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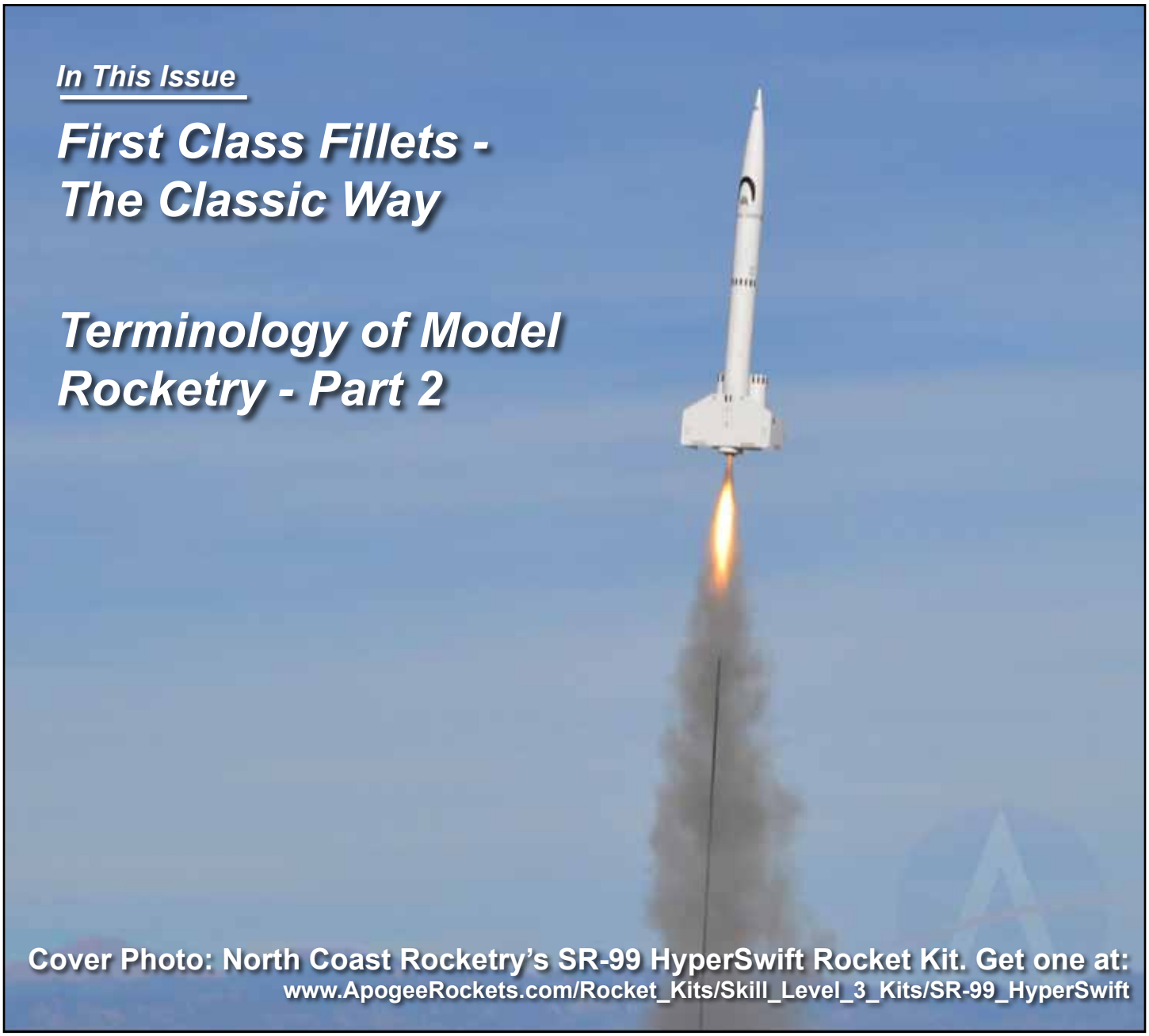
PEAK OF FLIGHT

NEWSLETTER



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Cover Photo: North Coast Rocketry's SR-99 HyperSwift Rocket Kit. Get one at:
www.ApogeeRockets.com/Rocket_Kits/Skill_Level_3_Kits/SR-99_HyperSwift

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First Class Fillets - Classic Way

By Matt Steele

Fillets are small glue reinforcements between a model rocket's body and fin. They are required on almost every model that you will build. As my kids were starting to fly competition rockets, I went looking for a simple method that would give good results, time after time. Once we got the details worked out, the method worked so well that I use it for all my models to this day.

