No. 65 NOVEMBER 1991

T.W.I.T.T. NEWSLETTER

EXAMPLE OF THE PECK-POLYMERS

PECK 1300 BLIMP

THE HI-PERFORMANCE REMOTE CONTROLLED BLIMP

T.W.I.T.T.
(The Wing Is The Thing)
P. O. Box 20430
El Cajon, CA 92021

The number to the right of your name indicates the last issue of your current subscription, e.g., **9111** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, November 16, 1991 beginning at 1330 hrs at hanger A-4, Gillespie Field, El Cajon, Calif. (First hanger row on Joe Crosson Drive - East side of Gillespie.).

THE WING IS THE THING
(T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other types of tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is an affiliate of The Hunsaker Foundation which is dedicated to furthering education and research in a variety of disciplines.

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Editor (Acting), Andy Kecskes

The T.W.I.T.T. office is located at Hanger A-4, Gillespie Field, El Cajon, California.

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48oz/48	16.75	23.00	16.75
60oz/60	21.75	30.25	21.75

Meetings are held on the third Saturday of each month, at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive, east side of Gillespie).

PRESIDENT'S CORNER

Well, another year is about to come to a close. For you new members, we do not meet in December, since the holidays usually take up enough of everyone's energy and time. The up side of this, of course, is that there is more room in the January 1992 newsletter for some of the backlogged material we haven't had room to publish.

Everyone who requested tapes of Don Mitchell's and Danny Howell's talks should have them by now. Hopefully, you are all enjoying hearing the real thing. If you have any problems with the cassettes, please let me know. We got them for a bargain price, which has kept your costs down, but you never know what they will be like.

As Jim Loyd will see in the minutes, we were able to get some critiques of his design this time around. We hope he can use some of the information, although I am sure one of the suggestions will be a little more than he is willing to work on. For all the details see the minutes.

I have heard we have a couple more logo designs coming in, so we will plan on having some type of vote in January or February. We are looking at making the last page a ballot so it can be mailed back to us with the minimum fuss.

I would like to thank those of you who have included both large and small donations to the TWITT treasury as you have renewed your memberships or ordered items. Every little bit helps us defray costs for supplies and equipment needed to conduct the meetings or the organization's business. Again, thanks.

That's about it for this month's column. Keep those cards and letters coming so we can keep everyone informed on your flying wing projects.

Andy

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NOVEMBER PROGRAM

The program for November will be very light, in fact lighter than air. Bob has sought the assistance of Sandy Peck of Peck Polymers in bringing in a R/C blimp, along with a video on these types of models flying. He has also enlisted the aide of Don Woodward and Mark dePiolenc to discuss airships in conjunction with two other flight videos. One will be on the Magnus Sphere, a Canadian project that is a unique way to provide lift, and other is about Tracy Barnes' blimp he has been trying to markey commercially.

In looking through a past issue of Aerostation, a publication "Serving The Lighter-Than Air Community," and having viewed several public television shows on the subject, it appears that this form of aviation is gathering steam since it provides an econmical means of accomplishing certain tasks not compatible with fixed or rotary wing aircraft.

If you are interested in learning something new about aviation, this should be a good meeting. Come join us.

MINUTES OF THE OCTOBER 19, 1991 MEETING

Andy opened the meeting with a small group of die-hard meeting attenders. After the usual pleasantries, he outlined the day's program, which would include an update from Jerry Blumenthal, discussion of Jim Loyd's design, a presentation by Lee Klaus and Doug Fronius on the CG-4 since Carl Gwartney was unable to make the meeting.

(As I started to listen to the tapes I found that the new tape recorder we bought for TWITT produces a much better quality tape and seems to pick up audience comments a little better.)

Jerry took Bruce Carmichael's question on why did the RATTLER needed so much twist and put it to the test. He took his little stability model and removed all the twist. On launch it quickly nosed over into the ground, since it had the affect of adding lift to the rear of the wing. He ballasted it until he got more stability, then gave it a harder push. This produced a tendency to spin, and it became more sensitive longitudinally.

After removing the weights and putting the twist back in, the model returned to its previous stable flight characteristics. Jerry felt he learned that the model was operating at the optimum position for that CG.

Andy asked Jerry how his scale model was coming along. Jerry commented that one problem he ran into was not having enough room in the fuselage area to mount a standard mixing system for the controls. So he invented a flat mixer, made out of two modified control horns, that could be mounted in the wing at the push-rod exit point. He will then run the two input rods out to the mixer to convert their motion into a single push-rod to the control surface. His prototype was very neat and looked easy enough to build from scratch.

Jerry had received a phone call from Jim Ealy in Pennsylvania who is interested in building a 1/3 scale R/C model (12' span) of the RATTLER. He has since called Jim back and let him know the results of the no twist tests so the airplane will fly when finished. Jerry said he would keep us informed of his and Jim's progress, and hopefully Jim will sent us some pictures of the project as it progresses.

