

**Methylene Chloride Consumer Product Paint Strippers: Low-VOC, Low Toxicity  
Alternatives**

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## EXECUTIVE SUMMARY

Methylene chloride (METH) is a carcinogen. The chemical is classified as a Hazardous Air Pollutant (HAP) by U.S. EPA. It is also classified as a Toxic Air Contaminant (TAC) in California. METH is listed on Proposition 65 and is a listed hazardous waste under the Resource Conservation and Recovery Act (RCRA).

The California Air Resources Board (CARB) estimates that emissions of METH from consumer product strippers amount to 9.68 tons per day. METH based strippers are also used by companies that offer stripping services to consumers. The METH strippers pose a cancer risk to workers and consumers in California.

IRTA is a nonprofit organization that tests and demonstrates low-Volatile Organic Compound (VOC), low toxicity alternatives in a variety of different industries. DTSC contracted with IRTA to identify, test, develop and demonstrate alternative non-METH stripping formulations in consumer product applications. The aim of the project was to find safer alternative non-METH strippers that minimized the increase in VOC emissions.

This project involved testing alternative non-METH stripping formulations in four sectors including:

- large furniture stripping companies that use equipment to apply stripper;
- small furniture stripping companies that apply stripper by hand;
- contract stripping companies that strip on-site and apply stripper by hand; and
- consumer stripping where consumers apply the stripper by hand.

Benco Sales, a stripper and equipment supplier, assisted IRTA in the project by developing alternative non-METH stripping formulations that could be tested in the four sectors.

The alternative non-METH stripping formulations that worked most effectively in all four sectors contain benzyl alcohol as the active ingredient. IRTA conducted a cost comparison of METH based stripping formulations and the alternative benzyl alcohol stripping formulations for large furniture stripping companies and for consumer stripping. The cost of using the most effective alternative in large furniture stripping companies is comparable to the cost of using the high METH content stripper most widely employed today. The cost of using the most effective alternative in consumer stripping is lower than the cost of using the METH strippers sold at hardware and paint supply stores.

The Department of Health Services Hazard Evaluation System & Information Service (HESIS) evaluated and compared the toxicity of the METH strippers used most widely today and the alternative non-METH strippers tested in this project. HESIS concluded that the alternative stripping formulations, which contain benzyl alcohol, are generally much safer for workers and consumers than the METH based strippers.

The South Coast Air Quality Management District (SCAQMD) regulates the VOC and toxic emissions from furniture stripping facilities. The alternative strippers tested during

this project meet the District requirements for stripping formulations. CARB regulates the VOC and toxic content of consumer product strippers in California. The most effective alternative consumer product strippers tested during this project meet the definition of an Low Vapor Pressure (LVP) material which indicates that CARB does not classify it as a VOC.

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## I. INTRODUCTION AND BACKGROUND

The California Air Resources Board (CARB) estimates that emissions from consumer product paint strippers amount to 16.72 tons per day. Emissions of methylene chloride (METH) from these paint strippers are 9.68 tons per day and emissions of VOC solvents from these paint strippers are 7.04 tons per day. Many of the stripping products are blends of METH and VOC solvents. Some of the stripping products may contain only VOC solvents and no METH.

The component of most concern in consumer product paint strippers is METH. The chemical is a suspect carcinogen. It is classified as a Hazardous Air Pollutant (HAP) by U.S. EPA and as a Toxic Air Contaminant (TAC) by the state of California. METH is a listed hazardous waste under the Resource Conservation and Recovery Act (RCRA). The chemical does not contribute to photochemical smog and has been deemed exempt from VOC regulations by U.S. EPA and the state of California.

The Institute for Research and Technical Assistance (IRTA) is a nonprofit organization established in 1989. IRTA works with companies and whole industries to identify, test, develop and demonstrate low-VOC, low toxicity solvent alternatives. Cal/EPA's Department of Toxic Substances Control (DTSC) contracted with IRTA to test and demonstrate alternatives to METH based consumer product strippers. This document presents the results of the analysis and testing.

### PREVIOUS RELATED WORK

Over the last several years, IRTA conducted four projects that are related to the current project. The first project, sponsored by the South Coast Air Quality Management District (SCAQMD), involved performing a survey of furniture stripping facilities in the South Coast Basin and determining their stripping practices and the quality of their ventilation systems. The second project, sponsored by the National Institute for Occupational Safety and Health (NIOSH), involved testing alternative low-METH content stripping formulations and designing, installing and testing high air flow ventilation systems to determine if they could effectively reduce worker exposure to METH strippers. The third project, sponsored by CARB, was designed to work with furniture stripping companies to investigate methods of reducing the risk of METH based strippers to the surrounding community. As part of that project, alternative low-METH content strippers were tested. The fourth project, sponsored by SCAQMD, involved limited testing of a few non-METH stripping formulations in furniture stripping facilities. No work has been performed to date on alternative consumer product strippers.

### CHARACTERISTICS OF PAINT STRIPPING

The most widely used paint strippers rely on METH as the active ingredient. The results of the earlier work indicated there may be as many as 80 facilities in California that have stripping equipment and use relatively large quantities of stripper. These companies generally purchase their stripper from suppliers that provide the stripper in quantities ranging in size from five gallon pails to 55 gallon drums. There are also companies in the

state that provide on-site services to consumers for stripping kitchen cabinets or to offices for stripping wood cabinets; these facilities use the stripper to strip in place. The stripping companies purchase their strippers from paint supply or hardware stores. There are probably some 500 additional facilities in the state that do some stripping as part of their business; typical facilities would include antique shops. These facilities purchase small quantities of stripper from hardware or paint supply stores. Consumers also purchase strippers from paint supply and hardware stores.

The SCAQMD began developing a regulation on METH furniture stripping facilities several years ago. The large furniture stripping facilities in the South Coast Basin that applied stripper with equipment believed it would be unfair to regulate their operations when small facilities that strip by hand could still purchase METH based strippers from paint supply and hardware stores and these operations would not be regulated. It is important to find alternative non-METH stripping formulations that can be used by large furniture stripping companies who purchase stripper from suppliers and by companies and individuals who purchase consumer product strippers. During this current project, IRTA focused on testing non-METH strippers in a comprehensive way. The structure of the tests was designed to find alternative non-METH strippers for:

- large furniture stripping firms that apply stripper with equipment;
- small furniture stripping firms that apply stripper by hand;
- contractors that provide stripping services to consumers and offices; and
- consumers that strip wood items by hand.

The items that are commonly stripped using consumer product paint strippers are made of wood and, less often, metal. A variety of coating types must be stripped using these stripping formulations. Stripping effectiveness is determined by the ability of a stripping formulation to strip the coating and the wood or metal type is comparatively unimportant.

The most common type of wood coating that requires stripping today is the conventional solventborne coating. This type of coating represents more than 50 percent of the coatings that require stripping by furniture strippers. Between 20 and 30 percent of the coatings encountered are conventional clear varnishes which include shellacs. Cross-linked clear finishes that also fall into this category have begun to be used over the last 15 or 20 years. Waterborne latex and acrylic coatings and high performance cross-linked pigmented and clear coatings account for the remaining 15 to 20 percent of the finishes encountered by furniture strippers today. The same types of coatings are likely to be encountered by on-site contractors and by consumers. The characteristics of metal coatings are likely to be similar. The most commonly encountered metal coatings are probably traditional solventborne coatings. Waterborne coatings and powder coatings probably account for a small percentage today. The cross-linked, powder and waterborne coatings that are more difficult to strip will be increasingly used in the future because of more stringent coating VOC regulations.

## PROJECT ALTERNATIVES STRATEGY AND FINDINGS

IRTA worked with a stripper supply company, Benco Sales, during this project to test alternative non-METH stripping formulations. Benco Sales formulated a variety of

different alternatives for the different stripping applications and these were tested for effectiveness. For furniture stripping companies with equipment and contractors who strip on-site, it was assumed that a stripper needed to strip relatively quickly. In contrast, for furniture stripping companies without equipment and consumers who strip items at home, it was assumed that strippers need not strip quickly.

During this project, IRTA tested and compared baseline and alternative non-METH strippers with two large furniture stripping firms that use equipment for stripping. IRTA also tested baseline and alternative strippers at the furniture stripping companies where the strippers were applied by hand. These tests represented stripping by small furniture stripping companies and by consumers. IRTA tested baseline and alternative strippers with one contractor who strips on-site. Finally, IRTA tested baseline and alternative strippers on wood and metal panels containing coatings that consumers commonly encounter today and coatings that consumers could encounter in the future.

