

VII INTERNATIONAL MEETING ON TITANIUM

FURTHER DEVELOPMENTS IN TITANIUM
AEROSPACE TUBING AND VERSATILITY
OF TITANIUM IN SPORTS

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FURTHER DEVELOPMENTS IN TITANIUM AEROSPACE TUBING
& VERSATILITY OF TITANIUM IN SPORTS

FIRST, I WOULD LIKE TO THANK GINATTA TORINO TITANIUM for making space, at the last moment for this brief presentation.

SECONDLY, the presentation is primarily on behalf of the Washington, U.S.A. division of the worldwide SANDVIK organisation, SANDVIK SPECIAL METALS.

It was the intention of CLYDE FORNEY & STEVEN MEREDITH of SANDVIK SPECIAL METALS to attend this TITANIUM event but their visit had to be postponed at the last moment.

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THIRDLY, to introduce myself, as SALES MANAGER for AEROSPACE PRODUCTS for EUROPE of TUBESALES In Europe, Tubesales is based in Southampton, U.K. & St. Nazaire in France.

TUBESALES is sole-distributor & stockist for SANDVIK SPECIAL METALS in EUROPE of BOTH THEIR AEROSPACE QUALITY TITANIUM ALLOY & Ti 32.5R Radial texture Titanium tubing for recreational or sports purposes.

TUBESALES does not represent SANDVIK SPECIAL METALS in Medical Implant distribution.

Finally an apology or explanation, that I am not technically qualified to go into detail with delegates today on the points that we are highlighting with Sandvik products but clearly we are only too happy to take written questions accompanied by a visiting card and to process these.

The numerous items on display here, especially those in the Titanium Alloy 3Al 2.5v, are covered in the S.S.M. Engineering Guide for which Clyde Forney & Steve Meredith are joint editors. I have many copies available for distribution.

I must also explain that the sporting items displayed, which include Golf Club Shafts, Ski Poles, Bicycle Frames - parts applicable to both Racing & Mountain Bikes, Hockey Sticks & Tennis Racquets & Pool Cues, do not represent the complete range of the products of SANDVIK TITANIUM SPORTS. Again, I cannot claim to have had any personal experience of any of the various types but I will go on now to outline the properties of Titanium 3Al 2.5v APPLICABLE TO THEM.

I hope, following that long introduction, I have put in perspective the SSM or SANDVIK SPECIAL METALS involvement and my own involvement through TUBESALES.

A GOLF SHAFTS

We all recognise the basic property of Titanium with its HIGH STRENGTH & LOW WEIGHT ratios... special Heat Treatment of Ti 3.2.5 tubing yields exactly this result so that a basic shaft is 15 grams lighter, i.e. typically 100 grams against 115 for a steel shaft.

The SOFT FEEL of Titanium is stressed by SSM In that its low elastic modulus (half that of steel) dampens or softens the shocks & vibrations which then reduces the injuries to elbows & to arms which can occur.

QUESTION: are there any GOLF enthusiasts in the room who have experienced TITANIUM SHAFTS?

The excellent torsional properties lead to low torque shafts. This makes for straighter hits and less spin to the ball. A detailed paper on torsional properties by Steven Meredith, is available for those who would like copies.

Durability: Titanium's good fatigue resistance & fracture toughness enhance the life of a shaft, especially compared to graphite composite shafts (...it is quite clear that this particular property is highly relevant to use in hydraulic systems of the very latest aircraft & here in Torino, this same tubing is being used on the Eurofighter prototypes).

Corrosion Resistance: Titanium is resistant to any type of natural environment including salt water. This too is of great importance as many golf links seem to be built along sea coasts. Shafts will never rust or corrode and do not need to be painted or coated except for purely cosmetic or decorative reasons.

B Probably the greater usage of Titanium in sport is now in the production of frames for both mountain & racing bikes. In the U.S.A., SSM are the major producers of frames to proprietary designs and of course supply a basic range of tube sizes in their Radial texture Ti 325R to bicycle manufacturers worldwide.

The Bicycle Trade Fair is being held in Milano next Monday & Tuesday and the increased availability of the SSM Titanium Alloy has resulted in much interest from all over Europe, but especially here in Italy, the home of the finest designers.

We should include in discussion about TITANIUM in bicycle frames, its usage in Wheelchairs, where it will be understood that the weight is very critical.

Again HIGH STRENGTH is emphasised... the strength to weight ratio of Ti 325R is much greater than traditional Chrome Molybdenum steel or Aluminium Alloys.

Titanium frames can therefore be of lighter construction whilst still providing a better safety margin...

comparison weights are	Titanium	1450 grammes	
	Aluminium	1775	“
	Steel	2275	“

dampening characteristics lead to a smoother reel & softer ride... ergonomics at high speed!

