HERE TODAY, MAYBE GONE TOMORROW

Ephemeral Materials in Ship Models

Dana Wegner

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The following article which appeared in the Nautical Research Journal and Ship Modeler's Shop Notes is reprinted here to give guidance to builders who desire to construct accurate and representative ship models. This material is as applicable now as when it was first written. The opinions expressed here are those of the author and are not necessarily those of the Nautical Research Guild.

What I offer here is information and general guidelines regarding the longevity of certain materials used in ship modelbuilding. In the end, some readers will agree with me, some will accept parts of what I say, and others will disagree with me wholly. If you disagree with me, please do not feel compelled to defend your choice of materials. I am only offering suggestions.

This article relates to static ship models. Certainly, the special materials needed for floating or operating models may be entirely different. Some of this information is based on personal observation, and some of it is based on the large body of technical literature produced within the international museum conservation field. Museum conservators are scientists who preserve museum objects such as paintings, books, statues, boats, planes, glasswork, furniture, and, occasionally, ship models. Several years ago, when we began investigating the problem of lead corrosion in ship-model fittings, we found that museum conservators had already studied that problem in considerable depth, but what they found had not yet been related to ship models. For the problem of ephemeral or short-lived materials in modelbuilding, we once again turned to the conservation field for advice.

I am neither a chemist nor a trained museum objects conservator, so I will not use many technical terms. I was once a ship model builder, but after academic museum schooling and some years as a historian, I became the curator of the U.S. Navy's collection of more than nineteen hundred ship models, which date from 1813 to today. The word curator means "caretaker," and I have been watching over the navy's collection for nearly two decades.

The U.S. Navy Collection

Since the U.S. Navy began collecting ship models in 1883, it has acquired them both by purchasing commissioned models and by accepting donations of models that had already been built. Living model builders have donated models because they moved to smaller quarters, had too many models, or did not like models anymore. Model builders' widows, children and grandchildren, and nieces and nephews have all offered models to the navy. It has also acquired models through divorce settlements and by confiscation by the Drug Enforcement Administration. In sum, the navy collection today consists of models made in a great variety of ways, by many people, both professional and amateur, over almost two centuries.

Indeed, ownerships and locations of ship models change for many reasons. Models can even migrate great distances and survive a surprisingly long time. Since World War II, the navy's collection of models has been too large to display in one museum, so an important part of our job is to lend ship models to qualifying museums and federal offices worldwide. Since the 1890s, navy models have been routinely shipped across the country. Some tend to reside in one place for years or decades, but others are reshipped about every three weeks. In fact, many of the models have been shipped hundreds of times in their lives and have endured hundreds of thousands of miles of bumping along in the backs of trucks.

In addition to moving more than 400 models a year, we repair an average of about 110 a year. There are only two navy ship-model conservators, so we are really interested in what materials and techniques tend to last longest and hold up best under physical stress.

In 1883, the U.S. Navy began a tradition of building one or more major exhibition models to represent new classes of ships, usually in 1:48 scale. This tradition helps explain why there are more than nineteen hundred of them today. At first, only the navy had the need and expertise to build the models, so they were made in-house at the navy yards. However, since around 1910, when Horace Boucher, a civilian model builder at the Washington (D.C.) Navy Yard, resigned and started his own company in New York, only some navy models have been made in-house, while others have been made by outside contractors.

Learning from the Navy's Models

Examining older U.S. Navy models and comparing their repair records with models built more recently have taught us much about how to assure a long life for a ship model while it is being built. We have some scant early records about the materials the U.S. Navy used when it began making its own exhibition ship models. These records dovetail nicely with our curatorial examination of the models. By examining the models and studying these records, we have learned considerably more about what materials navy model builders used and how the models themselves were designed and assembled.

Models from the earliest days of navy modelbuilding were routinely sent to distant national exhibitions such as world's fairs. In the 1890s, there were no cross-country trucks, so both the models and their cases were partially disassembled and crated for shipment by boxcar to the fair sites. Navy modelmakers traveled to the fairs to unpack and reassemble the models and install them in their display cases.