Some of the non-METH alternative strippers on the market today contain ingredients that have other toxicity problems. As an example, some stripping formulations contain n-methyl pyrrolidone (NMP) which is a reproductive and developmental toxin. IRTA tested two NMP strippers available on the market today for the consumer hand stripping application. Many of the non-METH stripping formulations are classified as VOCs so that conversion to these alternatives would increase VOC emissions. The aim was to formulate alternative strippers that did not contain other toxic materials like NMP and that had as low a VOC content as possible.

The results of the tests indicate that alternative non-METH strippers are available that can effectively strip items for consumer product applications and for large furniture stripping facilities that strip with equipment. The most effective and safest alternative stripping formulations contain benzyl alcohol. This chemical is classified as an LVP solvent in CARB's consumer product regulations meaning it is not considered to be a VOC.

## STRUCTURE OF DOCUMENT

Section II of this document describes the stripping process for large furniture stripping facilities that use equipment, contractors that strip on-site and smaller furniture strippers and consumers that apply stripper by hand. Section III includes a detailed description of the formulations and the stripping tests that were conducted to determine the effectiveness of the alternative strippers. Section IV provides a cost analysis and comparison for the METH and non-METH strippers for large furniture stripping companies and consumer stripping applications. Section V discusses and compares the environmental characteristics and the toxicity of the METH based and alternative stripping formulations. Finally, Section VI provides a summary of the results of the testing.

## II. CHARACTERISTICS AND DESCRIPTION OF STRIPPING FORMULATIONS AND STRIPPING PROCESSES

This section presents detailed information on the METH based stripping formulations that are commonly used today and the procedures that are used for stripping by large furniture stripping facilities that use equipment, contractors that perform on-site stripping and small furniture stripping facilities and consumers that strip by hand.

### LARGE AND SMALL FURNITURE STRIPPING FIRMS

The use of stripper varies widely from firm to firm. Table 2-1 provides estimates of stripper usage for the industry using the assumption that there are 248 firms that perform stripping in the South Coast Basin and twice that number in the state. The values for the South Coast Basin were determined from a survey that was conducted in one of IRTA's earlier projects sponsored by SCAQMD. The survey results indicated that 248 firms in the Basin used METH formulations for stripping. An estimated two or three of the largest strippers use more than 1,200 gallons of stripper per year. An estimated 15 strippers use between 700 and 1,200 gallons of stripper annually. About 20 strippers use between 200 and 700 gallons per year. The smallest strippers, about half of the firms in the Basin, use less than five gallons of stripper per year. The remaining 86 strippers use between five and 200 gallons of stripper per year. The stripping firms that use more than about 200 gallons per year are likely to purchase stripper from suppliers; the stripping firms that use less than 200 gallons per year purchase stripper from suppliers or from paint supply or hardware stores. The firms that use less than five gallons of stripper annually purchase stripper from hardware or paint supply stores.

**Table 2-1  
Estimated Annual Stripper Usage by Furniture Stripping Facilities**

Annual Stripper Usage (gallons per year)	Number of Firms in South Coast Basin	Number of Firms in California
1,200 - 2,000	3	6
700 - 1,200	15	30
200 - 700	20	40
5 - 200	86	172
< 5	124	248
Total	248	596

About half the people in California live in the South Coast Basin. Assuming that the South Coast Basin accounts for about half the stripping companies in the state, the statewide distribution might be expected to be similar. On this basis, there may be as many as 496 stripping facilities in California. Accordingly six of those stripping facilities use between 1,200 and 2,000 gallons of stripper annually and 40 stripping facilities use between 700 and 1,200 gallons per year. The vast majority of the stripping facilities use less than five gallons of stripper per year.

A Material Safety Data Sheet (MSDS) for a METH based stripper used by many of the large furniture stripping facilities that use equipment is shown in Appendix A. This stripping formulation, called Benco #B7 Industrial Paint Remover, contains METH (dichloromethane), methanol and small amounts of glycol ethers, wetting agents and wax. The stripper contains wax to prevent the METH, which has a very high vapor pressure, from being emitted immediately; it holds the stripper on the surface of the part. The stripper contains wetting agents because it is generally rinsed from the part after stripping.

Figure 2-1 shows a picture of a typical flow tray, the equipment used by the larger furniture stripping facilities to apply the stripper to parts. It is a sloped shallow tank eight feet long and four feet wide with a drain at the lower end. The stripper is pumped through a brush from a five gallon container. The item to be stripped is placed in the tray and the worker moves the brush over the part vigorously. At times, it is necessary to scrape the item to completely remove the coating.



Figure 2-1. Typical Flow Tray

When the worker is finished stripping the item, it is transferred from the flow tray to the water wash booth. A picture of a typical water wash booth is shown in Figure 2-2. High pressure wands containing water and oxalic acid are used to rinse the remaining stripper and coating residue from the item. The oxalic acid is used to brighten the wood surface.

Small furniture stripping firms do not use equipment for stripping. Rather, they apply the stripping formulation to the parts by hand. The #B7 stripper has low viscosity so it can be pumped through the pumps in the flow tray. The strippers used by smaller firms that are applied by hand are often more viscous so they will remain on the part long enough to strip the coating. The parts are generally rinsed off with water to remove the stripper and the paint residue.

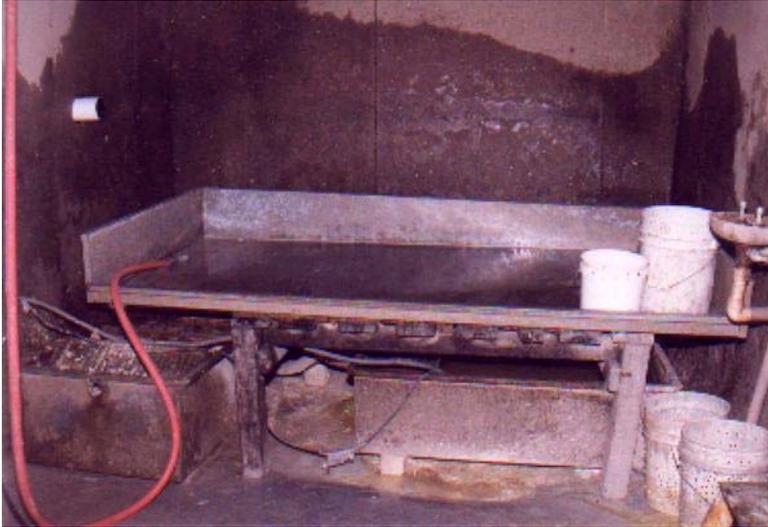


Figure 2-2. Typical Water Wash Booth

An MSDS for a typical stripper used for hand stripping by the industry is shown in Appendix A. This stripping formulation, called Benco #B4 Industrial Paint Remover, is used by some smaller stripping firms and by some contractors that perform on-site stripping. Like #B7, this stripping formulation contains METH, methanol, a glycol ether, a wetting agent and wax. It also contains a cellulose compound that thickens the formulation for hand stripping. Another typical stripping formulation used by small furniture stripping companies that can be purchased in a paint supply or hardware store is made by Jasco and is called Premium Paint & Epoxy Remover. An MSDS for this stripper is shown in Appendix A. Like #B7 and #B4, it contains a high concentration of METH and methanol.

### CONTRACTORS THAT PERFORM ON-SITE STRIPPING

There is no information on how many California firms there are that perform on-site stripping. Some of the large furniture stripping firms perform on-site stripping. Many painting contractors that provide painting services to consumers and offices likely also perform on-site stripping.

Kitchen cabinets are often stripped by on-site stripping contractors. When large furniture stripping companies perform this service, they remove the cabinet doors and kitchen drawers and take them back to their shops to be stripped. The other kitchen wood is stripped on-site. Wood cabinetry is also stripped by contractors in offices and office buildings. Figure 2-3 shows a picture of a kitchen before being stripped by a contractor.



Figure 2-3. Preparing Kitchen for Stripping

Stripping formulations used by contractors for stripping on-site are generally quite viscous since they must remain on vertical surfaces for a period. The Benco #B4 stripper described above is an example of a METH stripper designed for this type of stripping. An MSDS for another stripper used for this purpose, called Lifteeze Paint & Varnish Remover, is shown in Appendix A. The Lifteeze stripper contains between 35 and 45 percent METH, methanol, acetone and toluene. It has a lower METH content than the Benco #B4 stripper.

### CONSUMER STRIPPING

Consumers purchase stripping formulations in small quantities at paint supply or hardware stores. They generally use the strippers to strip doors, door jambs, kitchen cabinets and various types of wood furniture and, in some cases, metal items. Most of the stripping formulations used historically had fairly high concentrations of METH. As discussed in Section III, there are non-METH alternatives on the market today. These stripping formulations generally need to be more viscous because they are used to strip a variety of items and must be able to be used on vertical surfaces.

