Winter 2002
ISSUE 3

# WSA APPLIED TECHNOLOGY

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covering design and technology in the hardware sector

## Flexible friends:
problems and solutions in tent pole production

## It's the hands that suffer more than the ears:
a look at rucksac hardware innovation

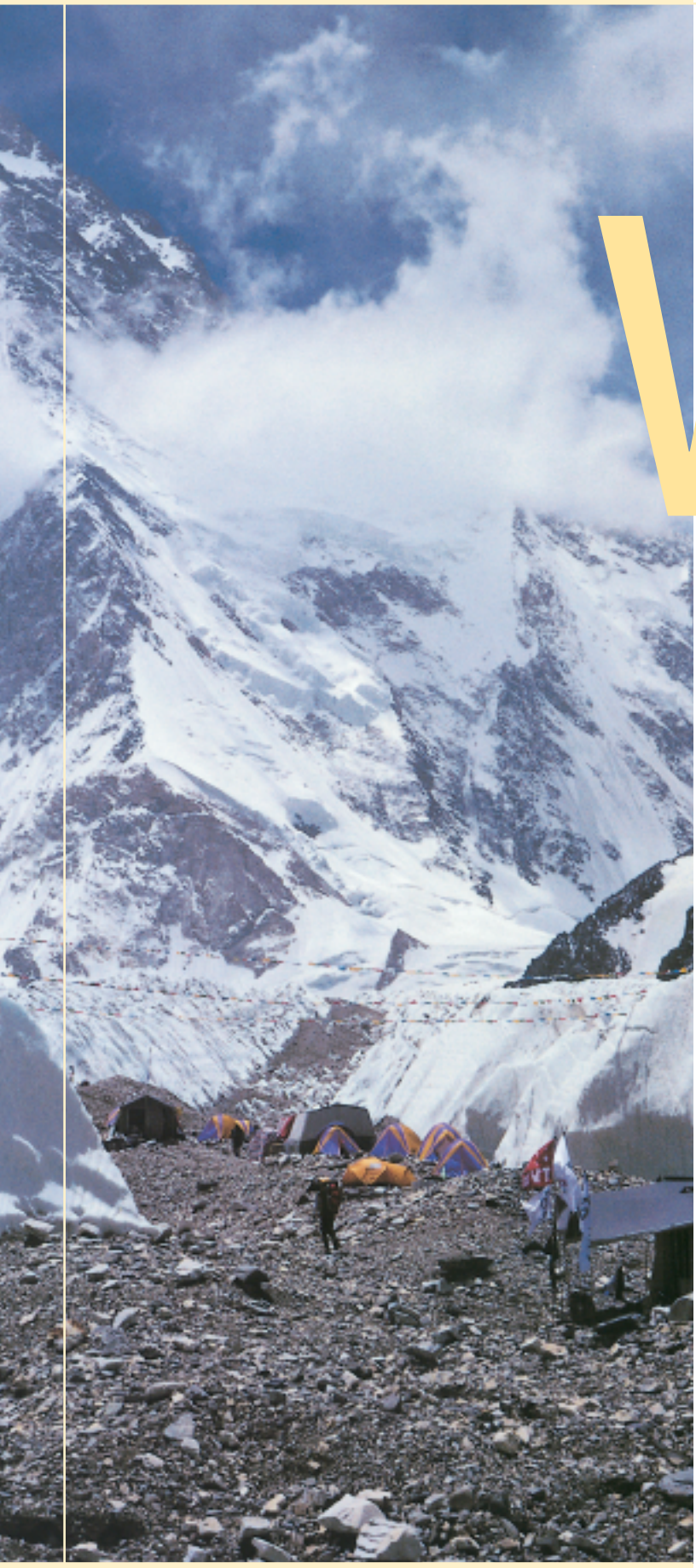






# flexible friends- pole to pole

by Graham Thompson



K2 Base Camp
Fairydown

Wilderness survival relies on food, drink and shelter. Take any one of these factors out of the equation and life is threatened. While the ability to find food and drink relies on being in the right place at the right time, coupled with the skill to find it or better still the forward planning to bring some along, shelters take a little more skill. Man has learnt to make shelters from whatever materials are locally available, so animal skins draped over branches pulled from trees or stone walls with a simple roof of branches again, but covered in foliage, have long been staple practices.

