15. Hinge, Tape and Adhesive Removal

15.1 Purpose

To remove degrading or potentially damaging attachments such as tape, hinge material, adhesive residues, and associated staining.

15.2 Factors to Consider

15.2.1 Conservation/Curatorial Decision-making

A. Historical or Artistic Importance of Attachment

1. The conservator must weigh preserving an artifact by removing a damaging material such as a pressure-sensitive tape against maintaining the original appearance or format. Curatorial input may be crucial to give an historical and aesthetic perspective on techniques, working methods and materials of artists, collectors, curators, historical figures, librarians, archivists, etc.

2. The mounting technique and/or attachment may be integral to the object. Artists may mount their own works onto secondary supports or other materials [e.g., Paul Klee (Swiss, 1879-1940)]. Collages, such as some by Claes Oldenburg (American, b. 1929), have certain elements attached with masking and/or other pressure-sensitive tapes. These collages served as studies for a series of prints where the masking tape was included as a design element. Other examples include: manuscripts or letters from well-known authors, historical or political figures where it is known that the writers made the mends themselves; old master drawings with decorative borders contemporary with the drawing; 19th century ship watercolors with metallic and decorative borders; primitive American paintings and drawings with additions; scrapbooks (MKW); attachments to mounts by famous collectors/curators; wrappings from stored objects, e.g., time capsules (CS); attachments indicating former use, as in illustrations which bear periscope markings (registration marks) or gummed tape applied to the edges of a drawing, to indicate centering, cropping. (LP)

3. The attachments may be an integral part of an artifact, serving an aesthetic and/or structural purpose. For example, the Starn twins (American, b. 1961) consider the degradation of pressure-sensitive tapes used in their composite photographs to be the natural evolution of the work. (LP) In such cases, it may be possible to treat the object by removing the most damaging portions of the attachment (e.g., the adhesive) and returning the remainder (e.g., the carrier) to an object. (See Treatment Variations)

B. Whether Attachment Obscures Information/Includes Important Information

Information may be obscured by an attachment, such as revisions in prints and collages. Earlier notations in archival material can be obscured by later notations applied on an overlap or attachment. Continuation sheets in roll petitions can cover information that is located at the top or bottom of the pages. These petitions are composed of multiple sheets which are lap joined by adhesive. The decision to remove an opaque overlap to see what may be obscured below is a joint decision of the curator and the conservator and should be based on the likelihood of important information being discovered and the risk of damage to the object.

C. Treatment Priorities

To determine treatment priorities and the extent of treatment to be carried out, the amount of damage or potential for damage and the relative importance of object(s) in a collection must be considered. This decision is made jointly between the conservator, who can estimate the time necessary for the removal, and the curator, who provides knowledge of the value and use of the collection.

15.2.2 Evaluating Condition of Artifact and Attachment

A. Quality and Composition of Attachment

1. The attachment may be fairly inert (e.g., a Japanese paper hinge adhered with starch paste). If so, little damage can be expected by allowing the hinge material to remain, and removal may be more hazardous to the object than the attachment itself.

2. An attachment may be actively affecting the object's condition, e.g., causing staining of paper and bleeding of inks. If so, this active damage may continue despite proper environment, and the attachment should be removed as soon as possible to avoid further damage. Tape that has been fairly recently applied may generally be separated from the paper support with mild solvents (i.e., petroleum benzine). If it is left on and allowed to age, more polar solvents which are potentially dangerous to the object may be necessary for removal.

   Removal may also be indicated if it is thought that future staining may occur. For example, acrylic tapes may contain plasticizers which are considered mobile and may migrate into the paper to which they are attached. If the paper is soft-fibered or unsized, the acrylic elastomer (adhesive) may flow into the fibers as well. This acrylic is very difficult to remove from the paper substrate. At times, the delicacy of the paper may make even removal of the carrier extremely difficult. On the other hand, if the adhesive is in the margin or another area where the legibility or aesthetics of the piece are not interfered with, removal may not be as urgent.

3. An exposed adhesive which remains tacky puts the object in danger of being skinned or torn if it sticks to another surface. Removal is generally the best immediate option. A temporary measure to reduce the risk of damage is to cover the area with a material that can be removed easily later, such as silicone release paper or silicone-coated polyester film.