The Lifteeze Paint & Varnish Remover discussed above is available in paint supply stores and is likely to be purchased by consumers. The Jasco Premium Paint & Epoxy Remover is another stripping formulation that consumers might purchase in hardware stores. In both of these formulations, METH is the major active ingredient.

### III. ALTERNATIVE STRIPPING TESTS

This section describes the test program IRTA used to determine the efficacy of the alternative stripping formulations. It discusses the test procedure and the test results of the baseline METH strippers and the alternative non-METH strippers.

#### LARGE FURNITURE STRIPPING FIRMS

IRTA worked with two large furniture stripping firms to compare the stripping capability of the METH and non-METH alternative strippers. The two companies, Sunset Strip in Huntington Beach and Strip Joint in Redondo Beach, collected a range of furniture items prior to the stripping tests. The stripping tests were conducted in flow trays.

The baseline stripping formulation for these tests was Benco #B7 Industrial Paint Remover which is the industrial stripping formulation used by most furniture stripping companies with equipment. This formulation, as discussed earlier, contains between 70 and 85 percent METH and eight to 15 percent methanol. The stripping procedure and test results for Sunset Strip and Strip Joint are discussed below.

#### Sunset Strip

Several items were stripped at Sunset Strip with #B7 and three alternative non-METH designed for flow tray stripping. One item was a chest containing three drawers that had a lacquer coating. A picture of the chest is shown in Figure 3-1. A picture of the three drawers before stripping is shown in Figure 3-2. The second item was a mirror frame containing a shellac coating. The third item was a door with a shellac coating. A picture of this item is shown in Figure 3-3. The fourth item was a chair with a white enamel coating. Figure 3-4 shows some of the items in the flow tray.



Figure 3-1. Chest at Sunset Strip



Figure 3-2. Drawers Before Stripping at Sunset Strip



Figure 3-3. Door at Sunset Strip

Some of the items or parts of the items were stripped with #B7 and with three alternative non-METH strippers. One of the alternatives, called #B94 Industrial Paint Remover, was too thick for flow tray stripping and the owner found it difficult to use. An MSDS for this product is shown in Appendix B.

An MSDS for the second alternative, called Benco #B96 Industrial Paint Remover, is shown in Appendix B. This formulation contains 50 to 60 percent benzyl alcohol (called aromatic alcohol on the MSDS), hydroxy benzene and formic acid.



Figure 3-4. Items in Flow Tray at Sunset Strip

An MSDS for the third alternative that was tested, called Benco #B73 Industrial Paint Remover, is shown in Appendix B. This formulation contains 40 to 50 percent benzyl alcohol (called alpha-hydroxy toluene on the MSDS) and 20 to 30 percent of an ester solvent.

The results of the flow tray stripping indicated that #B7 stripped the items more quickly than the alternatives. For instance, the #B7 stripped the drawer with the lacquer coating in five minutes whereas the #B96 stripper took about 15 minutes to strip the similar item. The #B96 also required more rinsing. This is to be expected since the stripper components have lower vapor pressure. An advantage of the #B96 was that it did not require rinsing with the oxalic acid which is used with the #B7. The owner of Sunset Strip stripped the furniture items himself and indicated that the #B96 performed acceptably.

The #B7 also stripped the items more quickly than the #B73 alternative stripper. The owner judged that the #B73 was not as effective as the #B96 alternative stripper. In addition, he indicated that the odor of the #B73 was retained on the furniture items and was difficult to eliminate.

During the testing, IRTA, Benco Sales and the owner observed that less of the alternative low vapor pressure strippers was required than the higher vapor pressure METH stripper. It was estimated that about half the amount of stripper was required. In addition, the participants noted that about twice as much waste was generated when the alternatives

were used because there was less evaporation. The waste generated in stripping operations should be considered hazardous waste because it contains the coating residue.

### Strip Joint

At the Strip Joint, several similar items were collected and stripped in the flow tray with the #B7, the baseline METH stripper, and two alternative stripping formulations, the #B94 and #B96 discussed above. The #B73 was not tested because it was less effective than the #B96 stripper and the odor was strong.

Figure 3-5 shows four of the items after they were stripped with the baseline #B7 stripper. The items that were stripped included a drawer made of mahogany with a lacquer coating, a dental cabinet drawer with multiple layers of a latex coating, a mahogany door with several coats of enamel and an oak drawer and door with a varnish coating. The #B7 stripped all the coatings effectively except the dental cabinet drawer with the latex coating. The worker had to abrade the coating off with a tool.



Figure 3-5. Items After Stripping With #B7 at Strip Joint.

The #B94 alternative stripper stripped the varnish coating and the lacquer coating easily. It did not strip the enamel panel completely in the same time allotted for the #B7 stripper. It did, however, strip the latex coating from the dental drawer which the #B7 was not able to strip. Figure 3-6 shows the items after stripping with the #B94. As was the case at Sunset Strip, the worker judged the #B94 stripper to be too thick for easy flow tray stripping.

The #B96 alternative stripper also stripped the varnish and lacquer coatings easily. It stripped the enamel coating as quickly as the #B7 stripper. This stripping formulation stripped the latex coating on the dental drawer more effectively and quickly than the #B94 and much more effectively than the #B7. Figure 3-7 shows the items after stripping with #B96.



Figure 3-6. Items After Stripping With #B94 at Strip Joint



Figure 3-7. Items After Stripping With #B96 at Strip Joint

The alternative stripper that performed best at the Strip Joint was #B96. It performed better than the #B7 in stripping the latex coating. The owner of the Strip Joint used the #B96 stripper to strip several items in the flow tray at a later date. He indicated that the stripper was acceptable and that it performed effectively as an alternative to #B7.

At Strip Joint, IRTA, Benco Sales and the owner made the same observations about usage and waste generation as at Sunset Strip. About twice as much of the METH stripper, #B7, was required and the alternative strippers generated about twice as much waste.

## CONSUMER HAND STRIPPING

At Sunset Strip and Strip Joint, IRTA conducted tests of alternative strippers that would be provided by suppliers to small furniture stripping facilities without equipment. The results of the tests are discussed below.

### Sunset Strip

At Sunset Strip, IRTA conducted preliminary hand stripping tests with a baseline METH stripper, #B4, and four alternative non-METH strippers. Two of the alternative stripping formulations, called #B74A and #B94A, contain benzyl alcohol and acetone. MSDSs for these strippers are shown in Appendix B. Two other alternative stripping formulations, called #B74 and #B95, contain benzyl alcohol but do not contain acetone. MSDSs for these products are shown in Appendix B.

The items that were hand stripped at Sunset Strip included a bed rail with a shellac coating, a chair with two coats of enamel and a bookcase shelf with a lacquer coating. Figure 3-8 shows a picture of the bed rail with the five strippers applied in the sequence right to left: #B95, #B74, #B74A, #B95A and #B4. The bed rail was checked after three minutes and after six minutes. After three minutes, the #B4 baseline stripper had stripped about 90 percent of the coating. #B95 was the best stripper of the five; it had stripped 100 percent of the coating. #B74 was comparable to the #B4 baseline stripper; it had stripped 90 percent of the coating. The #B74A was less effective; it stripped 70 percent of the coating. The #B95 stripped 85 percent of the coating. Figure 3-9 shows the bed rail after six minutes. #B4, #B95 and #B74 stripped 100 percent of the coating. #B95A stripped an estimated 95 percent of the coating and #B74A stripped only 75 percent of the coating.



Figure 3-8. Bed Rail After Applying Five Strippers at Sunset Strip



Figure 3-9. Bed Rail After Six Minutes at Sunset Strip

Table 3-1 summarizes the results of the bed rail stripping tests. The alternative, #B95, was the best performing stripper followed by #B4, the baseline METH stripper.

**Table 3-1  
Results of Stripping Tests for Bed Rail With Shellac Coating at Sunset Strip**

	Estimated Coating Removal (Percent)				
	#B4	#B95	#B74	#B95A	#B74A
Three Minutes	90	100	90	85	70
Six Minutes	100	100	100	95	75

The lacquer on the bookshelf was easier to strip. The baseline #B4 stripper stripped the coating in about one minute. The #B95 was faster; it stripped the coating in less than one minute. The #B95A stripped the coating in about one minute. The #B74 stripper removed the coating in three minutes but the #B74A stripper did not remove the coating in three minutes. Figure 3-10 shows the bookshelf after stripping. The sequence of strippers is the same sequence as before from right to left: #B95, #B74, #B74A, #B95A, #B4.

