Fabrication Instructions for Scandium Tube Sets

1.0. Introduction

Scandium is the eighth most abundant rare earth element. It is found in the earth's crust at 5 parts per million (ppm), but it is very difficult to extract from ore. Prior to the opening of the former Soviet Union in the early 1990's it was largely unavailable, even though it was discovered in 1879 by Lars Nilson. Scandium is a silvery white metal, numbered 21 on the periodic table, that is a potent grain refiner used in aluminum alloys to elevate strength and durability. Scandium alloys were first made commercially available in 1996 by the Ashurst Technology Group. Easton Sports first used Scandium alloys in February 1997, the product was the Redline C-Core bat.

Scandium alloys were first used for structural purposes in Soviet aircraft and missiles. In fact, some of the missiles used Scandium alloys for the guiding fins on missiles. The Soviets welded the guide fins onto these missiles, something that Western engineers could not do successfully. Most remarkably, the Soviet missiles were designed for launch from below the polar ice cap. The missiles were capable of piercing the ice cap without damaging these welded on fins. The strength that Scandium alloys brought to weldable alloys allowed Soviet built aircraft to utilize welded structures. This gave these planes tremendous weight, maneuverability, and range advantages.

In researching the Scandium alloys, Easton was able to develop a number of uses for this material. Obviously, welded bike frames could significantly benefit. Though the weight of Scandium alloys is no different than other weldable alloys, the Easton SC7000 alloy is twice as strong as 6061 or 7005 (standard welded frame alloys). Because the strength is so much higher, less material is needed to achieve the desired structural properties. In the end you get a lighter frame. Lighter is good, but durability and ride characteristics are just as important. Because Scandium creates a stronger tube, the weak link in a welded frame becomes the weld. However, using a special Scandium enhanced weld wire solves this problem. In fact, the Scandium weld wire creates an extraordinarily strong weld when combined with SC7000 tubes.

When Easton began developing the SC7000 (Scandium) tubesets, we analyzed all of the benefits of the material in order to make something more than just a super light tubeset. Easton designed a set of tubes that would provide significant benefits to the rider. Some of the benefits are:

- Ride Quality: Because of the material's strength, we were able to reduce the diameter of the tubes in specific areas. This design creates compliance within the finished frame. Compliance is what makes a frame ride smoother, be more comfortable, and provide better control on rough surfaces. Too much compliance can create flexibility which robs power from the rider. Easton utilizes various cold working procedures to form the tubes in critical areas. In the end, you get a frame that absorbs shock and vibrations, yet remains stiff in critical areas. No power is lost, and the frame is comfortable enough to ride all day long. In fact, the SC7000 frame has been used by European professional riders in the Giro d' Italia and the Tour De France. They are astounded by the comfort it provides, and the confidence in descending.

- Light Weight: With the additional strength of the SC7000 material, we were able to push the limits of light weight aluminum alloy tubing. In general, you will see about a 10% reduction in frame weight when compared to our full UltraLite frame. Remember too, that the UltraLite frame is one of the lightest, most durable aluminum frames you can get.

- Durability: While light weight is good, durability is paramount. Because SC7000 material is so strong, and was designed for additional compliance, the durability is excellent. Easton's fatigue and impact testing shows a remarkable increase in durability over standard frames.

With aluminum, fine elongated grains means high performance. The photo-micro-graphs in Figures 1 and 2 (next page) are cross sections of welds using SC7000 welded with Scandium Filler Rod and 7005 welded with 5356 filler rod. The effects of Scandium in both the base metal (tube) and weld bead are readily visible. The base metal of the SC7000 material has extremely fine elongated grains while the weld bead is characterized by equally fine equiaxed grains. These fine grains promote optimum properties including exceptional yield strength and fatigue life.