The DURABILITY factor again means that Titanium's excellent fatigue resistance & fracture toughness increase the life of a frame. Small cuts & nicks will not cause premature failure as is found in composite frames.

CORROSION RESISTANCE - No paintings or coatings are needed to protect the frame from the elements & weather. Unlike an Aluminium frame, salt water will not lead to stress corrosion cracking and premature failure as a result.

WELDABILITY - The Ti 325R alloy is readily weldable if proper techniques are followed. No post-weld heat-treatment is needed and the welds retain their strength and durability.

C OTHER SPORTS PRODUCTS

i Include TENNIS RACQUETS

These, and other types of racquet, benefit from Titanium's properties in the same way as we have seen in Golf Shafts & Bicycle Frames but here the dampening effects are much more important, where injuries such as 'tennis elbow' caused by excessive vibrations, are commonplace.

Titanium is also an excellent spring material & releases energy when a ball is struck, giving greater power than other materials.

ii SKI POLES... again benefit from Titanium's lightweight, durability & natural springiness.

iii HOCKEY STICKS & POOL CUES - all reflect the advantages created by the Titanium properties already covered in earlier sporting examples.

iv Finally, other usages such as Arrow Shafts, Polo Shafts & Back-Pack Frames will be seen to represent other ideal applications for Titanium tube.

and now to NON SPORTS applications

D MEDICAL IMPLANTS

Titanium's compatibility with the Human Body Fluids have meant that increasing use is being made for Medical Implants. It is replacing Stainless Steel in many cases.

For example, the Titanium 3Aluminium, 2.5Vanadium Alloy is used in Femur Nails & Bone Screws and is replacing Titanium 6Aluminium 4Vanadium Alloy in these applications.

E MEDICAL EQUIPMENT

We have covered, under Sports Goods already, the use of Titanium in Wheelchairs. Other prosthetic devices which include Stretcher Frames, Moveable Beds & Dental Braces etc., are now available.

For instance, Dentists' Drill Handles made by the super-plastic forming process are made in Europe using 325 Alloy.

Increasing research & development in the medical industry is certainly expected to raise the demand for this Titanium Alloy in this particular field.

F INDUSTRIAL APPLICATIONS

Titanium 3Al 2.5V Alloy is now approved for use in Boiler & Pressure Vessel applications under its ASTM designation, B338 Grade 9 (also Section 8, Division 1 of the ASME Boiler and pressure vessel code).

Its usage in this application is due to its superior corrosion resistance to seawater and other chemical environments, as well as its important high strength-to-weight ratio.

The Sandvik Special Metals Engineering Guide for this Titanium Alloy emphasises the design allowable stress at 250 Degs C which is nearly 250% higher than Commercially Pure Titanium.

Again, they make the point that on an allowable stress-to-density basis, this Alloy of Titanium is 50% better than Inconel 625 & is almost twice as high as Hastelloy C276.

The oil-well industry has shown an interest in using 325Ti for sour-well applications.

Its CORROSION RESISTANCE makes it an attractive candidate to replace traditional stainless steels in seawater systems, desalination plants and chemical processes where the environment is particularly corrosive.

G AEROSPACE APPLICATIONS

This presentation, as explained earlier, has concentrated on Titanium, alloyed with 3% Aluminium & 2.5% Vanadium. It was designed as a seamless tube primarily for aerospace hydraulic systems operating at pressures of between 3,000 p.s.i. in Commercial applications and up to 8,000 p.s.i. in Military aircraft, projects which are currently under development. These results are obtained through usage of heavier wall thicknesses but the incorporation of radial texture in the production process has ensured the finished tube is adaptable to production bending. The Sandvik Company are at the forefront of development of Titanium and Titanium Alloy usage in Tubular Form.

I have here an example of size 3/4" x .039" Seamless Ti 6Al 4V which is still at development stage at SANDVIK. It is in the Cold Worked Stress Relieved condition and has the following tensile properties:

Ultimate Tensile	145,800 psi
0.2% Yield Strength	126,200 psi
Elongation (% in 2 inches)	19.7%

over 3Al 2.5V this represents a considerable increase.

In Aircraft Engine applications Ti 3Al 2.5V is figuring more in the more modern examples such as V 2500 & the Eurofighter EJ200.

The use of tubing with higher mechanical properties is being studied to find new engine applications. It has been demonstrated that annealed tubing & tubing with higher grades of stress relieving can be formed using standard bending techniques.

In closing, I should refer to the use of Commercially Pure Titanium for Aircraft Ducting. Although in its various grades this is nothing new, there are examples here of very thin wall tube, welded tram annealed strip where once again, the strength-to-weight ratio of Titanium makes this metal a natural the aerospace world.

I hope, ladies & gentlemen, that this brief presentation with the Sandvik Company has proved of interest and I and they would be happy to receive questions but for my part, I cannot guarantee immediate answers.

Thank you and I thank the Ginatta Company for hosting this conference.