Table 3-2 summarizes the results of the stripping tests for the bookshelf. Again, the alternative #B95 performed best followed by the #B4 baseline METH stripper.

**Table 3-2  
Results of Stripping Tests for Bookshelf With Lacquer Coating at Sunset Strip**

	#B4	#B95	#B74	#B95A	#B74A
< One Minute	-	Stripped	-	-	-
One Minute	Stripped	-	-	Stripped	-
Three Minutes	-	-	Stripped	-	-



Figure 3-10. Bookshelf after Stripping at Sunset Strip

The strippers were also tested on a chair with two enamel coats and different results were obtained. After 30 minutes, the #B74, #B74A and #B95A had stripped 100 percent of the coating. The baseline METH stripper, #B4, had stripped 95 percent of the coating and the #B95 had stripped only about 50 percent of the coating.

Table 3-3 shows the results of the stripping for the chair. In this case, the acetone based formulations performed better than the baseline stripper.

**Table 3-3**  
**Results of Stripping Tests for Chair With Two Enamel Coats at Sunset Strip**

	Estimated Coating Removal (Percent)				
	#B4	#B95	#B74	#B95A	#B74A
30 minutes	95	50	100	100	100

The results of the testing indicated that the acetone based strippers did not perform well on the shellac coating but one of them performed well on the lacquer coating. The acetone coatings performed very well, however, on the enamel coating. A hybrid stripping formulation consisting of 80 percent of the #B95 and 20 percent acetone was formulated at the site. This stripper was used to strip the bed rail with the shellac coating, the shelf with the lacquer coating and the chair with the two enamel coatings. The stripper worked effectively on all items.

The results of the hand stripping tests at Sunset Strip indicated that alternative non-METH strippers can effectively strip coatings. This suggests that alternative consumer product stripping formulations could be used by the sector.

## Strip Joint

At the Strip Joint, the same hand stripping formulations were tested on several items including a panel with a lacquer coating, a dental drawer with three coats of latex, a panel with five coats of enamel and a mirror frame with a varnish coating. Figure 3-11 shows the items before the strippers were applied. The same sequence in applying the strippers was used here as at Sunset Strip: right to left, #B95, #B74, #B74A, #B95A and #B4.



Figure 3-11. Items Before Applying Strippers at Strip Joint

After five minutes, all of the stripping formulations stripped 100 percent of the lacquer from the panel and the varnish from the mirror frame.

After 15 minutes, the #B95 and #B95A had removed one of the five enamel coats on the panel. The #B4 had removed three of the coats. After 30 minutes, the #B4 had removed four enamel coats. The #B95 and #B95A had removed two of the five coats. The #B74 and #B74A had not removed even one coat. After 45 minutes, the #B95 had removed 2.3 coats, the #B95A had removed two coats and the #B74 and #B74 A had removed only one coat. After three hours, the #B4 and the #B95 had removed 4.2 coats, the #B74 had removed four coats and the #B74A and #B95 A had removed 2.5 coats. Figure 3-12 shows the panel after three hours.

Table 3-4 summarizes the results of the stripping for the panel. The results show that the #B4 stripped the fastest but that over a long time frame, the #B95 alternative performed as well as the #B4.

**Table 3-4**  
**Results of Stripping Tests for Panel With Five Enamel Coats at Strip Joint**  
Number of Coats Removed

	#B4	#B95	#B74	#B95A	#B74A
15 Minutes	3	1	-	1	-
30 Minutes	4	2	-	2	-
45 Minutes	4	2.3	1	2	1

Three Hours            4.2            4.2            4            2.5            2.5



Figure 3-12. Panel After Three Hours of Stripping at Strip Joint

After 15 minutes, #B4 had taken part of one of the three coats of latex off the dental drawer, the #B95 and #B95A were starting to work on the coatings but the #B74 and #B74A had not worked at all. After three hours, the #B4 had removed all three coats, the #B95 had removed 2.5 coats, the #B95A had removed 1.2 coats, the #B74 had removed 0.3 coats and the #B74A had not removed any of the coating. Figure 3-13 shows a picture of the dental drawer after three hours.



Figure 3-13. Dental Drawer After Three Hours of Stripping at Strip Joint

Table 3-5 shows the results of the stripping tests for the latex coating. The results demonstrate that the #B4 performed best on the coating, followed by #B95.

**Table 3-5  
Results of Stripping Tests for Dental Drawer With Three Latex Coats at Strip Joint**

	Number of Coats Removed				
	#B4	#B95	#B74	#B95A	#B74A
15 Minutes	0.5	-	-	-	-
Three Hours	3	2.5	0.3	1.2	-

The results of the hand stripping at the Strip Joint indicate that all of the stripping formulations can remove certain coatings like lacquers and shellacs. The #B4 METH stripper was somewhat more effective in removing the enamel and latex coatings. The #B95 was almost as effective as the #B4 in removing these coatings.

CONTRACTOR ON-SITE STRIPPING

IRTA conducted testing with a contractor who performs on-site stripping. The task was to strip and refinish the cabinets in a Palos Verdes home. The kitchen cabinets were made of pine and they had a varnish coating.

Figure 3-14 shows the contractor’s workers preparing the kitchen for stripping. The pieces are first broken down. The drawers and cabinet doors are removed and taken back to the shop for stripping in the flow tray. Figure 3-15 shows the drawers and doors removed from the cabinetry. The moldings, styles and frames of the cabinetry are stripped on-site. The procedure is to apply the stripper, remove the coating residue, sand and stain the cabinetry with the new finish.



Figure 3-14. Workers Preparing Kitchen for Stripping



Figure 3-15. Drawers and Doors Removed From Cabinetry

The contractor uses a METH based stripping formulation called Lifteeze for stripping the cabinetry. An MSDS for this stripper is shown in Appendix A. Two non-METH alternative strippers, #B95 and #B74, which contain benzyl alcohol, were tested. The MSDSs for the alternative products are shown in Appendix B.

The first test involved applying the three strippers to a panel. The #B74 was applied to the left hand side of the panel, the #B95 to the middle of the panel and the Lifteeze to the right hand side of the panel. Figure 3-16 shows the first panel with the three areas where the stripper is applied separated by tape. The normal procedure is to brush on the stripper as demonstrated in Figure 3-17, to let the stripper sit for four or five minutes and then to scrape off the coating as shown in Figure 3-18.



Figure 3-16. Panel #1 Areas Separated by Tape



Figure 3-17. Brushing Stripper on Panel #1



Figure 3-18. Scraping Panel #1

After the coating was scraped off, the worker judged that the Lifteeze stripper left the panel a little cleaner and it worked a little faster than the alternative strippers. The #B95 alternative was more effective and stripped faster than the #B74. A second coat of stripper was applied to the panel to remove the secondary finish that was still on the cabinetry. The worker then used steel wool and water to remove the rest of the finish. The Lifteeze stripped area appeared to be the best. The #B95 was somewhat better than the #B74 stripped area. Figure 3-19 shows the panel after the stripping work was completed.



Figure 3-19. Panel #1 After Stripping

The same strippers were tested again on a second panel. This time the strippers were left on for 10 minutes, the panel was scraped and the stripper was reapplied. Again the Lifteeze was the best and most effective stripper. The #B74 was not as good as the #B95 alternative stripper. The #B95 was almost as effective as the Lifteeze. Figure 3-20 shows the panel after the stripping.



Figure 3-20. Panel #2 After Stripping

The strippers were tested on another panel that had coating on the top and an adhesive residue on the bottom. This time the strippers were left on for about eight minutes. The Lifteeze was judged to work the best but the #B95 was almost as good. The #B74 was not as good as the other two stripping formulations.

The results of the testing indicated that the METH based stripper performed better than the alternative non-METH strippers. The contractor judged that the #B95 worked almost

as well as the Lifteeze and he said he would be willing to use it. The #B74 alternative stripper did not work as effectively as the #B95. In addition, the contractor indicated that the odor of the #B74 was unpleasant.

### CONSUMER STRIPPING TESTS

Most of the coatings that are stripped by consumers are wood items including doors, door jambs, cabinetry, chairs, bed frames and tables. When IRTA and Benco Sales performed the hand stripping at the two furniture stripping facilities, several wood items were stripped. The coatings that were stripped ranged from easy-to-remove lacquers and shellacs to hard-to-remove enamel and latex coatings. The vast majority of coatings that will be encountered by consumers that want to strip wood pieces are nitrocellulose lacquers. Benco Sales provided a wood panel containing a nitrocellulose lacquer for conducting comparative hand stripping tests for consumer product strippers. Other items that are fairly commonly stripped by consumers are metal patio furniture pieces. Benco Sales provided a green metal panel containing an epoxy primer and a cross-linked polyurethane topcoat for conducting hand stripping tests. A silver metal panel containing an epoxy primer and a UV cured topcoat was also provided by Benco Sales. The latter coating was meant to represent the future coatings that may be much more difficult to remove than the universe of coatings encountered today.

