# Richard Nakka's *Experimental Rocketry* Web Site

## Safety

First of all, let's consider an often-asked and perhaps prudent question. Is Amateur Experimental Rocketry (AER) a hazardous activity? I would have to answer this question with a straightforward "no". Otherwise, I would never have gotten involved. As I am not a risk taker in any regard, and tend to shun activities that could lead to bodily discomfort or harm (e.g. most sports), my avocational activities reflect this attitude.

Follow up question. If AER is not a hazardous activity, does this imply that there are no hazards to be concerned with? Clearly, the answer to this question is a definite "no". Rocketry most certainly has inherent *potential* hazards, and it is the responsibility of those who are involved in AER, or those who are considering to become actively involved, to recognize these potential hazards and take the necessary actions and precautions to keep these hazards in check. As is the case with many other recreational activities where harm could result from lack of knowledge or negligence, the use of good common sense and following conservative safety practices are two of the keys to keeping safe. The other key is **knowledge** of what you are dealing with. Knowledge takes over where common sense leaves off, as certain risk factors may not be readily apparent or obvious. Knowledge also comes from experience - either one's own experience or the experience of others. Take advantage of the latter, it tends to be much more vast! A great deal of such pertinent information is available on the internet, as well as in various publications, some of which are outlined in the Technical References section of this website.

What then, specifically, is it that introduces the potential risk factors? The main issue is that rocket propellant, in order to perform its function, must contain a large amount of stored thermal energy and be capable of releasing this energy rapidly. Consider, for example, the "Sugar Propellants" featured in this web site. The thermal energy released when such a propellant burns is approximately 2.7 kilojoules per gram of propellant. As such, one kilogram (approximately 2.2 lbs) possesses **2.7 megajoules** of stored thermal energy that is released when it burns. To relate this into more understandable terms, this is equivalent heat energy to that released by a 1000 watt heater over a period of 45 minutes...a heck of a lot of heat. Consider now, that in a rocket motor, all this thermal energy is released, typically, in 2 or 3 seconds! The more powerful AP based propellants possess nearly double that stored energy. *Respect* of rocket propellants is unquestionably in order. A rocket

motor is the amazing piece of engineering that converts this thermal energy to useful means. A daunting task that all-too-often is not successfully achieved, especially with experimental motors. Respect, therefore, of rocket motors and the consequence of failure of such are two further considerations that are crucial to keeping potential AER hazards fully in check.

There are other potential risk factors as well. Pyrotechnic materials such as *black powder* are used in rocket motor igniters and in parachute ejection charges. Although these are used in small amounts, respect and proper handling procedures and proper storage are essential. Extreme care is exercised if these materials are self-made, and such batches are to be restricted to a few grams. Consider, as well, that rockets are boosted aloft at high speed, typically several hundred kilometres per hour, and can achieve great heights. These two parameters represent a great deal of *kinetic energy* and *potential energy*...both of which must be fully dissipated by the time the rocket returns to the ground (as dictated by the 1st law of thermodynamics, "conservation of energy"). The safest and most desirable way to dissipate this energy, of course, is by the use of a parachute to gently bleed off the energy and return the rocket via a soft landing.

In summary, some things to bear in mind for those who may consider getting actively involved in AER:

- If you are a risk taker, don't bother reading any further, amateur rocketry is not for you.
- If you are a careless person, don't bother reading any further, amateur rocketry is not for you.
- If you are not willing to religiously and without fail follow requisite safety practices, some of which are outlined below, don't bother reading any further. Amateur rocketry is not for you.
- If you do not have complete respect for the safety and property of yourself and others, including the general public, then don't bother reading further, amateur rocketry is not for you.

For those of you still reading, the following represents a partial list of safety practices (common sense practices are not listed) applicable to amateur rocketry. Bear in mind that it is ultimately up to each individual to learn to recognize potential hazards and to determine which steps must be followed to prevent harm befalling individuals or property.

1. Wear appropriate safety apparel, including eye protection, at all times when the risk of personal harm is present. This includes workshop activities,such as metal or wood working.

2. Become familiar with the chemicals being used in propellant/pyrotechnic production, in particular, sensitivities and incompatibilities.

3. When working with propellants, always be alert and take the approach that such could ignite at any time. A dunk bucket full of water, fire extinguisher, and planned escape route must be three items always present.

4. Use a suitable work location for propellant preparation and suitable storage location for sensitive materials such as oxidizers.

5. Keep batch sizes of propellants and pyrotechnic materials to the minimum needed for the job at hand.

6. The beginner to AER should stick with well-proven propellants and well-proven motor designs. Propellant development is best left to those with a good deal of AER experience as well as acquired and theoretical knowledge of the subject. Bear in mind that even small amounts of certain additives can dramatically change the burning characteristics of rocket propellants. This can lead to catastrophic failure of otherwise well-proven designs.

7. Igniters should have the leads shunted at all times, and should only be un-shunted just prior to connecting to the ignition box (shunting refers to twisting the bared wire leads together to eliminate the possibility of electrical current flow to the bridgewire). This applies also to parachute ejection charges.

8. If an igniter fails to initiate a rocket motor, wait several minutes before cautiously approaching, then always disconnect the igniter electrical leads first.

9. Use an ignition box that has built-in safety checks to ensure that no current is inadvertently supplied to the igniter. A Safe/Arm switch represents only partial security.

10. When firing motors (either static or flight), distance is your greatest assurance of safety in case of catastrophic failure.

11. Avoid "boilerplate" motor designs. These thick walled heavy duty contraptions have the capability of storing an incredible amount of energy before bursting, increasing the potential risk associated with catastrophic failure. Casings should be sized to burst at no more than two and a half or three times the maximum expected operating pressure (MEOP) of the motor, representing a safety margin of 2.5 to 3.0. A *minimum* safety margin of 1.5 is appropriate for motor design.

12. It is a good practice to hydrostatic pressure test new motor designs. This involves filling a completed (and sealed) motor with water, then using a grease gun or hydraulic jack (fitted with a pressure gauge) to pressurize the motor, typically 1.2 to 1.5 times MEOP. Although

compressed water stores little energy, a plywood shield should nevertheless be placed between the motor and the operator, in case trapped air is present.

13. Do your utmost to keep Amateur Experimental Rocketry safe, not only for your own sake, but also for the sake of *all* participants of this unique and "out of this world" activity...!

**Back to Home Page**