NATIONAL ASSOCIATION of ROCKETRY

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# LEVEL 2 HIGH POWER CERTIFICATION

# STUDY GUIDE

| Exam Details | | |
|---|---|---|
| **Section A** | **Applicable Regulations** | **10 Questions from 22** |
| **Section B** | **Rocket Motor Designations** | **3 Questions from 9** |
| **Section C** | **Range and Safety Practices** | **24 Questions from 60** |
| **Section D** | **Rocket Stability** | **3 Questions from 9** |
| **Total Questions** | | **40 Questions from 100** |
| **Passing Grade** | **~87%** | **Minimum 35 Correct Answers out of 40** |

| Document Version History | | |
|---|---|---|
| **Date** | **Version** | **Description** |
| **10/01/2020** | **V1** | **Initial Document Release.** |
| **10/7/2020** | **V2** | **A16 – Corrected explanation reference; C3 & C4 - added NFPA 1127 to question.** |
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Note: Any mistakes or omissions found in this document should be directed via email to the current HPR Services Committee Chairman at hprservices@nar.org

## Section A: Applicable Regulations (10 Questions from 22)

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**A1) Which of the following National Fire Protection Association (NFPA) standards provides a Code for High Power Rocketry?**

A) NFPA 1122
B) NFPA 1124
C) NFPA 1125
D) NFPA 1127

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The answer is “D”. NFPA 1127 is the Code for High Power Rocketry. NFPA 1122 is the Code for Model Rocketry; NFPA 1124 is the Code for the Manufacture, Transportation, and Storage of Fireworks; NFPA 1125 is the Code for the Manufacture of Model Rocket and High Power Rocket Motors.

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**A2) What part of the Federal Aviation Regulations govern rocket activity?**

A) Part 95
B) Part 97
C) Part 101
D) Part 125

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The answer is “C”. Rocket activity is codified in Part 101, Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft.

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**A3) What is the maximum launch (flight-ready) weight allowable for a rocket which does not require an FAA Certificate of Waiver or Authorization (COA)?**

A) 113 grams (4 ounces)
B) 125 grams (4.4 ounces)
C) 453 grams (1 pound)
D) 1,500 grams (53 ounces or 3.3 pounds)

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The answer is “D”. Per Part 101.22(5), flight-ready rockets weighing no more than 1,500 grams (53 ounces or 3.3 pounds) are defined as Class 1-Model Rockets. Class 1-Model Rockets do not require a COA.

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**A4) What is the maximum propellant weight allowable for a rocket which does not require an FAA Certificate of Waiver or Authorization (COA)?**

A) 113 grams (4 ounces)
B) 125 grams (4.4 ounces)
C) 453 grams (1 pound)
D) 1,500 grams (53 ounces or 3.3 pounds)

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The answer is “B”. Per Part 101.22(1), rockets using no more than 125 grams (4.4 ounces) are defined as Class 1-Model Rockets. Class 1-Model Rockets do not require a COA.

**A5) Which of the following is a requirement for High Power Rocket Motor User Certification (excludes NAR Jr. HPR Participation Program)?**

A) The ability to understand written English instructions
B) A minimum of 18 years of age
C) A citizen of the United States of America
D) No felony convictions

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The answer is “B”. Refer to NFPA 1127, paragraph 5.4.1(1).

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**A6) What is the maximum total impulse permitted in a High Power Rocket per NFPA 1127?**

A) 20,480 Newton-seconds
B) 40,960 Newton-seconds
C) 81,920 Newton-seconds
D) There is no impulse limit provided the altitude requirements listed in the FAA Certificate of Waiver or Authorization (COA) are not exceeded

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The answer is “B”. Refer to NFPA 1127, paragraph 4.9.2.

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**A7) What is the maximum allowable weight for a High Power Rocket permitted per NFPA 1127?**

A) 100 pounds
B) 400 pounds
C) 3,069 pounds
D) There is no limit provided the rocket weighs less than 1/3 of the average certified thrust of the motors intended to be ignited at launch

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The answer is “D”. Refer to NFPA 1127, paragraph 4.9.1.

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**A8) What is the minimum age for User Certification (excludes NAR Jr. HPR Participation Program)?**

A) 16 years old
B) 18 years old
C) 21 years old
D) 25 years old

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The answer is “B”. Refer to NFPA 1127, paragraph 5.4.1 (1).

**A9) Which of the following characteristics does NOT meet the definition of a High Power Rocket motor?**

A) Total impulse is more than 160 Newton-seconds
B) The motor uses a “composite” propellant
C) Average thrust greater than 80 Newtons
D) Propellant weight greater than 125 grams

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The answer is “B”. Propellant type is not a defining characteristic. Refer to NFPA 1127, paragraph 3.3.15.1 and 3.3.15.3.

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**A10) Which of the following is (are) true of a complex High Power Rocket per NFPA 1127?**

A) The rocket is multi-staged or propelled by a cluster of rocket motors
B) The rocket contains electrical or electronic devices intended for control of the rocket’s functions (e.g. staging, recovery initiation, etc.)
C) The rocket uses other than parachute or streamer recovery (e.g. helicopter, glide recovery, etc.)
D) Both “A” and “B” above

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The answer is “A”. Refer to NFPA 1127, paragraph 3.3.13.1.1.

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**A11) According to NFPA 1127, a launch site is defined as containing areas for which of the following activities?**

A) Launching
B) Recovery
C) Parking
D) All of the above

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The answer is “D”. Refer to NFPA 1127, paragraph 3.3.9.

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**A12) A person shall fly a High Power Rocket only in compliance with:**

A) NFPA 1127
B) Federal Aviation Administration Regulations, Part 101
C) Federal, state, and local laws, rules, regulations, statutes, and ordinances
D) All of the above

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The answer is “D”. Refer to NFPA 1127, paragraph 4.3.

**A13) According to NFPA 1127, which of the following statements is always true concerning the definition of a hybrid rocket motor?**

A) The fuel component is composed of either paper or plastic
B) The fuel is in a different physical state (solid, liquid, or gaseous) than the oxidizer
C) The oxidizer component is nitrous oxide
D) Both "A" and "C" above

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The answer is "B". Refer to NFPA 1127, paragraph 3.3.15.2, for the definition of a hybrid rocket motor.

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**A14) You're attending a launch that has a thin (but see-through) cloud layer at ~3,000 feet and clear blue skies above it. Is it okay to "punch" through this cloud layer with a High Power Rocket if there's a Certificate of Waiver or Authorization (COA) granting Class 2 flights up to 6,000 feet?**

A) Yes, since there is an active COA, High Power Rockets can be flown up to the 6,000 foot altitude limit
B) No, flights into any clouds are prohibited unless specifically waived by the FAA
C) Yes, as long as the cloud layer can barely be seen through and the RSO allows it
D) Both "A" and "C" above

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The answer is "B". Part 101.25 Operating limitations for Class 2-High Power Rockets and Class 3-Advanced High Power Rockets specifically states that you must not operate Class 2-High Power Rockets…(c) ***Into any cloud***. This means that no matter how thin the layer is, even if nearly transparent, High Power Rocket flights are **NOT** to be flown into clouds unless the FAA has granted a waiver for this regulation, which is not common for our hobby.