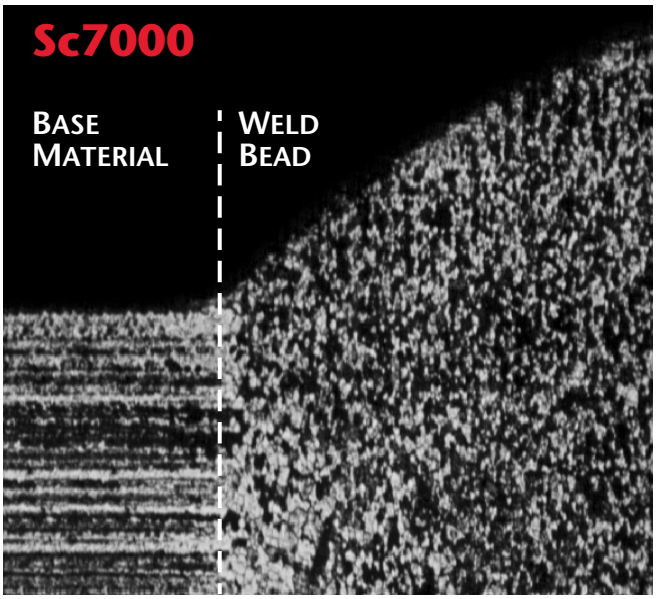


Figure 1: SC7000 Base Material and Scandium Weld Rod

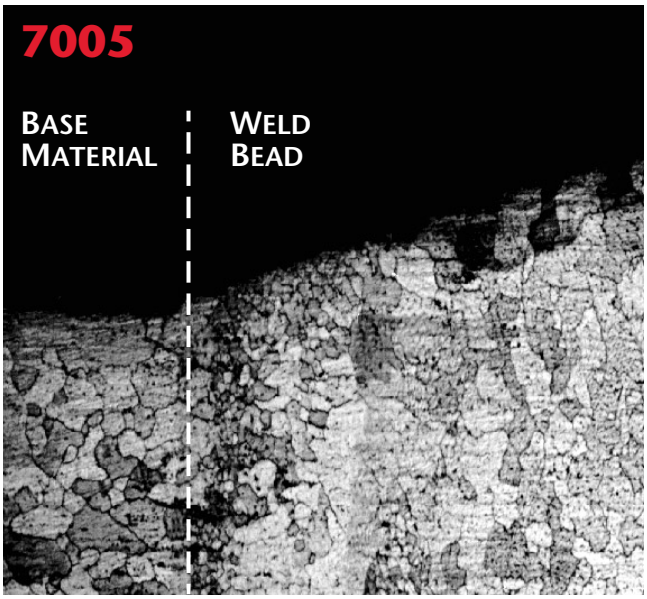


Figure 2: 7005 Base Material and 5356 Filler Rod

SC7000 is indeed a remarkable product. The proprietary Scandium alloys that Easton uses are just the beginning. Easton's proprietary TaperWall process, and extensive cold working take this material to a higher level. Grain refinement, precise manufacturing processes, and years of experience in frame tubing, all add up to the most refined tubes available. On top of all of this, the design of these tubesets is beyond all others. Easton researched every element of frame design when creating these tubes. The engineering and design investments in these tubesets is overwhelming.

Advanced materials, proprietary manufacturing processes, and superior development and design all add up to the Easton Advantage!

2.0 Frame Building Technical Information

SC7000 can be used successfully to build durable, smooth riding frames. To ensure such characteristics several safe-guards, construction techniques, and thermal processes must be carefully followed.

2.1 Cleanliness

Cleaning tubes properly immediately prior to welding is paramount to ensure joints with sufficient structural integrity. Recommended practice is to Scotch-Brite the ends of the tubes a minimum of 1.5 inches from the tube end. This should be followed by chemical treatment with any of the commercially available acidic solutions for aluminum.

Product: Aluma Kleen
Manufactured by: ABBOT CHEMICALS
11706 Sheldon Street
Sun Valley CA 91352
(818) 982-2707

Available from: Gordon Woods (and other Weld Supply Distributors Nationwide)
7254 Coldwater Canyon
North Hollywood CA 91605
(818) 759-6900

If the tubes are left for more than one hour without having been welded, it is advisable that they be acid cleaned again. This time is only a rough guideline and may increase or decrease depending on variables such as temperature and humidity.

2.2 Straightening

SC7000 is considerably stronger than either 7005 or 6061 and will therefore require more effort to straighten. The thin wall SC7000 tubes can wrinkle when high straightening loads are applied so frames should be tacked/welded as straight as possible to reduce the amount of post weld straightening required.

Minor alignment after welding should be performed as soon as possible while material adjacent to the weld is in its softest state. SC7000 age-hardens rapidly making alignment more difficult as time advances. As tubes re-age-harden the force necessary to straighten frames increases. This can lead to damage to either the tube or the weld that will not be easily detected and can shorten the life of the frame.

