Tech-Tip 017

Dedicated to the dissemination of detailed model building methods and techniques.

Materials and methods presented here are not intended as the best or only solutions to the modeling challenge(s) discussed, rather as methods and procedures which have a proven record of success in actual use. Please keep experimenting with new materials and techniques as this is the only way to expand the fields of knowledge. Written by: John E. McCoy Sr. NAR-15731

Working With Plastics

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We pick up a piece of plastic at the big box or home improvement store and take the material home to test and run experiments. The stuff has a blue translucent protective coating on it that make us think it's something we've seen before. In the shop we try to cold form (cold bend) a corner and SNAP! Hummm! This is not the material we thought we had.☹ How often has this scenario happened to many of us? Or we pick up a plastic object at the dollar store we think would make a pretty neat Odd-Roc, but once home we find NOTHING will stick to it! What to do? What to Do?

Hopefully this Tech-Tip will at least help sooth some of the frustration caused by these all too often unknown "Plastic Pieces". Determining which "type" plastic we are dealing with is sometimes more the half the battle. Unfortunately it is all but impossible to determine which plastic is what just by look or feel. Proper identification sometimes takes all the senses along with some experimenting just to give an educated guess. I wish it were possible to give absolute visual or other identifying rules for every plastic, but alas they do not exist. If there is a certain look or feel to a given material, they will be listed along with as many traits of the given types as space permits.

While just about all plastics are in some way synthetically produced from organic based compounds, they can vary so widely that no one adhesive or joining method works with every type or grade. In the Sign Business we use a huge variety of plastics from most of the various plastic suppliers & manufacturers. Over time we have found or invented adhesives and/or attachment methods that work for a good number of these various material types encountered. This Article will attempt to address only a small sliver of the many materials we in the hobby can run into that fall under the broad general heading of "PLASTICS". We well address the most commonly found material and hopefully help in the selection of good materials and methods for our flying model rockets. As we talk about the various plastic types we will try to suggest adhesives or attachment methods with a proven record of success keeping the jointed parts together.

While we're talking about Glues and Adhesives: Many of the industrial strength chemicals, bonding agents and adhesives we'll be discussing come with warning labels. Most should be carefully stored out of the reach of small children and some have even harsher use warnings. Please read the labels and be diligent in following use and storage recommendations. I personally have, store and use every product listed in this article and have since entering the sign business as a very young man more the 40 years ago. My family has always had these materials around the house and to date we haven't created any third generation 3 eyed monsters.☺ Common sense use of some of these somewhat hazardous materials is all that's needed to ensure your safe and successful plastic fabrication work.

To start let's list a few of the major "types" of plastics we commonly run into everyday:
Acrylic and *Modified Acrylic*, *ABS* (Acrylonitrile-Butadiene-Styrene), *Cellulose Acetate*, *Delrin* (Acetal), *Kydex* (PVC/Acrylic), *Lexan, & Tuffak* (Polycarbonate), *Mylar* (Ethylene glycol & Terepthalic Acid), *Nylon, P.E.T.G*.(Polyethylene terepthalate), *Polyethylene*, *Polypropylene*, *PVC* (Polyvinyl Chloride), *Styrene* (Polystyrene), Teflon, *Uvex* (Cellulose Acetate Butyrate). These are but a few of the many materials that qualify under the term "Plastics".

While we look at the most common sheet materials, we will consider what effect each product type will have on making clear fins for Scale, PMC and Odd-Rocs. We will discuss other sheet material that while not recommended for fins can be used for other purposes such as ground support and detailing. Quite a few of these materials can be found in clear or transparent but only a few are really suitable for the stress of flight when used as fins.

Acrylic Plastics: Standard Plexiglas, Acrylite, Polycast:

These are the most commonly available form of Sheet Plastic. It can be had in crystal clear or in an assortment of colors, textures, surface patterns, and tints. Acrylic plastic is about 43% the weight of glass and has about 6+ times the break strength of Glass but that really is not saying much when faced with landing impact stresses. Thickness varies considerably, ranging from 1.6mm (1/16") to 50mm (2.0"). Special order Cast Acrylic can be as thick as 6" in sheet, rod or bar up to 100" x 150". Because Acrylic plastic is rigid and somewhat brittle we have little use for it for anything other then support stands, display cases and some limited ground support equipment. Acrylic plastics should not be use in flying model rocket construction.

Acrylics can be Thermoformed with a molding temperature of about 325-350°f. However thermoformed parts are even more subject to shatter under moderate loads from the same brittleness limiting Acrylics use to non-flying applications.

Acrylics can be worked with standard wood cutting tools, 18Tooth band, table, saber and scroll saw blades, and hollow point or dulled HS drill bits. When working Acrylic plastics in any drilling operation keep in mind the material is very brittle and cracks without much misaligned force. Generally a drill press or very steady hand, at slow speeds are required to prevent snapping or splitting.

That said standard Acrylic plastic can be drilled and tapped for mechanical fasteners but very careful torque pressures must be observed to prevent thread stripping or damage due to over tightening. Thicker clears acrylics over 3/8“can be useful in ground support equipment, in blocks, spacers and other hard points. Assembly with Nylon screws and fasteners are an excellent non-solvent welding choice for attachment.