We find certain common construction characteristics when we examine these early models: Gun mounts are pinned, not glued, to decks; gun turrets are held by pegs to their barbettes; and some heavier, tall structures, like masts and stacks, probably detach. We can bet that each smokestack is hollow and made from sheet brass or copper, and at the bottom of each stack is a screw that mounts it to the deck below. Most rigging that actually supports something is braided wire. We have also learned to expect superstructures to be permanently screwed and glued to the deck below. We think that every model has been repaired many, many times. These early models were deliberately made to survive frequent travel, borrowing a phrase, to "take a licking and keep on ticking."

We have also found that the older models need less frequent repair than the newer ones. The key to understanding this is that the number of different kinds of materials available to modelers in the past was small compared to the number available today. When the navy model builders built an exhibition ship model in 1883, they made the hull and superstructure from sugar pine. They glued the lifts together using LePage's wood glue. They made their own paints from pigments, vehicles, and dryers. They made small parts for subassemblies from brass, or nickel silver, and soldered them together. They used linen line or braided wire for rigging. Pine, wood glue, paint, brass, nickel silver, solder, linen, and braided wire, these materials were basically all they used, maybe half a dozen different things on a given model.

The chances of material incompatibility become greater when the number of dissimilar products used on a model increases. The bottom line is that the larger and more eclectic the selection of materials, the higher is the risk of material-specific or overall deterioration. Model builders were probably not aware of the potential for conservation problems in 1883, but the simplicity of their "palette" of materials has inadvertently helped older models to survive.

U.S. Navy Specifications

During World War II, the U.S. Navy built and purchased ship models feverishly, and in 1945 the first curator, Commander Joseph Appleton, a respected ship model builder himself, devised the first set of written specifications for navy models based on the experience accumulated by the navy up to that time. He wrote the specifications to ensure that finished models built for the navy, whether built in-house or outside, would have a uniform style, a homogeneous level of detail, and a superior level of craftsmanship. They were also designed to assure that the models were portable and sturdy enough to last a long time, in order to justify the government's expense. Appleton's specifications have been modified a little from time to time, but basically they are the same today as when they were first promulgated. In the 1960s, Howard Chapelle began to use the navy's specifications at the Smithsonian Institution, and most of the models in the famous watercraft and naval history halls there now were built to U.S. Navy standards. Many maritime museums also use them.

U.S. Navy model specifications are relatively strict. If you are not already familiar with them, they can be found on the Nautical Research Guild's Web site and in the March 1994 issue of the Nautical Research Journal. Over the years, we at the navy have been branded ship-model "purists" by some. By that, I think people mean that we are traditionalists. However, you can see that with so many models deteriorating at various rates and only two people to take care of them, we need to be cautious.

Modern Materials

The development since World War II of a variety of new synthetic compounds has complicated the selection of materials with which to build models. My first inclination when preparing this paper was to divide new materials into categories and then comment on every item. Upon reflection, I realized that there are too many, and what we really need to discuss are some of the modern materials most widely available to exhibition ship model builders. So let us start with a controversial one, styrene plastic.

Styrene

In 1839, a chemist distilling tree resin discovered a material he called styrol, one of the basic ingredients of polystyrene plastic. By 1934, both Dow Chemical in the United States and I. G. Farbin in Germany were designing a process to manufacture styrene and polystyrene to be used as a superior, but expensive, electrical insulating material. When the Japanese overran Malaya in 1942 and cut off the Allies' supply of natural rubber, the U.S. government initiated a major program to build chemical plants capable of manufacturing a synthetic rubber made from butadiene and styrene. After the war, it was found that the surplus capacity of these plants could be used to manufacture cheaply huge quantities of the general-purpose thermoplastic we now call styrene. Styrene is known as the plastic of the twentieth century: Millions of tons are produced by a large number of foreign and domestic firms annually.

I well remember those Revell plastic model kits of the 1950s. The injection-molded parts inside the box were made from either acetate plastic or styrene plastic, and the appropriate adhesive had to be used. (The labels on the boxes instructed the builder to use either "type A" or "type S" cement‹ A for acetate and S for styrene.) Eventually, styrene became the standard material used. Today, in addition to injection-molded parts, sheet and extruded polystyrene is manufactured and sold in a variety of shapes and colors, and appears to be a boon to model builders because it has many desirable properties: It glues well with specific solvents; it cuts, saws, files, and sands like a dream; it takes many finishes well; and it is nearly waterproof. Finally, because of its smooth surfaces, the styrene siren calls out to the modeler of steel ships, "Use me! Use me! I'm perfect!"