4. An attachment may passively threaten the object's condition due to diminishing adhesion or strength properties. For example, hinges made from glassine or framers tapes may fail, allowing an object to slip or fall.

5. Attachments such as kraft paper tapes, masking tape, transparent scotch tape and linen tapes can contract with age and/or leave an impression. In such cases,

immediate removal may not be necessary unless it is possible that the damage would be exacerbated by handling or fluctuations in temperature and relative humidity. Furthermore, it is the nature of collage and other composite paper objects to expand and contract and often one can only stabilize the environment to minimize the dimensional changes. Brown paper tapes used by the artist to stretch watercolors may cause distortions but may also have watercolor on the tape. This becomes a part of the original and is normally not considered for removal. (VBH)

B. Degree of Degradation of Attachment and Potential for Further Degradation

In some cases, performing a treatment sooner rather than later may significantly reduce the time involved and the risk to the object and conservator:

1. Rubber-based adhesives are easier to remove before they've reached the oxidized stage; increasingly, polar solvents are needed as this degradation advances. Chemical breakdown of the adhesive often coincides with increased tack and migration into the paper object upon which the adhesive is affixed. Finally, the adhesive becomes brittle and yellowed, indicating a very cross-linked, degraded condition.

2. Starch or protein adhesives may require enzymes for removal if aged.

3. If untreated, the dimensional instability/shrinkage of a tape carrier (particularly in cellulose acetate and cellophane carriers) may expose areas of tacky adhesive which could damage adjacent paper. The physical strain of carrier shrinkage can cause tears or breaks in the paper object to which it is adhered.

C. Need for Analysis/Exact Identification of Attachment

In many cases, the results of non-analytical tests performed by the conservator can be used to devise removal strategies without knowing the exact composition of a tape or adhesive. Some cases justify the time and resources needed to identify the hinge material and hinge adhesive; tape carrier and adhesive mass; degradation products of the previous;

presence of other plasticizers, pigments, dyes, fungicides, and alkaline salts. Analysis may be necessary in the following cases:

1. When a large quantity of identical objects require tape removal. If initial testing does not quickly reveal the best removal method, then the time taken to perform an analysis might make treatment more efficient and effective.

2. If the objects are of extremely high value. It may be worth the time and expense to analyze the attachment's components, to make treatment more controlled and reduce the risks to the object.

3. To formulate more effective and less toxic solvent combinations. If an adhesive is identified, its solubility parameter can be determined and the Teas chart used to formulate a less toxic solvent combination.

4. To identify recently manufactured, so-called "archival" tapes (pressure-sensitive as well as moisture and heat activated) prior to treatment. Some of these tapes contain fungicides, buffers, u.v. stabilizers -- all new components in the history of tape and tape removal. These components may complicate future removal or other treatment.

5. When a tape carrier is suspected of being highly soluble (e.g., cellulose acetate) or of having a low melting point (e.g., polypropylene).

6. When the tape is dyed, or contains pigments which may be released or transfer under certain conditions.

7. To help determine residual substances left in paper (plasticizers, or other compositional elements of tape adhesives).

8. To aid in understanding degradation mechanisms of the area of contact.

9. When paper is very sensitive and a battery of solvent tests on the object would be damaging.

10. When the attachment covers media, and/or has affected the media in some way (solvation, color change) so that solvent testing involves too high a risk.

11. In a collection survey, identification of a tape/adhesive can help the conservator establish priorities for preservation. For example, objects with rubber-based tapes might be considered for treatment before those with acrylic- based tapes (EO'L)

15.2.3 Treatment Options and Associated Risks

A. Sensitivity of media to solvents, moisture, steam, pH, mechanical action. Any loss, change or movement of media or media components is generally considered undesirable. (See AIC/BPG/PCC 24. Backing Removal 1985 and 10. Spot Tests 1990)

B. Sensitivity of paper to solvents, moisture, steam, mechanical action. Strength or weakness of paper fibers and paper surface should be considered. For example, many optical brighteners in paper are moveable in organic solvents and can accumulate to form purple/blue tide lines. (See AIC/BPG/PCC 4. Support Problems 1990)

C. The potential for uncontrolled movement of dissolved adhesives and associated staining. This could lead to formation of tide lines or penetration of staining to reverse of paper. Localized "over cleaning" could occur if the solvent selected to remove the adhesive also removes the degradation products in the sheet, creating a lighter area.