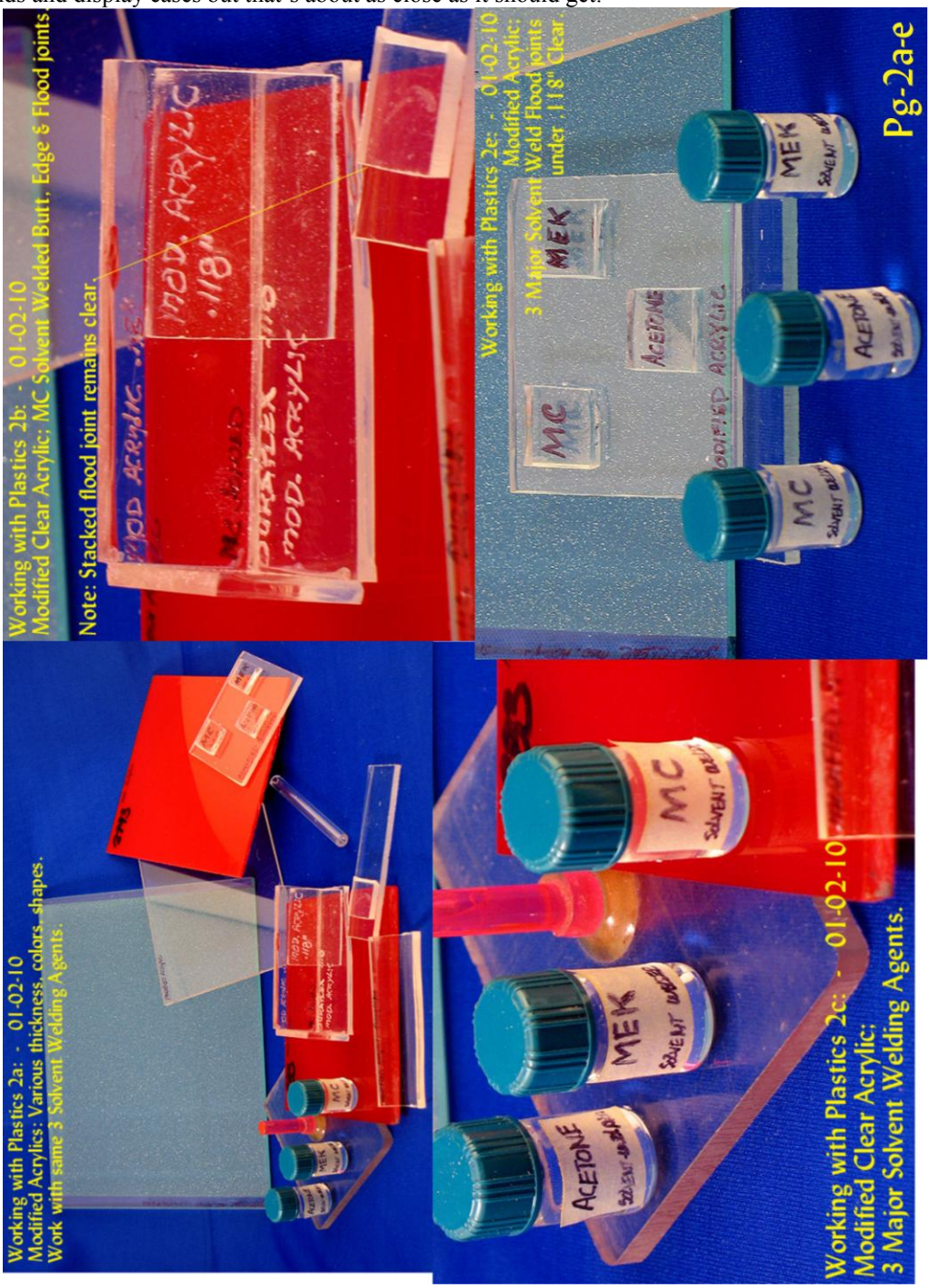
All Acrylic plastics solvent weld very well with any of the many welding agents on the market. Methylene Chloride (MC) is the most aggressive, Testors Liquid cement at the weakest end of the available agents. Other forms of solvent welders available to the model builder can be found at your local hobby shops and craft supply vendors. Many of these agents are good for the purpose intended but because they are targeted at the modeling community they can be very expensive to use. Termac-7R, Plastruct; Plastic weld & Bondene, Ambroid: Pro-weld. Other solvent welding agents can be had at the Home Improvement Centers. Lowe’s & Home Depot offer Acetone and MEK which make fair solvent welding agents. MC, MEK and Acetone should all be used following the suggested safety measures.

Modified Acrylic Plastics: Duraplex, Acrysteel:

Modified or so called High Impact Acrylics are still basically acrylic with an added polymer making modified acrylics more flexible, there by increasing the impact break strength by another 20%. This makes these modified acrylics up to 17 times stronger then glass. While better these straight acrylic plastics it still does not make a very good choice for clear fins. All the same tools and methods work with modified acrylics and bonding can be accomplished with the same solvent welding chemicals used on straight acrylics.

These are also the blue liner clad plastic sheeting sold at many of the big box and home improvement chains for window replacements. Occasionally at some of these places the workers have misrepresented the material as Lexan, which it is not. Be very careful when talking with the employees of these Home Improvement shops, as some really do not know the difference. If you are in doubt as to a specific material, ask if the material is cold formable, or if it can be bent 90° without breaking. If they don't know or say it can't it very likely is not Lexan or any other brand of Polycarbonate.

All that said to say Modified Acrylic like Standard Acrylic Plastics shouldn't be used for Model Rocket Construction or fins. It can also be use for stands and display cases but that's about as close as it should get.



***Kydex and Uvex*:**

These are two different forms of Thermoforming Plastics that can also come in clear. With or without forming both are a good bit more flexible then Acrylics but are not very impact or shock resistant. Because of this neither would make good fin material, nor do these generally make very good stands unless thermoformed into a one piece cover. Both materials can be worked with standard carbide router and saw blades but are subject to shattering if drilled with HS steel bits. Uvex has been replaced with better forming materials in the last 10 years. Both are solvent weldable with MC, MEK, or most of the lesser strength solvent welders.

P.E.T.G. (Polyethylene terepthalate):

This is some very interesting stuff! If you've ever struggled to open a blister pack of motors or just about anything these days it's very likely PETG that you're dealing with. The material is extremely well suited for thermoforming and is very tear resistant. PETG is available in sheet thickness down to .010"or as thick as 3/16". While this material is super flexible it is sort of soft. PETG is a wonderful material for making hinges and other repetitive bending parts. While not the best solvent welding material it can be jointed with a hotter solvent then MC, usually MEK or Acetone can be used as well as PS-30, Weld-on 16 and Weld-on 40 adhesives. Several of these adhesive materials MC, PS-30, Weld-on 16 & Weld-on 40 are Sign Supply products that can be purchased over the counter at just about any Sign Supply or Industrial supplier. Acetone and MEK can be found at most Hardware, Paint and Home improvement stores. P.E.T.G. Plastic sheet can be found as thin as .010", .020" and .030" thick. These thinner thicknesses can be purchased from a few on-line vendors, in various sheet sizes 8.5" x 11", 11" x 17" and 28 x 44". These super thin sheets are mainly for custom vacuum forming aircraft canopies and other clear model parts. Normal sheet size is 48" x 96" for thickness .040", .060", .080" .125 & .187". www.warmplastic.com can supply most of these sheets, styrene and a very nifty little vacuum-forming table for use with your shop-vac & heat source.