But, straight polystyrene has two shortcomings: It has little resistance to heat, and it deteriorates with age, becoming yellow and brittle, and cracking on its surface. Its aging is accelerated by exposure to ultraviolet light. (The soft bumper of your car is probably covered with rubbery "ABS" plastic, the S in ABS stands for styrene. You may have noticed that one of the first exterior parts on your car to fade is the bumper.)

The plastics industry has sometimes combated these deficiencies by adding ultraviolet absorbers and plasticisers to the formula, thereby further complicating the basic composition. Correcting one deficiency may, indeed, create a dozen others. The so-called "plastic of the twentieth century" has been modified over and over until it has just about any characteristic manufacturers and consumers want. Different versions of styrene are manufactured to different tolerances for sunlight, heat and cold, and impact, and for other characteristics such as tensile strength, smell, color fastness, or chemical resistance. So now, as with many other modern, highly processed materials, the trouble with polystyrene is that we just do not know what we are getting when we buy something called "styrene."

Although it would appear that the usual method of fusing two or more polystyrene parts together, using a styrene solvent containing a hydrocarbon to dissolve the edges so that it "welds" them together, is effective, achieving lasting bonds of styrene with other materials is problematic. Some model builders use styrene to sheathe over wood, but this practice has its own bonding problems. First, the chosen adhesive must join nonporous plastic with porous wood. There also may be trouble if the wood substrate expands and contracts at a different rate than the styrene covering it, causing the styrene to buckle, or the joints to open. Finally, polystyrene is not compatible with certain types of paint, mainly those containing the very solvents that make for a good bond. For these reasons, the navy would not use it on a good model or permit its use on models it commissions. Museum conservators consider polystyrene generally unstable and of questionable longevity.

Plexiglas

A Class "A" Product In 1975, some museum conservators started a system of evaluating materials according to how stable they are, or, for our purposes, to how long they will last in a museum environment. In order of longevity, materials that will last fewer than six months are labeled class "T," which stands for "temporary." Unstable or fugitive materials that will last fewer than twenty years are class "C." Materials in the intermediate class of twenty to one hundred years are class "B," and materials that will last more than one hundred years, class "A." Materials that will last more than five hundred years are class "A-1."

Some synthetic polymers are sometimes a thousand times more stable than similar traditional materials. Acrylic (commonly known by the brand name "Plexiglas") was first developed in World War II for aircraft canopies, and the first types tended to yellow rapidly and to become brittle. However, modern acrylic plastics generally fall into at least the class A category, and most Plexiglas-like sheet materials are generally acceptable, even though some technical literature indicates that some acrylic sheets are inadvertently stressed during the manufacturing process, and that this invisible defect may manifest itself as mysterious surface cracking at some future time. Despite its potential usefulness, we have found that Plexiglas is actually not very popular among model builders because it is a difficult material with which to work. Its best use seems to be in large, solid blocks rather than in slab construction. Navy specifications discourage the use of Plexiglas except in solid blocks, primarily because of the difficulty in achieving good joints. When Plexiglas is used, solvents should be used to join it, and paints must be carefully selected to adhere.

Casting Materials

While on the subject of plastics, we should mention polyurethane and epoxy casting materials. One rule of thumb museum conservators follow is: "If you can smell it, it's not stable." There are hundreds of two-part casting formulas available, not to mention polyester resins. Our experience has been that those that smell after they have cured are likely to shrink, deform, or deteriorate over time, so I recommend avoiding two-part mixtures that smell like mothballs, vinegar, or worse after they set up. With this caveat, conservators generally agree that many epoxies are likely to last a long time and are an appropriate adhesive and casting material. On the other hand, expanded polyurethane foams have caused us nothing but trouble because of their warping and rapid deterioration.