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**A15) You are attending a launch where the sky is almost completely obscured by clouds at 5,000 feet except for a ~1,000 foot wide "hole" directly over the launch pads. Is it okay to launch a High Power Rocket to 6,000 feet if there's a Certificate of Waiver or Authorization (COA) granting Class 2 flights up to 8,000 feet?**

A) Yes, as long as the High Power Rocket stays within the cloud opening
B) Yes, as long as the RSO approves the launch and the COA is active
C) No, the five-tenths coverage and horizontal visibility limitations apply
D) Both "A" and "B" above

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The answer is "C". Part 101.25 Operating limitations for Class 2-High Power Rockets and Class 3-Advanced High Power Rockets specifically states that you must not operate Class 2-High Power Rockets…(a) ***At any altitude where clouds or obscuring phenomena of more than five-tenths coverage prevails***, and (b) ***At any altitude where the horizontal visibility is less than five miles***; (a) means that if more than 50% (5/10ths) of the sky is cloud-covered at a certain altitude, High Power Rocket flights are NOT to be flown to that altitude or above unless the FAA has granted a waiver for this regulation; (b) means that unless the "hole" is ten (10) miles wide (5 miles each direction), flights to that altitude or above cannot be made unless the FAA has granted a waiver for this regulation. The FAA granting a waiver for either of these limitations is not common for our hobby.

**A16) According to NFPA 1127, which one of the following statements is true concerning the definition of a High Power Rocket motor?**

A) Total impulse is less than 81,920 Newton-seconds
B) The total impulse is more than 160 Newton-seconds
C) The motor must use either fiberglass or metal case materials
D) Both "A" and "B" above

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The answer is "B". Note: there are other reasons a motor might be considered a High Power Rocket motor. Refer to NFPA 1127, paragraph 3.3.15.1, for the complete definition of a High Power Rocket motor and paragraph 3.3.15.3, for the definition of a model rocket motor.

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**A17) Which of the following (hypothetical) rocket motors is NOT a High Power Rocket motor?**

A) An F90 with 40 grams of propellant
B) An H60 with 62 grams of propellant
C) A G35 with 66 grams of propellant
D) All of the above are High Power Rocket motors

---

The answer is "C". A High Power Rocket motor has more than 160 Newton-seconds of total impulse, ***or*** an average thrust greater than 80 Newtons, ***or*** more than 125 grams of propellant.

The F90 has an average thrust greater than 80 Newtons; the H60 has more than 160 Newton-seconds of total impulse (it's an "H" motor); the G35 does not have more than 125 grams of propellant. Refer to NFPA 1125.

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**A18) What information does FAA FAR 101.29(a) require you to provide when filing for FAA Launch Authorization?**

A) Estimated number of rockets and type of propulsion (liquid or solid), fuel(s) and oxidizer(s)
B) Description of the launcher(s) planned to be used, including any airborne platform(s) and description of recovery system
C) Highest altitude, above ground level, expected to be reached, launch site latitude, longitude, and elevation, and any additional safety procedures that will be followed
D) All of the above

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The Answer is "D". Refer to the Code of Federal Regulations, Part 101.29(a) for more information.

**A19) Which of the following are operating limitations for Class 2 High Power Rockets per the FAA's FAR 101 Regulations?**

A) At any altitude where clouds or obscuring phenomena of more than five-tenths coverage prevails
B) At any altitude where the horizontal visibility is less than five miles
C) Into any cloud
D) All of the above

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The answer is "D". See explanations for Questions A14 & A15. Refer to Part 101.25 Operating limitations for Class 2-High Power Rockets and Class 3-Advanced High Power Rockets for these as well as other operating limitations.

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**A20) According to NFPA 1127, a High Power Rocket shall only be launched if:**

A) It contains any combination of motors having 40,960 Newton-seconds of total impulse or less
B) It contains a recovery system that is designed to return all parts to the ground intact and at a landing speed at which the rocket does not present a hazard
C) It utilizes an electronically actuated recovery system as either a primary or backup deployment method if the installed total impulse is greater than 2560 Newton-seconds
D) All of the above

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The answer is "D". Refer to NFPA 1127 paragraphs 4.9.2, 4.10.1, and 4.10.2.

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**A21) According to NFPA 1127, when is it acceptable to alter a High Power Rocket motor?**

A) When the results of a simulation show that a different delay time is needed for optimal deployment
B) When the motor manufacturer allows it
C) It is never acceptable to modify a High Power Rocket motor
D) Both "A" and "B"

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The answer is "B". Refer to NFPA 1127 paragraphs 4.5.2 and 4.5.3. Note: Motor delay times should only be adjusted using procedures provided by the motor manufacturer.

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**A22) According to NFPA 1127, the definition of a High Power Rocket is a rocket vehicle that:**

A) Is propelled by one or more High Power Rocket motors
B) Is propelled by a combination of model rocket motors having an installed total impulse of more than 320 Newton-seconds or a combination of model rocket motors having more than a total of 125 grams (4.4 ounces) of propellant weight
C) Weighs more than 1500 grams (53 ounces or 3.3 pounds) with motor(s) installed
D) All of the above

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The answer is "D". Refer to NFPA 1127 paragraph 3.3.13.1.

## Section B: Rocket Motor Designations (3 Questions from 9)

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**B1) What does the "H" in the motor designation H100-5 stand for?**

A) It is the first letter in the manufacturer's name
B) It indicates the total power range or impulse range of the rocket motor
C) It indicates the total thrust of the rocket motor
D) It indicates that the motor uses black powder as a propellant

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The answer is "B". In a rocket motor designation, the alphabetic character indicates the total impulse range (or total power) for the rocket motor. High power rocket motors are rated as follows: "H" = 160.01 to 320.00 Newton-seconds, "I" = 320.01 to 640.00 Newton-seconds, "J" = 640.01 to 1,280.00 Newton-seconds, "K" = 1,280.01 to 2,560.00 Newton-seconds, "L" = 2,560.01 to 5,120.00 Newton-seconds, "M" = 5,120.01 to 10,240.00 Newton-seconds, "N" = 10,240.01 to 20,480.00 Newton-seconds, "O" = 20,480.01 to 40,960.00 Newton-seconds. Note that the total allowable impulse doubles with each letter class.

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**B2) What does the "100" in the motor designation H100-5 stand for?**

A) It is the peak thrust in pounds of the rocket motor
B) It is the rocket motor burn time in seconds
C) It is the average thrust in Newtons of the rocket motor
D) It is the manufacturer's retail price code

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The answer is "C". In a rocket motor designation, the number after the impulse range letter but before the dash is the average thrust of the rocket motor in Newtons. Divide this number by 4.45 for the average thrust in pounds.

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**B3) What does the "5" in the motor designation H100-5 stand for?**

A) It is the rocket motor burn time
B) It is the peak thrust (in kilograms) of the rocket motor
C) It is the average thrust of the rocket motor
D) It is the ejection charge delay time

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The answer is "D". In the standard designation system for rocket motors, the number after the dash indicates the delay, in seconds, between the rocket motor burnout and the ejection charge operation. A "0" (zero) delay indicates a booster rocket motor in which no delay or ejection charge is incorporated. These are typical with model rocket motors, not high power rocket motors. High power rocket motors with no ejection charge included are designated by a "P" after the dash, indicating that the end of the motor where the ejection charge normally resides is plugged. Note: More and more high power rocket motors are being manufactured with adjustable delays, i.e. a longer than typical delay (e.g. 14 seconds) is included which can be reduced using the manufacturer's delay adjustment tool.