Styrene(Polystyrene) & ABS(Acrylonitrile-Butadiene-Styrene):

Styrene and its modified cousin's (Cross-linked, General purpose, High Impact, Rexolite & ABS) are some of the most familiar "Plastics" to most modelers since childhood as G.P. Polystyrene is the preferred material used by most commercially available Plastic Model Kit manufacturers worldwide. Polystyrene is one of those multipurpose, all around plastics that has excellent properties for wear resistance, thermoforming, vacuum forming, blow and injection molding as well as hot extruding and pressing. The material is available in a huge variety of shapes and forms, bars, rods, rounds slabs, and sheets. Polystyrene can be just about any color but is most commonly seen white, or sometimes obtained in gray, black, and natural beige. General purpose Polystyrene Sheet is available in 1/32" to 2.0" while high impact polystyrene can be had in sheets as thin as .010" to ¼". Styrene sheets range from small 20"x 40" size to standard 48" x 96" panels. Both are generally smooth or matte finished both sides.

Most forms of Polystyrene have a fairly low molding temperature of 212° f. That's correct, the boiling point of water. That's one of the plus points of this material, we can reshape model parts by placing them in boiling water for less then a minute then reshaping as desired and allowing the part to re-harden to room temperature.

ABS: We'll just stay with the letter abbreviation to keep things rolling, is another form of annealed alloy Styrene sheet and rod that exhibits a higher rigidity, impact strength, abrasion resistance and is almost completely resistant to most aqueous acids, alkalis and salts. ABS thermoforms with remarkable transfer of detail from the molds to finished parts lending itself to box molding in all forms…Plano tackle boxes come immediately to mind. Some ABS box manufacturers add chemicals to increase UV and resistance to animal and vegetable oils that can make these products difficult or impossible to solvent weld. In such cases reverting to mechanical fasteners and/or Epoxy rivet methods are sometimes necessary.

In sheet form ABS comes with one very smooth almost polished side. ABS is harder to find in .060" thickness or under. ABS makes great small models parts including fins that will be painted. Unfortunately styrene and ABS are not available in clear but its one of those base building material modelers should always have around.

Both materials can be worked with most common woodworking tools, cut, sawn, drilled, tapped and machined. It also lends itself to being scored and broken making hand knife cutting a breeze even in thicker sheets.

Both materials solvent weld with any of the agents previously mentioned and of coarse good old tube type plastic cement though I wouldn't suggest it for most fabrication. Water thin Liquid agents flow best when natural hair-brush applied. Fine details can be scribed into both materials with a needle in a pin-vise.

Sanding and shaping can be performed with much the same grits and methods as used on woods.

Filling of dents and dings can be accomplished with medium CA as long as the material is not allowed to sit in a closed portion of the model. TIP: Dried CA and styrene sand at the same rates and will polish up to an undetectable match.

For the majority of small part custom fabrication Styrene Sheet, Rod and Shapes can give an almost endless source of possibilities. A Couple outstanding sources for pre-made construction shapes, T's, Channels, I-beams, H-beams, WF beams, Angles, rounds, rods, bars, half rounds, girders and on and on are Plastruct Corp. and Evergreen Inc. Both of these companies are generally common displays at all hobby shops, craft stores and on-line Hobby vendors. It is possible to order direct from both sources but there are some hefty minimums required. I find it better buy from our favorite Local Hobby vendor. Another very familiar form is "Styrofoam" originated by Dow Chemical, Styrofoam is Expanded Polystyrene in either Open or Closed Cell varieties. Styrofoam is also available in a multitude of shapes and densities. Join with most white or yellow glues, 5 minute epoxy, contact cement and some urethane glues.

Polycarbonate: (Lexan, Tuffak, Comco, Makrolon):

Before we get too far into Polycarbonates let us do away with the myth. Lexan, tuffak and all other brand named Polycarbonates out there are NOT UNBREAKABLE. Polycarbonates are very Highly Impact resistant. At most temperatures **above 32 degrees f** "freezing" Polycarbonates are impact resistant to the extreme. But in cold weather or below freezing they well crack or shatter like most other plastics.

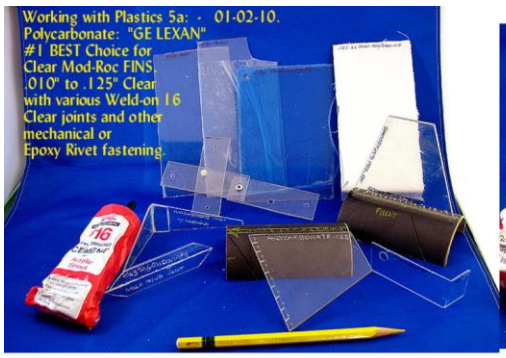
*All that said: Polycarbonates are my **Number ONE**, always First Choice model rocket clear fin material. "There is no finer plastic product out there for clear flying model rocket fins, Period".*

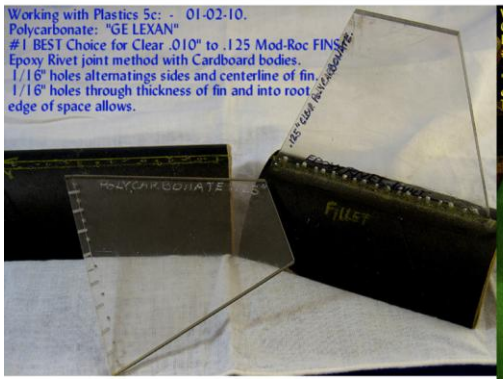
Is there a difference between brands of polycarbonates? No; polycarbonate is polycarbonate. But be very careful what you are buying. Some sales people have been lead to believe that the *Modified Acrylic* they are selling is polycarbonate. Home Depot was one such vendor where even the store managers in Maryland and Virginia did not know that the product they were selling as "lexan" was in fact Plexiglass DR a simple modified acrylic. It took individual phone calls from these managers to Home Depot's central purchasing department to clear up the mistake. Sometimes you can't tell a book by its cover, or in this case translucent blue polypropylene protective film. Under the lining and to the touch Plexiglass DR has the feel of Lexan, sort of sounded like Lexan if tapped, but cannot be cold formed. It snaps when bend past about 60°. All Polycarbonates are cold formable, that means they can be folded more then 90° at room temperature without cracking or breaking. It's possible to cold fold Polycarbonates back on themselves 180° without breaking. This is particularly true in clear polycarbonate. The addition of color pigments to cast white and colored Polycarbonates does reduce the bend ability on some brands.