Little has changed over the centuries, with portable and easy to erect accommodation still being designed around the idea that a sheet of material can be draped over a configuration of poles to form a shelter. When George Mallory attempted Everest in 1924, he used a tent made of balloon silk draped over wooden poles. Lightweight cotton and bamboo poles were the height of technology in the 1960s, but it was not until the 1970s that flexible alloy poles started to appear to form dome, geodesic and tunnel tent designs with the advantage of offering lightweight, stable and spacious shelters to the backpacker. Today the materials may have improved; being lighter, more durable and more weatherproof, but little has changed in the basic concept. In short you need a quality tent pole to build a quality tent.

## Desirable performance

The option of travelling across a wilderness with a shelter packed into your rucksac, is one that relies on that shelter performing in a variety of weathers. While low level campers can find shelter from trees and natural land formations, the mountaineer or wilderness traveller may have to contend with rain, snow, hail and wind storms. So the failure of a tent pole could be at best annoying and uncomfortable, or at worst life-threatening.

Experience and extensive laboratory testing have shown that the strength of a tent pole lies in its ability to flex; to move with the wind or the weight of rain and snow rather than just breaking.

Persistent rain often means gear being packed when wet, so tent poles must not lose performance in such conditions nor when stored wet for long periods.

Temperature fluctuations can range from Arctic to

High Sierra, and pole materials should, ideally, be unaffected and jointing systems continue to work. And finally there is the day to day wear and tear of using a tent on a regular basis.

Ultimately a backpacker's tent pole needs to be durable, strong, ductile, have good recovery, be well priced and as light as possible.

## Materials

Wood may have been abundant to the early travellers and, of course, it is easy to work, but it has several disadvantages when used as a tent pole. The main problem is that it is heavy. It also needs to be maintained to withstand the elements and it breaks easily when flexed.

In the 1980s glass fibre poles brought lower weights and lower prices to backpacking tents and they are still used today for family or low altitude camping. Glass fibre tends to fracture readily during windy weather and at low temperatures, precisely the conditions experienced during high altitude camping, and poles of this material are not as springy nor as strong as quality alloy poles.

Since the mid - 1970s the better tent poles have been made from aircraft-quality aluminium alloy. Today most manufacturers of performance lightweight tents use alloy poles made by Yunan, Dongah Aluminium Corporation (DAC) or Easton, a small group of companies that specialise in aluminium tubing and have experience of producing aerospace structures, archery bows, arrows, ski poles, softball and baseball bats, hockey sticks, bike frames and snowshoes, as well as tent poles.

Aluminium alloy comes in many different forms usually being made from a mix of aluminium (the Earth's third most abundant element) and smaller quantities of copper, zinc, magnesium, titanium, zirconium or chromium. Heat treatment processes develop the final properties according to specification and intended use.

Since 1975 manufacturers of specialist tents have had the opportunity to use California-based Easton tubing for their poles. The current workhorse of the range is the Easton 7075-T9 which has supported tent systems from Antarctica to the top of Everest for more than 25 years. Eastons claim these are 25% stronger than any 7001-T6 tube on the market and that they will stand up to wind and snow for longer. The company proudly claims 'This option will bring you back alive - from the weekend or the expedition'.

Easton 78-HS (High-Strength) aluminium alloy poles use the 7178 alloy in T9 temper. These match the performance, strength and ruggedness of the industry standard Easton 7075-T9, but as they have a higher tensile strength the thickness of the pole walls can be reduced to provide a 15+% weight saving in the poles on their own. When matched to Easton's lightweight elastic cord, weight savings are in the order of 20%.