IRTA went to Home Depot and Virgils Hardware to purchase consumer product strippers that are available on the market today. The baseline stripper that was used for comparison was #B4 which is a thickened stripper used for industrial stripping. It contains between 70 and 85 percent METH. The MSDS for this stripper is shown in Appendix A. This stripper and five other stripping formulations were tested and compared for stripping the coatings on the wood and two metal panels. MSDSs for the five other consumer product strippers are shown in Appendix C. They include:

- KS Brushable Stripper made by W.M. Barr & Company which contains 80 to 85 percent METH and methanol;
- BIX Stripper made by BIX Mfg. Co. which contains 15 to 25 percent METH and methanol;
- CS Stripping Gel made by W.M. Barr & Company which contains 40 to 50 percent NMP and a methyl ester;
- Ready-Strip Pro made by Back to Nature Products Co. which contains 25 to 30 percent benzyl alcohol, NMP and formic acid; and
- Ben's Nu-Tech Stripper made by Benco Sales which contains 50 to 60 percent benzyl alcohol and formic acid

The panels were masked off with tape. A picture of the masked panels is shown in Figure 3-21. From right to left are the wood panel, the green metal panel and the gray metal panel. The strippers were applied to the masked off sections of the panels and allowed to sit.

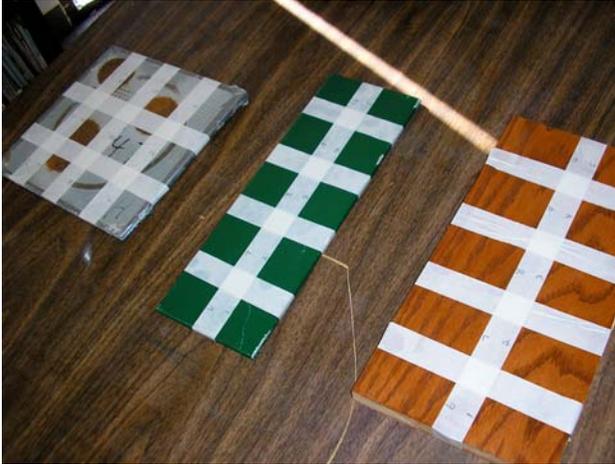


Figure 3-21. Three Masked Panels

The wood panel, after the strippers were applied, is shown in Figure 3-22. On the bottom of the panel from left to right the strippers that were applied are CS Stripping Gel, KS Brushable Stripper, BIX Stripper, #B4 and Ben’s Nu-Tech Stripper. On the top left hand side of the panel, the Ready-Strip Pro was applied. After 10 minutes, the corner of the wood was scraped. Section numbers 1, 2, 4 and 5 were fully stripped. These sections contained the CS Stripping Gel which contains NMP, the KS Brushable Stripper which contains high concentrations of METH, #B4 which contains high concentrations of METH and Ben’s Nu-Tech Stripper which contains benzyl alcohol. Section number 3 was also stripped but not as well as numbers 1, 2, 4 and 5. Section number 3 contained BIX Stripper which has a lower concentration of METH. Section number 6, which contained the Ready-Strip Pro containing benzyl alcohol and NMP, was not stripped at the 10 minute mark. After 20 minutes, section number 6 was still not stripped. Figure 3-23 shows the wood panel at the 20 minute mark. The panels were checked again at the one hour mark. All the stripping formulations had removed the coating by then.

Table 3-6 summarizes the results for the stripping tests of the wood panel. An S in the table indicates the coating was fully stripped. After 20 minutes, the only stripper that did not strip the coating was Ready-Strip Pro.

**Table 3-6  
Results of Hand Stripping Tests for Wood Panel With Lacquer Coating**

Stripper	Description	10 Minutes	20 Minutes	One Hour
CS Stripping Gel	NMP	S	-	-
KS Brushable Stripper	High METH	S	-	-
Bix Stripper	Low METH	-	S	-
#B4	High METH	S	-	-
Ben’s NuTech Stripper	Benzyl Alcohol	S	-	-
Ready Strip Pro	Benzyl Alcohol, NMP	-	-	S



Figure 3-22. Wood Panel With Strippers Applied



Figure 3-23. Wood Panel After 20 Minutes

The coatings on the green metal panel were more difficult to strip. The strippers were applied in the same order as was the case for the wood panel. Figure 3-24 shows the panel after the strippers were applied. After about 30 minutes, the only sections that were beginning to be stripped (indicated by a bubbling up of the coating) were number 2 and number 4. These sections contained the high METH content strippers, the KS Brushable Stripper and the #B4. At the 30 minute mark, the coating residue was removed and the strippers were reapplied. After five and a half hours, both the topcoat and primer were removed for section numbers 3, 4 and 5. Section number 3 contained the Bix stripper with the low METH concentration. Section number 4 contained the #B4 which has a high METH concentration and section number 5 was Ben's Nu-Tech Stripper which contains benzyl alcohol. The Ready-Strip Pro that contains benzyl alcohol removed the primer and topcoat on panel number 6 after considerable scraping. Section number 2, which contained the KS Brushable Stripper that has a high METH concentration removed the topcoat and with hard scraping and was starting to remove the primer. Section

number 1, which contained the CS Stripping Gel with NMP, had removed only the topcoat with hard scraping.

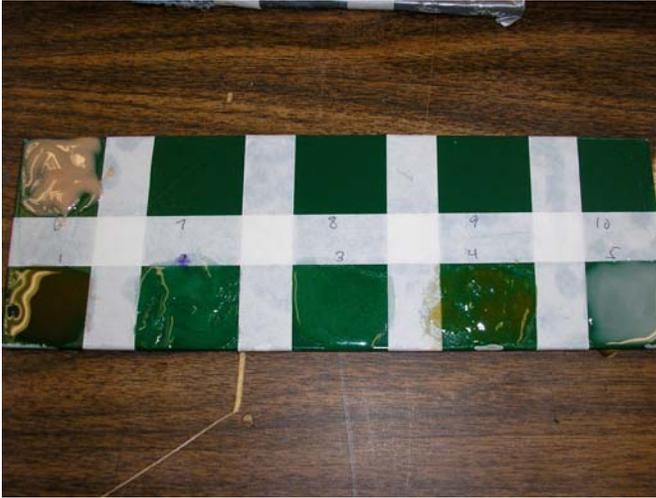


Figure 3-24. Green Metal Panel After Strippers Applied

After more than 20 hours, all of the stripping formulations had removed the primer and topcoat on the green metal panel. After scraping the coating residue off and rinsing the panels, they were inspected. Figure 3-25 shows the green metal panel at this stage. The appearance of panels number 1, number 2, number 3, number 5 and number 6 was very good and clean. These were stripped with the CS Stripping Gel which contains NMP, the KS Brushable Stripper which contains a high METH concentration, BIX Stripper which contains a low METH concentration, Ben's Nu-Tech Stripper which contains benzyl alcohol and Ready-Strip Pro which contains benzyl alcohol. Section number 4 was very clean but darker; the stripper used on this panel was #B4 which has a high METH concentration.

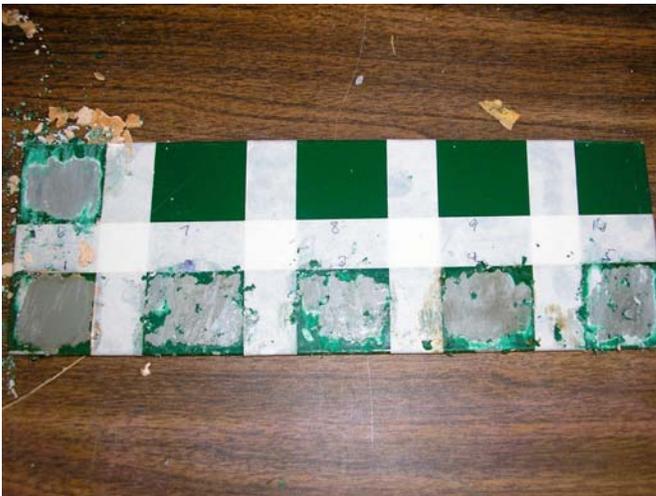


Figure 3-25. Green Metal Panel After More Than Twenty Hours

Table 3-7 summarizes the result of the stripping tests for the green metal panel. B indicates the strippers were beginning to work on the coatings. T indicates the topcoat was removed and P indicates the primer was removed.