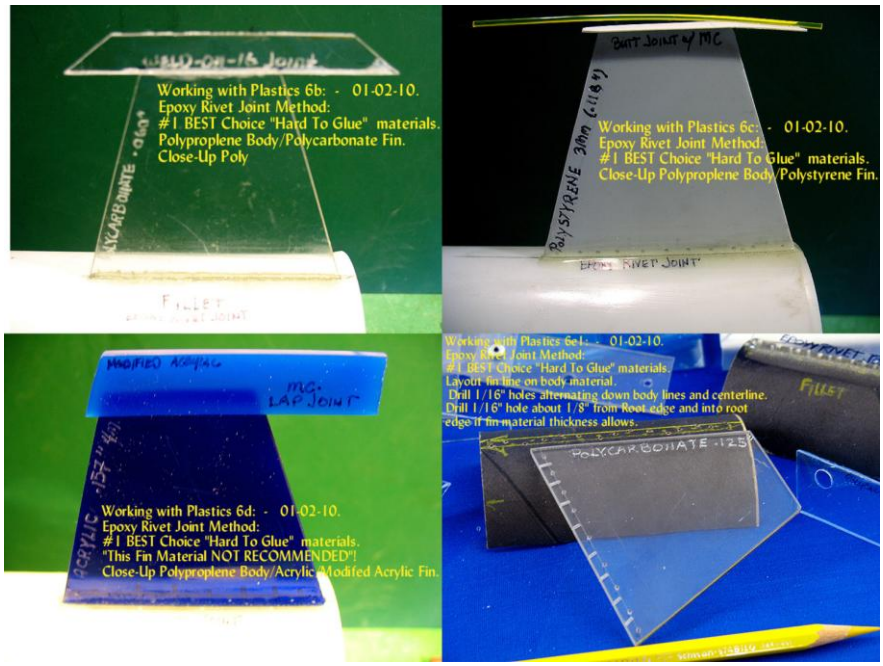
Clear Polycarbonate sheet can be found from .030" to 1-1/2", Matte finished calendared Polycarbonate films can be had .010" to .030". I've personally seen a sheet of 1" clear "G.E. Lexan" stop a 44mag. Bullet cold fired from less then 3 feet away. The stuff is tough! For most Model and Odd-Roc fins I prefer Clear Polycarbonate in .030", .040" .060", .080", .093" or .125". Beyond .125" the material becomes too heavy to be useful. I'll list the lbs/Sq. Ft. for your future reference. .030"=.19lb/Sq Ft. .040"= .25lb/Sq Ft., .060=.38lb/Sq ft., .080"= .50lb/Sq ft., .093"= .58lb/Sq Ft., .125"= .78lb/Sq Ft.
Sheet size varies by thickness also: .010", .020", .030" & .040" are in 24" x 48" sheets, .060 and Up are in standard 48" x 96" sheets or larger.

Working Polycarbonates can be done with carbide-toothed wood cutting tools, router bits and saws. The material can be drilled and tapped, for use with standard metal fasteners. I prefer stainless steel but any type will work, including Nylon, and ceramic. Another plus, Polycarbonates can be pop rivet fastened without fatigue fracturing over time. This can be very helpful on many attachment applications on models and ground support equipment. Working with clear polycarbonate lines can be lightly scored and cold folded or heavily scored and snap broken with care. This process is particularly helpful with Thin Film Calendared Polycarbonate sheet construction with very thin .010 to .030" fins and parts. These same thin film sheets can be sliced or cut with sheet metal shears or heavy scissors if the lines are transferred with a scribe or a "stabilo" grease pencil. Threading with standard drill bits and hand taps should be done without use of lubricating oils as these oils can cause crazing of the surface as the part or parts age. It is possible to thread Polycarbonate rod , bars or tubes with standard thread cutting dies for use as custom polycarbonate screws and fasteners.

Polycarbonates require special adhesives to obtain true welded bonds. Weld-on 16 is by far the most widely used agent for permanently bonding polycarbonate to polycarbonate. One of the early application tests of this product had several of the testing group, lap joint clear 1/8" thick clear polycarbonate 2" wide strips, clamping until dry, then unsupported, cold bend a 90° angle fold at the joint without breaking the bond. Many of the other chemical agents like MC, Acetone and MEK will craze the surface but will not bond parts. Very thin .010, .020 and .030 calendared material can be cut, folded and weld-on 16 adhesive fabricated into pretty intricate parts and dimensional fins.

