Cleaner Technologies Substitutes Assessment Case Studies: Foam Fabrication

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Bulletin Contents

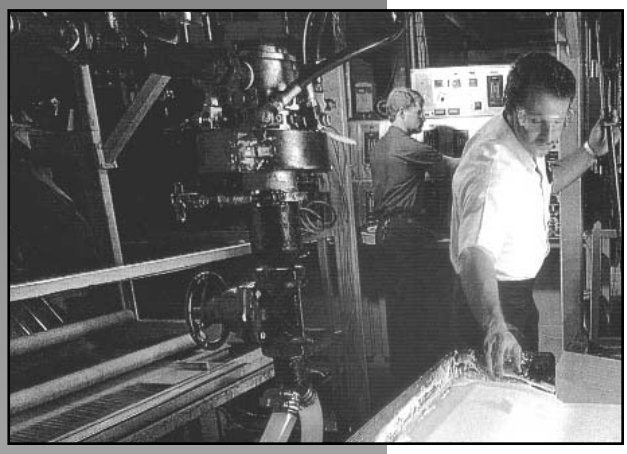
Alternatives to Chlorinated Solvent Adhesives in the Foam Fabrication Industry

The Institute for Research and Technical Assistance (IRTA), a nonprofit organization located in Santa Monica, California, analyzed the cost and performance of alternative adhesive technologies used by the furniture and sleep products industries. This project was sponsored by the U.S. EPA with a grant from the Design for the Environment (DfE) Program. The Cleaner Technologies Substitutes Assessment (CTSA) is a partnership with industry including Southern California Edison (SCE) and the Association of Woodworking & Furnishings Suppliers® (AWFS®).

Industry Description

Flexible slabstock polyurethane foam is produced by 23 companies in about 75 pouring plants in the United States. In 1977, approximately 830 million pounds of slabstock foam were produced. By 1998, slabstock foam production doubled to about 1.6 billion pounds.

Flexible slabstock foam is fabricated (cut and shaped) into pieces to be used in carpet underlay, furniture, bedding, packaging, transportation



Flexible slabstock foam manufactured at a pouring plant.

seating, and other products where a durable and resilient cushioning material is required.

Many foam manufacturers are vertically integrated and have on- or off-site foam fabrication operations using the foam stock they manufacture. Flexible foam manufacturers fabricate about half of the foam produced in their own facilities. The other half is purchased by independent fabricators who cut and shape it into various products. There are approximately 350 foam fabrication plants in the United States. All foam fabricators perform fabrication services for other companies that manufacture bedding, upholstered furniture and other products.

Some of the foam is fabricated using adhesives and some is not. In many cases, the foam requires a particular shape or a particular feel. During fabrication, several different densities of foam or other materials, like polyester fiber, are bonded together to form a particular shape with specific characteristics. The foam used in sofa arms, for example, does not require adhesive because it has the proper shape and density. In contrast, pieces of foam are cut then bonded together with adhesive to achieve the proper shape for sofa seat cushions. It is estimated that about one-third of the foam used in furniture manufacture and five percent of the foam used in bedding manufacture requires adhesive in the fabrication operation.

Adhesive Alternatives

In the 1980s and early 1990s, most of the adhesive used by foam fabricators was based on 1,1,1-trichloroethane (TCA), a chlorinated solvent. TCA was an effective carrier for the adhesive because it evaporates rapidly leaving an instant bond, it is fairly low in toxicity, it does not have a flash point, and it is not classified as a Volatile Organic Compound (VOC) that contributes to photochemical smog.