The method involves masking off the area before you get any glue near the model. By masking the areas before you apply any adhesive, you avoid making a mess in areas that do not need glue, saving a lot of clean up (and aggravation).

I used the upper fins of the new North Coast Lance Delta for these photos. It has two sets of fins, both a forward and an aft set, so there are twice as many fillets required as on most four-finned models.

This method lets you do two fillets at a time, so for a four finned model, it takes four operations to complete the model. My approach lets gravity do a lot of the work, so you don't have to fight with drips or runs.

Most of the time, I use epoxy for my fillets, though I have also had good luck with wood glue. I generally use a five-minute epoxy, although for best results (when I am not in a hurry), 30-minute epoxy works best. The longer cure time of the 30-minute epoxy allows the liquid to "smooth" before curing.

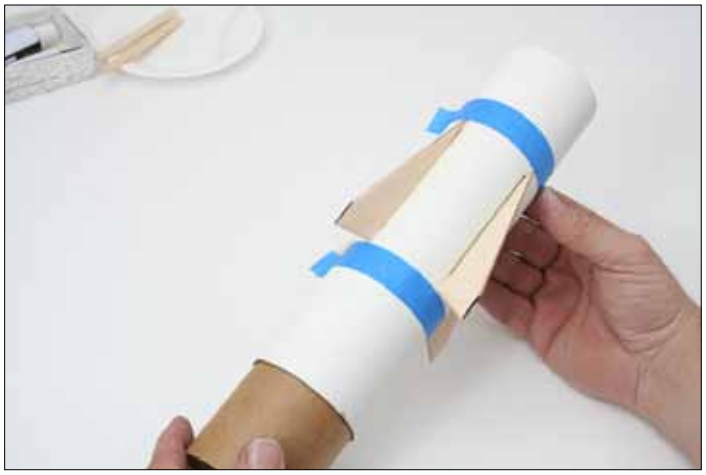

Photo 1: Mask off the tube in front and behind the fins.

Use a "low tack" masking tape for this type of work. I like the "blue" painter's tape, as it sticks well enough to keep epoxy from leaking under the edge, but lifts easily when you are done. Other tapes tend to lift the paper layers off the tube

I begin by masking off the tube at the forward and aft edge of the fin root (see Photo 1). On models where the fins are flush with the aft edge of the tube, you do not need a piece of tape.

Once the forward and aft tape is in place, lay two pieces of tape lengthwise along the fin root, about 1/8" apart for mid power rockets, and 1/16" apart for smaller rockets (see Photo 2). The width dictates how big the fillet will be. Repeat for the other fin.

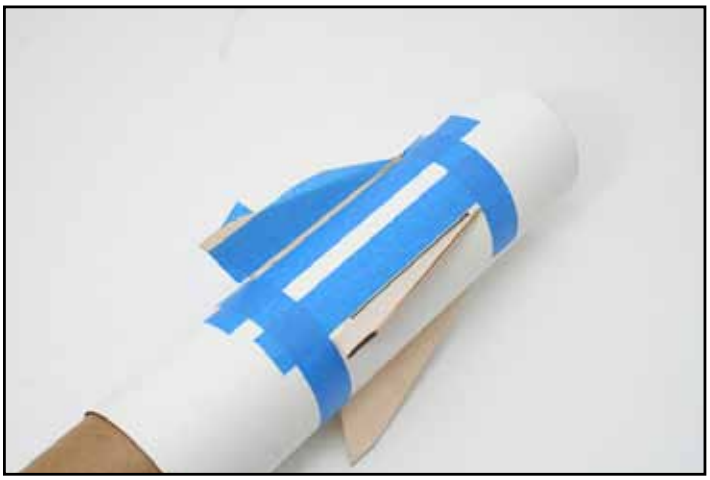

Photo 2: Tape is then placed along the tube and the fins, about 1/8-inch from the joint.

Mix up a small batch of epoxy. The easiest way to get enough without wasting material is to run a line of each part the length of the fillet, then mix it up. I use a popsicle stick to apply a generous amount to the joint.

Once the joint has epoxy the entire length, use the curved end of the popsicle stick to scrape away the excess epoxy. Be sure to fill in any areas where bubbles may have popped up.