Adhesives

Recently, I thought I would familiarize myself with the various adhesives available in the marketplace, so I went to our local arts and crafts superstore. I found no fewer than twenty-eight different products marketed by Elmer's alone. (Why, they still even make and sell mucilage! Remember that?) There were sixteen sold under the Loctite label and another six sold under the Duro name, which, by reading the fine print, I discovered is the same company as Loctite. So, which products should we use? To find out more about adhesives generally, I highly recommend Gene Larson's excellent article on the Nautical Research Guild's Web site. It gives details about various categories of glues and other adhesives, and their potential applications.

Cyanoacrylates

Currently the hot topic is whether or not cyanoacrylates, sold variously as Hot Stuff, SuperGlue, and CA‹ are suitable for modelbuilding. The basic liquid form of CA "glue" is a monomer that, when exposed to certain chemicals, rapidly changes to a polymer and hardens. Minute amounts of water can also start the action, and most solids have enough water condensed on their surfaces to trigger the reaction.

CA was formulated by accident in 1951 by two scientists working for the Eastman Kodak Company. They were trying to come up with a stronger, clearer, and more heat resistant acrylic plastic for jet plane canopies. By 1958, Kodak, which called it Kodak 910 Adhesive, developed a way to manufacture this material commercially, outside the laboratory and in quantity. It may have been instant "glue," but it was far from an instant hit in the marketplace. Apparently, 910 was not widely marketed for domestic use at first; rather, the first applications were in the manufacture of cameras, electronic instruments, automobiles, and atom bombs. In 1966 during the Vietnam War, a surgical grade of CA was used by some combat medical teams. It worked well, but the product was not approved by the Federal Drug Administration for general medical use because it appeared to cause tumors when implanted in rats. Public interest in CA products for general use began to grow when the inventors suspended Gary Moore on live national television with a single drop. That feat is still used in some TV commercials.

Early on, CA was prized highly for its optical clarity. Because it remains largely invisible when used to repair broken glass objects, museum conservators regularly used CA for glass repairs. But then they found that some types of glass deteriorated the adhesive. So, while CA is still used in museums for temporary repairs, conservators now use epoxy or clear polyvinyl acrylic adhesives, which are rated class A, for permanent repairs.

There are a lot of different CA permutations now being formulated that have particular viscosities and cure rates for specialized applications. Cyanoacrylates can be divided into two main types, methyl and ethyl, plus, there are also propyl, butyl, and methoxyethyl types. They vary in consistency from watery to gel-like. Gap filling depends on the type of CA used. Certainly, viscous CAs can fill gaps well. Regardless of the type, CA is nearly a class A substance whose magic lies in its ability to form superior long-lasting acrylic bonds between small surfaces.

CA does have some limitations. It is brittle and has little strength in shear, being especially sensitive to impact. Some types of CA are not waterproof, and, like all acrylics, CA generally has a small tendency to absorb water, though this has not been shown to be detrimental. We also know that CA is gas permeable, and therefore does not prevent airborne acetic acid from attacking lead, or ferrous metals from rusting.

Commercial-grade CAs, repackaged in smaller quantities, are no doubt the type sold by hobby suppliers. We have used industrial grade methyl and ethyl CAs on navy models for small jobs and quick repairs since 1983. Our uses have included coating bare brass and Britannia fittings and securing rigging line, and we have not seen any evidence of its giving way. Although there has been some concern that accelerants weaken the bond, we frequently use accelerants, or "kickers," to speed up the cure, and have not noticed any difference. However, CAs should not be used exclusively in modelbuilding, however tempting that might be. For larger surface bonds, like between the lifts of bread-and-butter hulls, or between block superstructures and decks, I recommend using another adhesive.

Polyvinal Acetates

As far as other adhesives go, it seems that polyvinyl acetates (PVACs) are most popular. These are products like Elmer's Glue-All and Elmer's Carpenter's Glue. You will find that all PVACs bond wood well, the main differences among them being their viscosities, drying time, and hardness when cured. Conservators have found that these adhesives are generally long lasting. Though they are susceptible to weakening by humidity and water, waterproof adhesives are generally not necessary for exhibition models. It should be noted that it may take up to two or three weeks for PVACs to completely cure, and, while drying, many of them emit acetic acid, which will affect lead if kept in the same microenvironment. (The navy report on the causes of "lead rot" in ship models can be found on the Guild's Web site and in the March 1998 issue of this journal.)