Andy then opened the floor for comments on Jim Loyd's design. Bob Chase took the opportunity to talk about the affects of high thrust lines on low wing aircraft. This puts the center of thrust so high in relation to the CG that it will give a nose down tendency. The results of this are a hard to rotate aircraft since the pitch moment is so short, and require a lot of up elevator during flight which will cause a drag.

Bob went on to comment about making sure you don't get a negative angle of attack on a flying wing on the ground. You may not be able to rotate it and lift off.

Harald Buettner thought the basic design was good, but because of the inherent pitch problems of the low wing Jim should move the wing on top of the fuselage and take out the dihedral. This will put the wing and thrust lines in close proximity to each other and allow for a zero angle of attack on the ground since it has a lifting airfoil, versus a symmetrical airfoil.

Rod Shappel used an extended nose gear to achieve a positive angle of attack on his prototype flying wing. When the wing reached flying speed it leveled out, taking the mains off the ground while castering along on the nose gear. In this case it ended in an accident when the nose wheel got caught in a runway seam crack and snapped the nose gear off.

Harald added that the higher wing position will also aid in the problem of wing tip ground clearance experienced by some swept back flying wing designs during landing. The high position

also means the dihedral can be removed, increasing performance. He also noted the fuselage may have to be a little deeper to accommodate the passengers, but the wing would be in less disturbed air from the fuselage junctions.

Andy introduced Doug Fronius, who was going to give us an overview of the CG-4 project he and a small group of other enthusiasts are contemplating.

The CG-4 is a large WWII troop glider, of which there are only four in existence today; one in France and England, one at Wright Patterson AFB in Ohio, and one at the Glider Pilots Museum in Texas. None of these are in flying condition.

It is a 7500 pound gross weight aircraft, capable of carrying about 13 troops and a crew of two. The co-pilot was typically a trooper who was taught to fly during the trip to the battlefield just in case the pilot got shot during the later stages of the flight.

Although the group has located a number of parts for the aircraft, there are not enough to create a viable reconstruction project. The glider is not complex, but it is rather large with an 85' wing span and 11' chord and comes in four pieces. Doug has some of the parts stored in the hanger as a means of preserving them for possible future use.

He and Jeff Byard attended the Glider Pilots Association convention in Tucson, Arizona. This event was attended by over 900 people interested in this type of activity.

Doug said the project was currently in the searching stage, looking for more parts that could be added to what they already know about. Once this occurs then a decision would be made as to whether or not to go ahead with purchasing the parts and building the plane. Right now there is no commitment to build, only to search and research.

One of the things they are looking for is a set of wings, with ailerons, that are trashed but contain all the metal fittings. They estimate it would take almost a year to build all these fittings if they can't find them in existing wings. They would also like a fuselage with all the bell cranks and brackets no matter what condition the main structure is in. With these two finds they feel they would have enough to put together a project and establish a commitment to build.

Secondary to these items are a set of wing and tail struts. They have a complete tail assembly available, along with microfilm drawings of the entire aircraft. A set of construction drawings would be more helpful than the microfilm records.

Doug says they have located at least two people with C-47 (DC-3) aircraft that have expressed an interest in providing them as tow planes. But, if this project does get "off the ground" it will be about ten years before actual flight.

An interesting side light to all of this was that Ford Motors woody station wagon section built about 7000 of the Wacos at a cost of $18,000 each. Tim Aircraft Co. built one at a cost of $100,000, at the same time their next door neighbor, Douglas Aircraft, was building DC-3s for $80,000. Doug said that after the war the gliders were being sold for $50 each still packed in the shipping crate.

Bob showed a series of slides that he and Doug took during one of their parts hunting expeditions. Doug explained where they got some of the parts and how they fit into the airframe.

Andy then introduced Lee Klaus, who has presented a program on Rotax engines for TWITT in the past. He was a crew chief on C-47s for the Air Guard stationed at Fairfield-Suisun airport in northern California (probably now Travis AFB).

There particular aircraft had tow hook arrangements and they became involved in a test program for using troop gliders to deliver cargo to Berlin during the big airlift. Although the concept might have worked for getting cargo into Berlin, the problem that stopped the program was lack of ground space for the gliders to unload and then be towed off again.

The C-47 and glider pilots all had to learn together about how the combination would work. The C-47s were rigged with winches attached to the cargo floor with a line going out through a tube. Once the glider released the line was reeled in so it wouldn't be lost or get tangled on landing. The winch had a guillotine type arrangement so the line could be cut if there were a problem with the glider releasing the cable.

Although he was not involved in testing the snatch method of glider pickup, he did observe several attempts. The cable used was made out of woven nylon which provided a great amount of stretch. This help reduce the initial takeoff shock experienced by the glider as the slack was removed from the line after pickup by the C-47.

One interesting thing done to the C-47s was to add four JATO bottles to use in the case

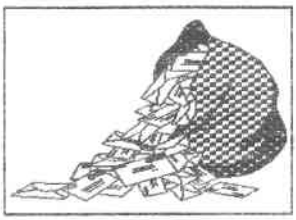
of an emergency. Lee said he knew of at least one occasion when the glider had gotten too high on takeoff and prevented the C-47 from lifting off. The pilot fired the JATO, which brought the nose up and allowed them both to complete the takeoff.