D. Paper tape carriers are often bleached or semi- bleached (if not kraft) and may have damaged associated paper object with residual contaminants. Other white paper tapes are loaded with CaCO3 (i.e., Filmoplast P-90), which may protect the paper support beneath, leaving it a lighter color than the remainder of the sheet. Other white paper tapes contain titanium dioxide (e.g., paper masking tape) which is a known catalyst of oxidation and may damage the adjacent paper.

E. Toxicity of solvents used in treatment and associated health risks to the conservator should be considered. Solvents should

only be used with adequate ventilation such as in a fume hood.

F. Non-treatment alternatives such as re-housing or limiting handling should be considered (See Special Considerations).

15.3 **Reference List of Adhesives, Tapes, and Hinges**

This list is provided as a reference to commonly occurring adhesive, tape, and hinge materials. It is divided into Generic and Brand Name sections to simplify access. The Generic section gives general background, history, common components and other information about the adhesive, tape, or hinge material. The Brand Name section is a compilation of analytical reports from various conservation sources and includes information from manufacturers' literature. In most cases, the product listed was tested for a particular component or property. For specifics on the test method, and for further information, consult the sources listed as noted.

The products are described as follows:

Brand Name: manufacturer, description of product/designed use
Known Components: (e.g., carrier, adhesive, plasticizer, other) (Source of testing, year)
Comments: information of interest, contributors' observations

WARNING! The information contained in this section regarding currently manufactured products is likely to change without notice at the discretion of the manufacturer. This list is meant to be a guide to further research and should NOT be considered a complete source for identification of component materials of adhesive, tape, and hinge products.

Note on the Sources: Sources are indicated using one of the following symbols:

\+ Mfr.: information provided by the manufacturer in product literature or by telephone request.

* CCI: Canadian Conservation Institute Analytical Research Services Conservation Report Summaries.

^ CAL: Conservation Analytical Laboratory, Smithsonian Institution

\# NARA: National Archives and Records Administration. Please note, analytical reports are not numbered. If you need further information, contact the Research and Testing Laboratory.

15.3.1 Mucilage (Vegetable Gum) Adhesives, Tapes and Hinges

A. Generic Mucilage Adhesives

(See AIC/BPG/PCC 46. Adhesives 1989 pp. 12-20.)

B. Generic Mucilage Tapes and Hinges

1. **"Gummed" tapes**: The papers of choice in these tapes were usually kraft papers, white papers made from sulfite pulp or esparto, glassine, and gold or silver-bronze paper.

   A variety of finishes were available from highly calendered to machine finished. Various adhesives were used such as animal glue, fish glue or dextrin (often from tapioca starch).

2. **Passe-Partout tapes**: The literature on passe-partout tapes often refers to them as "gummed" tapes. However the adhesives used in these tapes is more often an animal glue, a fish glue, or a dextrin. Oils of wintergreen or sassafras were often added as a flavoring, and glycerine, soluble oil, or glucose was added to improve working characteristics. Dextrin was often chosen for its excellent adherence to glass. Grey, black, and brown were the most popular colors, and a "pebbled" finish was described as desirable by one source.

   (See Sections 15.3.2 and 15.3.3 for information on starch and protein adhesives, respectively.)

C. Brand Name Mucilage Adhesives

1. **Lepage's Mucilage**: Lepage's Inc., amber colored liquid
   Adhesive: gum, unidentified
   (+mfr.)
   Comment: LePage's changed from gum to modified starch in 1960, but continues to market the product as "mucilage" (See section 15.3.2 for information on starch.)

D. Brand Name Mucilage Tapes and Hinges

No entries.

15.3.2 Starch Adhesives, Tapes, and Hinges

A. Generic Starch Adhesives

(See AIC/BPG/PCC 46. Adhesives 1989, pp. 4-12)

Shortages in animal glue supply favored the development of starch adhesives for water re-moistenable adhesive tapes and labels.

Thin-boiling starches (waxy cornstarch) alone, or combined with dextrin (potato, tapioca, and waxy maize) penetrated the market on the basis of availability, uniformity, and ease of preparation and handling. These adhesives are free of the unpleasant odors of animal glue and remoisten more easily in cold conditions.