Contact Cements

We should be wary of certain adhesives. Our experience has been that contact cements using volatile spirits eventually dry out and give way after between five and ten years, depending upon display conditions. One of the ingredients of contact cement is usually rubber, which is highly unstable, so I would recommend avoiding resilient adhesives like Walther's Goo (and latex paints, which are various emulsions in water of a synthetic rubber or plastic).

Celluloid Products

As a teenaged model builder, I loved one particular kind of adhesive, one that has an interesting story. Celluoid, one of the earliest synthetic plastics, was first manufactured commercially in England in 1866. Between 1866 and

1950, it was used primarily as a substitute for ivory, bone, and tortoise shell. During this time, a wide variety of things, products as diverse as false teeth, movie film, and ping-pong balls, was made from it. Like plastics in general, it was first belittled as a cheap substitute for more expensive natural materials. By 1900, however, celluloid itself had become a desirable cultural substance. [Its use became so prevalent, in fact, that the term celluloid (with a lower-case c) now appears in the dictionary. ‹Ed.] However, it did have some shortcomings: It sometimes turned smelly, oily, and brittle, and sometimes shrank and deteriorated rapidly. But its worst problem is that celluloid is very similar chemically to an early high explosive called gun cotton, in that it is highly combustible and sometimes bursts into flames for seemingly unknown reasons! In all, celluloid symbolized at once both what a plastic could be, and what a plastic should not be.

So, a scientific search began for a substitute for celluloid, itself at first a substitute. Although the connection is not direct, the search for a substitute contributed to the eventual manufacture of polystyrene. The celluloid industry faded away by the 1950s, and today only limited amounts of it are manufactured for specific uses. One of the few remaining uses of celluloid is as an ingredient in Ambroid glue, Duco cement, and perhaps some other so-called model airplane adhesives. (I have fond memories of golden Ambroid, perhaps brought on by the highs from smelling it, but, seriously, I do not recommended it for a long-lasting model.)

Paints

When the U.S. Navy began building its own exhibition models, it made some of its paints from powdered pigments, vehicles (like linseed oil or turpentine), and dryers. These thick, pigment-laden paints were applied in several layers with a brush. When dry, the surface was polished with a hard felt pad impregnated with pumice or rottenstone. The superb finish achieved in this way was as good as, perhaps better than, what we can get today with an airbrush. And the paints were particularly hardy and colorfast.

Today we are concerned with the "dumbing down" of many products, mainly petroleum-based paints and some solvent-based adhesives. As you know, to increase consumer and environmental safety, and probably to mitigate potential law suits, the trend has been toward eliminating spirit solvents in a number of products. Thus, we have many lines of acrylic paints, clear coatings, and even contact cements that boast easy, nontoxic water cleanup. Museum conservators have found that the manufacturer of one such clear water-based sealant used by artists adds various chemicals to it in order to allow water to work like a spirit solvent. The result is an unstable product, filled with complex additives, that covers and dries poorly.

In general, other than traditional watercolors, I caution against using any paint that cleans up or thins with water, and I recommend using solvent-based paints as long as they are available. Based on extensive testing of modern artists' paints, museum conservators have concluded that solvent-based acrylics generally are stable and long-lived. We also know from experience that traditional artists' oils, enamels, and lacquers are enduring. Real varnish and white enamels, however, tend to yellow with time, so I do not recommend using them on navy models.

Guidelines for Models

Based on the U.S. Navy's experience of caring for its own models and on conservators' analyses of modern materials, I offer for consideration the following three guidelines for making ship models that will last.

- **Build it well.** Use pins, nails, dowels, and screws wherever possible to supplement adhesive bonds. Select good-quality, well-seasoned woods. Avoid lead, balsa, wax, rubber, styrene, decals, highly processed cheap paper, and ordinary cardboard. Engineer the model so that masts are strong enough to support the weight of their extremities. Be sure to attach parts well that will not be accessible later. Never glue anything directly to a painted surface. Although fine model builders generally know better, applying adhesives over painted surfaces is still one of the most common causes of connection failure.