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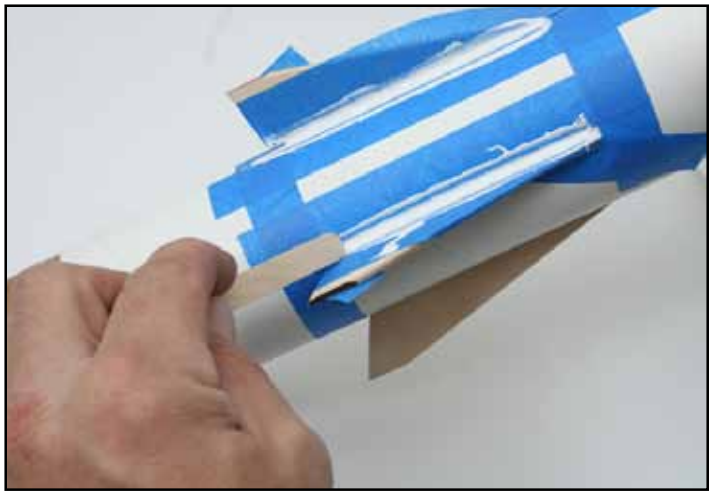


Photo 3: Lay epoxy in the joint, and scrape off excess with a popsicle stick.

Once you have the excess epoxy scraped away, remove the lengthwise sections of tape, starting in reverse order from the way you applied it.

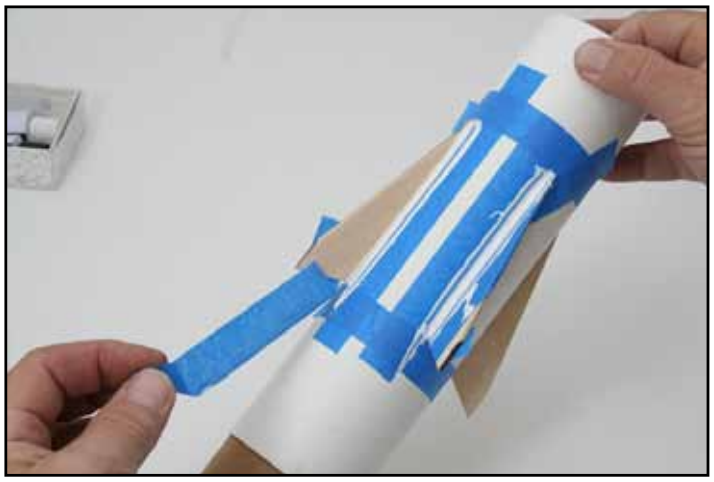


Photo 4: Peel off the tape while the epoxy is still in a semi-liquid state.

Clean up any epoxy that may have gotten out of place. I usually dip my finger in some rubbing alcohol and then smooth the joint out, but that is not necessary for small fillets or ones that use 30-minute epoxy.

Photo 5: Smooth out the edges with rubbing alcohol.

Then I remove the tape at the leading and trailing edges of the fin and clean up those joints, if needed.

Let the model cure, rotate to the next set of joints that need filleting, and repeat until the model is finished. The same technique works for launch lugs and other joints.

This has become my standard technique for model building. I hope you find it useful.

{*Editor's Note:* I call this method shown here the classic way, because it requires you to wait until the epoxy has cured before starting the next set of fins. If you use the Fix-It Epoxy Clay (www.ApogeeRockets.com/Building_Supplies/Epoxy_Clay), you can do all the fin joints at one time, because the clay epoxy does not run like liquid epoxy. You can see the technique on the Apogee web site at: www.ApogeeRockets.com/Advanced_Construction_Videos/Rocketry_Video_65}

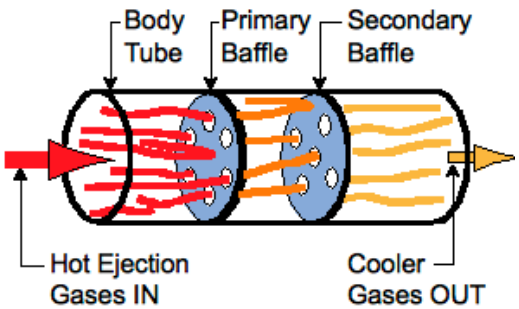
Terminology Of Model Rocketry - Part 2

By Ken Kosanke

{editor's note: Ken Kosanke has released a new product called the Encyclopedic Dictionary of Pyrotechnics. To promote this new reference dictionary, Ken has allowed us to reprint a few of the entries here that pertain to model rocketry. This thing is massive, and you'll want to get a copy for yourself. For information about this publication contact Bonnie@JPyro.com. Also, if you're ever thinking about writing for the Peak-of-Flight, this could be used as an idea generator. Take a topic, explain its importance, give background information and then take the subject even deeper. See Part 1 in Peak-of-Flight Newsletter, issue 321 at: www.ApogeeRockets.com/Education/Downloads/Newsletter321.pdf}

Ejection Baffle

This is an assembly that eliminates the need to use disposable wadding to protect the recovery device of an amateur rocket. The ejection baffle works by forcing the gas from a burning ejection charge to travel through a maze-like path before reaching the recovery device. In the process, the temperature of the gas is reduced by its mixing with cooler air; also any large hot particles will likely be trapped within the baffle.