**Table 3-7**  
**Results of Hand Stripping Tests for Green Metal Panel With Epoxy Primer and Polyurethane Topcoat**

Stripper	Description	30 Minutes	5.5 Hours	20 Hours
CS Stripping Gel	NMP	-	T	T, P
KS Brushable Stripper	High METH	B	T	T, P
Bix Stripper	Low METH	-	T, P	-
#B4	High METH	B	T, P	-
Ben's NuTech Stripper	Benzyl Alcohol	-	T, P	-
Ready Strip Pro	Benzyl Alcohol, NMP	-	T, P	-

The coating on the gray metal panel was extremely difficult to remove. After 20 hours, with intense scraping, the coating was starting to be removed on panel number 5 and number 6. Number 5 contained the Ben's Nu-Tech Stripper and number 6 contained the Ready-Strip Pro. Both of these strippers are formulated with benzyl alcohol.

The results of the panel testing demonstrates that all strippers--METH and non-METH--stripped the nitrocellulose coating fairly easily. This type of coating is the most commonly encountered by consumers who strip items at home. The metal coating that is commonly found on patio furniture required much more time for stripping for all the stripping formulations tested. Nearly all of the formulations, including those with METH and those without METH, were able to strip the topcoat and primer if an extended period was allowed. The best performing stripper that does not contain either METH or NMP was Ben's Nu-Tech Stripper which was specially formulated with benzyl alcohol for the testing. For the coatings likely to be encountered in the future, none of the strippers did a good job. The best strippers for these coatings were those that contained benzyl alcohol. This makes sense because the METH in some of the other strippers is likely to evaporate more quickly leaving the stripping formulation dry and inactive.

#### IV. COST ANALYSIS AND COMPARISON

This section presents a cost analysis that compares the cost of using the high METH content strippers with the alternative non-METH strippers. It first presents a cost comparison for large furniture stripping companies that use stripping equipment. It then presents a cost comparison for consumer strippers.

##### COST ANALYSIS FOR LARGE FURNITURE STRIPPING COMPANIES

For the cost analysis and comparison, IRTA considered a furniture stripping facility that uses 550 gallons of #B7 stripper annually. The facility has a flow tray and a water wash booth.

The stripping formulation that performed best at Sunset Strip and Strip Joint was #B96 which contains a high concentration of benzyl alcohol. If a furniture stripping company converted to this benzyl alcohol stripper, new polyethylene equipment would be required. One flow tray and one water wash booth tray would be required. The cost of these trays is estimated at \$800 each for a total of \$1,600. A new pump for the flow tray would also be required; the cost of the pump is \$469. The total capital investment a furniture stripping company must make is \$2,069. Assuming a 10 year life for the equipment and a cost of capital of five percent, the annualized cost of the capital investment would amount to \$217.

The furniture stripping company currently purchases 10 drums or 550 gallons of #B7 stripper annually. The cost of the #B7 stripper is \$479 per drum. On this basis, the annual cost of purchasing stripper is \$4,790. The vapor pressure of the #B7 METH based stripper is very high so it evaporates quickly. During the testing of the alternative strippers with the furniture stripping companies, it was estimated that about twice as much of the METH stripper was required as the alternative non-METH stripper. The vapor pressure of the benzyl alcohol is low and it does not evaporate as readily. Under the assumption that half as much of the #B96 would be required, the stripping company would use only 275 gallons or five drums of the stripper annually. At a cost of \$850 per drum, the annual cost of purchasing the alternative non-METH stripper would be \$4,250.

As discussed earlier, the #B7 stripper is rinsed in the water wash booth with water and with oxalic acid. The oxalic acid must be used in about a three percent concentration. The cost of the oxalic acid is about \$1 per pound. For every 100 gallons of METH based stripper, about 10 pounds of oxalic acid is required. Under this assumption and assuming the facility uses 550 gallons of stripper, the annual cost of the oxalic acid is \$55.

The benzyl alcohol stripper must be rinsed with a dilute 30 percent concentration of hydrogen peroxide in water. The cost of the hydrogen peroxide is \$1.50 per gallon. For every 100 gallons of benzyl alcohol stripper, about 30 gallons of hydrogen peroxide is required. On this basis and assuming the stripper use is 275 gallons, the annual cost of purchasing the hydrogen peroxide is \$124.

The spent METH stripper and the spent benzyl alcohol stripper must be disposed of as hazardous waste. Because the vapor pressure of the METH stripper is higher, more evaporates so there will be less waste generated than when the benzyl alcohol is used. During the stripping tests, when equal volumes of METH and Benzyl Alcohol stripper are used, it was estimated that two to three times the waste would be generated with the Benzyl Alcohol stripper. Currently, for every drum of METH stripper used, five gallons of waste is generated. Since 10 drums of stripper are used by the furniture stripper in this case, 50 gallons of hazardous waste is generated. Assuming the facility must dispose of one drum annually and taking into account that the cost of disposing of one drum of METH stripper is \$300, the annual waste disposal cost with the METH stripper is \$300. For every drum of benzyl alcohol stripper that is used, between 10 and 15 gallons of waste will be generated. Selecting the higher number to be conservative, the stripper will generate 75 gallons or two drums of waste annually. The disposal cost of one drum of benzyl alcohol stripper waste is estimated at between \$150 and \$175. Again, assuming the higher figure, the annual waste disposal cost of the benzyl alcohol stripper is \$350.

Table 4-1 shows the annualized cost comparison for the furniture stripper using the METH based stripper and the benzyl alcohol based stripper. The results indicate that the cost of using the #B7 METH stripper and the alternative stripper are comparable.

**Table 4-1  
Annualized Cost Comparison for Furniture Stripping Company**

	METH Stripper	Benzyl Alcohol Stripper
Capital Cost	-	\$217
Stripper Cost	\$4,790	\$4,250
Rinse Agent Cost	\$55	\$124
Disposal Cost	\$300	\$350
Total Cost	\$5,145	\$4,941

The analysis presented in Table 4-1 assumes no difference in labor costs for using the two strippers. Certain work practice changes would be required, however, if a furniture stripping facility converted from the METH based stripper to the benzyl alcohol based stripper. The METH stripper is applied several times to the item to complete the stripping. The benzyl alcohol stripper takes longer to penetrate the typical coatings. Instead of applying the stripper and fully stripping one item at a time in the flow tray, the benzyl alcohol stripper should be applied to several items at once. Once the benzyl alcohol stripper is applied to the items, no additional stripper will need to be applied because of the lower vapor pressure of the alternative non-METH stripper. After a slightly longer residence time, each of the items can be fully stripped.

## COST ANALYSIS FOR HAND STRIPPING

IRTA compared the cost of hand stripping for a consumer using METH based strippers and the alternative strippers that were tested on the wood and metal panels. The stripping formulations that were included in the cost analysis included:

- KS Brushable Stripper made by W.M. Barr & Company which contains 80 to 85 percent METH and methanol;
- BIX Stripper made by BIX Mfg. Co. which contains 15 to 25 percent METH and methanol;
- CS Stripping Gel made by W.M. Barr & Company which contains 40 to 50 percent NMP and a methyl ester;
- Ready-Strip Pro made by Back to Nature Products Co. which contains 25 to 30 percent benzyl alcohol, NMP and formic acid; and
- Ben's Nu-Tech Stripper made by Benco Sales which contains 50 to 60 percent benzyl alcohol and formic acid.

Four assumptions were made for the cost analysis. First it was assumed that about twice as much of a METH based stripper would be required for a stripping task. This follows from the fact that the vapor pressure of METH is very high so the stripper evaporates and needs to be reapplied. During the panel testing, the METH strippers did dry out much more quickly than the alternative strippers with lower vapor pressure components. Second, the cost analysis was performed assuming a consumer would use two quarts of a METH containing stripper and one quart of a non-METH stripper for a particular stripping job. Third, it was assumed that the consumer would dispose of the waste from the stripping operation in the garbage. Fourth, the price of the strippers was the price paid at a hardware store. Under these assumptions, the cost of using a particular stripper depends only on how much is used and the cost of the stripper.

Table 4-2 shows the cost comparison for using the METH based and alternative consumer hand strippers. The figures show that the lowest cost consumer stripping formulation is Ben's Nu-Tech Stripper. The CS Stripping Gel is also a relatively low cost stripper. The Ready-Strip Pro Stripper is the highest cost stripper.