Lee then asked if anyone had ever heard about some gliders that had been built for stealth landings in remote areas of Southeast Asia. They were made of wood and linen and coated with chemicals that would make it burn very easily. They carried a two man crew and were towed by a Helio Stallion until the glider released for its final glide. He and a friend had been discussing them and wondered if any had ever made it back to the US after the war.

Bob Chase took the floor for a few minutes and related a story about using troop gliders for air rescue in Greenland. Ed Lockhart then told us about his trip to an antique modelers get together at Jean, Nevada.

After these exciting stories, the meeting was concluded with Bob showing a video on test pilots, which included some flying wings.

LETTERS TO THE EDITOR



10/15/91

TWITT

I am moved to comment on several items in the 10/91 newsletter.

First, I really like the LOOKS of Jerry Blumenthal's RATTLER, but I think we need to keep our fingers crossed for him until he gets a large-scale test model in the air--then we can get excited! Potential detractions from this concept (as a sailplane) include substantially less than optimum lift distribution due to the lifting body effect of the fuselage strakes; also, I hope there won't be a pitch control problem related to long MAC, but short-chord control surfaces on the thin wing; also, I agree that there may be a yaw problem related to adequate aft vertical area; it seems that one of the things most commonly corrected in aircraft design development is to add additional vertical tail. Additionally, the question of vortex shed over the inner portion of the thinner wing, by the fuselage strake, may detract from optimum--could this be controlled by flow fences?

I wish Jerry well - if the design works he will belong to a very exclusive club of successful designers.

I would like to comment on the use of laminar-flow airfoils on flying wings. First, the NACA airfoil "stolen" from the P-51 and used on the Horten IV-B was never intended for that purpose - it has no reflex, and its laminar flow separation characteristics with increasing AOA are very sharp - just the opposite of what we want for a flying wing. I have recently acquired the Eppler Airfoil Book, and the Eppler Airfoil Program; the book has some VERY interesting information pertinent to this subject - he shows how the NACA 60-series airfoils have sharp separation, and how their stall character is poor as a result; then, he shows how simple it is to change the pressure recovery to control laminar separation, and to tame the stall. Additionally, he has a catalog of airfoils in the back of the book, including those specifically designed for flying wings; I believe this information should be made available to TWITT's because it represents an advance we could apply to our "dream" projects, as well as to existing designs such as Horten-style or Marske-style planforms.

A Marske Pioneer with the proper airfoil (and a proper wing surface to promote and maintain laminar flow) would be a way to extend the performance of a well-proven design.

Also, I never have seen a Horten design that didn't have washout (or it aerodynamic equivalent) - this is contrary to a statement in the last newsletter issue.

I believe that we have to have software that addresses the nature of 3 dimensional flow as applied to aircraft; only then can we analyze the effects planform changes such as taper, wing sweep, lifting strakes, wing fences, etc. We are only guessing at what is right until we get such help.

Hope the above provides some food for thought.

Bill Hinote

(Ed. Note: Jerry has already seen your letter and taken your comments under advisement. As of publication we are not sure if he has undertaken any significant changes to the design as a result of these and other comments by TWITT members. He has received an call from Jim Ealy in Pennsylvania, who plans on building a 1/4 scale version, which will yield a 12' wing span. I am sure you comments will be of value to him also, and the Jerry will be in touch with him as the project continues.)

10/19/91

TWITT

I am looking for plans, etc., for RUBBER POWERED, flying wings. Can any of your members come up with some copies, or perhaps point me towards some publications? I will be happy to pay for the copying if you have something in magazines, etc., that I can use. I usually use folding propellers for my models, whether pusher or tractor, and sometimes I use gearboxes too. I would really appreciate any help, suggestions, ideas, or comments.

Please find enclosed a check to renew my membership in TWITT. Also, I wanted to express my thanks for your suggestions and thoughtfulness over the phone.

Best Wishes,
Dave Laney
P.O. Box 604
Happy Camp CA 96039
(916) 493-2760

(Ed. Note: Dave, you may be interested in subscribing to the Tailless News, published by John Pool, 8 Sycamore Road, Barlby, SELBY, North Yorkshire Y08 7XB ENGLAND. This newsletter often contains rubber powered aircraft of all types, including flying wings. John may also be able to put you in touch with others he knows that contribute material on these models.

Hopefully we have enough modelers out there that someone has information that would help Dave. Apparently he lives in a heavily wooded area that prohibits R/C type models so he has elected to go with rubber power and the smaller sized models. Please help if you can.)

We also received the following comments from Dave just before publishing date.