In the 1990s, TCA was designated as a class one ozone depleting substance and, in 1996, its production was banned for that reason. Although TCA inventory was still available, the chemical had become very expensive because of a Federal tax on ozone depleting substances. Virtually all adhesive formulators stopped making TCA adhesives and began offering adhesives based on methylene chloride (METH), also a chlorinated sol-

About IRTA

IRTA is a nonprofit organization established in 1989 to assist companies in adopting low- and non-solvent technologies. IRTA provides technical assistance in general and precision cleaning, drycleaning, paint stripping and coating, adhesive and ink operations.

vent. Like TCA, METH evaporates quickly, does not have a flash point and is not classified as a VOC. However, METH is a suspected carcinogen. In 1997, the Occupational Safety and Health Administration (OSHA) issued a regulation on METH that lowered the worker exposure level from 500 ppm to 25 ppm measured as an 8-hour time weighted average. The regulation also set an action level at 12.5 ppm. Companies with worker exposure above that level are required to institute monitoring and medical surveillance. The regulation was effective for foam fabricators with more than 150 employees in April, 1999 and for fabricators with less than 150 employees in April, 2000. Many foam fabricators have converted to alternative adhesives because they do not believe they can meet the new worker exposure levels for METH. Other fabricators are testing alternatives and still others have not done anything to address the changing regulatory requirements. A few fabricators plan to continue using METH adhesives.

In the early 1990s, the formulators developed one-part and two-part water-based adhesives and many foam fabricators, particularly in Southern California, began testing them. In Southern California, METH is classified as a toxic and could not be used when the formulators stopped using TCA adhesives. The early one-part water-based adhesives were based exclusively on natural latex and they did not bond instantly like the solvent-based adhesives. The two-part adhesives were difficult to use in equipment but did bond instantly. Because they were much more expensive than the one-part adhesives, however, the foam fabrication industry did not adopt them. At this stage, new one-part water-based adhesives composed of natural latex and a small amount of synthetic polymers are available. These adhesives bond much more rapidly than the older one-part adhesives that are based exclusively on latex. Many California foam fabricators have converted to these new one-part latex/synthetic water-based adhesives.

Another alternative is an adhesive based on acetone, a non-chlorinated chemical. Acetone is low in toxicity and like TCA and METH, readily evaporates leaving a quick bond. It does have a very low flash point, however, and measures must be taken to minimize the chance of fire or explosion. The National Fire Protection Association (NFPA) has rated acetone as an NFPA 704 level 3 flammability hazard. State building codes and fire codes are based on NFPA guidelines. The codes vary according to loca-

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New one-part latex/synthetic waterbased adhesives bond more rapidly.

About SCE

SCE, the flagship of the Edison International family of companies, is the nation's second largest investor-owned electric utility company. Central to the growth of the region's economy, SCE continues its decades-old commitment to assist businesses seeking to start, expand, or relocate to its service territory.

About AWFS®

AWFS® was incorporated to fulfill a major need to represent the interests of companies and individuals who supply the home and institutional furnishings manufacturing industries. Today, AWFS® has an international membership that includes manufacturers and distributers of machinery, hardware, lumber, upholstery materials, bedding, wood products and other supplies to furniture and cabinet manufacturers.

tion and local fire departments have regulations that affect the amount of the adhesive that can be stored, require explosion-proof motors and high air flow ventilation systems. Some formulations based on acetone also contain other chemicals like heptane, hexane, and mineral spirits. The other chemicals in these formulations are classified as VOCs.

Another alternative is an adhesive based on n-propyl bromide (nPB). This chemical, like TCA and METH, evaporates readily and has no flash point. It has unknown but likely high toxicity. nPB is structurally similar to other brominated chemicals that are carcinogens or have reproductive toxicity problems. nPB-based adhesives used by fabricators contain some 2-bromopropane (2-BP) as a contaminant. 2-BP is toxic and has caused reproductive problems in Korean workers. nPB is currently classified as a VOC and it also contributes to stratospheric ozone depletion. OSHA and the National Institute for Occupational Safety and Health (NIOSH) have nominated nPB and 2-BP for carcinogenicity and reproductive toxicity testing.

In Southern California, VOC regulations are very stringent and fabricators cannot use adhesives based on nPB or the acetone adhesives blended with other chemicals. In most cases, California fabricators have adopted one-part water-based or acetone-based adhesives. In other parts of the country, North Carolina in particular, where VOC regulations are less stringent, many fabricators, especially small ones, are adopting nPB-based adhesives. A few are adopting the acetone adhesives that contain other chemicals and very few have converted to water-based adhesives.