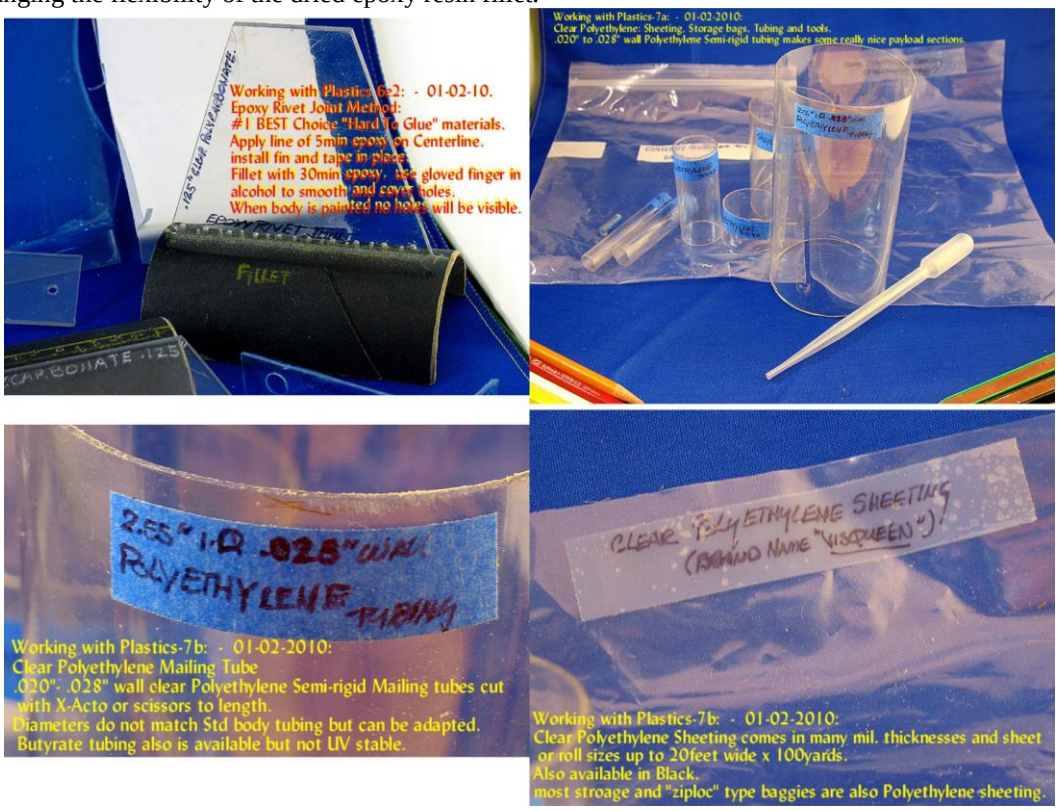






EPOXY RIVET ATTACHEMENT METHOD:

While this method can be used with several other plastic types, it is the most preferred method of attaching polycarbonate fins to cardboard or other materials where mechanical fasteners are not desired. To use the Epoxy Rivet method layout your attachment lines on the body tube or part was usual. Drill an alternating series of 1/16" diameter holes down both sides of the attachment line just a little beyond the thickness of the fin to be attached. Add a third line of holes directly on the line avoiding placing any hole directly adjacent (3 to one another. Now drill a series of holes in the side of the root edge of each fin drilling these holes all the way through the fin about 1/8" for the base edge of the plastic. If the polycarbonate is thicker then .060" also drill a few holes in the root edge itself between the through holes to a depth of about ¼". Apply a line of 5-minute epoxy to the line with enough material to squeeze out a bit on each side and into the root edge holes if drilled. Once setup apply heavy fillets of 30minute epoxy to both sides of the fin being very sure to fill all holes drilled and smooth out with an alcohol soaked rubber gloved finger or swab. Repeat the process with all remaining fins. Fins and finished fillets should completely fill all holes and hide their existence. I have many models that were built with this method that are decades old and are still completely flight worthy. Over time the epoxy will yellow but in most applications these fillets will completely hind the rivet holes. It is possible to add a few drops of casting resin dye to color the epoxy but this must be limited to a semi-transparent color to avoid changing the flexibility of the dried epoxy resin fillet.



Polyethylene:

Polyethylene in Low and High density are about the most common, inexpensive and most versatile of all plastics. They can also be one of the most difficult to join. While Polyethylene is the most widely used thermoplastic in all manor of different blow, injection, rotational and vacuum forming and extruding methods it is almost never used as a flat sheet. Polyethylene can also be found in sheet and block form as well as several different diameter plastic welding rods and tubes of many sizes. To be honest with only way to join or weld Polyethylene is with a plastic welding machine using extruded rod manufactured for that specific purpose.

As a Thermoforming material Polyethylene is the most widely used material on the international market today, its forming properties lend itself to just about any type or style mold.

Polyethylene films are currently available as thin as .002" and sheet product from .020" to 1inch in thickness. Also good supplies of different density tubes, square and blocks make this material among the most easily attainable of all plastics.

Alas it has only limited uses for our purpose mainly as Polyethylene mailing tubes, converted into clear bodies and payload sections. Thinner wall tubes are more preferable then thicker wall tubes obviously to save some mass and make available the most inside payload storage area. Tube availability varies somewhat from manufacturer to manufacturer but can generally be easily obtained from about .28" ID .32" OD to a respectable 2.55" ID, 2.606 OD tubing which is about as close to the 2.60"OD of Standard BT-80 as we're likely to see. Many of these tubes can be used with a bit of adaptor sizing to our standard Craft paper body tube. These very thin wall (.020" to .028") clear tubes make excellent payload sections, but they must be protected from hot ejection gases if used as model rocket bodies. Polyethylene softens at temperatures as low as 250 degrees f. In main body applications it's best to use a standard craft paper tube stuffer with centering rings held in place with standard 5 or 30-minute epoxy. Lightly scuffing the area of contact greatly increases the epoxy adhering at these attachments. When applying fins to such a tube it is highly recommended that some form of fastener be used in addition to the epoxy mechanical bond. Epoxy rivet method has shown good success with such construction. Additionally some of the thicker solvent welding agents like PS-30 and Weldon-16 have some etchant effect but they are not true solvent bonds and must be supplemented with other fastenings.

Polypropylene:

Lightest of the Polyolefin family this material is characterized by toughness, near-zero moisture absorption, excellent chemical resistance, excellent insulating properties, low coefficient of friction and ease of processing. Polypropylene has a low density while remaining fairly rigid with a heat distortion temperature of +150 to +200 degrees f. Polypropylene is another widely used thermoplastic featured in all manor of inexpensive blow, injection and vacuum formed parts in the auto, toy, carpet, general merchandise and some fabric markets. Fibers and yarns of Polypropylene are made into many fabrics such as undergarments, sportswear and medical gowns. Threads and lines are also twisted or woven into carpet backings, upholstery, automobile seats, ropes and rot resistant lines. The clubs new "Glow-in-the-Dark" Launch perimeter rope is Polypropylene. Many of the dollar store toys and novelties we pick up for Odd-Roc conversion end up being made of Polypropylene or many of the their parts. Most any size Crayon Bank base and nose or Plastic Piggy banks seen recently are Polypropylene. These parts will not solvent weld at all with any of our available chemicals. We are left with Epoxy riveting and/or standard fasteners for joining Polypropylene parts to our Cardboard and other model parts. Centering rings and other motor mount or structural parts should have internal connections with wood to wood, or wood to cardboard type adhesives or epoxies. Final attachment of Polypropylene parts should be accomplished with some form of mechanical fastener including epoxy riveting.

PVC: Polyvinyl Chloride:

Polyvinyl Chloride (PVC) is the most commercially significant member of this group of vinyl homopolymers and copolymers. The Extensive use of PVC is based on a combination of basic properties, including Chemical and corrosion resistance, physical strength and electrical insulating properties. Its properties can also be extensively modified through compounding and its cost is very low. Several types of PVC resins have been developed to accommodate its diverse and wide range of applications. We well look only at the applications and types that would be most likely used in our hobby applications. That is the Rigid and expanded Foam forms.