One day I'll build another airplane, hopefully a 2 place wing, but a lot of ideas and brainstorms are flitting around out there, and I feel that some solid, basic, building options (designs) should be presented. I don't want to wait for the "perfect flying wing design," but am willing to accept a SAFE design, with reasonable compromises. There are some from the past, and I'm sure there are some out there now....but GOOD, PROVEN designs that have plans, and ready for builders is what I would like to see. We have plenty of talent, and can have some teams look over a few designs and recommend some that will fly well if the plans are followed. The various discussions, and arguments, over ones pet theory is great. But to get wings into the sky, we need to use our resources a little more, and help make our wings a flying matter, rather than perhaps talking a little too much. Flying has been good to most of us, and I believe that we should make the effort to have flying wings viable building option for the 40-180hp builder. Let me make it clear, that I am NOT advocating a complete work up or even an official endorsement, but soundly engineered wings, using the knowledge, and ideas we know that works can be recognized as a good candidate to build. If a wing has some areas that aren't the best for the builders our there, it is not listed. We need not explain, but list plans which utilize things we know that work. It is import to look back and see what has been done, but tomorrow is important too, and I feel we can help "shape" the planes. Few groups as small as TWITT, has so much talent at its fingertips.

I am sure that I have opened myself up to every nay sayer in the group.....save your ink, guys! Those of us that have discussed this in the past, had a pretty good list ourselves, and probably have turned up most of the "pedantic" skids and yaws. I would rather hear from those that are going to have plans for a machine, or know of a possibility. Obviously our lawsuit situation will have to change or most of the aviation scene that I am talking about will die. I am hopeful that we can go on, and be ready for the times when common sense again, prevails.

(Ed. Note: Although we have had a number of designs come through over the past several years, there haven't been many in which we have heard of final building plans. If you have plans for a flying wing and would be willing to share them with other TWITTers, please let us know. For Dave, if you have a "pretty good list" perhaps you could share it with TWITT since there may be some members who could benefit from knowing what has been available in the past.)

10/21/91

TWITT

Please start my subscription to TWITT. I have heard people threaten to fly a wing in F3B competition. Has this ever been seriously tried?

Thanks,
George Burr
1614 McCarthy Blvd.
Wausau, WI 54401

(Ed. Note: Welcome to TWITT George, and the answer to your question is YES. Bill and Bunny Kuhlman (B^2) have been working on Project Penumbra which is a swept flying wing designed specifically for F3B. The January and February 1991 TWITT Newsletters contain articles and drawings of this effort (available for $.75 each), and B^2 are regular columnists for R/C Soaring Digest (see advertisements). If you are interested, you might contact them directly at P.O. Box 975, Olalla, WA 98359-0975. We may have other modelers out there who may also be trying it but have not come forward yet, so maybe this will spur them into action.)

10/16/91

TWITT

Enclosed is $8. Please send me the tapes of Danny Howell from the August meeting and Don Mitchell from the September meeting.

This seems like a great way for those that cannot attend to hear people of the caliber of Howell and Mitchell. Thanks for providing this kind of service.

Sincerely,
Joseph Gasidlo

(Ed. Note: Joe should have both his tapes by now, as do the others who ordered them. We are happy to provide the service, as long as we don't get overwhelmed with requests at any one time. So far there have only been a couple of meetings that draw the kind of attention Don Mitchell and Danny Howell drew. This is what TWITT has dedicated itself too as an organization, so it is gratifying to know we are accomplishing our goals.)

10/24/91

TWITT

Enclosed please find my check in the amount of $17 for your information package and one year membership.

(A little background - soled 1944 in 50 hp Cub; retired Army aviator; member of EAA; not an engineer; and interested in an ultralight (Part 103) powered sailplane.)

Sincerely,
Roger A. Waterbury
917 McKimmon Road
Fayetteville, NC 28303

(Ed. Note: Welcome to TWITT, Roger. I am sure there are others out there interested in ultra-lights so I included your address in case they have something to offer you. TWITT is not just a bunch of engineers, but a composite group made up of people from all walks of life and with very diverse interests in aviation. We hope you will feel at home, and enjoy the information offered throughout your membership.)

10/25/91

(This is not really a letter but asks for some input from other members.)

Karl Sanders, a frequent contributor of material to TWITT, wants to know if anyone has any experience with an IBM based program called "Secret Weapons of the Luftwaffe" produced by LucasArts Entertainment. He says, "I'm a "MAC-ADICT," so I cannot try this out."

If you have the program and wish to comment on its merits or lack of such, please drop us a line so we can pass it on to Karl.

(Ed. Note: To give Karl a little edge on what someone thinks of the program, my 19 year old son told me he was going to ask for it for Christmas this year. He is a Chuck Yeager "Air Combat" nut and enjoys flying the different types of aircraft provided by the program, so thinks this will be just as good. At least that's what his friends tell him.)

10/7/91

Dear Bob:

Thank you for the information you sent me on Dr. Dave Marsden.

Enclosed is an article I wrote on an automatic hot wire cutter and two articles I wrote about "Spectra." If you can use any of it you are welcome to it.

The Usual,
Gene Sandburg

(Ed. Note: Thank you for the articles, the first one on "Spectra" which is included in this newsletter. The remaining Spectra material and hot wire cutter will find its way in as filler in a later newsletter. An article on building materials seems appropriate at this time considering we have several members embarking on construction project of various sizes. Thanks for the input.)