Less than six hours is the recommended time for frame alignment. If frames are built in sub-assemblies, alignment should be done on each subassembly within six hours.

To promote welding straight frames all mitered gaps should be less than .030 inches.

2.3 SC7000 Filler Rod
The entire frame must be welded with Easton Scandium Filler Rod, which has been formulated to optimize the properties of the Scandium Tube Kit. This includes the rear triangle. SC7000 frames require different thermal processes than complete 7005 frames necessitating the use of Scandium Filler Rod throughout the frame.

2.4 Weld Bead Treatment
2.4.1 Double Passes
Double passes across the weld bead (a technique sometimes employed to smooth the bead look) should not be employed. Violating this recommendation will result in a dramatic decrease of tensile properties in the area around the heat affected zone.

2.4.2 Filleting Joints
Sanding or filing weld beads smooth is also not recommended.

2.4.3 Starts and Stops
Through rotary beam fatigue testing conducted in Easton's Sports Lab of aluminum alloys that were circumferentially welded, it was determined that in nearly all cases, fatigue cracks leading to joint failure will initiate at the weld starts/stops. Good design and fabrication practice is to have start and stop placement offset from the plane of the frame where the stress is the highest by 90 degrees.

For example, at the head tube-down tube junction the stress is the highest at the bottom of the head tube. Therefore the starts and stops for this weld should be placed on the side of down tube.

2.5 Frame Construction
2.5.1 Seat Tube – Bottom Bracket Connection
As with any high-performance aluminum tube set, it is imperative that the seat tube be completely welded 360 degrees to the bottom bracket prior to attaching the down tube or chain stays (see Figure 3). If this is not done, failure of the joint is likely.

2.5.2 Down/Top/Head Tube Connection
If there is any overlap between the Down and Top Tubes at the Head Tube (as there may often be on small frames) the Down Tube must be completely welded to the Head Tube 360 degrees before attaching the Top Tube (see Figure 4).

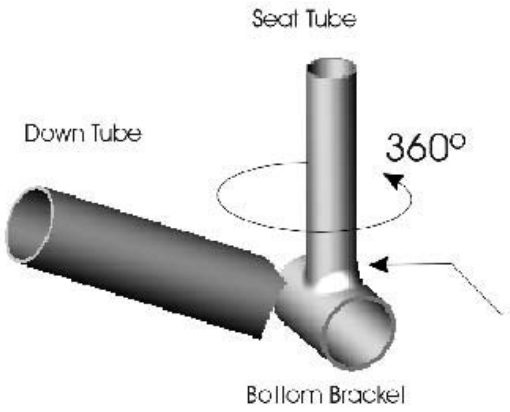


Figure 3: Proper Attachment of Seat Tube to Bottom Bracket

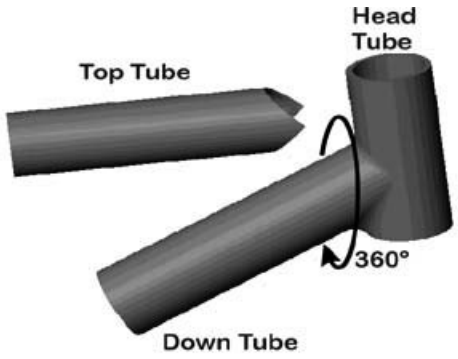


Figure 4: Proper Attachment of Down Tube to Head Tube

2.5.3 Weld Vent Holes
Vent holes should not drilled in any SC7000 tube or 7005 Chain and Seat Stays. Venting of tubes should be done at the intersection of two tubular sections. For example, Chain Stays should be vented through the Bottom Bracket Shell and Seat Stays should be vented through the Seat Tube.

2.5.4 Cable Guides
If cable guides are to be welded on the tubes, they must be a minimum of two inches from the edge of weld bead. They should also be placed on the thick sections of the tubes. If attachment to thin wall is

necessary, it is recommended that rivets instead of welding be used. Easton does not recommend welding or riveting mounts on the underside of the down tube.

2.5.5 Tube Crimping and Cold Working

SC7000 Main Tubes and 7005 Chain and Seat Stays should not be cold worked in any manner. Examples include crimping or dimpling Chain Stays for more tire clearance or crimping tubes elliptical at tube junctions. Easton tubing is supplied in a thermal state that is designed for a post weld age only. Cold working tubes prior to welding will dramatically increase the susceptibility of the frame to Stress Corrosion Cracking (SCC).