Fabricators that wish to continue using METH-based adhesives have to purchase and install effective ventilation systems that reduce the worker exposure to the legal OSHA limit. Fabricators that wish to use acetone adhesives must also install ventilation systems to ensure that the acetone concentration is below the lower explosion limit of the chemical. Fabricators that are converting to nPB adhesives are installing ventilation systems to reduce the worker exposure to a potentially toxic chemical. Fabricators adopting one-part water-based adhesives generally install a ventilation system; the water-based systems produce aerosol particulates that can be removed from the workplace with the ventilation system. In effect, fabrication facilities that select any one of the alternative adhesives must expect to install a ventilation system.

Characteristics of Alternatives

Adhesive	Classified as VOC	Toxicity	Ozone Depleter	Flash Point	Issues
1,1,1-Trichloroethane	No	Medium	Yes	No	Production banned
Methylene Chloride	No	High	No	No	Heavily regulated
n-Propyl Bromide	Yes	Likely high	Low	No	Unknown but likely high toxicity
Acetone	No	Low	No	Yes	Fire regulations
Acetone Blends	Yes	Some high	No	Yes	Fire regulations
Water-Based	No	Low	No	No	Forms aerosols

Foam Fabricator Helps Push Water-Based Adhesive Technology

"The ban on TCA was a good thing. It forced us to examine our process and find a better alternative for workers and the environment," says Bob Nylander.

Foam Craft Inc., located in Cerritos, California, employs 160 people. The firm started operation in 1965 and was bought by Future Foam, a flexible slabstock foam manufacturer, in 1994. Foam Craft fabricates foam for use in packaging, furniture and bedding. Products like futons, recreation vehicles, trucks, tractors and dog beds use the foam fabricated by Foam Craft.

Several years ago, like most of the industry, Foam Craft used methylene chloride (METH)-based adhesives for bonding foam-to-foam in their fabrication operations. Because of air regulations put in place by the South Coast Air Quality Management District, Foam Craft converted their processes from METH to 1,1,1-trichloroethane (TCA)-based adhesives. Like other companies in Southern California, Foam Craft used TCA-based adhesives until the cost of the chemical became prohibitive. TCA contributes to stratospheric ozone depletion and production was banned in 1996. A Federal tax placed on the chemical made it extremely expensive to use.

"We have completely converted to water at this stage," says Bob Nylander, Foam Craft's plant manager. The company began investigating water-based adhesive alternatives about six years ago when it became clear that TCA would be phased out. At that time, the water-based products were new to the market and Foam Craft went through a long learning curve to optimize their use. Foam Craft and the vendors, in a partnership, were able to solve all the problems that arose during a long testing phase.

Foam Craft emerged as one of the industry pioneers for water-based foam bonding

adhesives. The company spent two years of intensive testing to determine the best methods of using the new adhesives. They began work with a one-part adhesive made by Upaco. Foam Craft found that the adhesive did not dry as fast as the solvent-borne adhesives so they tested different application techniques. Instead of spraying two pieces of foam and putting them together for an instant bond, the workers now spray a stack of foam pieces and then join them. Worker application time is virtually identical now to what it was before the conversion.

Foam Craft had to work out several other problems over the two-year period. They had difficulty developing an adhesive feed system for their eight stations that had a total of 32 spray booths and guns. Going to a gravity feed system eliminated shearing issues.

They also found that at first they used about 1.6 times more of the water-based adhesive than the solvent-borne adhesive. With experience, they were able to optimize the application process and now they use about three-fourths as much of the water-based adhesives. This reduction in materials use means that the cost of doing business for Foam Craft was reduced by the switch to water-based adhesives.

Foam Craft is now testing new water-based products to see if they can reduce their costs further. The company is also investigating new cutting processes that could help eliminate some of the requirements for adhesive use altogether.

"The ban on TCA was a good thing. It forced us to examine our process and find a better alternative for workers and the environment," says Bob Nylander. "We've provided information to the other Future Foam plants in the country. They are planning to use our example to convert now that methylene chloride can't be used. We're investigating other methods to reduce our costs further."

Prestige Evaluates Several Glue Technologies

"I think we'll go with acetone glues," says Joe Wingfield. "Acetone is flammable, but it has low toxicity and the glues perform well."