**B4) What are the units of measurement for the "100" in the motor designation H100-5?**

A) Newtons per second
B) Newtons
C) Newton-seconds
D) Feet per second

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The answer is "B". In a rocket motor designation, the number after the impulse range letter but before the dash is the average thrust of the rocket motor in Newtons. Divide this number by 4.45 for the average thrust in pounds.

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**B5) What is the maximum allowable impulse for a "J" rocket motor?**

A) 320.00 Newton-seconds
B) 640.00 Newton-seconds
C) 1280.00 Newton-seconds
D) 2560.00 Newton-seconds

---

The answer is "C". In a rocket motor designation, the alphabetic character indicates the total impulse range (or total power) for the rocket motor. The upper end of the range is the motor's maximum allowable impulse. High power rocket motors are rated as follows:

"H" = 160.01 to 320.00 Newton-seconds, "I" = 320.01 to 640.00 Newton-seconds, "J" = 640.01 to 1,280.00 Newton-seconds, "K" = 1,280.01 to 2,560.00 Newton-seconds, "L" = 2,560.01 to 5,120.00 Newton-seconds, "M" = 5,120.01 to 10,240.00 Newton-seconds, "N" = 10,240.01 to 20,480.00 Newton-seconds, "O" = 20,480.01 to 40,960.00 Newton-seconds.

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**B6) Assuming that each motor has the full allowable impulse, how many "H" motors have the same total impulse as a single "J" motor?**

A) 3 motors
B) 1 motor
C) 2 motors
D) 4 motors

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The answer is "D". A full "H" motor has a maximum allowable impulse of 320.00 Newton-seconds and a full "J" motor has a maximum allowable impulse of 1,280.00 Newton-seconds, thus it takes four (4) full "H" motors to equal one (1) full "J" motor (4 x 320 = 1,280).

**B7) You have an H64-8 rocket motor which has been certified to have a total impulse of 320.00 Newton-seconds. What is the approximate burn time for this motor?**

A) 3 seconds
B) 5 seconds
C) 8 seconds
D) 10 seconds

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The answer is “B”. Divide the total impulse by the average thrust to determine the motor burn time. In this case, 320 (Newton-seconds) divided by 64 (Newtons) = 5 (seconds).

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**B8) The manufacturer’s test data shows a total impulse of 690 Newton-seconds for your motor. What impulse class does your motor represent?**

A) “H”
B) “I”
C) “J”
D) “K”

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The answer is “C”. Refer to the answers and explanations for questions B1 and B5 above.

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**B9) The manufacturer’s test data shows an average thrust of 100 Newtons for 6 seconds for your motor. What impulse class does your motor represent?**

A) “H”
B) “I”
C) “J”
D) “K”

---

The answer is “B”. The total impulse is calculated by multiplying the average thrust by the burn time. In this case, 100 (Newtons) multiplied by 6 (seconds) = a total impulse of 600 (Newton-seconds). Refer to questions B1 and B5 above for the letter versus total impulse class table.

## Section C: Range and Safety Practices (24 Questions from 60)

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**C1) What is the maximum launch angle, measured from vertical, for a High Power Rocket?**

A) 10 degrees
B) 15 degrees
C) 20 degrees
D) 25 degrees

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The answer is “C”. Refer to Section 7 of the NAR High Power Rocket Safety Code and NFPA 1127, paragraph 4.12.3.

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**C2) What is the maximum wind velocity allowable for launch operations?**

A) 20 miles per hour
B) 25 miles per hour
C) 15 miles per hour
D) 30 miles per hour

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The answer is “A”. Refer to Section 9 of the NAR High Power Rocket Safety Code and NFPA 1127, paragraph 4.17.2.

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**C3) The minimum launch site dimension for your field is 1,500 feet. According to NFPA 1127, what is the minimum distance between the launch site boundary and the launcher for a 320 Newton-second motor assuming no public highways or occupied buildings in the area?**

A) 100 feet
B) 320 feet
C) 750 feet
D) The launcher may be located anywhere on the launch site to compensate for wind

---

The answer is “A”. The launcher shall be no closer than the Minimum Personnel Distance from any boundary of the launch site, and the Minimum Personnel Distance for an H motor (320 N-sec) is 100 feet. Refer to Section 11 of the NAR High Power Rocket Safety Code and NFPA 1127, paragraph 4.15.4.

**C4) You plan to break the altitude record for "H" motors with a flight to 10,900 feet. You have a field that is 6,000 feet by 6,000 feet and a Certificate of Waiver or Authorization for flights up to 12,000 feet AGL. According to NFPA 1127, what is the minimum distance between the launch site boundary and the launcher for an H-powered altitude record attempt assuming no public highways or occupied buildings are in the area?**

A) 100 feet
B) 1,500 feet
C) 3,000 feet
D) The launcher may be located anywhere on the launch site to compensate for wind

---

The answer is "A". The launcher shall be no closer than the Minimum Personnel Distance from any boundary of the launch site, and the Minimum Personnel Distance for an H motor (320 N- sec) is 100 feet. Refer to Section 11 of the NAR High Power Rocket Safety Code and NFPA 1127, paragraph 4.15.4.

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**C5) The FAA has granted a Certificate of Waiver or Authorization for High Power Rocket flights up to 18,000 feet AGL for your event. If flights up to that altitude are expected, what is the minimum launch site dimension?**

A) 1,800 feet
B) 4,500 feet
C) 9,000 feet
D) 18,000 feet

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The answer is "C". The size of the launch site is no less than one half (1/2) of the maximum altitude expected, calculated, simulated, or granted (by FAA Certificate of Waiver or Authorization/Authority Having Jurisdiction). Refer to Section 10 of the NAR High Power Rocket Safety Code and NFPA 1127, paragraph 4.14.2.

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**C6) The FAA has granted a Certificate of Waiver or Authorization for High Power Rocket flights up to 2,500 feet AGL for your 2x "N" cluster-powered rocket. What is the minimum launch site dimension?**

A) 500 feet
B) 1,250 feet
C) 1,500 feet
D) 4,000 feet

---

The answer is "D". The minimum size of the launch site is no less than one-half (1/2) of the maximum altitude expected, calculated, simulated, or granted (by FAA Certificate of Waiver or Authorization/Authority Having Jurisdiction), or 1500 feet, whichever is greater. However, in this case, the launcher has to be the Minimum Personnel Distance, which for an O-impulse cluster is 2,000 feet, from the edges of the launch site. So even for a COA of only 2,500 feet, it would require a minimum 4,000 foot launch site dimension. Refer to Section 10 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.14.2(2).

**C7) Except as provided in NFPA 1127 Paragraph 4.14.2(3), in no case shall the minimum launch site dimension be less than _____ the estimated altitude of the High Power Rocket to be flown, or _____.**

A) 1/4, 1,500 feet
B) 1/2, 1,500 feet
C) 1/4, 2,500 feet
D) 1/2, 2,500 feet

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The answer is "B". Refer to Section 10 of the NAR High Power Rocket Safety Code, **Excepting for this special provision that enables motors defined as HPR by NFPA but not requiring an FAA COA to be launched on somewhat smaller launch sites than would otherwise be required.* Per NFPA 1127 paragraph 4.14.2(3), "For high power rockets containing motors with a combined total impulse of less than 160 N-sec (36 lb-sec), a total liftoff weight of less than 1500g (53 oz), and a maximum expected altitude of less than 610m (2000 ft), the minimum dimensions of the launch site shall be permitted to be 305m (1000 ft)."