**Table 4-2**  
**Cost Comparison of Consumer Hand Strippers**

Stripper	Type	Stripper Cost Per Quart	Amount Used	Total Cost
KS Brushable Stripper	METH	\$7.47	2 quarts	\$14.94
BIX Stripper	METH	\$5.97	2 quarts	\$11.94
CS Stripping Gel	NMP	\$10.99	1 quart	\$10.99
Ready-Strip Pro	NMP, benzyl alcohol	\$17.69	1 quart	\$17.69
Ben's Nu-Tech	benzyl alcohol	\$7.95	1 quart	\$7.95

## V. ENVIRONMENTAL CHARACTERISTICS AND TOXICITY OF STRIPPING FORMULATIONS

This section focuses on the environmental and health characteristics of the METH based strippers and the alternative non-METH strippers. The Occupational Safety and Health Administration (OSHA), CARB and SCAQMD regulations that apply to stripping formulations in California and southern California are reviewed. that they could substitute for the METH based strippers under the current regulations. The section also summarizes the results of a toxicity evaluation and comparison conducted by the California Department of Health Services Hazard Evaluation System & Information Service (HESIS) for METH based formulations and alternatives. The section provides an assessment of the alternatives in terms of the regulations and the toxicity findings. The characteristics of the alternative strippers are described to show that they could substitute for the METH based strippers under current regulations.

### REGULATIONS THAT AFFECT THE USE OF STRIPPING FORMULATIONS IN CALIFORNIA

OSHA passed a landmark regulation on methylene chloride in 1997. As mentioned in Section I, the SCAQMD in southern California initiated a regulatory development for furniture stripping with METH but this regulation was not finalized. CARB has jurisdiction over consumer products in California, those containing METH and other materials. These regulations and regulatory developments are reviewed below.

#### OSHA Regulations

On January 10, 1997, OSHA finalized a regulation on METH that was under development for 10 years. It lowered the Permissible Exposure Limit (PEL) of METH from 500 ppm to 25 ppm over an 8-hour time-weighted average (TWA). The regulation established a Short-Term Exposure Limit (STEL) of 125 ppm; the previous STEL was set at 1,000 ppm. The regulation also established an action level of 12.5 ppm for METH. If workers' exposure exceeds 12.5 ppm, the employers must institute exposure monitoring and medical surveillance. If the exposure is above the PEL, monitoring is required every six months. Where the action level is exceeded, the employees with exposure to METH for more than 30 days per year must see a health care provider and this must be paid for by the employer.

Many furniture stripping firms that use METH based stripping formulations have poor ventilation in their shops. Based on measurements taken in earlier projects, most stripping firms do not meet the 25 ppm PEL or the action level of 12.5 ppm. In contrast to most of the furniture stripping facilities in the country, the two facilities IRTA worked with during this project have high air flow ventilation systems that were installed and tested in earlier projects.

## SCAQMD Regulations

The first SCAQMD regulation that applies to stripping formulations is Rule 1136 “Wood Products Coatings.” It limits strippers to those with a VOC content of 350 grams per liter of material or less or those that have a composite vapor pressure of 2 mm Hg or less. METH is not classified as a VOC; the other components in stripping formulations are the contributors to the VOC content of the strippers. Many of the other local air districts in California have regulations that have requirements similar to SCAQMD Rule 1136.

The second SCAQMD rule that has had a substantial effect on furniture stripping firms in southern California is Rule 1401 “New Source Review of Carcinogenic Air Contaminants.” This rule contains a list of chemicals that are classified as carcinogens, including METH. New firms and firms that relocate or modify their operation that use one of the listed chemicals are covered by the rule requirements. The rule requires that the Maximum Individual Cancer Risk (MICR) posed by the facility not exceed one in a million. If the facility installs Toxics Best Available Control Technology (T-BACT), then the MICR must not exceed 10 in a million. The MICR is defined in Rule 1401 as the estimated probability of a potential maximally exposed individual contracting cancer as a result of exposure to toxic air contaminants over a period of 70 years for residential and 46 years for worker receptor locations.

The third SCAQMD regulation that affects existing stripping firms is Rule 1402 “Control of Toxic Air Contaminants from Existing Sources.” Rule 1402 requires that existing facilities reduce the MICR to no more than 25 in a million. This rule applies to larger facilities that use toxic air contaminants and all of these facilities have prepared and submitted risk assessments to the District. An additional 7,500 facilities in the South Coast Basin, most of them small businesses, are likely to pose an MICR higher than 25 in a million. SCAQMD has developed technology based industry specific regulations for all of these industries except furniture strippers.

As discussed in Section I, SCAQMD began developing a regulation specifically for stripping firms that use METH based stripping formulations. The regulation was never finalized because the large furniture stripping companies indicated that regulating their METH emissions would be unfair. A large number of smaller firms like antique shops also use METH strippers but they apply them by hand rather than with equipment. These smaller companies that apply stripper by hand most often purchase their stripping formulations from hardware or paint supply stores. A more comprehensive approach would be a regulation that applies to both large furniture stripping firms that use stripping equipment and smaller companies that apply stripper by hand. This project involved finding viable and cost effective alternatives for large stripping firms and smaller firms.

Other local air districts in the state have policies and regulations on toxic air contaminants. These policies and regulations affect the METH emissions from furniture stripping facilities.

## CARB Consumer Product Regulations

CARB consumer product regulations established a VOC limit for “paint remover or stripper” of 50 percent on January 1, 2005. The regulations also define an LVP or Low Vapor Pressure material that is not classified as a VOC if it meets certain criteria. LVP-VOC means a chemical “compound” or “mixture” that contains at least one carbon atom and meets one of the following three criteria”

- (1) has a vapor pressure less than 0.1 mm Hg at 20 degrees C as determined by ARB Method 310; or
- (2) is a chemical “compound” with more than 12 carbon atoms or a chemical “mixture” comprised solely of “compounds” with more than 12 carbon atoms as verified by formulation data, and the vapor pressure and boiling point are unknown; or
- (3) is a chemical “compound” with a boiling point greater than 216 degrees C as determined by ARB Method 310; or
- (4) is the weight percent of a chemical “mixture” that boils above 216 degrees C as determined by ARB Method 310.

## TOXICITY EVALUATION OF METH AND ALTERNATIVE FORMULATIONS

The HESIS evaluation involved examining the MSDSs of the METH based strippers and the alternatives that were tested during this project and evaluating the toxicity of the stripper components. This subsection summarizes the results of the HESIS analysis.

### METH Based Strippers

Appendix A shows MSDSs for several of the METH based stripping formulations that functioned as baseline strippers for the testing performance comparison. According to the MSDS, #B7, the baseline flow tray stripper, contains 70 to 85 percent METH. #B4, one of the baseline hand strippers, also contains between 70 and 85 percent METH. Jasco Stripper, a typical consumer product stripper, contains more than 80 percent METH. KS Brushable Stripper, another consumer product stripper, contains 80 to 85 percent METH.

METH most often affects the central nervous system (the brain) causing headaches, nausea, dizziness, clumsiness, drowsiness and other effects like those of drinking alcohol. At very high levels, it can cause unconsciousness and death.

METH causes cancer in animals and is regulated as a cancer-causing substance in the workplace. Because it forms carbon monoxide in the body, METH can increase angina (chest pains) and can cause other heart symptoms in workers who have heart disease. Pregnant women are at increased risk due to METH metabolism to carbon monoxide.

The MSDS in Appendix A for Lifteeze Paint & Varnish Remover and Hand Stripper indicates the stripper has a lower METH content, 35 to 45 percent, than the other high METH content strippers. The MSDS for another stripping formulation, Bix Stripper,

shown in Appendix C as a consumer product stripper, has a lower METH concentration of 15 to 25 percent. Based on the reduced concentration of METH, these materials could be considered of lower toxicity than the high METH content strippers discussed above.

#### n-Methyl Pyrrolidone (NMP) Based Strippers

NMP is an ingredient of CS Stripping Gel and Ready-Strip Pro. MSDSs for these formulations, which are alternative non-METH consumer product strippers, are shown in Appendix C. NMP is listed on California's Proposition 65. Exposure to NMP by inhalation or through skin absorption poses risks of developmental toxicity and male reproductive toxicity. In addition, the chemical also poses risks of solvent-induced acute and chronic nervous system damage, dermatitis and respiratory irritation.