AVAILABLE PLANS/REFERENCE MATERIAL

Tailless Aircraft Bibliography
by Serge Krauss
Cost: $20
Order from: Serge Krauss
3114 Edgehill Road
Cleveland Hts., OH 44118

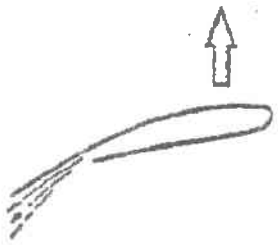
Horten H1c construction drawings with full size airfoil layout. 30 sheets 24" x 36" with specification manual. Price: $115.

Horten Newsletter
Cost: $5 per year for US/$7.50 foreign
Order from:
Flight Engineering and Developments
2453 Liberty Church Road
Temple, GA 30179
(404) 562-3512

FLYING WING SAILPLANE PLANS AND KITS: Two time-proven, 13m homebuilt designs suitable for the novice pilot. Build either the MONARCH "F" ULTRALIGHT (19 to 1), or the PIONEER II-D (35 to 1) sailplane.

Info packs $8 each, or $15 for both.

Marske Aircraft Corp.
130 Crestwood Drive
Michigan City, IN 46360



THE HIAM AIRPLANE
NEEDS YOUR HELP

For those of you who would be interested in assisting Budd Love with some aspect of his High Internal Air Mass (HIAM) project, he would be glad to hear from you. This concept has great potential for the future of air transportation.

Contact: AIRLOVE, LTD.
6423 Campina Place
La Jolla CA 92037
(619) 459-1489

MODEL WINGS

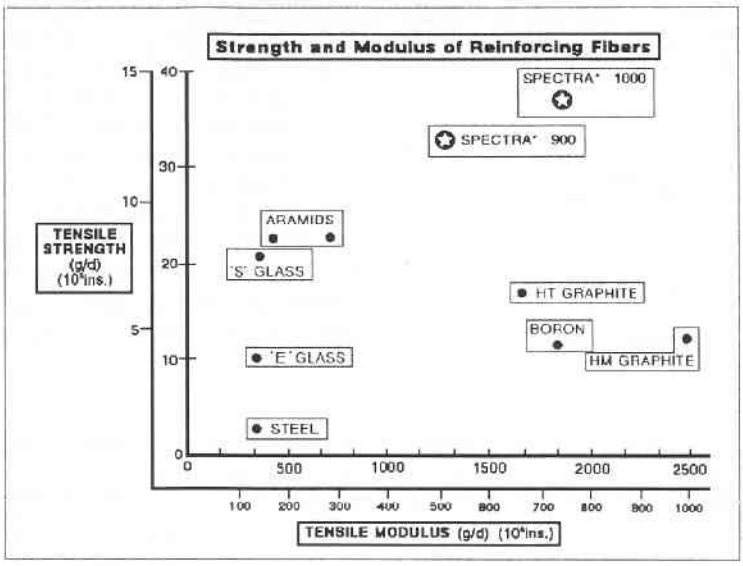
The cover of the July 1991 issue of RCModeler features a flying wing called the "Stealthbat" offered by Wing Manufacturer. There was no price listed, but they can be contacted at:

306 E. Simmons
Galesburg IL 61401
(309) 342-3009
Catalog: $4.00

Omni Models carries the Future Flight Klingberg Wing kit for $39.99 (item #FTF4000). They can be contacted at:

P.O. Box 1601
Bloomington IL 61702
1-800-747-6664 or (309) 663-5798
Shipping: $5.00

The object of this article is to inform our readers of the physical properties of Spectra. Spectra is a realitively new material on the scene and one that has definite possibilities in the construction of homebuilts. It is currently finding extensive use in model airplane construction. This is, as you may know, where much of our composite construction started.



STRENGTH: Spectra is, quite simply, the strongest, lightest weight fiber ever made. Pound for pound, Spectra is ten times stronger than steel, twice as strong as carbon fiber, 35% stronger than aramid and S-glass. . Spectra has the highest specific strength, the highest specific modulus, and requires the highest energy to break.

Spun from a solution of Ultra High Molecular Weight Polyethylene (UHMWPE), Spectra fibers combine a very high degree of molecular orientation with a very low density. The result is a fiber with a unique and quite extrordinary performance profile.

WEIGHT: Yet with all of its strength, Spectra is so light that it floats. The specific gravity of Spectra is only 0.97, making it the only reinforcement fiber lighter than water (sp. gr. 1.00). Compare this with fiberglass at 2.54, aramid at 1.45, and polyester at 1.38. A nice choice when strength to weight ratio is critical.

IMPACT and ABRASION RESISTANCE: Spectra offers unmatched impact and abrasion resistance. The impact energy absorption of Spectra is in the range of 20 times that of glass, aramid and graphite.

VIBRATION DAMPING: The vibration damping characteristics are unequaled among other reinforcing fibers and provide a superior ability to absorb and disperse shock energy.