2.5.6 Frame Size Limits

SC7000 Road and ATB Tube Kits are designed to accommodate a specific size range of frames. Exceeding the size recommendations will compromise frame life and stiffness. Frames larger than those defined in Table 1 should not be fabricated with SC7000 Catalog Tube Kits.

TABLE 1: SC7000 FRAME SIZE LIMITS

SC7000 Tube Kit Type	Large Size Limit
Road – Small Down Tube	56 cm
Road – Large Down Tube	61 cm
ATB	20 in.

Note: Frame Size is measured Center Bottom Bracket Shell to Top of Top Tube along Seat Tube axis.

2.5.7 Rivet Nut Installation

Due to the thin wall thickness in the center of the SC7000 Down and Seat Tubes, proper installation of Rivet Nuts used for water bottles is essential to insure frame integrity. The following items must be addressed:

- Rivet Nuts must be designed to work on the grip range of the SC7000 Tubes (see Table 2 for wall thickness)
- Rivet Nut Manufacturers installation torques must be followed. Rivet Nuts must not be too loose or too tight (see Figures 5 and 6 for an example of an over-torqued Rivet Nut that lead to frame failure).

TABLE 2: CENTER WALL THICKNESS OF SC7000 TUBES

SC7000 Tube Description	Center Thickness (in.)
ATB Down Tubes	.035
ATB Seat Tubes	.035
Large Road Down Tube	.028
Small Road Down Tube	.032
Road Seat Tubes	.035

NOTE: Some Rivet Nuts may be installed on thicker walls due to tube trimming and mitering. Always check Easton Tube Drawings to verify wall thickness at rivet nut location.

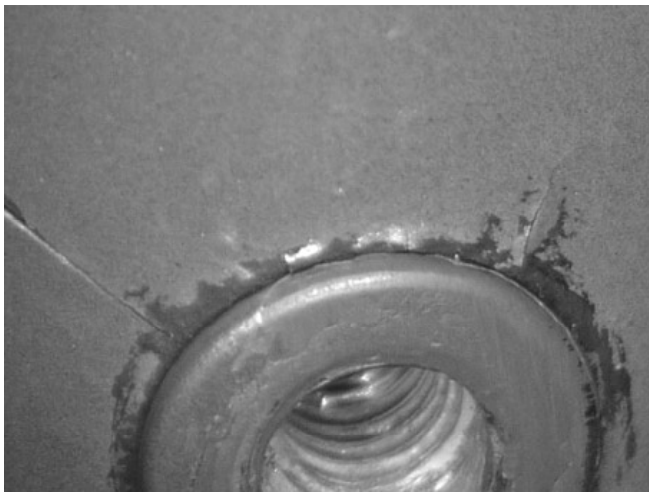


Figure 5: Example of Over-Torqued Rivet Nut that Lead to Frame Failure

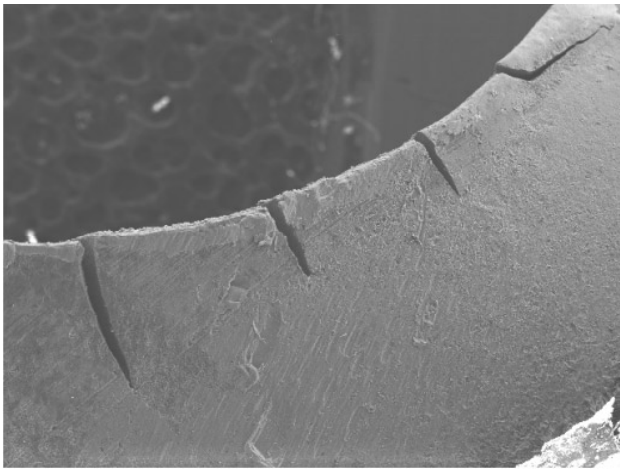


Figure 6: SEM Photograph Showing Mechanical Deformation Caused by Over-Torqued Rivet Nut

NOTE: Some race frames use a Rivet Nut in the Top Tube for Racing Number Attachment. The thin wall of Road and ATB Top Tubes is .030 in.

