tool to decrement the maximum delay time in a quantifiable, repeatable manner.

**10.1.2** Instructions on the use of the tool must be included with the motor instructions as required by either NFPA 1125 Section 8.1.7(5), or 8.2.7(5), and the motor instructions must clearly state the maximum delay time and minimum delay time (maximum decrement) that is permissible with each motor.

**10.1.3** The certification testing of an adjustable delay motor system will involve the test firing of a minimum of 10 motors. Three motors will be fired at the maximum delay time, 3 motors will be fired at the minimum delay time, and two motors will be fired at each of at least two intermediate delay times. The delay reductions will be accomplished with the manufacturer's delay adjustment tool. The resultant delay times will be plotted and the ensemble data must be in compliance with the error tolerance limits for individual delays as defined by 8.2.7(1)(b) of NFPA 1125.

### **10.2 Cross-Compatible Reload Kits**

**10.2.1** Chapter 8 of NFPA 1125 requires the testing of complete reloadable motor systems, but it does not require the propellant manufacturer to actually manufacture the casing and/or motor housing components for their reloads therefore NAR will certify "cross-compatible" reloads provided that all components of the "cross-compatible" motor system are clearly defined and specified by the reload manufacturer and the complete reloadable system is supplied to S&T for full certification as defined in Chapter 8 of NFPA 1125 and this document. The reload kit manufacturer shall submit documentation showing that the complete "cross-compatible" reloadable system submitted to S&T for certification testing is in compliance with sections 7.3 and 7.4 of NFPA 1125.

### **10.3 Model Rocket Average Thrust Labeling**

The labeling requirements for new model rocket motor certification is + or – 10% of the tested average thrust rounded to the nearest whole number. This does not affect currently certified motors when they are periodically recertified.

## **Section 11 –Hybrid Motor Requirements**

### **11.1 General Requirements**

All hybrid rocket motors submitted for certification must meet the design requirements as specified in NFPA 1125 for use as specified in NFPA 1127. The manufacturer of a hybrid motor system who supplies igniters or manufactures a propellant grain containing an oxidizer must have the required BATFE manufacturer's permits and have obtained the required DOT materials classifications described in **Section 2.1.6** before submitting motors for certification.

### **11.2 Design Characteristics**

Manufacturers submitting hybrid motor systems for testing shall provide proof that the motor combustion chamber is designed with a pressure relief system that relieves at pressures not exceeding 50% of the flight cylinder yield pressure, as required by NFPA 1125. If the motor uses a pyrotechnic module, the manufacturer shall also provide proof required by NFPA 1125 that this module alone will not produce a motor pressure exceeding 400 psi, and that the combustion chamber will fail at a pressure no greater than 50% of the flight cylinder yield pressure.

### **11.3 Sealed Hybrids**

Any hybrid motor that is not filled on the pad immediately before launch is considered a sealed hybrid.

**11.3.1** All sealed flight cylinders used on a sealed hybrid must be DOT approved for transportation, and evidence of this DOT approval must be provided by the manufacturer when the motors are submitted for testing.

**11.3.2** All cylinder, cylinder fittings, cylinder valves, and pyrovalves for sealed hybrid motor systems must be rated for and tested to a minimum of 1800 psi working pressure, and evidence of this testing, or alternatively of DOT approval of these items, must be provided by the manufacturer when the motors are submitted for testing.

### **11.4 Vented Hybrids**

Any hybrid that is loaded at the pad immediately before launch is considered a vented hybrid.

**11.4.1** All flight cylinders used in vented hybrid motor systems are required to have a design yield pressure of at least 3000 psi and to have been proof-tested to 2000 psi. Evidence of meeting these requirements must be provided by the manufacturer when the motors are submitted for testing.