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**C8) Your launch site borders with an interstate freeway. What is the minimum distance allowable for location of a High Power Rocket launch pad from the interstate freeway?**

A) 750 feet
B) 1,500 feet
C) 3,000 feet
D) 5,280 feet (1 mile)

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The correct answer is "B". Refer to Section 10 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.15.3(2). When occupied structures or busy roads are near the launch site, a 1500 foot minimum separation is required between the launcher and the road or building. Refer to the answer explanation for question C7 for an **Exception* to this.

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**C9) A farm owner offers you the use of their two (2) mile square farm property for a launch site. Their house is located in the middle of the farm. What is the minimum distance allowable for location of a High Power Rocket launch pad from the owner's house, assuming it is occupied?**

A) 750 feet
B) 1,500 feet
C) 3,000 feet
D) You cannot launch unless the house is empty

---

The answer is "B". Refer to Section 11 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.15.3(1). When occupied structures or busy roads are near a launch site, a 1500 foot minimum separation distance is required between the launcher and the road/building. A launch site will have to be defined on the farm that does not contain the occupied house **AND** where the pads are at least 1500 feet from the occupied house. Refer to the answer explanation for question C7 for an **Exception* to this.

**C10) A farm owner offers you their farm for a launch site. Their house is located in the middle of the farm, which is one quarter (1/4) mile by one quarter (1/4) mile square. Assuming you can get an FAA Certificate of Waiver or Authorization for High Power Rocket flights up to 2,500 feet, can you conduct a high power launch from this farm?**

A) Yes
B) Yes, but the pads have to be the minimum personnel distance from the edge of the field
C) Yes, but the house has to be empty
D) No

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The answer is “D”. Refer to Section 10 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.14.2. The launch site must be at least 1500 feet square, and may not contain occupied buildings. You may be able to construct a launch site using part of that farm and that of a neighbor, if the adjoining land has no occupied buildings. If the pads for this larger site are within 1500 feet of the house, the house must be unoccupied Refer to the answer explanation for question C7 for an **Exception* to this.

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**C11) What is the minimum personnel distance from a High Power Rocket containing a single “I” motor?**

A) 200 feet
B) 100 feet
C) 75 feet
D) 50 feet

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The answer is “B”. Refer to the Minimum Distance Table in the NAR High Power Rocket Safety Code and NFPA 1127 Table 4.16.3.

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**C12) What is the minimum personnel distance from a High Power Rocket containing three (3) “H” motors?**

A) 200 feet
B) 100 feet
C) 75 feet
D) 50 feet

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The answer is “A”. Refer to the Minimum Distance Table in the NAR High Power Rocket Safety Code and NFPA 1127 Table 4.16.3.

**C13) What is the minimum personnel distance from a High Power Rocket containing two (2) "K" motors?**

A) 50 feet
B) 100 feet
C) 300 feet
D) 500 feet

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The answer is "D". Refer to the Minimum Distance Table in the NAR High Power Rocket Safety Code and NFPA 1127 Table 4.16.3.

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**C14) Which of the following items used for motor ignition may accidentally ignite by the continuity test of some launch controllers?**

A) Nichrome wire
B) Flashbulbs
C) Very low current electric matches
D) Both "B" and "C" above

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The answer is "D". Some electric matches may be affected by continuity tests, some may not; consult the manufacturer for further information and when in doubt, test the set up before inserting into the motor.

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**C15) In the event of a misfire, how long should you wait before approaching the launch pad?**

A) 15 seconds
B) 60 seconds
C) 5 minutes
D) As soon as signs of smoke are gone

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The answer is "B". Refer to Section 5 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.18.4.

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**C16) Which of the following is most likely to cause catastrophic failure of a black powder rocket motor?**

A) Temperature cycling
B) Electromagnetic fields
C) Vibration
D) High altitude

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The answer is "A". Temperature cycling is the primary cause of black powder rocket motor catastrophic failure. Temperature cycling causes expansion and contraction of the black powder grain and motor casing causing delamination between the case and propellant grain and cracks within the grain. The delamination and cracks expose additional burning surface that increases combustion pressures. The result is a motor failure. Note that shock or vibration can also damage a black powder rocket motor, however thermal cycling is the most likely cause of failure. Refer to the May and June 1992 issue of American Spacemodeling magazine, page 10, the article "A Theoretical Analysis of Why Black Powder Model Rocket Motors Fail".

**C17) Unless the motor manufacturer instructs otherwise, igniters for clustered rocket motors should be wired together in:**

A) Series
B) Parallel
C) Short Circuit
D) Open

---

The answer is “B”. Parallel connections allow all of the igniters to independently receive electrical power. If igniters are wired in series, the first igniter to burn out opens the circuit preventing any other igniters from receiving electrical power. However, motor manufacturers may suggest electric matches to be wired in series for igniting their motors. In these cases, follow the manufacturer’s instructions.

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**C18) When can igniters that are installed in rocket motors be checked for continuity?**

A) Any time
B) Only in an enclosed shelter
C) Only on the launch pad when ready for launch
D) Igniters should never be checked for continuity while installed in a rocket motor

---

The answer is “C”. Continuity is typically checked by the launch controller when the rocket is placed on the launch pad. This is considered safe practice because the number of personnel around the model is at a minimum and the model is pointed skyward which minimizes the hazard in the event of inadvertent ignition.

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**C19) Which of the following is the preferred method for attaching fins to a High Power Rocket?**

A) Tube surface mounting
B) “Wedge” mount
C) “Though the wall” mounting
D) All fin mounting methods are all equally strong; it does not matter

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The answer is “C”. Through the wall mounting is stronger because the fins are supported and attached to the rocket at two locations (both the motor tube and the body tube). In cases where through the wall mounting is not feasible, “wedge” mounting may be possible. Wedge mounting places the fin at the junction of two tubes; this mounting is typically used in cluster models. Surface mounting, like that used in most model rocket kits, is not recommended for high power rockets.

**C20) Which of the following adhesives should not be used on rubber (or elastic) shock cord components?**

A) Slow-curing epoxy adhesives
B) Cyanoacrylate glues (AKA “CA” or super glue)
C) Aliphatic resin-based (yellow) glues
D) White “Elmer’s” type glues

---

The answer is “B”. Cyanoacrylate glues will chemically attack rubber or elastic shock cord components allowing them to break when stretched.

---

**C21) Which of the following adhesives is most likely to be weakened under humid or wet weather conditions?**

A) Slow-curing epoxy adhesives
B) Cyanoacrylate glues (AKA “CA” or super glue)
C) Aliphatic resin based (yellow) glues
D) White “Elmer’s” type glues

---

The answer is “D”. White glues are weakened under high humidity conditions. Use aliphatic resin based (yellow wood or carpenter’s) glues instead of white glue.