Most model rocketeers are familiar with both PVC plumbing pressure tested (White) pipe and PVC Electrical untested (Grey) Conduit. We often use these Schedule 40 and Schedule 80 pipes for various ground support equipment, fittings and stands. All of these tubes from about ¼" diameter are compounded to be both rigid and impact resistant. Like so many polymers they are mostly unaffected by chemicals including our normal plastic welding agents and adhesives. PVC pipe and fittings must use a combination of liquid primer (for water pipe systems) and a specially formulated cement to achieve permanent bonds, both purple primer and cement can be found along with the pipe or conduit in most Home improvement, Hardware and Industrial supply shops. A bit less known but equally useful are sheet forms of PVC. These are mostly in the Expanded PVC form and can range from 3mm (1/8") to 20mm(3/4"+) in thickness. Brand names like Sentra, Komacel, Comco and others have the same strengths, specialty primer and cements properties as the more (4 familiar pipe and tubing. While Comco and other industrial PVC sheeting can be ordered in Pallet lots in clear it is for the most part unavailable to the general public. Because PVC cement does not react with most other plastics or other materials white and grey PVC sheet is not recommended as a flying model fin material. Several people in the HPR community have build and flown models constructed mainly of PVC with varying degrees of success. These Rockets tend to be poor performer due mainly to the excess mass and wall thickness of standard PVC materials.

PVC Tubing can be used with confidence in rocket support stands, Rings for Tower launchers, Tube type launchers. By Adding screw-on cap attachments, sections of tubing can be converted into rod holding and other useful containers. White (Pressure Tested) PVC tubing can be used in construction of Water pressure and even Hydrogen powered model rocket launchers.

PVC can be worked with standard Carbide and wood working tools. PVC can be used with Aluminum and Stainless steel mechanical fasteners, wood screws and pop rivets. PVC will take drilling with standard HSS drills and can be tapped for machine screw fasteners or nylon fasteners but tend to distort under load or stress.

Nylon:

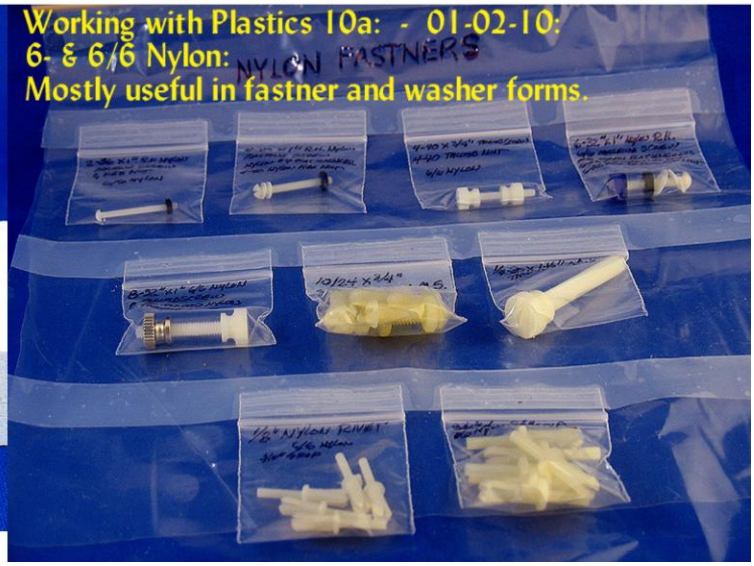
There are two general classes of nylons. Those polymerized by condensation of a dibasic acid and a diamine.

1) Nylon 6/6 is polymerized from adipic acid (6 carbons) HOOC-(CH2)4-COOH and H2N-R2-NH2 diamine (6 carbons). Other commercial nylons are made this way with combinations of hexamethylene diamine and azelaic or sebacic or dodecanedioic acids forming types 6/9, 6/10 and 6/12 Nylons.

2) Those Polymerized by addition reactions of ring compounds that contain both acid and amine groups on the monomer. Nylon 6 is polymerized from e-caprolactam (6 carbons) to form polycaproamide. Other commercial nylons are made by addition reactions are types 11 & 12. While the theoretical number of nylons is huge, relatively few are actually being commercially produced. Nylon 6 and 6/6 comprise the bulk of production because they offer the most favorable combination of price, properties and processibility.

As a combined group these engineered thermoplastics offer high strength especially at elevated temperatures, toughness at low temperatures, stiffness, wear & abrasion resistance, and low friction properties. Nylons of either class can be combined with other materials to form specialty products such as Nylon/Kevlar composites, Nylon/epoxy glass copper clad and Nylon/Teflon/glass clad.

Our major use of nylons will be in gears, bearings, and low friction fasteners or in manufactured parts like terminal blocks, wire ties, receptacle plugs and covers. Generally we'll find these items in the 6/6 class. Exposure to UV light results in the degradation of nylon over an extended period of time. The effects of the radiation can be reduced by use of UV absorbers and other chemicals. Most we will commonly see is the use of 2 to 3 percent by weight of finely dispersed carbon black. Many of the fasteners we can find will be opaque black or deep blue rather then the natural milky white. Nylon sheet can be obtained from commercial plastic distributors for use in making custom bearing plates, washers and other flat parts from sheets .032" to 1.0" in thickness. Rod can be purchased for custom die threading or other used in many diameters ranging 1/16" to 6.0". Nylons can be worked with standard metal working tools, drills, taps and saw blades in the 18 to 32tooth range. Punch and die working gives better results over drilling for finished flat holes. Like so many thermoplastic polymers Nylons have no decent solvent welding or chemical bonding agents available to the public. Some thread locking materials seem to give a temporary hold but vibration and or a sharp rap will generally break most loose. Thread deforming lock nuts are the best answer to making vibration resistant threaded connections.