The company's newest addition to the range, the T8 Advantec, is a mid-market pole that employs 7075 aluminium alloy in a T8 temper, to give additional strength



***Above:*** Golite's Cave 2 shelter can be pitched vertically or horizontally making it ideal for the worst conditions and terrain. As set of walking poles has a dual purpose.

at a moderate price. Easton claims these are 25% stronger than any 7001-T6 tube available.

The Yunan Aluminium Company make a pole using 7X5X-T6 material, called the Hercules, which is expensive but is said to be 20% lighter than a standard pole. They also make Air Hercules tubing that is 30% lighter than a normal pole. These use Scandium, an alloy used in the production of Mig 29 aircraft by the former Soviet Union that has only been commercially available since 1996. A chemical element is added to the alloy to increase its breaking strength by up to 20% over a conventional 7001 alloy. Flexural strength is also 8% higher and this pole appears far less prone to fracture under stress.

| Aluminium Alloys | Examples | |
|---|---|---|
| The 7000 and 6000 series of numbers (7075, 7001, 7178 etc) is the universal system used to describe the composition of an aluminium alloy, with each 4 digit number representing a different blend of elements such as zinc, magnesium, titanium, zirconium, or chromium. | **7075**<br>90% aluminium<br>5.6% zinc<br>1.6 % copper<br>2.5% magnesium<br>0.23% chromium | **7001**<br>87% aluminium<br>2.1% copper<br>0.25% chromium<br>7.3% zinc<br>3% magnesium |

| Heat Treatments | |
|---|---|
| T6,T8,T9 are different types of heat treatment, with T9 creating a harder, stiffer and more brittle material than T6. | |
| T6 | Heat treated, artificially aged |
| T8 | Heat treated, cold worked, artificially aged |
| T9 | Heat treated, artificially aged and then cold worked |

| Final Material |
|---|
| **7001-T6:** 87% aluminium, 2.1% copper, 0.25% chromium, 7.3% zinc, 3% magnesium and then trace elements of iron, manganese, silicone and titanium. This produces a pole that is soft, bends easily and stays bent without breaking, but it has less 'spring' and therefore has a tendency to fail under extreme stress. |
| **7075-T9:** 90% aluminium, 5.6% zinc, 1.6 % copper, 2.5% magnesium, 0.23% chromium and trace elements of titanium, zirconium, iron, manganese, silicon and titanium. These poles are harder, tougher and are able to flex and return to the original set without snapping. |

In the continual search for lighter poles manufacturers are also looking at carbon fibre as the way forward. Stronger and lighter than aluminium, Easton's new C2 Carbon Defined pole offers innovation with 25% weight saving. These poles are created with a unidirectional pultrusion process, combined with a double bias offset directional winding of additional carbon fibre, and connectors of glass fibre reinforced plastic.

## *Pole designs*

Manufacturers use wind tunnels and computer simulations of the wildest mountain weather to determine exactly what is happening when a pole is fitted to a tent. This has led to tent poles generally being made from tubes with diameters ranging from 7.9mm to 19mm, with wall thickness and overall diameter determining final weight and performance.

DAC also make a Combination pole that allows 9.9mm diameter poles to be used where strength is needed and attach these to 9.0mm diameter poles to save weight where less strength is needed.

Although most are straight and flexible, prebending is sometimes used to alleviate the excess stress put on the tubes when a pole needs to be flexed around a tight curve. Tubes with prebends form a constant arc, with approximately 5cm at each end of the tube remaining straight to allow the inserts to function smoothly. However, too much bending of the poles does make it difficult to store them in a rucksack or tent stuffsack, and of course they are more expensive to manufacture.

Most poles sections are made in standard lengths as a price regulator, with perhaps one pole in a set being specially made with a prebend or shorter length to accommodate the overall size requirements of the tent. Smaller producers, such as Hampton Works in the UK, are able to produce custom made poles, with each pole section cut to the optimum length to allow them to pack down neatly.

So that 90 degree arches can be made to create a 'corner' for special tent designs, most manufacturers produce connectors consisting of a short main tube bent to a 115, 125, or 145 degree angle and available in 5-12cm lengths.