WATER ABSORBTION: Many high performance fibers degrade in water. Spectra fibers exibit less than 1% absorption compared to 5% for aramids, which allows for composite construction without the standard fiber drying stage. Likewise, Spectra composites absorb less than 0.1% water upon submergence tests at 10,000 psi for 7 days. Even more extraordinary, the properties remain unchanged after such prolonged exposures. It is an excellent material for hulls, floats, and skis.

CHEMICALLY INERT: Spectra remains unaffected by almost all solvents, even extremely strong acids and bases, for at least two years. It is expected that the fiber remains stable indefinitely in common solvents such as water, gasoline, hydraulic oil, cleaning solvents, etc.
OTHER ATTRIBUTES: 1) Has extremely low elongation. 2) Low flex fatigue. 3) Low Dielectric Constant (2.3) and loss tangent (0.0004). Composite systems made with Spectra have the highest radar transmission and lowest signal distortion. Won't interfere with a radio antenna.

DETRIMENTS: Spectra is great, but not for every use. The very molecular properties that imbue Spectra with strength, light weight, and toughness have other properties that might not fit into your application. Consider the following characteristics before deciding if it will work for you.

Melting Point - 300 F (147 C) This is sufficient for the majority of uses.

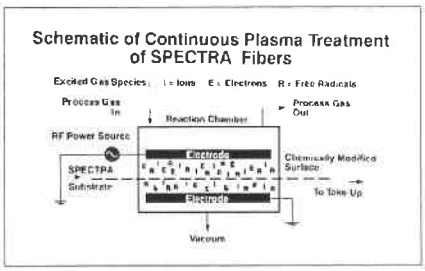
Creep - (or elongation under load over a period of time) 3.6% can be a detriment. Spectra 1000 PT is 2.7 % which is considerably better.

Compression Strength - 10,000 psi Spectra should not be used for an upper spar cap.

GAS PLASMA TREATMENT: To improve the bonding of Spectra to comonly used resin matrices, gas plasma treatment is used to modify the fiber or fabric surfaces. A Spectra substrate is placed in a reduced pressure chamber. Process gases are injected and then excited by the application of radio frequency energy. Excited gas species such as electrons, ions, and free radicals generated inside of the chamber interact with the fiber surface. The result is a chemically and physically modified fiber (or fabric) surface which is now more compatable with resin matrices. The plasma treatment alters the tensile properties of Spectra fibers. They increase 50,000 psi. There is no change in the melting point or crystalline content of the fibers.

* SPECTRA is the registered Trade Mark of Allied-Signal Inc., P.O. Box 31, Petersburg, VA 23804. Telephone (804) 520-3321. All information above is taken from their publications.

Plasma treated Spectra products have the code PT attached to them. (Example: Spectra 900 PT, Style 951 PT).



HYBRIDS: Hybridization of Spectra fibers with others such as glass, aramid, carbon, quartz, etc. can be easily accomplished in order to combine attributes of the respective fibers. Generally speaking, the moduli (tensile, flexural, shear) of the hybrid composites closely follow the rule of mixture (the modulus of a hybrid composite is the volume average of the moduli of the individual fibers). Strengths are more complex to predict but the stiffer fibers (e.g. carbon) contribute to the composites' stiffness, while Spectra contribtes to its ductility and impact resistance. Fibers can be mixed or co-wove together in intralaminar or layered hybrids. If slightly higher service temperatures are required, carbon or glass plies should be placed on the side facing the heat source. If abrasion resistance is important, Spectra plies should be placed facing the out-

RESIN SELECTION:
A varity of commercial room temperature cure resins are available. Under most circumstances these resins can be used with Spectra without any modifications. A vinylester resin system gives superior impact properties. An epoxy system translates better structural properties, while a polyester resin system provides a more economical alternative.

Note: For hand layup, a lower resin viscosity (300-700 centipose) is recommended for Spectra fabrics. Unlike aramids, Spectra has wet out characteristics similar to glass and becomes translucent when wet.

PREPREG:
A number of companies have formulated resins for Spectra prepregs. Any typical thermosetting resins (polyurethanes, epoxies, vinylesters, and polyesters) can be used with Spectra fibers or fabrics, as long as that resin can be cured below 250 F. The prefered curing temperature is around 200-220 F. Thermoplastics can also be used as long as they have melting points below that of Spectra fibers (147 C).

PROCESSING TECHNIQUES:
Spectra fibers and fabrics are used in wet layup, prepreg layup, filament winding, pultrusion, and resin transfer molding processes to produce composite parts. For layup techniques, both vacuum bagging and matched metal die molding have been used to form Spectra composite items. It is recommended that the curing, post curing, and/or molding temperatures for Spectra composites be kept below 250 F.

CUTTING:
Because of their extremely high strength, Spectra fibers and fabrics are difficult to cut by conventional methods. Dry fabrics can be cut with carbide blade shears, power shears or rotary shears. In addition, Spectra's low melt temperature allows the use of hot knife and hot wire cutting techniques. For prepregs and laminates, water jet cutting, laser cutting or ultrasonic cutting can be used. Conventional cutting techniques such as band saw and circular saw offer economical ways to cut fully cured laminates.