---

**C22) Which of the following adhesives is best for motor mount construction using phenolic motor tubes?**

A) Slow-curing epoxy adhesives
B) Cyanoacrylate glues (AKA “CA” or super glue)
C) Aliphatic resin based (yellow) glues
D) “Hot melt” adhesives

---

The answer is “A”. Epoxies can be used to easily form fillets at the bond joints which provide increased strength. Epoxies bridge the gaps in loose-fitting parts to improve bond strength. One caution when using epoxies is that they are relatively heavy; they can degrade model stability by making the model tail heavy. Cyanoacrylate glues are not recommended for motor mount construction because they tend to soak into paper/cardboard body tube materials and are poor gap fillers. Aliphatic resin (yellow) glues, when properly applied, can be used for cardboard, wood, and paper components, but do not bond as well to phenolic or fiberglass materials. “Hot melt” adhesives should never be used for motor mount applications because they weaken with heat.

**C23) The centering rings provided with your High Power Rocket kit are a loose fit around the phenolic motor tube. Which of the following adhesives is the best choice for a strong joint?**

A) Slow-curing epoxy adhesives
B) Cyanoacrylate glues (AKA “CA” or super glue)
C) Aliphatic resin based (yellow) glues
D) “Hot melt” adhesives

---

The answer is “A”. Epoxies can be used to easily form fillets at the bond joints which provide increased strength. Epoxies bridge the gaps in loose fitting parts to improve bond strength. One caution when using epoxies is that they are relatively heavy; they can degrade model stability by making the model tail heavy. Cyanoacrylate glues are not recommended for motor mount construction because they tend to soak into paper/cardboard body tube materials and are poor gap fillers. Aliphatic resin (yellow) glues, when properly applied, can be used for cardboard, wood, and paper components, but do not bond as well to phenolic or fiberglass materials. “Hot melt” adhesives should never be used for motor mount applications because they weaken with heat.

---

**C24) A small hole is typically recommended near the top, but below the nosecone or payload section shoulder, of a High Power Rocket’s booster section. Why?**

A) This hole allows excessive ejection charge pressures to vent to reduce shock cord stress
B) The hole is used for air pressure readings for onboard altimeters
C) The hole vents internal air pressure as the rocket gains altitude to prevent internal air pressure from prematurely separating the model
D) The hole allows easy verification that a parachute is installed

---

The answer is “C”. Air pressure external to the rocket decreases as the rocket ascends. Air pressure trapped within an unvented compartment can cause premature separation. The added hole allows this internal air pressure to vent and prevent separation. Note that the hole size is dependent upon the rocket size; larger models require larger holes. Use caution in locating the hole such that a nosecone/transition shoulder or stage coupler does not block it. Also, position and size the hole on the airframe so that ejection charge pressure is not vented before ejecting the recovery system from the body tube.

---

**C25) When clustering combinations of black powder and composite motors, which type of rocket motor should be ignited first?**

A) Composite motors should be ignited first
B) Black powder motors should be ignited first
C) It does not matter which motors are ignited first
D) Clusters should never mix composite and black powder motors

---

The answer is “A”. Composite motors take longer to ignite than black powder motors. The concern is that the rocket will leave the launch pad before the composite motor has ignited.

**C26) Why should composite motors be ignited first in a composite and black powder mixed cluster?**

A) Composite motors are more difficult and take longer to ignite
B) Composite motors are more likely to “cato” than black powder motors
C) The exhaust products from black powder motors prevent composite motor ignition
D) Composite motors are more powerful than black powder motors

---

The answer is “A”. Composite motors take longer to ignite than black powder motors. The concern is, depending upon the configuration and intended function of each motor, the rocket will leave the launch pad before the composite motor has ignited and therefore be underpowered.

---

**C27) If individual igniters are used for igniting a motor cluster, which of the following statements is typically true:**

A) The launch control must have an audible as well as visual indication of igniter continuity
B) The launch control must provide additional current to ignite the additional igniters
C) The launch control must provide higher voltage to ignite the additional igniters
D) The launch control must use a car battery as a power source

---

The answer is “B”. Parallel wiring used in cluster ignition models “shares” the current among all the igniters. If the ignition circuit is marginal, those igniters which are slightly more sensitive will ignite before their mates. The model may leave the launcher prior to full ignition of the cluster. Common practice is to use a battery which can deliver a higher current than dry cells; automotive, motorcycle, and “gel cell” batteries are common. Increased voltage will not significantly improve cluster ignition reliability. AC voltage (i.e., house voltage), should never be used for ignition systems.

---

**C28) What is (are) the advantage(s) of using a “relay” type launch control?**

A) It is cheaper than a non-relay launch control
B) The relay allows a better indication of igniter continuity
C) It can deliver more power to the rocket motor igniters
D) Both “B” and “C” above

---

The answer is “C”. A relay launch system allows the battery to be placed close to the launch pad resulting in shorter power wires. The shorter wires minimize the normal loss of amperage that occurs over the 100+ feet of wire required to reach a high power launch pad. The wires connecting to the relay launch controller carry only the power required to operate the relay; this power is typically much less than that required by an igniter.

**C29) Petroleum based lubricants should not be used with the oxygen or nitrous oxide systems used in hybrid rocket motors. Why?**

A) They thicken when exposed to oxygen or nitrous oxide
B) They lose their lubricating properties when exposed to oxygen or nitrous oxide
C) There is a risk of spontaneous ignition or explosion
D) The lubricant can promote corrosion of the metal components in the presence oxygen or nitrous oxide

---

The answer is “C”. Petroleum lubricants are a fuel. Oxygen rich environments are more likely to use the petroleum based lubricants as a fuel which could increase the risk for a spontaneous ignition/explosion.

---

**C30) Which of the following safety hazards may be associated with hybrid rocket motors?**

A) High pressure gas & low temperatures (frostbite)
B) Low temperatures (frostbite)
C) Corrosive materials
D) High pressure gas

---

The answer is “A”. The pressure within a nitrous oxide cylinder used with hybrid rocket motors is approximately 750 psi. When filling or venting the nitrous oxide cylinder, individuals need to use caution to avoid having the high pressure gas or liquid impinge on skin or eyes. Oxidizer cylinders need to be inspected after crashes for damage that may compromise their structural integrity. Nitrous oxide boils at -127 degrees F. Partially filling and allowing the liquid to drain (boil-off) from a nitrous oxide cylinder is a technique used to pre-chill the nitrous oxide cylinder in some motor applications (called shock chilling). The low temperatures achieved through this method may present a hazard to exposed skin (frostbite).

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**C31) The Range Safety Officer (RSO) says that your model is unsafe to fly. Who has the authority to overturn this ruling?**

A) The Launch Control Officer (LCO)
B) The individual who “checked-in“ the model
C) Three high power certified flyers who agree the model is safe
D) The RSO’s decision cannot be overturned by anyone

---

The answer is “D”. The Range Safety Officer’s decision is final. If the flyer can produce additional information which confirms the safety of the model, e.g. simulations or previous flight data, then the flyer should present the information to the RSO.

**C32) Parachute ejection systems that sense barometric pressure for activation need a vent to the outside in their compartment because:**

A) This hole allows excessive ejection charge pressures to vent
B) This hole is used to sample air pressure readings outside the rocket's airframe
C) This hole vents internal air pressure as the rocket gains altitude to prevent internal air pressure from prematurely separating the model
D) This hole allows easy verification that the battery is installed

---

The answer is "B". Air pressure external to the rocket decreases as the rocket ascends. Most barometric based electronic ejection systems trigger after detecting a change from the negative pressure trend to a positive trend (which typically happens as the rocket arcs over after apogee). This hole allows the sensor to continuously sample the pressure outside of the airframe. Use caution in locating the hole so that a nosecone/transition shoulder or stage coupler does not block it and size it per the electronics manufacturer's recommendations.