WARNING!! Scandium Road and Mountain Tube Kits are not designed for use with Water Bottle Cage Mounted Lighting System Batteries.

2.6 Frame Identification

If stamping is to be used to identify frames (i.e. to mark builders ID, customers name, or any other serial number or identification) it should only be applied to the bottom of the Bottom Bracket Shell at least 1 inch from any weld beads. Stamping should never be done on any other areas of the frame.

2.7 Post-Weld Thermal Processing

2.7.1 Post Weld Age

Correct Post Weld Aging is absolutely critical!! Failure to do so will result in reduced properties and a susceptibility to Stress Corrosion Cracking (SCC). The required post weld age is:

- Step 1: Allow oven temperature to reach 275° F +/- 5° F
- Step 2: Insert frame for 5 hours +/- 5 minutes at 275° F +/- 5° F
- Step 3: Change oven temperature to 300° F +/- 5° F. Note: Oven must ramp to 300° F in no more than 10 minutes.
- Step 4: 2 hours +/- 5 minutes at 300° F +/- 5°.
- Step 5: Remove frame from oven and allow to cool to ambient without fan assist.

WARNING!!! Failure to conduct the recommended age will lower frame strength and may promote frame cracking, which can cause premature frame failure.

2.7.2 Solution Heat Treatment

Due to the alloy mix and material properties, post weld solution heat treating should not be performed. SC7000 frames can not be water quenched, the most common heat treating process path. The only way that SC7000 frames can be solution heat treated is with a company that has a great deal of experience performing forced air quenches. If this process is to be employed Easton recommends using a source that has been qualified to perform this service.

Newton Heat Treating Company
19235 E. Walnut Dr. North
La Puente CA 91748
(626) 964-6528
Contact: Greg Newton

Easton assumes no responsibility for solution heat treating of SC7000 frames at other sources.

2.7.3 Checking Thermal Processing Using Conductivity Measurement

Checking material hardness is not the recommended way to correlate correct thermal processing and material properties as they can often be misleading. Easton recommends using an electrical conductivity meter to verify frame thermal processing. These meters can be purchased from:

HOCKING NDT Ltd.
Inspec House
Camp Road
St. Albans, Herts
UK, AL1 5HL
Tel.: +44(0) 1727 795500
FAX: +44(0) 1727 795400
To find a distributor near you check the World Wide Web at: http://www.hocking.com
Product: AutoSigma 3000

STAVELY NDT
Customer Support: (509) 736-2751 or email: sndt1@staveleyndt.com
World Wide Web: http://staveleyndt.com
Product: Nortec 1700

K.J. Law Engineers, Inc.
42300 West Nine Mile Rd.
Novi Michigan 48375 USA
Tel.: (248) 347-3300
Toll Free: (800) 521-5245
FAX: (248) 347-4113
E-Mail: info@kjlaw.com
World Wide Web: http://www.kjlaw.com
Product: Verimet M4900C

Table 3 defines the conductivity ranges that should be observed near welds and in non-heat affected zone material (greater than two inches from weld bead) for both pre and post age conditions.

TABLE 3: CONDUCTIVITY RANGES FOR THERMAL PROCESSING

Frame Location	Pre Age	Post Age
Heat Affected Zone SC7000	39.0 – 47.0	43.0 – 49.0
Virgin Tube Sc7000	41.0 – 44.0	42.0 – 44.0
Heat Affected Zone 7005	28.0 – 36.0	29.0 – 38.0
Virgin Tube 7005	33.0 – 36.0	33.0 – 36.0

2.8 Frame Finishing

2.8.1 Wet Paint

Wet paint is the preferred finish for SC7000 to promote an attractive finish and maximize material properties.

2.8.2 Anodizing

Anodizing SC7000 frames should not be performed. Anodizing will significantly reduce frame fatigue life. In addition, the unusual grain structure of SC7000 tubes will become visible after anodize resulting in an undesirable cosmetic finish.

2.8.3 Powder Coating

Traditional powder coating can not be used on SC7000 frames due to the curing temperatures. Powder coating (or any other thermal process) can only be performed as long as the curing temperature is not higher than 325 degrees and the cure time is less than 30 minutes.

These lower temperature powder coat materials can be obtained from:

SPRAYLAT Corp.
3333 N. Interstate 35
Gainesville TX 76240
(817) 665-9590
Toll Free: (888) 725-7250