Prestige is one of the largest foam fabricators in North Carolina. The company also manufactures polyurethane slabstock foam in Asheboro. About 80 percent of the foam the company manufactures is used in the fabrication operation and 20 percent is sold to other firms.

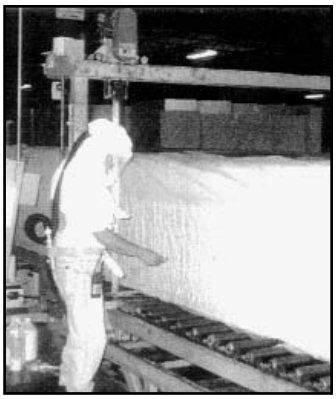
The foam pouring and fabrication operations were located in the same building until recently; the foam fabrication now takes place in a separate 200,000 square foot facility. Prestige does fabrication for a variety of furniture manufacturers. Adhesive is used to bond the foam-to-foam in the fabrication operation. The company also manufactures sleeper mattresses for sofa beds but, in this case, has found that lifetime testing results are better with sewing for those products.

Prestige produces thousands of styles and sizes of cut foam, pillows, sleeper mattresses, and garnetted fiber.

Prestige has a very large fabrication operation with 30 gluing stations. The company has 250 employees and about 40 of them apply adhesive. In 1991, the company used a 1,1,1-trichloroethane (TCA)-based adhesive. Prestige started evaluating alternative technologies when it became clear that TCA production would be banned because of the chemical's contribution to ozone depletion.

The company converted to a one-part water-based adhesive and has been using it for several years. They also used a two-part water-based adhesive for critical bonding

In 1983 Prestige began manufacturing its own foam.



The fabricated foam is cut, buffed, glued, labeled, and prepared for shipment.

applications on furniture arms, ears, seams and other complex parts. "We never liked the performance of the water-based glue," says Danny Sykes, General Manager at Prestige. "It took four to six weeks for the workers to learn to spray the water-based glues and six to eight weeks to get their speed up," he says. The company purchased and installed 30 spray booths when they converted from TCA to the water-based adhesives.

Recently, the company began using an n-propyl bromide adhesive on the line where they used the two-part water-based glue. The two-part adhesives are very costly to maintain. "We like the performance of the n-propyl bromide glue but are concerned about possible regulation," says Joe Wingfield, President of Prestige.

The company has also evaluated the costs of acetone-based adhesives and is considering using them. "I think we'll go with acetone glues," says Joe Wingfield. "Acetone is flammable but it has low toxicity and the glues perform well. The cost of using acetone glues is also lower than the cost of using the n-propyl bromide products."

Annual Cost Comparison for Prestige

Cost	One-Part Water-Based	Two-Part Water-Based	Acetone Adhesive	n-Propyl Bromide Adhesive
Capital Cost	$11,182	$11,182	$12,160	$11,182
Adhesive Cost	$656,250	$1,356,000	$218,700	$656,100
Labor Cost	$720,000	$720,000	$720,000	$720,000
Maintenance Cost	$3,780	$7,200	$3,780	$3,780
Electricity Cost	$2,160	$2,160	$2,160	$2,160
Training Cost	$1,080	$1,080	$1,080	$1,080
Total Cost	**$1,394,452**	**$2,097,622**	**$957,880**	**$1,394,302**

Santa Fe Springs Foam Fabricator Converts to Water-Based Adhesives

"We did a lot of testing and converted away from solvent-based adhesives entirely," Roger Coffey says. "The water-based adhesives work effectively and they are better for the workers and the community."

Latex International, a large manufacturer of latex foam, has two manufacturing plants worldwide. The company has a fabrication plant in Santa Fe Springs, California with 50 employees where they fabricate foam used primarily in the bedding industry.

In the 1980s, like other companies in the country, Latex International used methylene chloride-based adhesives in their fabrication operation. More recently, as methylene chloride was more heavily regulated by the local air district, the company converted to an acetone-based adhesive. Latex International did not want to continue to use solvent-borne adhesives and initiated work on water-based products. Today, the company is exclusively using water-based adhesives.