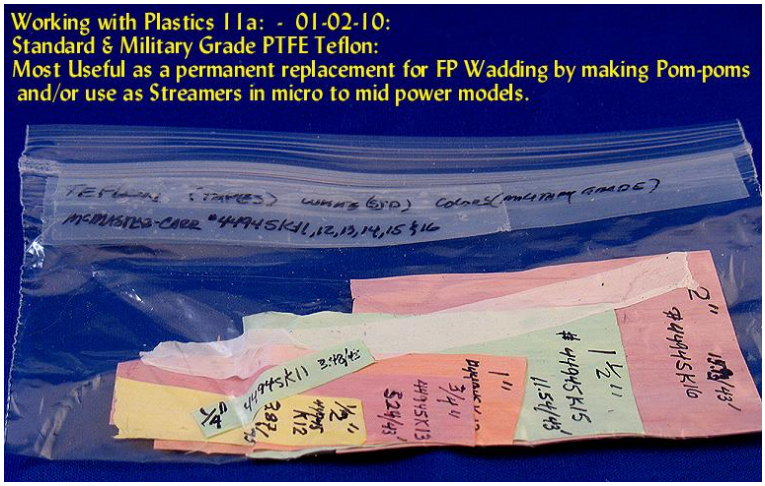
Teflon:

Teflon-TFE was the first of the fluorocarbon materials developed by the Dupont Company. Both TEFLON TEF and FEP are high melt-point thermoplastic materials having the familiar whitish opaque appearance. TEFLON TFE has the higher melting point and is capable of continuous service at +500°F Both TFE and FEP have combined chemical, electrical, thermal and mechanical properties unmatched by any other material. Because of these properties, TEFLON resins are used as gasket, and packing materials in chemical processing equipment: AS electrical insulation for maximum reliability: and in bearings, seals, piston rings and other mechanical applications requiring these properties combined with anti-stick characteristics. Wow that sounds like a commercial but really this stuff is as good as is stated.

TEFLON TEF and FEP processed sheet, Rod, Hexagon, square, rectangular bars and many style, size and stiffness tubings are all commercially available. Skived Tapes in TFE only are likely the most common from of Teflon we see in the form of Plumbers thread sealing tape. Teflon tapes can also be found in muted colors and heavier thickness for use on military and other grade applications.

We can use TEFLON tapes as permanent wadding Pom-Poms, as combination streamer-wadding. Or any number of other threading sealing applications. Teflon micro thin tubing can be used to insulate one leg of home made nichrome igniter leads. And other Teflon tubing can be used to help protect our micro-clip leads for motor burn. Some have used Teflon spray on films as mold releases and other non-stick applications.

Nothing sticks to TEFLON! Well, That's not completely accurate. We can use some adhesive tapes to "sort-of " hold Teflon tapes on body tubes, but to be honest if really put under stress it'll pop right off, much better to tie Teflon to the shock cord directly. Teflon does stick to itself pretty well, and can be mechanically fastened in some of the thicker forms. I used ¼" Teflon rods on then inside of my Tower launcher rails to reduce the friction, fastening the rods to the aluminum rails with VHB tape and #2 Stainless screws as well.



Polyurethanes:

Polyurethane and expanded polyurethane foams are another Plastic that has found its way into our hobby in recent years. Chemically the addition-polymerization of polyols with polyisocyanates yield polyurethanes.

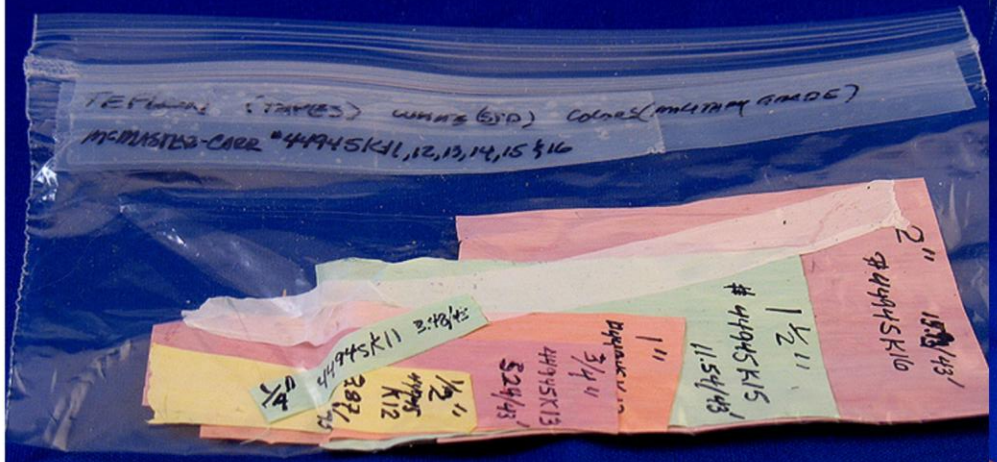
Major polyurethane grades include flexible, semirigid, rigid and integral skin foams, thermoset and thermoplastic elastomers, paints and coatings, adhesives, binders, and elastomeric fibers. Nearly 75% of the polyurethane produced worldwide is consumed by four major industries: Furniture and bedding, Automotive, construction and appliances. In recent years high grade polyurenthane paints have all but taken over the century old enamel and lacquer paints of these same industries. **Chemistry:** Just a little background to help understand where the major types come from . The basic building blocks for polyurethanes are isocyanates containing two or more isocyanate groups, and polyols containing two or more hydroxyl functions. The most important commercial polyisocyanates on a volume basis are the 80/20 isomer ratio of toluenediisocyanate (TDI) and polymeric diphenylmethanediisocyhanat (PMDI), both of which are aromatic isocyanates. TDI is the standard isocyanate used for the production of flexible polyurethane foams and is the largest volume isocyanate on a worldwide basis. PMDI is used primarily for the production of rigid foams. Many modified isocyanates based on TDI and PMDI are commercially available.

In our hobby we use a number of flex foam pads, These foams come in any number of strengths from super soft pillow like foam used in our egg capsules to sheet forms used to wrap instruments in our payload bays and transport boxes and crates. These foams can generally be cut with scissors, hobby knife or a great trick I found with electric carving knifes. These sponge foams can be joined to other materials with wood glues, epoxies and some VHB acrylic foam Tapes.

More recently a number of high density rigid foams have come into use as solid nosecones and transitions. These foams go by a number of names. Signfoam, Ultraboard, and Polyboard to name just three. These foams come in a variety of densities for 15lb to 30lb/ cu.ft. generally in sheets 48" x 96" or 48" x 120" and in thickness ranging ½" to 6". Working these rigid foams can be done with standard wood working tools, bits and saw blades. Polyurethane foams in the 18 –25lb/cu ft. range can be turned on standard wood lathes with ease. Rigid foams can be glued with just about any glue or adhesive. Most woodworkers prefer a decent cabinet grade wood or yellow glue. And they can also be joined with polyurethane type glues as long as they can be securely clamped just like wood.