POLISHING AND FINISHING:
Spectra is highly abrasion resistant. That makes the job of finishing Spectra composite parts relitively difficult. A 400 grit material is recommended for wet sanding and polishing. If a highly polished surface is desirable, a thin layer of resin impregnated glass veil can be used on the outside of a Sprectra composite for finishing purposes. If drilling is required in the final assembly stage, Deep-Fiber-Cut Drills (a trade-marked product of International Carbide Corp.) are recommended for drilling fuzz-free holes.

FIBERS:
Spectra fibers come in basic product types, Spectra 900 and Spectra 1000 (both are available in untreated and plasma treated (PT) forms).

SPECTRA 900 has a tensile strength in the range of 375 KPSI and is used for a variety of applications. Deniers are available as follows:

Denier/Fil
4800/480
1200/120
650/60
325/30

Spectra 900 PT is available in 4800 denier/480 filaments.

SPECTRA 1000 is used for more demanding applications and/or more continous loading:

Denier/Fil
2600/480
650/120
375/60

Spectra 1000 PT is available in 2600 denier/480 filaments.

Note: Denier, by definition, is a unit of yarn equal to the weight in grams of 9,000 meters of the yarn. A filament is a single strand.

CHOPPED FIBER:
For non-woven fabrics and other short fiber applications.
These are available in lengths from 1/4" to 2 1/2".

SPECTRA can be purchased ,by the yard from:

JOHN R. SWEET (703) 468-2222
US 220 South, Box 10
Mustoe, VA 24468

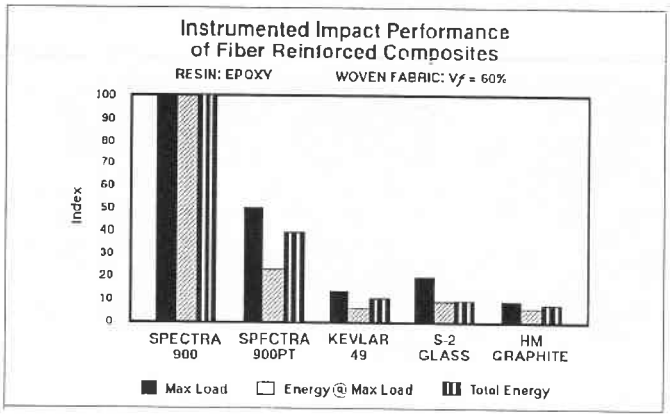
THE NUMBERS IN THIS ARTICAL ARE TO BE USED FOR COMPARISON ONLY. REMEMBER, YOU ARE THE DESIGNER, ENGINEER, AND MANUFACTURER OF THE COMPOSITE BUILDING MATERIAL THAT YOU MAKE. THEREFORE YOU ARE SOLELY RESPONSIBLE FOR IT'S RESULTING PHYSICAL PROPERTIES !

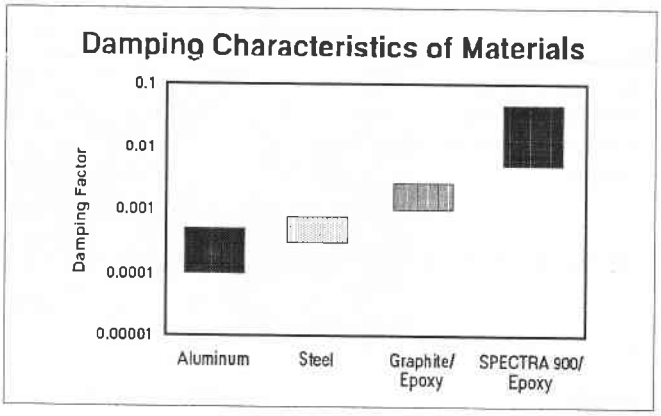
Gene Sandburg, Modesto, CA 9/91

Interlaminar Shear Strength and Flexural Properties of some Spectra Fabric Composites

Resin: Bisphnol-A Based Epoxy
Reinforcement: Spectra Fabrics at $V_f = 65\%$

		SPECTRA 900						SPECTRA 1000			
		Style 902 17x17 Plain Weave		Style 903 21x21 Plain Weave		Style 922 8 Harness Satin		Stryle 951 17x17 Plain Weave		Style 973 8x8 Basket Weave	
		PT	Untreated	PT	Untreated	PT	Untreated	PT	Untreated	PT	Untreated
ILSS	(Kpsi)	2.3	0.6	2.1	0.8	1.9	0.6	2.2	0.8	1.9	0.7
Flex Strength	(Kpsi)	23.4	6.0	21.0	5.8	23.0	7.1	20.9	9.5	18.9	8.9
Flex Modulus	(Mpsi)	2.2	0.6	2.9	0.4	3.1	0.5	2.0	1.7	1.8	1.2





Spectra fabric comes in a variety of weaves and deniers as indicated in this chart. Currently most fabric is utilized for composite applications or for soft-ballistic armor.