Often an ejection baffle is merely two or more perforated disks with a separation between them (illustrated below-left).

As an alternative, the ejection baffle may incorporate metal mesh or metal wool for additional gas cooling.

Vieille equation

(Also Vieille's law, St. Robert's law or burn rate equation)

This was initially proposed by Paul Vieille (1854–1934), a French chemist and the inventor of a smokeless powder. The Vieille equation states that the linear burn rate (r) of a pyrotechnic material or propellant, at constant temperature, is equal to some power (n) of local pressure (P) times a constant (a):

$$r = a \cdot P^n$$

Here, a and n are constants that depend on the nature of the pyrotechnic material. Further, n is sometimes described as the pressure exponent and a as the pressure coefficient (discussed below). Accordingly, the pressure

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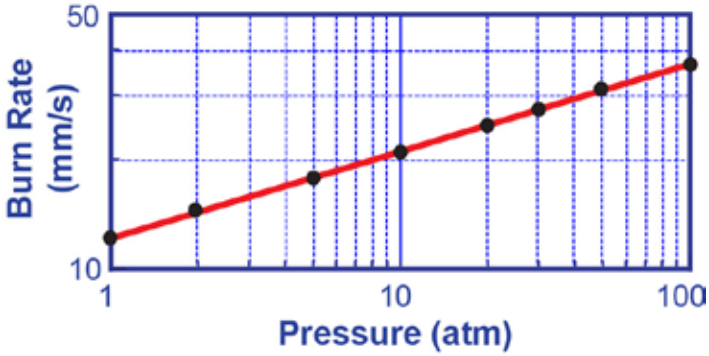
exponent is the slope of the burn rate curve when burn rate is plotted against pressure in a log-log format.

For Black Powder, with the burn rate in mm/s and a pressure in atmospheres, a = 12.1 and n = 0.24 (Shidlovskiy, 1964). This relationship is presented below.



For some pyrotechnic compositions, this relationship holds over a wide range of pressures, but for others, it only applies over limited pressure ranges (i.e., the constants are not truly constant).

The mechanism through which burn rate increases as a function of increased ambient pressure is by increasing the efficiency of thermal energy feedback. With increasing pressure, any flame produced will shrink in size to become a more concentrated source of radiated thermal energy, and it will be held closer to the burning surface. The effect of greater thermal energy feedback is to decrease the time taken for each successive thin layer of composition, in a larger block of composition, to be raised to its ignition temperature. The result of taking less time is an increase in burn rate.

An example of the effect of increased pressure on a flame is shown below for a double-base, smokeless propellant. The flames are burning under pressures of 1, 2 and 3 MPa (approximately 150, 300 and 450 psi), from left to right, respectively.

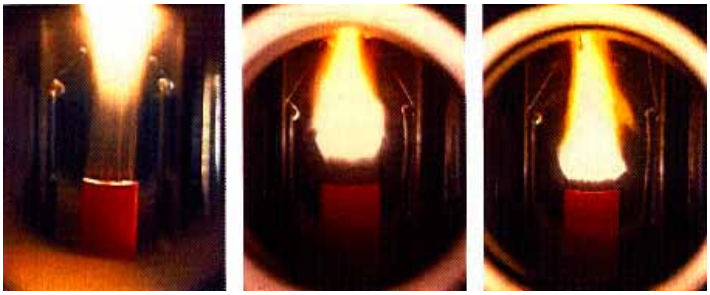


Photo credit: Naminosuke Kubota

Many seemingly slow-burning compositions become fast burning when strongly encased. Smokeless powders (i.e., nitrocellulose-based propellants) are especially good examples of the importance of the pressure exponent on burning behavior. A small trail of smokeless powder, such as used in small-arms ammunition, burns fairly slowly in the open. However when the same powder is ignited in the confined space of a weapon, it burns almost instantaneously.