---

**C33) Which of the following individuals has the final authority in permitting a High Power Rocket to fly?**

A) The Launch Control Officer (LCO)
B) The Range Safety Officer (RSO)
C) The Check-in Officer
D) The rocket owner

---

The answer is "B". The Range Safety Officer's decision is final.

---

**C34) Which of the following individuals has the ultimate responsibility to ensure that a rocket was built in a safe manner?**

A) The Launch Control Officer (LCO)
B) The Range Safety Officer
C) The rocket owner/builder
D) All of the above

---

The answer is "C". Range personnel can do inspections to catch lapses in construction quality or rocket design errors, but the owner/builder bears all responsibility for the safety and integrity of the model.

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**C35) Parachute ejection systems that sense barometric pressure can malfunction during supersonic flight because:**

A) Aerodynamic heating changes the values of electronic components
B) The outside pressure distribution is not continuous around the model
C) Static discharges will "zap" sensitive electronic components
D) Both answers "A" and "B" are correct

---

The answer is "B". During supersonic flight, shock waves are generated off various model features. The pressure distribution across the shock wave is not continuous. This may fool the ejection system logic causing premature ejection.

**C36) Your rocket returned from its flight with "zipper" damage where the shock cord tore through the model's airframe. What is the most likely cause?**

A) Parachute ejection occurred too soon after motor burnout
B) Parachute ejection occurred too late after apogee
C) Parachute ejection occurred at apogee on a vertical flight
D) Both "A" and "B"

---

The answer is "D". "Zippers" are caused when the model is moving too quickly during parachute deployment. Ejection too soon after burnout does not allow the model to slow down. Ejection too late after apogee allows the model to gain velocity. Ejection at apogee is best because the rocket's velocity is typically the lowest. Even then, a zipper can occur if the horizontal velocity of the rocket is high enough (e.g. due to weathercocking).

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**C37) Your payload section, with a heavy payload, separated from your model immediately after motor burnout. What might be the cause?**

A) The center of pressure at burnout was behind the center of gravity
B) The payload shoulder was too loose in the body tube
C) The rocket motor had a failure of its delay system
D) Both "B" and "C" are correct

---

The answer is "D". Delay train failures do happen and can cause this problem. More often, though, "drag separation" causes this problem, not motor failure. Drag separation is caused by higher drag on the aft (rear) section than that on the forward (front) section of the rocket. The difference in drag causes the aft section to be pulled away from the forward section. This problem is more pronounced with heavier forward sections as the momentum of that section tends to pull the model apart. Preflight inspection should confirm that the forward section cannot separate under its own weight. More sophisticated models use some form of positive retention, e.g. shear pins, to prevent premature separation.

---

**C38) What is the distance around a launch pad for a "J" powered model that must be cleared of easy to burn material, assuming the motor is not "sparky?"**

A) 10 feet
B) 30 feet
C) 50 feet
D) 75 feet

---

The answer is "C". Refer to Section 7 and the Minimum Distance Table of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.15.1 and Table 4.15.1.

**C39) What is the distance around a launch pad that must be cleared of easy to burn material for a rocket using a 2-motor cluster of full impulse "J" motors, assuming the motors are not "sparky?"**

A) 10 feet
B) 30 feet
C) 50 feet
D) 75 feet

---

The answer is "D". Refer to Section 7 and the Minimum Distance Table of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.15.1 and Table 4.15.1.

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**C40) What is the distance around a launch pad to clear of all combustible and burnable materials for a rocket using a single "J" motor that uses titanium sponge in the propellant to emit sparks ("sparky" motor)?**

A) 30 feet
B) 50 feet
C) 75 feet
D) 150 feet

---

The answer is "C". Refer to Section 7 and the Minimum Distance Table of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.15.1 and Table 4.15.1.

---

**C41) What is "titanium sponge?"**

A) A substitute for ejection wadding
B) An ingredient used in some rocket motors that emit sparks in the exhaust
C) An effective cleaning tool for high power rocket motor casings
D) A lightweight material used in nose cones on supersonic rockets

---

The answer is "B". As the answer states, titanium sponge is used in some propellant formulations to create a "sparky" effect in the motors exhaust. Note that the use of these propellants requires an increase in the clear area distance around the launch pad. Refer to Section 7 and the Minimum Distance Table of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.15.1 and Table 4.15.1.

**C42) Consequences of inadequate motor retention can include:**

A) The motor being ejected at apogee instead of the parachute, resulting in two falling objects
B) The motor being ejected from a cluster and flying on its own, under power
C) The motor flying through the rocket, destroying it
D) All of the above

---

The answer is “D”. The most common result of inadequate motor retention is that the motor is ejected when the deployment charge fires. A free-falling HPR motor is a safety hazard, and the rocket may not eject its recovery system, also becoming a hazard.

There have been documented cases of motors “falling out” of cluster mounts and then igniting, turning them into unguided missiles. It is important to ensure positive retention is provided in both directions, as motors can also break loose and fly through the rocket during boost.

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**C43) According to NAR studies, the vast majority of unsuccessful flights fail because of:**

A) Unstable rocket designs
B) Rocket motor malfunctions
C) Recovery system failures
D) Structurally unsound rockets

---

The answer is “C”. 75% of flight failures are due to recovery system problems. See Chapter 2 of Launching Safely in the 21st Century: Final Report of the Special Committee on Range Operation and Procedure to the National Association of Rocketry.

---

**C44) The kinetic energy of a descending rocket is a function of:**

A) Its mass
B) Its velocity
C) Its mass times its velocity
D) Its mass times the square of its velocity

---

The answer is “D”. Kinetic energy is a function of 1/2 the mass times the square of the velocity (KE=1/2mvA2). A forty pound rocket at 30 feet per second has a KE of one half times (18.1 kg) times 9.1 meters per second squared, or 749 joules. For reference, a bowling ball hitting pins has about 58 joules, a batted ball has about 147 joules, a .357 Magnum bullet when fired from a gun has about 740 joules, and a 200 pound adult has about 3,780 joules after falling from a second floor window. See Chapter 2 of *Launching Safely in the 21st Century: Final Report of the Special Committee on Range Operation and Procedure to the National Association of Rocketry.*

**C45) You have an excellent flying field except that when winds are from the northwest at over 10 mph, rockets often drift into neighboring fields where you don't have permission to fly. Your alternatives include:**

A) Limit flights to lower altitudes so rockets stay on the field
B) Move the launch pad closer to the NW edge of the field, provided there are no roads or houses within 1500 feet
C) Don't fly at times when the wind is problematic
D) All of the above

---

The answer is "D". Refer to Section 13 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.17.1. Other alternatives include using dual deployment, smaller parachutes, and tilted launch rods.