- **Keep it simple.** Limit the palette of adhesives to a minimum number of types and brands. If possible, stick to one type and brand of paint. Avoid new and untried materials in important models. Suppress the urge to overbuild models, and use as few pieces as reasonable. Remember: Every piece fastened on has the potential to fall off.
- **Keep a bill of materials** so that, in the future, there is a record of what and where on the model products were used when it was built.

Guidelines for Display Cases

A few words are due on the subject of display cases. Make sure the model is mounted firmly on a base that is large and strong enough to protect it when it is moved or repaired. Keep the model and display case away from sources of direct heat, cold, vibration, humidity, and sunlight. Avoid exposing the model to rapid changes in temperature and humidity. And be sure the air in the display case can change once or twice daily, for the reason I explain next.

All things deteriorate at some rate, and some things deteriorate faster than others. Even a well-built model will deteriorate more quickly if it is kept in an adverse environment. Environmental conditions can retard or accelerate the rate of deterioration. For example, a newspaper placed in sunlight turns yellow faster than a newspaper kept in a file drawer. When things deteriorate or change chemically, they release molecules into the air in a process museum conservators call "off-gassing." When you can smell paint or glue, whether it is wet or supposedly dry, you are smelling the off-gassing of those products. Usually the smell diminishes considerably or seems, according to your nose, to stop altogether. Nevertheless, each material still off-gasses as it undergoes inherent chemical changes, or as it changes because of heat, time, humidity, or light. One easy way to tell if your model is off-gassing is to smell it. If it is more than a few months old and still smells like glue or paint, either something has not dried yet, or something is inherently unstable. If the model or the inside of the display case smells like vinegar, serious decomposition is likely taking place.

Insignificant as these weak gasses seem, when a ship model is placed in a microenvironment where the air does not move much, like in a display case, the gasses become relatively concentrated and may begin interacting in various and unpredictable ways with the materials with which the model and case were made. Much of the interaction between off-gasses and particular materials is harmless, but some can be perilous. Think of a display case as a heatless cooker that will bake a model and anything else within its walls.

Model builders can help retard deterioration by allowing a little free air into the display case. Air inside even loosely fitted display cases can be one hundred times more stagnant than the air in the surrounding room. The air in the exhibit case should exchange at least once or twice a day. A 1-inch-diameter hole will allow a cubic yard of air to exchange naturally daily. So, a 1-inch hole is sufficient to ventilate an exhibit case with an interior of 36 by 36 by 36 inches. Of course, many modelers display their work without exhibit cases, and if you are willing to accept some mechanical breakage, that is fine. However, frequent dusting then becomes necessary, because dust, when combined with humidity in the air, will form a concrete-like coating that is difficult to remove, even with solvents.

Conclusion

We have learned a lot from more than a hundred years of experience and recent analyses of modern products. Model builders do not have to build their models to last a thousand years, but with a little forethought and wise consideration, they can help preserve their legacies. After we have rung down the curtain and joined the choir invisible, someday some unfortunate people are going to have to care for our models. Have pity! Remember, you cannot take it with you, so you might as well leave something nice behind.

Dana Wegner is curator of ship models, Department of the Navy, Naval Surface Warfare Center. This article, taken from a speech presented at the annual conference of the Nautical Research Guild in San Diego, California (6 November 1999), is published here by courtesy of the U.S. Naval Surface Warfare Center, Carderock Division Headquarters, but contains the views of the author, which are not necessarily the views of the Naval Surface Warfare Center or the Department of the Navy. Nothing herein is meant to indicate that the U.S. Navy either endorses or rejects any particular material, product, chemical, or process

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Founded in 1948, the Nautical Research Guild (NRG) is an IRS 501(c)(3) approved nonprofit educational organization with an international membership of historians, ship model makers, artists and laypersons with a common interest in the history, beauty and technical sophistication of ships and their models.

The NRG publishes the quarterly Nautical Research Journal, a quarterly magazine whose articles span the broad spectrum of topics in the linked disciplines of nautical research and ship model building. The NRG also holds an annual conference and operates the Model Ship World online community.

For more information about the Nautical Research Guild, including membership options, visit http://www.thenrg.org.

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