In rocketry, the Vieille equation constants (a and n) play

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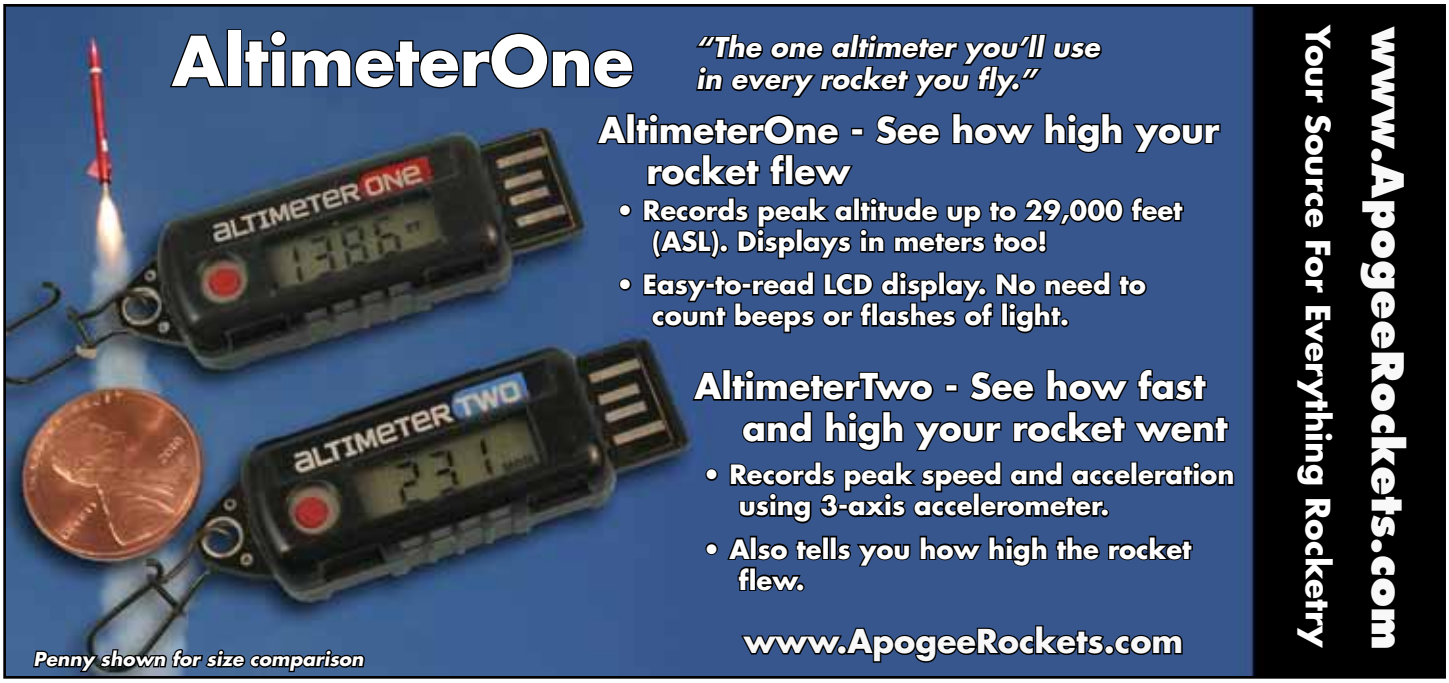

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a central role in determining chamber pressure (P_c).

$$P_c = \left(\frac{a \cdot \rho \cdot C^* \cdot K_n}{g}\right)^{\frac{1}{1-n}} = \left(\frac{a \cdot \rho \cdot K_n}{g \cdot c_d}\right)^{\frac{1}{1-n}}$$

Here, ρ is the density of the propellant (in lb/cu.in.), K_n is the ratio of the burning surface area to the cross-sectional area of the nozzle, g is the gravitational constant (32.2 ft/s2), C^* is the characteristic exhaust velocity (in ft/s), and c_d (in s/ft) is the discharge coefficient of the nozzle (a function of the temperature and composition of the combustion products). Note that c_d is equal to 1/C*.

Pressure exponent – (Also burn-rate pressure sensitivity or combustion index) – The exponent (n) placed on the pressure term in the Vieille equation can be determined experimentally. This can be accomplished by making a minimum of two, but preferably more, linear burn rate determinations at different pressures (at constant ambient temperature). This can be accomplished using a closed bomb, such as a strand burner, that has been pre-pressurized with an inert gas. A strand burner, self-pressurized by combustion gases can also be used. (As an alternative, a series of small, specially-made and instrumented test rocket motors can be used.) With the burn rate and pressure data from these tests, n (i.e., the slope of the log-log curve) can be determined by curve fitting.

The pressure exponent is a property of the pyrotechnic composition and is not highly sensitive to temperature.

Pressure coefficient – The constant (a) in the Vieille equation can be easily determined experimentally. It is simply the linear burn rate at a pressure of one atmosphere.

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