---

**C46) When should onboard energetics and/or electronic controls be activated and when should they be inhibited?**

A) The function of firing circuits and onboard energetics shall be inhibited until the High Power Rocket is in the launch position. They can then be activated when non-essential personnel leave the pad area.
B) When the rocket is in the prep area.
C) The function of firing circuits and onboard energetics shall be inhibited prior to removing the High Power Rocket from the launch position, and doing so only when non-essential personnel are not in the pad area unless otherwise directed by the RSO
D) Both "A" and "C"

---

The answer is "D". Refer to Sections 4 and 6 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraphs 4.13.7 and 4.13.8. Note: many altimeters require that the rocket be on the pad in a vertical orientation in order to properly initialize.

---

**C47) What equipment is required at launch sites?**

A) Fire suppression devices (such as fire extinguishers)
B) First Aid kits
C) Fire suppression devices and First Aid kits
D) Fire suppression devices, First Aid kits, and a method of communicating with everyone at the launch site

---

The answer is "D". Refer to NFPA 1127 paragraphs 4.14.3 and 4.18.3.1.

**C48) The Range Safety Officer (RSO) is concerned about your High Power Rocket's stability. Which of the following can be applied to determine the model's stability?**

A) Fly a sub-scale, model rocket version of the actual model
B) Perform manual calculations to determine the rocket's Center of Pressure (CP) location and verify the prelaunch Center of Gravity (CG) location
C) Provide simulation data showing the rocket's Center of Pressure (CP) location and prelaunch Center of Gravity (CG) locations
D) All of the above

---

The answer is "D". Refer to Section 6 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.8.2. Note: unlike model rockets, performing a swing test with most High Power Rockets is not feasible due to their size/weight. The best and most accurate way of determining stability with a High Power Rocket is to use a simulation program such as RockSim or OpenRocket or using the Barrowman method.

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**C49) Your High Power Rocket lands on a power line. Which of the following is true?**

A) You can retrieve it if the power line is on a wooden (not metal) pole
B) You must leave it alone and you must call the power company
C) You can retrieve it if you have a non-conductive tool, such as a "hot-stick"
D) You can retrieve it if part of it is already on the ground

---

The answer is "B". Refer to Section 13 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.10.5 and 4.10.6.

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**C50) Your field is 1500 x 1500 feet and your FAA Certificate of Waiver or Authorization is 3,000 feet AGL. If you use parachutes sized to bring your rockets down at 20 feet per second, what is the maximum wind you can fly in for a rocket that will reach the altitude limit with an "H" motor?**

A) You are limited only by the HPR maximum wind of 20 miles per hour
B) You can fly at 15 mph, if you locate the pad at the upwind edge of the field and tilt into the wind
C) You can fly in winds up to about 6 miles per hour, if you have the pads located closer to the upwind edge of the field and the rocket flies vertically (assuming minimum distances are maintained)
D) This field can only be used in calm winds for flights to the 3,000 foot altitude limit

---

The answer is "C". With a 20 feet per second (fps) descent rate, a rocket takes 150 seconds to descend from 3,000 feet. In 20 mph (~30 fps) winds, the rocket will drift 4,400 feet downwind and out of your launch site boundary, which is contrary to Section 13 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.17.1. Placing the rocket at the edge of the launch site and launching into the wind may keep the recovery on the field, but it means the ascending trajectory is beyond the boundaries of the launch site, contrary to Section 9 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.17.1 (Note: it could also be a violation of the Minimum Personnel Distance from any boundary of the launch site rule). With a 6 mph wind speed (8.8 fps), the rocket will travel 1,320 feet horizontally and you may be able to fly within the boundaries of the launch site, assuming all other rules/regulations are met.

**C51) According to NFPA 1127, which of the following is NOT a required feature of a rocket motor ignition system (launch controller)?**

A) A removable interlock device in series with the launch switch
B) The system is electrically operated
C) The launching switch returns to the "off" position when released
D) An audible or visual indicator showing continuity through the rocket motor igniter

---

The answer is "D". Refer to Section 4 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraphs 4.13.1 and 4.13.2.

---

**C52) According to NFPA 1127, which of the following are prohibited activities for participants prepping or launching High Power Rocket's as well as for spectators in the prepping areas?**

A) Consumption of alcohol
B) Use of medication that could affect judgment, movement, or stability
C) Using a cell phone due to possible interference with a rocket's onboard energetics and/or electronic controls
D) Both "A" and "B" above

---

The answer is "D". Refer to NFPA 1127 paragraph 6.1(11).

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**C53) According to NFPA 1127, High Power Rocket motors, motor reloading kits, and pyrotechnic modules shall be stored at least _____ away from smoking, open flames, and other sources of heat.**

A) 10 feet
B) 25 feet
C) 50 feet
D) 75 feet

---

The answer is "B". Refer to Section 3 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraph 4.19.1.

**C54) According to NFPA 1127, what extra constraints and launch distances are required when launching multiple High Power Rockets simultaneously?**

A) The LCO shall appoint a contest judge to determine which rocket wins the liftoff
B) For three (3) or more rockets, the minimum spectator and participant distance shall be the value set forth in Table 4.16.3 for a complex rocket with the same total installed impulse but not more than 610 m (2000 ft), or 1.5 times the highest altitude expected to be reached by any of the rockets, whichever is less
C) For more than one (1) rocket, a minimum distance of 3 m (10 ft) shall exist between each rocket used
D) Both “B” and “C”

---

The answer is “D”. Refer to Section 6 of the NAR High Power Rocket Safety Code and NFPA 1127 paragraphs 4.16.3.3 and 4.16.3.4, and Table 4.16.3. Although not required by NFPA 1127, it is also a best practice for the RSO to appoint a spotter for each of the rockets to be able to warn the LCO of any unsafe flight or recovery anomalies.

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**C55) What is a common safety practice to follow just before hooking up the igniter leads to a rocket?**

A) Touch the igniter clips together to test for sparks in case the launch system is still accidentally energized
B) Run an additional simulation to ensure the rocket and motor are a safe combination
C) Check the skies to ensure no aircraft are in the area
D) Stand next to the rocket for a photograph

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The answer is “A”. Touching the metal clips together before hooking them up to the igniter is a common safety practice which can help prevent accidental launching if the igniter clips are still energized.

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**C56) An electronically actuated recovery system, as either a primary or backup deployment method, is required if the installed total impulse exceeds:**

A) 1280 N-sec
B) 2560 N-sec
C) 5120 N-sec
D) 10240 N-sec

---

The answer is “B”. Refer to NFPA 1127 paragraph 4.10.2.

**C57) Twisted wire pairs in rocket wiring are considered good practice because:**

A) It reduces strain on solder joints
B) It improves the routing of wire bundles
C) It resists electromagnetic interference from internal and external sources
D) It reduces resistance in wire bundles

---

The correct answer is “C”. A twisted pair can greatly reduce the effect of noise currents induced on the line by coupling of electric or magnetic fields. The idea is that the currents induced in each of the two wires are very nearly equal. The twisting ensures that the two wires are on average the same distance from the interfering source and are affected equally. Many circuits will ignore common noise present on both input connections.

---

**C58) Black powder charges for recovery systems can be unintentionally fired by:**

A) Electrostatic discharge (static electricity)
B) Electromagnetic fields, e.g. nearby radios
C) Control electronics malfunction
D) All of the above

---

The answer is “D”. Static electricity can be caused by rubbing together different materials, e.g. wool sweater rubbing a plastic body tube and can remain until released by means of an electric current or discharge that could ignite a black powder charge. Nearby radios/transmitters can induce enough energy into ejection charge wiring to ignite a black powder charge. Transients during electronics startup, mis-wiring, and improper environmental sensing can cause control electronics to fire unintentionally.