The latex foam cores that are used in mattresses are manufactured in Latex International's plant in Conneticut. The ingredients are poured into molds of various types. Two twin molded cores are glued together to form a king sized core. The plant in Santa Fe Springs receives latex foam cores from the Conneticut plant and bonds two types of foam products. In one operation, latex is bonded to latex to form the foam core of a high end mattress. The latex foam takes the place of springs that are commonly used in lower end mattresses. The company also uses glue to attach aluminized "cigarette tape" to the edges of the mattress to prevent cigarette fires. In the second operation, Latex International uses

Latex is bonded to latex to form the foam core of a high-end mattress.

adhesives to bond "racetracks" which are smaller cores of latex foam with an outer perimeter of polyurethane. These cores are used in less expensive bedding.

In the polyurethane foam-to-latex operation, Latex International uses a one-part latex water-based adhesive which does not have an immediate tack. In the latex-to-latex operation, a different one-part water-based adhesive which has a shorter tack time is used. The latex is less porous than polyurethane foam so a faster tack adhesive is required.

Says Ron Bruneau, Plant Manager at Latex International West, "our adhesive use has been reduced by about 30 percent since we converted from acetone to water-based adhesives." The cost of using the water-based adhesives is roughly the same as the cost of the acetone adhesives. "We are testing other water-based adhesives to see if we can lower our costs," says Ron Bruneau.

Roger Coffey, President of Latex International West, is pleased with the conversion and continued work to find lower cost adhesives. "We're an environmentally conscious company. "We did a lot of testing and converted away from solvent-based adhesives entirely," he says. "The water-based adhesives work effectively and they are better for the workers and the community."

Annual Cost Comparison for Latex International

Cost	Acetone Adhesive	Water-Based Adhesive
Capital Cost	$400	—
Adhesive Cost	$34,188	$27,360
Labor Cost	$196,000	$196,000
Maintenance Cost	$490	$372
Electricity Cost	$1,440	$1,440
Training Cost	—	$470
Regulatory Cost	$352	$352
Total Cost	**$232,870**	**$225,994**

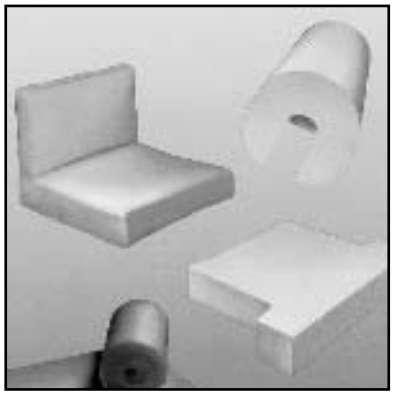
Hickory Springs Decides on Acetone

"Acetone is low in toxicity and it's as effective as METH as a blowing agent and in the glues," says Bobby Bush. "We think it's the best overall solution."

Hickory Springs is a major manufacturer of flexible slabstock polyurethane foam. The company has six pouring plants in the country, including Conover, North Carolina and City of Commerce in California. The foam is used in diverse applications like packaging, bedding, furniture and recreational vehicles.

In addition to manufacturing the polyurethane foam, Hickory Springs also has a number of fabrication operations. The company has fabrication operations in all of their foam pouring plants; in addition, Hickory Springs owns about 30 separate fabricating companies. About half the foam the company produces is used in their own fabrication operations. In all, the company has about 2,000 employees who manufacture and fabricate foam.

Hickory Springs historically used methylene chloride (METH) as an auxiliary blowing agent in their slabstock foam production operations. Because of more stringent toxic regulations on METH, the company began investigating alternatives in the early 1990s. In 1993, Hickory Springs patented a new blowing agent process that used acetone as



The foam is used in diverse applications including packaging, bedding, furniture, and recreational vehicles.

the auxiliary blowing agent in foam manufacture in place of METH. A few years, later, when acetone was deemed exempt from VOC regulations, the company converted all of their pouring plants from METH to acetone.

Like other companies, Hickory Springs used TCA-based adhesives in the early 1990s. When the production ban on TCA was announced and the price of TCA increased, the company converted to METH-based adhesives for their fabrication operations.

