Model rocket motor classification

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Motors for rockets[1] and high powered rockets[2] (together, consumer rockets) are classified by total impulse (power) into a set of letter-designated ranges, from **¼A** up to **O** as the largest. Class A is from 1.26 newton-seconds (4.448 N per Lb.) to 2.5 N·s, and each class is then double the total impulse of the preceding class, with Class B being 2.51 to 5.00 N·s. The letter (**M**) would represent the total impulse of between 5,120.01 and 10,240.00 N·s of impulse. Motors G and below are in the realm of model rocketry. Motors which would otherwise be classified beyond **O** are in the realm of amateur rocketry (in this context, the term *amateur* refers to the rocketeer's independence from an established commercial or government organization). Professional organizations use the nomenclature of average thrust and burning time.

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Rocket Motor Codes

The designation for a specific motor looks like **C6-3**. In this example, the letter (**C**) represents the total impulse range of the motor, the number (**6**) before the dash represents the average thrust in newtons (4.448 N per Lb.), and the number (**3**) after the dash represents the delay in seconds from propelling charge burnout to the firing of the ejection charge (a gas generator composition, usually black powder, designed to

deploy the recovery system). So a C6-3 motor would have between 5.01 and 10 N·s of impulse, produce 6 N average thrust, and fire an ejection charge 3 seconds after burnout.

An innovation called ILP was adopted by motor manufacturers starting in about 1982 to further clarify the motor code, for example 120G40-8FS, where the total impulse in Newton-seconds precedes the code so the burning time can be computed from the provided numbers (120/40=3.0 sec) , followed by a letter designation denoting the style of propellants (Firestarter™ brand, sparky style).[3] Other styles include white smoke (W), black smoke (J), red flame (R), green flame (G) and others. Each manufacturer self designates these letter codes. The remainder of the numbers and letters represent the result of batch testing with data collection. The ILP method is important because you might have a G motor in your model rocket but a G can be anywhere from 81 N-s to 160 N-s and that is a sufficient difference to shred (mechanically destroy from combined forces of thrust and drag) some model rockets.

The largest model rocket motor is a 160 N-s G according to NAR, TRA, and the NFPA codes (1122, 1125, 1127) they drafted and invented. Although the largest FAA exempt motor is a 125g propellant 240 N-s (53.95 Lb-sec, 195 ISP) APCP propellant H motor, so they could conceivably change the codes to include that if they choose. A nearly perfect efficiency APCP motor with an ISP of 230 would have 283 N-s with the FAA exempt propellant mass of 125g. (0.276 Lb.). An efficient BP propellant motor with an ISP of 80 would have 110 N-s (24.9 Lb-sec) with the FAA exempt propellant mass of 125g. (0.276 Lb.)

Motor impulse by class

Class (Base 26)	Total Impulse (N·s)	Total Impulse (lbf·s)	Aerospace Vehicle or Rocket(s)	US Requirements
Micro	0–0.3125	0–0.07		
1/4A	0.3126–0.625	0.071–0.14		
1/2A	0.626–1.25	0.141–0.28		
A	1.26–2.50	0.281–0.56		
B	2.51–5.00	0.561–1.12		
C	5.01–10.0	1.121–2.25		
D	10.01–20.0	2.251–4.5		
E	20.01–40.0	4.51–8.99		
F	40.01–80.0	8.991-18.0		
G	80.01–160	18.01-36.0		Largest model rocket motor according to TRA and NAR.
H	160.01–320	36.01-71.9		Level 1 Certification required from Tripoli or NAR, if you join those clubs. Under 125g propellant is Federal Aviation Administration exempt.
I	320–640	71.9–144		
J	640–1,280	144-288		Level 2 Certification required from Tripoli or NAR, if you join those clubs.
K	1,280–2,560	288-576		
L	2,560–5,120	576-1,150		
M	5,120–10,200	1,150-2,300		Level 3 Certification required from Tripoli or NAR, if you join those clubs.
N	10,200–20,500	2,300-4,600		
O	20,500–41,000	4,600-9,210		
P	41,000–81,900	9,210-18,400		FAA/AST Permit or License required.
Q	81,900–164,000	18,400-36,800		
R	164,000–328,000	36,800-73,700		

S	328,000–655,000	73,700-147,000		Largest motor used by amateurs.[4] The remainder of this chart is an application of consumer rocket nomenclature to professional rockets which do not use this nomenclature at all.
T	655,000–1,310,000	147,000-295,000		
U	1,310,000–2,620,000	295,000-589,000	Apollo launch escape rocket	
V	2,620,000–5,240,000	589,000-1,180,000	Falcon Project Ltd. Bloodhound SSC hybrid rocket[5]	
W	5,240,000–10,500,000	1,180,000-2,360,000		
X	10,500,000–21,000,000	2,360,000-4,710,000		
Y	21,000,000–41,900,000	4,710,000-9,430,000	Delta II GEM-40 SRB	
Z	41,900,000–83,900,000	9,430,000-18,900,000		
AA	83,900,000–168,000,000	18,900,000-37,700,000		
AB	168,000,000–336,000,000	37,700,000-75,400,000		
AC	336,000,000–671,000,000	75,400,000-151,000,000		
AD	671,000,000–1,340,000,000	151,000,000-302,000,000	Space Shuttle SRB	
AE	1,340,000,000–2,680,000,000	302,000,000-603,000,000	Falcon 9 v1.1	
AF	2,680,000,000–5,370,000,000	603,000,000-1,210,000,000	Delta IV Heavy	
AG	5,370,000,000–10,700,000,000	1,210,000,000-2,410,000,000	Space Shuttle Saturn V	