---

**C59) The use of launch rails, e.g. 1010 and 1015, in lieu of launch rods is encouraged because:**

A) Launch rails create less drag on the launching rocket
B) Launch rails are stiffer and less likely to impose unintentional tipoff on the rocket (no rod whip)
C) Launch rails are easier to clean than launch rods
D) All of the above

---

The answer is “B”. Launch rods are known for their flexing under a rockets initial boost (i.e., rod whip). Due to their stiffer profile, the use of launch rails reduces this flexing and allows for a more predictable launch trajectory.

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**C60) Which sequence below provides the highest level of range safety when launching a rocket utilizing an onboard electronically actuated recovery system?**

A) Arm recovery system electronics, install igniter, touch igniter clips together, connect clips to igniter
B) Install igniter, touch igniter clips together, connect clips to igniter, arm recovery system electronics
C) Install igniter, arm recovery system electronics, touch igniter clips together, connect clips to igniter
D) None of the above

---

The answer is “A”. Having electronics completely powered up prior to installing and hooking up the igniter provides the highest range safety level should the rocket accidentally launch. Installing the igniter before the recovery electronics are armed could create an unsafe ballistic return should an accidental ignition occur during installation.

## Section D: Rocket Stability (3 Questions from 9)

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**D1) For a rocket to be stable, which of the following statements is true?**

A) The center of pressure (CP) must be behind the center of gravity (CG)
B) The center of pressure (CP) must be in front of the center of gravity (CG)
C) The rocket must have fins
D) The length of the body tube must be at least 5 times the model diameter

---

The answer is “A”. Refer to the “Handbook of Model Rocketry” by G. Harry Stine, 7th edition, Chapter 9 on “Stability”. Note references on pages 137 and 138.

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**D2) An unstable rocket can be made stable by:**

A) Adding sufficient weight to the nose cone
B) Removing sufficient weight from the nose cone
C) Moving the fins sufficiently forward towards the nose cone
D) Making the rocket sufficiently shorter

---

The answer is “A”. To make the rocket stable, the center of gravity (CG) must be moved forward of the center of pressure (CP). Adding weight to the nose cone moves the CG forward. Removing weight from the nose cone moves the CG aft, which is incorrect. Moving the fins forward towards the nose cone moves the CP forward, which is also incorrect. Finally, making the rocket shorter reduces the correcting moments produced by the aerodynamic forces at the CP; the reduced moment makes the rocket less stable.

---

**D3) Rocket stability can be estimated by:**

A) Center of pressure “Barrowman” equations
B) “Cardboard cutout” method
C) Determining the relative positions of the center of pressure (CP) and center of gravity (CG)
D) Stability cannot be estimated before a test flight.

---

The answer is “C”. The “Barrowman” equations and “cardboard cutout” methods are used to determine the Center of Pressure (CP), which is only half of what is needed to estimate stability. The Center of Gravity (CG) location must also be known to determine stability. Refer to the “Handbook of Model Rocketry” by G. Harry Stine, 7th edition, Chapter 9 on “Stability”. Note Figure 9-6 on page 134.

**D4) A rocket's center of pressure can be estimated by using:**

A) The "Barrowman" method
B) Finding the point where the model balances
C) The "cardboard cutout" method
D) Both "A" and "C" above

---

The answer is "D". The "Barrowman" method is a set of equations developed by J. Barrowman for determining the Center of Pressure (CP), which is then used to help estimate model rocket stability. More sophisticated methods are available to cover conditions not covered by the Barrowman method, e.g. supersonic flight. Refer to the "Handbook of Model Rocketry" by G. Harry Stine, 7th edition, Chapter 9 on "Stability". Note references on pages 140 and 141, Appendix II, and Appendix IV. While primitive, the cardboard cutout method can provide a first order determination of the approximate CP. It only needs to be a representative silhouette of the shape and can be a subscale of the full size model's silhouette.

---

**D5) An unstable rocket can usually be made stable by:**

A) Using a shorter nose cone
B) Increasing the size of the aft fins
C) Using a larger, heavier rocket motor
D) Increasing the rocket diameter

---

The answer is "B". To make the rocket stable, the center of pressure (CP) must be moved aft of the center of gravity (CG). Adding larger fins on the aft portion of the model moves the center of pressure aft. A shorter nose cone removes weight from the front of the rocket and therefore moves the CG aft, which is incorrect. A larger, heavier rocket motor has the same effect of moving the CG aft. Increasing the rocket diameter has essentially no effect on its stability.

---

**D6) During boost, a rocket powered by a solid rocket motor tends to:**

A) Become less stable in flight
B) Become more stable in flight
C) Have no change in stability
D) Become unstable

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The answer is "B". During powered flight the solid rocket motor consumes its fuel causing the aft end of the rocket to become lighter. This moves the CG forward away from the CP and enhances stability. This can be seen in instances where an unstable rocket becomes stable partway during the rocket motor burn; this can be particularly dangerous because the now-stable rocket may be pointed in any direction. Also, the increasing rocket speed also increases effectiveness of the fins, thereby increasing stability.

**D7) Which of the following can cause unstable flight?**

A) Weak tubes or couplers that permit airframe bending
B) Misaligned motor mount tube or motor nozzle
C) Inadequate airspeed leaving the launch pad on a windy day
D) All of the above

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The answer is “D”. Rockets that bend in flight can loop under power, as can rockets with misaligned thrust vectors caused by misaligned motor mounts or nozzles. Rockets that leave the launcher too slowly may be subjected to high angles of attack due to wind. High angles of attack move the CP forward, which can make a rocket go unstable. Slow airspeed deprives the fins of the corrective action needed to compensate for forces causing pitch or yaw.

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**D8) As a rule of thumb, how far should the center of pressure be from the center of gravity?**

A) The center of pressure should be at the same location as the center of gravity
B) The center of pressure should be at least 1.0 body tube diameters behind (aft) the center of gravity
C) The center of pressure should be at least 1.0 body tube diameters ahead (forward) of the center of gravity
D) The center of pressure should be 1.0 body tube diameters ahead (forward) of the fin leading edge; the center of gravity does not matter

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The answer is “B”. Refer to the “Handbook of Model Rocketry” by G. Harry Stine, 7th edition, Chapter 9 on “Stability“. Note references on pages 133 and 134.

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**D9) The definition of Positive Stability in regards to a rocket is:**

A) Where the center of gravity (CG) is located ahead (forward) of the center of pressure (CP)
B) Where the center of gravity (CG) and the center of pressure (CP) lie at the same locations
C) Where the center of gravity (CG) is located behind (aft) of the center of pressure (CP).
D) None of the above

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The answer is “A”. If a rocket has Positive Stability, the CG is located ahead of the CP and the rocket is stable. If a rocket has Neutral Stability, the CG and CP are located at the same location so there are no stabilizing or restoring forces present. Negative Stability is where the CG is behind the CP and the forces acting upon the rocket will cause it to fly tail-first. Refer to the “Handbook of Model Rocketry” by G. Harry Stine, 7th edition, Chapter 9 on “Stability“. Note the definitions on pages 133 and 134.