Thin-boiling modified waxy cornstarch types, as well as cyanoethylated potato starch or other low viscosity noncongealing types, alone or in combination with protein resin fortifiers (e.g.: vinylpyrrolidone-vinyl acetate copolymer, polyacrylamide), represent another improvement. These adhesives have been applied to fabric and paper to make tapes.

B. Generic Starch Tapes and Hinges

1. **Fabric Tapes**
2. **Paper Tapes**

C. Brand Name Starch Adhesives

1. **Zen Insta Paste**: Archival Products, Los Angeles
   Adhesive: "Wheat paste crystals. Water reversible, fast drying, pH neutral with fungicide for long shelf life."+
   (+mfr., 1990; NARA)

2. **Spraytex Good Glue**: Spraytex Companies, smooth liquid adhesive with acrylic-like odor
   Adhesive: vegetable starch and/or modified starches such as dextrin*
   Additives: formaldehyde (probably as a preservative)*
   Other: unidentified hygroscopic component -

flexibilizer or modifier*
(*CCI ARS 2375, [n.d.])

3. **LePage's Original White Paste**: LePage's, Inc., opaque white paste
   Adhesive: dextrin with unidentified plasticizer and preservative+
   (+mfr., 1992)

4. **LePage's Mucilage**: LePage's Inc., clear, amber-colored liquid
   Adhesive: modified starch+
   (+mfr., 1992)
   Comment: Bill Radoslovich, Chief Chemist, says that LePage's switched their mucilage product to a starch derivative in around 1960.

5. **Talas Dry Wheat Paste #30**: Talas
   Adhesive: starch*
   Other: copper and iron detected spectrographically*
   (*CAL 2458)

6. **Aytex P**: (See AIC/BPG/PCC 46. Adhesives 1989, p. 7.)

7. **LePage's Library Paste**: LePage's Inc., white opaque paste
   Adhesive: dextrin preservative, plasticizer, fluidizer, oil of wintergreen+
   (+mfr., 1983)
   Comment: Bill Radoslovich, Chief Chemist, says that the company buys starch and converts it.
   (CS)

D. Brand Name Starch Tapes and Hinges

1. **Dennison Gummed White Tape**: Dennison Manufacturing Company, gummed white paper tape for hinging
   Carrier: paper, neutral pH, no lignin content, chemical wood pulp, small amounts of Si, Al, Ti.*

Adhesive: starch*
(*CCI ARS 2343.1 1985)

2. **Holland Gummed Tape**: 2.5 cm wide gummed tape
Carrier: starch treated cellulosic fiber*
Adhesive: starch/gelatin combination proportion not reported*
(*CCI ARS 1844.11 1982)

3. **Dennison Gummed Linen Tape**: Dennison Manufacturing Co., white gummed linen tape
Carrier: linen*
Adhesive: starch and animal glue*
(*CCI ARS 1330 1975)

4. **University Products Linen Gummed Tape**: University Products, linen gummed tape
Carrier: linen filled with talc and hydrated magnesium silicate
Adhesive: mixture of gelatin and starch*
Other: traces of silicone, sulphur, chlorine and possibly aluminum detected in adhesive layer.*
(*CCI ARS 2343.2 1985)

5. **Insta Hinge**: Archival Products, Los Angeles
Carrier: heavyweight Japanese paper+
Adhesive: wheat starch+
Other: fungicide added as preservative+
(+mfr., 1991; NARA)
Comment: Paper carrier is coated on both sides with adhesive.

6. **Insta Mend**: Archival Products, Los Angeles
Carrier: heavyweight Japanese paper+
Adhesive: wheat starch+
Other: fungicide added as preservative+
(+mfr., 1991; NARA)

15.3.3 Proteinaceous Adhesives, Tapes and Hinges

A. Generic Proteinaceous Adhesives
(See AIC/BPG/PCC 46. Adhesives 1989, pp. 42-43.)

1. **Animal Glue** - The water-moistenable adhesives of "gummed" tapes are principally composed of animal glue blends, both bone and hide, with small amounts of dextrin added to provide quicker wetting and longer tack time. Sodium chloride may be added to improve wetting ability and calcium chloride to strengthen the wet tack. Also included may be urea for rapid wetting, sulphonated vegetable oils for improved compatibility between dextrin and glue, and to lend pliability to the glue film. Scenting agents are frequently added to mask the glue odor.

2. **Casein** - (See above, 46.3.2.B., p. 45.)