Style No.	Weave	Denier	Construction (w x f)	Weight (oz/yd2)	Thickness (inch)	Suggested Composites Applications
			Spectra 900			
901	Plain	1200	10 x10	3.0	0.012	Sailboards, surfboards.
902	Plain	1200	17 x 17	5.5	0.018	Canoes, kayaks, bicycles, impact helmets.
903	Plain	1200	21 x 21	7.0	0.020	Ballistic helmets.
904	Plain	660	34 x 34	6.0	0.017	
912	4x4 Basket	1200	34 x 34	11.3	0.028	
913	8x8 Basket	1200	48 x 48	15.5	0.038	
921	4H Satin	1200	18 x 18	6.2	0.019	Canoes, kayaks, surfboards.
922	8H Satin	1200	21 x 23	7.3	0.018	Bicycle products, power boats.
			Spectra 1000			
951	Plain	650	17 x 17	2.8	0.011	Bicycle products, aerospace products, radomes, subsea vehicles.
952	Plain	650	34 x 34	6.0	0.017	Ballistic helmets, panels, radomes.
953	Plain	375	50 x 51	5.1	0.013	
955	Plain	215	56 x 56	3.1	0.008	
973	8x8 Basket	1300	48 x 48	16.4	0.042	Ballistic panels, spall-liners, subsea vehicles.
985	8H Satin	650	32 x 32	5.5	0.014	Subsea vehicles, radomes.
986	8H Satin	650	43 x 42	7.5	0.019	
988	4H Satin	650	32 x 32	5.5	0.015	Radomes.

Gene Sandburg, Modesto, CA 9/91

Tensile Properties of Plasma Treated (PT) Spectra Fibers

Test Method: ASTM D-885

Properties:	SPECTRA 900		SPECTRA 1000	
	Spectra 900	Spectra 900 PT	Spectra 1000	Spectra 1000 PT
Denier / Filament	4800/480	4800/480	2600/480	2600/480
Tensile Strength (Kpsi)	250	300	310	360
Tensile Modulus (Kpsi)	12	13	16	19
Elongation (%)	3.0	3.0	2.7	2.7

Tensile Properties of Unidirectional Composites

Resin: Bisphenol-A based Epoxy
Test Method: ASTM D-3039

Properties:	REINFORCING FIBERS			
	Spectra 900	Spectra 900 PT	Spectra 1000	Spectra 1000 PT
Thickness (in)	0.020	0.019	0.016	0.026
Fiber Loading (Vol%)	58	50	53	54
Tensile Strength (Kpsi)	80 +/- 13	98 +/- 15	150 +/- 33	129 +/- 8
Tensile Modulus (Mpsi)	4.0 +/- 0.1	3.5 +/- 0.1	7.3	7.2 +/- 0.5
Elongation (%)	*	3.6 +/- 0.2	*	2.1 +/- 0.4

NOTE: Tensile specimens reinforced with untreated Spectra fibers do not fracture. Failure modes are predominantly fiber slippage and resin cracking.

Interlaminar Shear Strength and Flexural Properties of Unidirectional Composites

Resin: Bisphenol-A based Epoxy

Properties:	REINFORCING FIBERS			
	Spectra 900	Spectra 900 PT	Spectra 1000	Spectra 1000 PT
Fiber Loading (Vol%)	58	54	54	53
Flex Strength (Kpsi)	21 +/- 1	29 +/- 1	23 +/- 1	31 +/- 1
Flex Modulus (Mpsi)	3.2 +/- 0.2	4.3 +/- 0.2	3.3 +/- 0.2	5.5 +/- 0.5
Interlaminar Shear Strength (Kpsi)	1.2 +/- 0.1	4.1 +/- 0.1	1.3 +/- 0.1	3.1 +/- 0.4

NOTE: Flexural properties were measured by the 3 point bend tests according to ASTM D790.
Interlaminar shear strengths were measured by the short beam shear method of ASTM D2344.

Axial Compressive Properties of Unidirectional Composites

Resin: Bisphenol-A based Epoxy

Properties:	REINFORCING FIBERS			
	Spectra 900	Spectra 900 PT	Spectra 1000	Spectra 1000 PT
Fiber Loading (Vol%)	70	70	55	65
Axial Compressive Strength (Kpsi)	7.5 +/- 0.3	8.6 +/- 0.2	10.5 +/- 0.4	10.0 +/- 0.2
Axial Compressive Modulus (Mpsi)	4.7 +/- 0.7	5.8 +/- 0.7	2.7 +/- 0.9	7.8 +/- 0.4
Ultimate Strain (%)	*	*	3.8 +/- 0.5	3.8 +/- 0.2

NOTE: Compressive properties were obtained according to the "Wyoming End Loaded Side Supported" test.

Coefficient of Thermal Expansion of Unidirectional Composites

Fiber: Plasma treated Spectra V_f = 60%
Resin: Epon 826
Temperature Range: -40 C to 80 C #

Properties:	Spectra 900 PT	Spectra 1000 PT
Axial (10^{-6} / C)	-9	-10
Traverse (10^{-6} / C)	100	105