## *Joint designs*

The first wood, glass fibre and alloy poles were made from solid bar and the sections were assembled with male to female ferrules being fitted to the ends. This low cost method works well when there are just two sections to a full-length pole and it is intended to stand vertically, but when there are three or four sections and the pole is flexible they tend to come apart during the erecting process, particularly while threading long poles through the sleeves of a dome or geodesic tent. To overcome the problem, performance tent poles are made from tubes and then linked by an elastic cord that is threaded through the centre of each pole section and then tied off at the end to hold the assembly together.

As has already been noted the simplest, and most cost-effective, method to join hollow pole sections is to make a male to female joint by fitting a small diameter tube insert into one end of a section and a ferrule at the other. Both Yunan and DAC have developed a method of joining their respective Air Hercules and Featherlite poles by reducing the diameter at one end of a section so that it fits inside the preceding one. Yunan discovered that when reducing the pole diameter to form these joints breakages could occur, the poles could jam on the taper or the pole joint would snag in the pole sleeve, so it fits an external ring at the base of the taper to improve strength and eliminate the problem of jamming.



## Cords

When the elastic cord is the right length the poles snap together like a magician's wand and yet can collapse down to around half a metre in a matter of seconds. Achieving the correct 'double' of quality and length is the secret. Too many backpackers have become accustomed to adjusting the length by pulling through extra cord and tying it off at the end of the pole because the 'double' has been lacking in terms of quality.

Freezing conditions, stress and heavy use can effect performance of cords, so in their 7075-T9 poles, Easton use SHOKcord – a quality level specified by the U.S. Army and Marine Corps in all their personal shelter systems. (Easton suggests this is an over specification.) For particularly lightweight tents Easton also offers a lighter version of SHOKcord. The company's T8 Advantec poles use a lower quality, value priced cord.

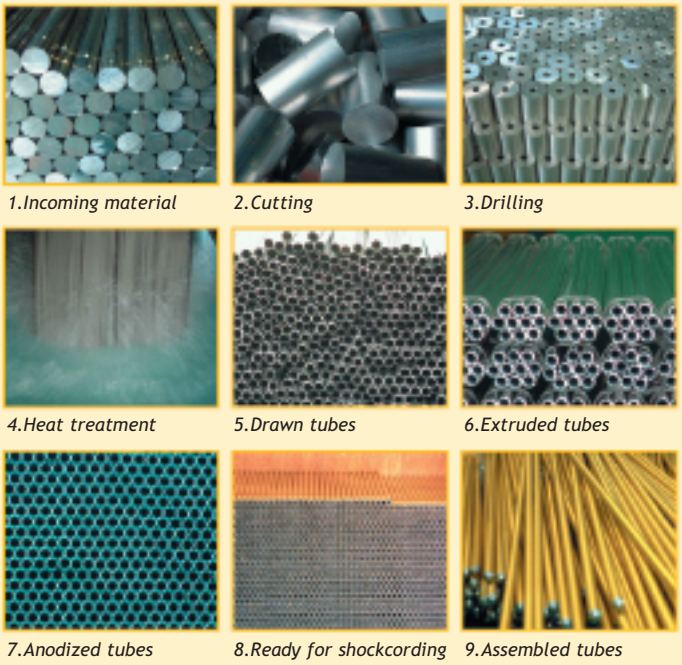
To save weight the latest Featherlight poles from DAC use thinner than standard shock cord, but this has a rubber and silicone treatment applied to increase durability and rebound strengths. DAC claims these new cords have a greater than 80% rebound at -20 degrees C. Yunan poles feature a shock cord that is also cold resistant and claims that it only loses 20% of its tension at -30 degrees C. compared to the tension at room temperature.

## Manufacturing

Manufacturing techniques play an important part in how strong the final pole will be. Around 60 production steps are required to transfer an ingot of alloy into a tent pole. The two basic methods used to produce the tubes are seamless extrusion and sheet welding a flat panel that has been rolled into a tube.