#### Benzyl Alcohol Based Strippers

Several of the alternative strippers tested in the project, #B94, #B96 and #B73 flow tray strippers, #B74 #B74A, #B94A and #B95 hand strippers and Ready-Strip Pro and Ben's Nu-Tech consumer product strippers, contain benzyl alcohol. HESIS indicates that benzyl alcohol is of comparatively low toxicity relative to METH. Exposure to benzyl alcohol can occur through inhalation and skin absorption. The vapor is a skin, eye and respiratory irritant. Cases of allergic contact dermatitis have been reported. Animal tests of its reproductive and development toxicity and carcinogenicity are negative.

#### Other ingredients

All four of the high METH content strippers and the two low METH content strippers also contain methyl alcohol, a chemical that is often combined with METH in strippers for a synergistic effect. Like many solvents, methyl alcohol can also have toxic effects on the brain or central nervous system. The symptoms of long-term health effects include fatigue, sleeplessness, poor coordination, difficulty in concentrating, loss of short-term memory and personality changes such as depression, anxiety and irritability. It can also irritate the eyes, nose, throat and skin and contact with skin can cause dermatitis. Methyl alcohol exposure has been associated with visual disturbances and neuropathy and birth defects in animals.

The best performing alternative flow tray stripper, #B96, contains benzyl alcohol, phenol (called hydroxybenzene on the MSDS) and formic acid. Two of the consumer product strippers, Ready-Strip Pro and Ben's Nu-Tech Stripper also contain formic acid. The workplace health standard or PEL for phenol of five ppm is established to minimize the potential for eye and respiratory irritation and cardiovascular, hepatic, renal and neurologic toxicity. As a vapor, liquid or solid, phenol can penetrate intact skin and cause serious systemic effects, including death. Formic acid is corrosive and can burn the skin and eyes upon contact. The vapor is irritating to the skin, eyes and respiratory tract. It does not pose risks of long-term health damage.

## Summary of HESIS Evaluation

METH is a major ingredient of widely used stripping formulations. The chemical is a carcinogen and poses a significant risk to workers and community members located near furniture stripping facilities and consumers. The alternative non-METH stripping formulations that performed best in the testing contain benzyl alcohol as the active ingredient. The HESIS evaluation indicates that benzyl alcohol poses much less of a toxic risk than does METH.

## EFFECTS OF REGULATIONS AND THE TOXICITY EVALUATION ON STRIPPING FORMULATIONS

The toxicity evaluation by HESIS indicates that METH is a carcinogen and poses severe health risks to the workers in stripping facilities and consumers that use formulations containing the chemical. Furniture stripping facilities that use METH based products also must meet a very stringent OSHA regulation and certain risk requirements set by local air districts in California. The HESIS evaluation also indicates that NMP, which is present in some of the alternative stripping formulations, is a reproductive and developmental toxin. The analysis of the best stripping formulations below is based on eliminating from consideration all formulations containing METH or NMP.

There is a strong incentive to convert to stripping formulations that do not contain METH. Companies can avoid the OSHA and local air district regulations on Toxic Air Contaminants with this strategy. Consumers can avoid the use of a carcinogen. The purpose of this project was to find alternative stripping formulations that do not contain METH, NMP or other components that pose significant toxic risks. The major focus was to find alternatives that perform well, are reasonably cost effective, do not increase VOC emissions substantially and comply with the existing regulations in California that affect stripping formulations.

The best performing alternative stripping formulation for large furniture stripping firms was #B96. According to the MSDS for this product which is shown in Appendix B, the formulation contains 50 to 60 percent aromatic alcohol, 10 to 20 percent hydroxybenzene and 10 to 20 percent formic acid. The aromatic alcohol is benzyl alcohol and hydroxy benzene is phenol. Another formulation, #B95, performed well in the hand stripping tests conducted at the furniture stripping facilities that participated in the project. This formulation, according to the MSDS is Appendix B, contains 50 to 60 percent aromatic alcohol, one to five percent formic acid and less than two percent aromatic petroleum distillates. These formulations could serve as alternatives to #B7 used by larger stripping companies with equipment. #B95 could serve as an alternative to #B4 and Lifteeze which are used and applied by hand by smaller furniture stripping facilities and contractors.

The only requirement for furniture stripping facilities in the South Coast Basin is that the stripping formulations have a vapor pressure of two mm Hg or less. The MSDSs for these alternative products both indicate that the vapor pressure of the mixture is less than

0.1 mm. The formulations meet the SCAQMD Rule 1136 requirement that strippers have a vapor pressure of two mm Hg or less. One of the ingredients in the #B96 formulation is phenol which is listed on SCAQMD Rule 1401. It is present at a concentration of 10 to 20 percent. The chemical is not a carcinogen but it does pose a variety of toxic hazards according to HESIS. Even so, the tradeoff of using this material instead of a formulation containing more than 70 percent METH is likely beneficial.

The best performing consumer product alternative stripper that does not contain METH or NMP is Ben's Nu-Tech Stripper. The MSDS, shown in Appendix C, indicates that the formulation contains 50 to 60 percent of an aromatic alcohol, one to five percent formic acid and less than two percent aromatic petroleum distillates. The aromatic alcohol in this formulation is also benzyl alcohol. This particular stripping formulation, because it is sold as a consumer product, must meet the CARB regulations. The MSDS lists the vapor pressure of the formulation as less than 0.1 mm Hg. This indicates the mixture meets the CARB LVP-VOC definition which means the formulation is not defined as a VOC. It therefore meets the requirement that stripping formulations have a VOC content of 50 percent or less.

## VI. RESULTS AND CONCLUSIONS

The most widely used and effective stripping formulations contain METH. The chemical is a carcinogen, is classified as a HAP by U.S. EPA, is classified as a TAC in California and is listed on California's Proposition 65. METH is also a listed hazardous waste under RCRA.

This project involved identifying, developing, testing and demonstrating safer alternatives to METH based stripping formulations. Alternatives were tested in four sectors including large furniture stripping companies who utilize stripping equipment and purchase stripper from suppliers, smaller furniture stripping companies who apply stripper by hand and purchase stripper either from suppliers or from hardware and paint supply stores, contractors who hand strip wood items and cabinetry on-site and generally purchase strippers from hardware and paint supply stores and consumers who hand strip wood and metal items and purchase stripper from hardware and paint supply stores. IRTA tested the alternative stripping formulations in flow trays with two large furniture stripping facilities. IRTA also tested the alternative formulations by applying them by hand in the two stripping facilities. IRTA tested alternative strippers with one contracting firm that strips on-site in homes and offices. Finally, IRTA conducted panel testing to find the best alternative strippers that could be used by consumers.

The non-METH strippers that were tested during the project were formulated by Benco Sales or purchased from hardware and home improvement stores. The best performing alternative stripping formulations contained benzyl alcohol as the active ingredient. For large furniture stripping companies that use equipment, the alternative that performed most effectively in two shops was #B96 which contains 50 to 60 percent benzyl alcohol. The most effective alternative for hand stripping in furniture stripping facilities was #B95 which also contains 50 to 60 percent benzyl alcohol. Adding about 20 percent acetone to the #B95 formulation improved its hand stripping capability for certain types of coatings. The #B95 also worked well for on-site contract stripping of wood items. Finally, the best performing stripping formulation in the consumer product testing was Ben's Nu-Tech Stripper which also contains benzyl alcohol.

The results of the cost analysis for large furniture stripping facilities that generally use #B7 stripper which contains a high concentration of METH indicate that the cost of using #B7 and #B96, the alternative containing benzyl alcohol, is comparable. For consumer product stripping, the cost of using the best non-METH alternative is lower than the cost of using METH based strippers that are on the market today.

In general, the non-METH alternatives that performed best contained benzyl alcohol. The toxicity evaluation conducted by HESIS indicated that benzyl alcohol is much lower in toxicity than METH.

The SCAQMD began developing a regulation for METH stripping facilities that use equipment several years ago. The regulation was never finalized because the stripping

companies believed it was unfair to regulate them when smaller stripping companies could still purchase METH strippers from hardware and paint supply stores. The testing conducted in this project demonstrates that alternative non-METH stripping formulations can be used by large and small furniture stripping companies. The alternative non-METH stripping formulations comply with SCAQMD Rule 1136 which requires the stripping formulations to have a composite vapor pressure of 2 mm Hg or less.

CARB estimates that emissions of METH from consumer product strippers amounted to 9.68 tons per day in 2006. Emissions of VOC solvents from these strippers totaled 7.04 tons per day. The testing conducted in this project with small furniture stripping companies, contractors and on panels demonstrates that effective non-METH stripping formulations can substitute for the METH based strippers that are widely employed today. The alternative benzyl alcohol strippers that performed most effectively in these applications are classified by CARB as LVP materials based on their composite vapor pressure. This suggests that substituting the alternatives would not increase VOC emissions from consumer product strippers.