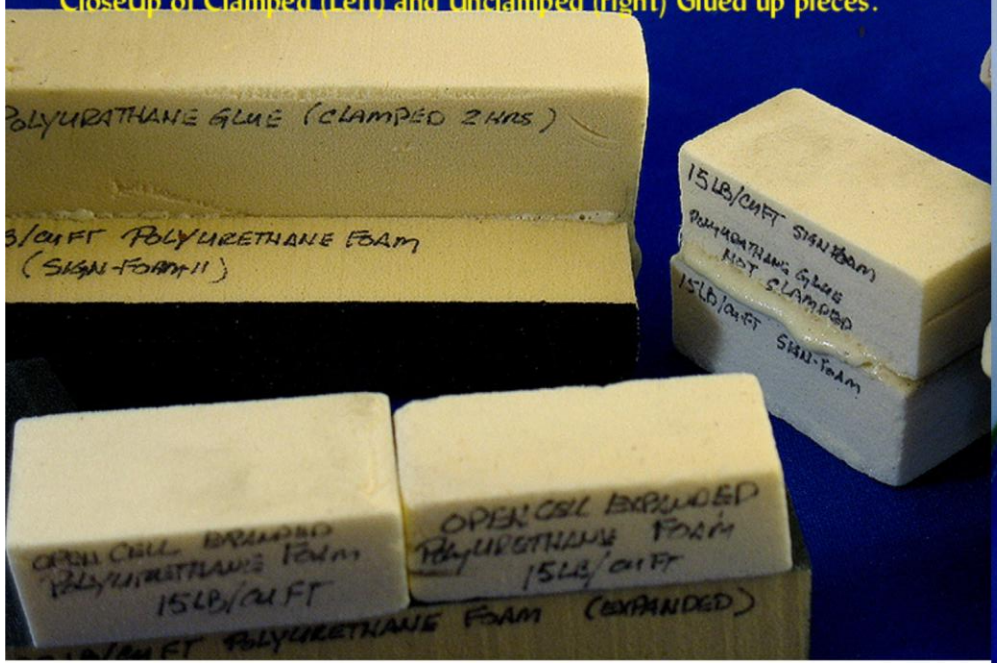
Urethane and Polyurethane glues have been developed mainly for the furniture and cabinetry making industries. These glues have come into some limited use in our hobby but as they require solid clamping and use of water activated curing along with the massive mess that can be made by the expanding of the adhesive foam as it cures they are really limited to those areas where this mess will never be seen or in glue up processes where the part or parts can be securely clamped during curing. Gorilla Glue and Elmer's Ultimate HP glue are two of the best know examples but there are quite a few others.

Working with Plastics 11a: - 01-02-10:
Standard & Military Grade PTFE Teflon:
Most Useful as a permanent replacement for FP Wadding by making Pom-poms and/or use as Streamers in micro to mid power models.



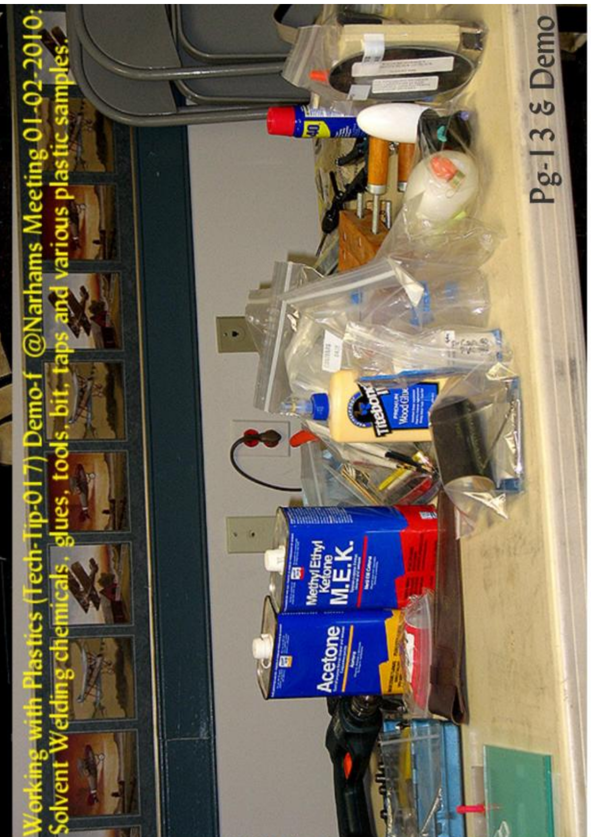
Working with Plastics 12a: - 01-02-10:
Hi-density Polyurethane sheet foams:
Polyurethane foams come in forms from very soft "polybrush" to 22lb hard as nails and solid core materials like the fux-Brick (far right).
While these Hi density foams can be joined with regular fasteners, nails carpenters glue and more..2 most popular Polyurethane Glues have a place in CLAMPED workworking..

Working with Plastics 12b: - 01-02-10:
Hi-density Polyurethane sheet foams:
CloseUp of Clamped (Left) and Unclamped (right) Glued up pieces.



Working with Plastics 12c: - 01-02-10:
Polyurethane Glues:
Gorilla Glue & Elmer's Ultimate, both are water activated Polyurethane glues.
BUT Gorilla Glue has a much shorter unopened shelf life.
Bottle shown was purchased less the 6 months before opening, contents were Hard as a rock, totally unuseable.
Elmer's Ultimate was purchased almost 3 years ago. Opened for this project and worked perfectly.
Be sure to squeeze ALL bottles of Gorilla Glue before buying:)

Pg-11,-12a-c



Author note: Some of the Photo Captions may be too small to read in the reduced size presented on these 12 pages. If there are particular photos that anyone would like to see full size, the individual photos are in the Photo Supplement Folder posted with this Tech-Tip.

I'm sure we've overlooked or forgotten something that will come back to bite me with this writing so it is my hope this Tech-Tip will remain open to allow updating as time and information come along. We've only scratches the surface of all the different "Plastics" out there; hopefully these quick overviews, suggested use and application methods will help. As always keep experimenting with new or unfamiliar materials to help keep the learning going.