In the extrusion process a bar shaped billet is put into a strengthened steel container and then squeezed out through a die using high pressure. The extrusion process is slower and more expensive than sheet welding but, according to DAC, it is a more reliable method of providing uniform microstructure in the tubes.

In the sheet welding process a thin sheet is sliced into a continuous narrow strip, rolled and the edges bonded together to make a tube. Easton uses the sheet method and fusion-bonds (not welds) the strips into tubes in its Salt Lake City facility. Through a series of solution heat treatments, ageing and cold work (drawing), the fusion line is totally absorbed into the adjacent metal.



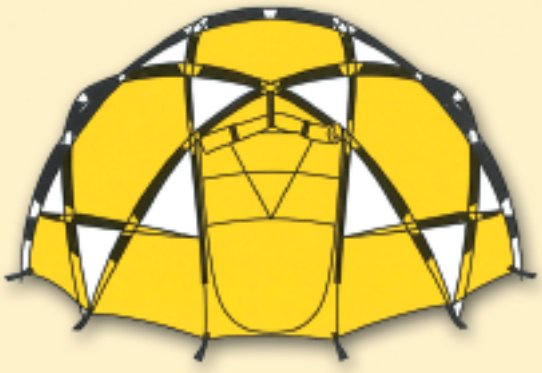

***Above:*** Tent pole manufacturing procedure in nine stages.

Once the poles have been made a further drawing process is required to make a small outside diameter tube with a thin wall section. To achieve the correct mechanical properties it is then heat-treated. The standard heat treatment for high strength aluminium, where the aluminium tubes are heated to allow changes in the molecular structure before being quenched in water to freeze the structure, is T6. For additional strength a T8 or T9 temper can be used where work hardening is applied

***Below left:*** In 1975 The North Face introduced the Oval Intention, the first lightweight geodesic dome tent.

***Below right:*** It is a design which set the standard for high altitude exhibition tents as shown here with the modern 2 Meter Dome tent.





that creates internal stresses within the molecules of the material to add greater strength. However, the harder the material, the more brittle it will become, and this can be a problem, for as we have seen, flexibility is essential to the efficiency of a tent pole.

The processing continues with cutting and de-burring, and the ends of the poles are fitted with either inserts or ferrules, or swaged as discussed earlier. Finally the poles are anodised to prevent corrosion and chemically polished.

## *Quality control*

The quality of the base materials is the most important contribution to the finished quality of the pole. In the case of DAC, its material supplier is the only company in Asia which is approved by the US aerospace industry and, as already mentioned, Yunan's Scandium alloy occupied a similar position in the former USSR's aviation programme.

To harden the alloy it is tempered by heating and then quenched to lock the internal structure; thus achieving the correct temperatures is essential to maintain the properties of the finished tent pole. Get this part wrong and the pole will fail.

The hardness of the surface is related to anti-scratch, anti-abrasion and anti-corrosion properties that are all essential if a pole is to be durable. So a Vickers hardness test is used on the outer skin, while an Eddy Current tester searches for scratches. Shockcords are tested at -30 to -50 degrees and then their rate of recovery is measured.

Once a pole is made it can be tested in many ways to gauge its performance on the hill. Pull tests are used to measure the tensile strength, yield strength and elongation. Bending tests indicate bending strength and display how the tube will ultimately deform if pushed too far.



***Above:*** Mid and low altitude tents from Fairydown. The top tent is the Escape, designed for moderate conditions with a combination of mesh and fabric to keep it lightweight and cool. The second tent is the Trios, which is a strong mid altitude tent with space for three or more people. These tents use prebent poles.

## *The Future*

The future of pole design will no doubt see lighter poles that are more flexible, stronger and more resistant to the corrosive effects of the environment. But with some of the latest designs in tents making use of the trekking poles that a great many walkers now use when backpacking, perhaps this is the time for a more radical redesign of the relationship between tent and tent pole, the most important building block of a wilderness shelter.