In 1990, the pouring plant in City of Commerce used TCA-based adhesives. From 1991 to 1998, the company decided not to continue fabrication at that site. In 1998, the company decided to reenter the fabrication market. At that stage, METH was heavily regulated by the local air district and Hickory Springs investigated and adopted water-based adhesives. "We tried for about a year to make the water-based adhesives work for us but we were unsuccessful," says Steve Isenhour, Plant Manager at the City of Commerce plant. "We're using acetone adhesives now and we've had no problems," he says.

When the Occupational Safety and Health Administration (OSHA) regulated METH more stringently, Hickory Springs decided to convert away from METH in their fabrication operations throughout the country. In the Conover plant, the company converted to water-based adhesives for a short time. In 1998, the company began testing acetone-based adhesives in their fabrication operation at the pouring plant. "The company was very familiar with acetone because it was used as a blowing agent in our pouring plants," says Bobby Bush, Vice President of the Foam Products Division at Hickory Springs. "People are nervous about acetone because of its combustibility," he remarks. "Our insurance rates did not go up; we had to install a ventilation system but we would have had to do that with water or METH adhesives too."

The Conover plant has 16 stations where adhesive is applied. With the conversion to acetone, the company installed ventilation systems that collect from the floor at 11 of the stations; at the remaining five stations, a fan pulls the air outside. At the City of Commerce plant, which has a much smaller fabrication operation, the company has always had one spray booth and no additional ventilation was necessary for the conversion to acetone adhesives.

In the Conover plant, the company uses an adhesive formulation that is a blend of acetone and heptane. In the City of Commerce plant, the company uses a straight acetone-based adhesive because of the more stringent local air district regulations on VOCs. "Acetone is low in toxicity and it's as effective as METH as a blowing agent and in the glues," says Bobby Bush. "We think it's the best overall solution."

At the City of Commerce plant, the company reduced their costs in converting from

water-based to acetone adhesives. The company's production efficiency is much greater with the acetone-based adhesive. The table below shows that the production adjusted cost of using acetone adhesives is about 43 percent less than the cost of using the water-based adhesives.

Annual Cost Comparison for Hickory Springs, Conover Plant

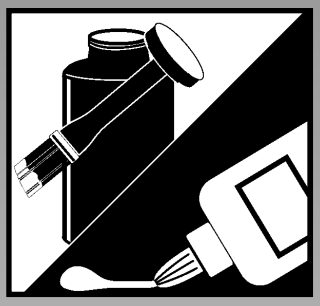
Cost	METH Adhesive	Acetone Adhesive
Capital Cost	—	$1,793
Adhesive Cost	$55,000	$66,000
Labor Cost	$288,000	$288,000
Maintenance Cost	$2,403	$2,403
Electricity Cost	—	$1,260
Total Cost	**$345,403**	**$359,456**

Annual Cost Comparison for Hickory Springs, City of Commerce Plant

Cost	Water-Based Adhesive	Acetone Adhesive
Capital Cost	—	$100
Adhesive Cost	$7,560	$7,800
Labor/Maintenance Cost	$23,833	$15,889
Electricity Cost	$215	$143
Total Cost	$31,608	$23,932
Production-Adjusted Total Cost	**$31,608**	**$17,949**

About the Design for the Environment (DfE) Program

The Design for the Environment (DfE) Program is a cooperative effort between the Environmental Protection Agency (EPA), industries, research institutions, environmental/public interest groups, and other government agencies. Working with these partners, the DfE program identifies cost-effective alternatives to existing products and processes that reduce risks to workers and the environment while maintaining or improving performance and product quality. Through the DfE program, EPA encourages businesses to incorporate environmental considerations into their products, processes, and technical and management systems. To help industry implement some of the ideas and technologies identified, the DfE program has published a number of case studies of companies which have found that environmental improvements can also lead to economic benefits. The case studies encourage other vendors, as well as other businesses, to learn from these environmental successes and adapt the techniques to their own processes.



Check Out DfE's Adhesives Web Site:

http://www.epa.gov/opptintr/dfe/adhesive/adhesive.html

For More Information

To obtain additional copies of this or other case studies, or for more information contact:

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