Governmental regulation

In many countries, the sale, possession, and use of model rocket motors is subject to governmental rules and regulations. High-power rockets in the United States are only federally regulated in their flight guidelines by the FAA. The U.S. government regulatory documents surrounding unmanned rocketry is FAA FAR Part 101. Rockets under 125g propellant and 1500g liftoff mass are exempt. Beyond that a free "Waiver" is required from a FAA field office.

However, some of the consumer motor manufacturers and two U.S. national rocketry organizations have established a self-regulating industry and codified it in National Fire Protection Association (NFPA) "model" code documents, which are adopted only in specific circumstances and jurisdictions, largely in conjunction with fire and building codes. This self-regulation of industry suggests a user to become certified for use before a manufacturer will sell him a motor. In North America, the two recognized organizations that provide high-power certifications are Tripoli Rocketry Association and the National Association of Rocketry. Both these organizations have three levels of certification which involves building progressively more complex and higher powered rockets and taking a test of safety rules and regulations. With the national member association bodies using published safety codes. In Canada the Canadian Association of Rocketry has a four-step certification process, but all three organizations accept the other's certifications if a flyer shows up at a high-power launch and wishes to fly under their sanction. Level 1 certification from NAR or TRA qualifies one to purchase and use an H or I motor, Level 2 certification J, K, and L motors, and Level 3 certification M, N, and O motors. Canada adds another step in between, and has a Level 4 which is the same as US Level 3.

The Federal Government has informed four consumer motor manufacturers they would prefer a "know your buyer" system instead, which is actually less restrictive to end user access. That has not been adopted by NAR or TRA or its associated vendors. They total 6000 members worldwide. (source: Irvine personal archives)

In the late 1990s, the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives began requiring[6] that individuals obtain a Low Explosives Users Permit (LEUP) to possess and use high-powered motors. On February 11, 2000, Tripoli Rocketry Association and the National Association of Rocketry filed suit in the United States District Court for the District of Columbia claiming that the BATF applied "onerous and prohibitive civil regulations" against sport rocketry hobbyists due to the Bureau's improper designation of ammonium perchlorate composite propellant (APCP) as an explosive. APCP is used in most high-power rocket motors. The commentary by BATFE staff in response to objections to adding new enforcement against hobby rocket motors is quite instructive.[7] In 2009, the court ruled in favor of the hobby organizations and ordered the BATF to remove APCP and other slow burning materials from its list of regulated explosives.[8] That judgement established 1 meter per second burning rate ("ATFE's own burn rate threshold for deflagration is 1000 millimeters (or one meter) per second." Tripoli Rocketry Ass'n, 437 F.3d at 81-82) as the threshold for a material on the BATFE list of explosive materials.[9]

Vendors

The largest vendor of model rocket motors in the world is Estes Industries. The largest vendors of high power rocket motors in the world are Cesaroni Technology Incorporated and RCS Rocket Motor Components, Inc.

The very first model rocket motor certified was by Model Missiles Inc. (Orville Carslile). Circa 1958. The very first high power rocket motor certified was by U.S. Rockets (Jerry Irvine). Circa 1985. The very first APCP propellant model rocket motor made was by Rocket Development Corporation (Irv Wait). Circa 1970. (source: Irvine personal archives)

The largest vendor of professional solid rockets in the world is Orbital ATK.

See also

- High-power rocketry

External links

- National Association of Rocketry (NAR) - Model Rocketry and High-Powered Rocketry Certifications (http://www.nar.org/)
- Tripoli Rocketry Association (TRA) - High-power rocketry Certifications (http://www.tripoli.org/)
- Canadian Association of Rocketry (CARWeb) - Model Rocketry and High-Powered Rocketry Certifications in Canada (http://www.canadianrocketry.org/)

References

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2. NAR website: http://www.nar.org/safety-information/high-power-rocket-safety-code/
3. USR website FS photograph: http://v-serv.com/usr/motors/images/CinerocFS5.jpg
4. "Civilian Space eXploration Team".
5. "Falcon Project Ltd. UK Bloodhound SSC test firing". Telegraph. 3 October 2012. Retrieved 3 July 2015.
6. "Commerce in Explosives--Amended Definition of Propellant Actuated Device". Federal Register. 13 February 2009. Retrieved 4 July 2015.
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