3. **Parchment Size** - There are traditional parchment size and versions containing acid.

B. Generic Proteinaceous Tapes and Hinges

Both low test hide glue and bone glue have been employed in the manufacture of "gummed" tape. Glue has to a certain extent been replaced by dextrin or combined with dextrin to lower cost. The open time, tack, set time, wettability and strength of bonding are often altered depending upon the end use, by varying the test or adding modifiers such as dextrin, wetting agents, gel depressants, and plasticizers. The following describes proteinaceous tapes and hinges by type of carrier.

1. **Kraft paper tape** - Kraft paper grade 1 is a sulphate pulp. Grade 2 is basically a sulphite and ground wood pulp. Unreinforced sealing tapes utilize 35, 60 and 90 lb. krafts.

2. **Cloth tape** - (also known as bindery tape) - A variety of substrates are used ranging from Holland, cambric and gossett cloths, through strong latex-impregnated "rope" papers and embossed coated krafts. These tapes come in an assortment of colors, mainly black, white, tan, red, blue, green and brown.

3. **Acid-free "gummed tapes"** - These tapes are made from highly refined glues which have been neutralized with hydrated lime, and mold-proofed with phenolic

derivatives. Substrates used are usually neutral krafts free from acidic constituents.

4. **Water-resistant tape** - These tapes are formulated from high test hide glues or gelatins which can readily be insolubilized by moistening with water solutions of aldehyde compounds such as formaldehyde or glyoxal, with a small amount of alum.

C. Brand Name Proteinaceous Adhesives

1. Franklin's Hide Glue

D. Brand Name Proteinaceous Tapes and Hinges
No entries.

15.3.4 Pressure-Sensitive Adhesives, Tapes and Hinges

The term "pressure-sensitive" describes an adhesive which will stick to a surface by means of applied pressure (usually from the fingertips). Pressure-sensitive adhesives are made from many different kinds of elastomers (see Glossary) ranging from natural rubbers to synthetic polymers such as polyacrylates. Pressure-sensitive adhesives are applied to many different carrier (or backing) materials, including paper (tapes and labels), plastic (tapes and protective coverings such as an acrylic sheeting), fabric (medical and decorative products), and metal foil (photographic and electrical tapes).

Pressure-sensitive adhesive products are made to satisfy requirements defined by different industries, such as packaging, paint and coatings, printing and graphic arts, and the building and electrical trades. Medical uses of pressure-sensitive tapes continue to occupy a large portion of the market. The performance of a pressure-sensitive product is measured by the successful functioning of all of its components within the parameters set for its designed application. See ASTM D-1000, Test Methods published by the Pressure-Sensitive Tape Council, and in Federal Commercial Product Descriptions, published by the General Services Administration. (See Bibliography)

A. Generic Pressure-Sensitive Adhesives: Rubber-Based

The invention of rubber-based pressure-sensitive adhesives is attributed to Dr. Horace Day during the mid-19th century. The adhesive consisted of India rubber, spirits of turpentine,

turpentine extracts of cayenne pepper, litharge, pine gum, and other ingredients. A U.S. patent based on this formula, was issued to Shecut and Day in 1845. A German patent was issued in 1882 to a druggist named P. Beiersdorf for a plaster based on gutta-percha.

Natural rubber dominated pressure-sensitive adhesive applications until a shortage during WWII prompted the search for elastomer substitutes. Polyisoprene and styrene-butadiene synthetic rubbers were among the first polymers to temporarily replace natural rubber.(Satas, 1989) By the time rubber was again in plentiful supply the synthetic rubbers had gained a foothold and are now being used at least as partial replacements for natural rubber. (Patrick, 1976)

Most elastomers must be compounded in order to become tacky adhesives. Tackifying resins and plasticizers (See Glossary) are added to create mixtures ranging from bone hardness to extremely soft tackiness. Antioxidants and pigment fillers are often included in rubber-based pressure-sensitive adhesive formulas.

Tackifier resins are brittle solids which impart the property of "quick-stick" to the insufficiently tacky rubber materials. Wood rosin was commonly employed in the natural rubber-based adhesives made up through the mid-1930's. By 1940, the less acidic esterified rosin was introduced because of its greater resistance to aging. Succeeding esterfied rosin, terpene and petroleum-based resins were incorporated in rubber adhesives during the late 1950's and the 1960's.

A good tackifier resin must exhibit three properties. It must be reasonably compatible with the base elastomer. Second, it must have a very low molecular weight relative to the elastomer. Finally the tackifier must have a glass transition temperature (Tg) that is higher than the elastomer. Indeed, most tackifiers are glassy solids with Tg values from 30-60 degrees Centigrade. Tackifiers are blended with rubber elastomers in ratios ranging from 1:4 to 1:1.

The introduction of plasticizers represented a further refinement of rubber adhesive compounding. In contrast to resins which are generally hard materials, plasticizers are liquids or soft solids at room temperature. Plasticizers make

an elastomer softer and more conformable to the surfaces to which the adhesive is applied. Mineral oil and lanolin were incorporated into rubber adhesive mixtures early on. Phthalate and phosphate plasticizers became available in the 1920's and 1930's respectively. Plasticizers tend to migrate and/or volatilize over time. (Kirk and Othmer)

Pigment fillers are employed in rubber-based pressure-sensitive adhesives to color the adhesive or to mask the tendency to yellow on aging. Titanium dioxide is the most commonly used pigment due to its opacity and is used in masking tapes. Carbon black is used in electrical tape. Pigments are also added to extend the adhesive mass, thereby reducing costs. Clay, hydrated alumina, or calcium carbonate are used for this purpose. Finally, pigments are added to improve adhesive firmness and tack. Zinc oxide and fine silica improve pressure-sensitive adhesive formulations in this way. Zinc oxide is used in medical tapes.

Rubber-based pressure-sensitive adhesives require antioxidants to inhibit oxidative degradation. Chemical attack by oxygen and ozone is compounded by exposure to elevated temperature and UV light. Three main types of antioxidants have been utilized in the industry. First, there are the amine antioxidants, which guard efficiently against aging, but stain the adhesive and materials in contact with the adhesive. The most widely used antioxidants are phenolic types: they are non-staining and are particularly effective as UV absorbers. The third class is the dithiocarbamates, which impart thermal stability and some UV light protection. Often a combination of antioxidants is required to provide optimum resistance to aging.

B. Generic Pressure-Sensitive Tapes and Hinges: Rubber-Based

Rubber-based pressure-sensitive adhesives are applied to tape carriers in the following three ways: as a solution in aliphatic (n-hexane, heptane) or aromatic hydrocarbons (toluene), by calendaring while hot, or as a latex (a colloidal dispersion of rubber particles in water). The following describes pressure-sensitive tapes by type of carrier.

1. **Fabric Tapes** - Woven fabric is the oldest backing material used for pressure-sensitive adhesive tapes. Hospital tapes were, and many still are, made with a

woven fabric backing. Fabric backing can be heavily filled and coated with starch, nitrocellulose, vinyl, or acrylic coatings. Uncoated fabrics can be used as tape carriers. While cotton and rayon are the most common fibers used, polyester fabric backings are used for many applications, including high tensile packaging uses. The most common adhesives used for fabric tapes are natural rubber, styrene-butadiene, reclaimed natural rubber and block-copolymer adhesives.

2. **Paper Tapes** - The need for an inexpensive tape to use as a mask for painting for the automotive industry prompted the development of masking tape and other saturated (impregnated) paper tapes. The two main types of saturated paper backings are crepe paper and flatback paper. The paper color can vary from white (bleached) to light tan (semibleached), and dark tan (unbleached). If a darker raw paper is used and a lighter shade of tape is desired, some TiO2 may be incorporated into the adhesive and/or saturant formula. Saturants include natural rubber, styrene-butadiene rubber, and various water-based latexes. The first release coatings for saturated paper tapes were natural and synthetic polymers such as shellac, starch, casein, and nitrocellulose (Satas, 1989). Saturated papers, coated with pressure-sensitive adhesives, sometimes show a lowering of tack and adhesion on aging. In most cases, this effect is due to the tackifier resin migrating from the adhesive into the saturant. (Satas, 1989)

   Unsaturated kraft paper tapes have been developed most recently. The adhesive is usually a natural rubber type, but hot melt adhesives are also used. Silicone-based release coatings are used on the reverse of the paper carrier to keep the layers of tape from attaching to each other in the roll and to counter the tendency for delamination of the adhesive and kraft paper backing.

3. **Film Tapes** - The oldest transparent film tape carrier is cellophane, made from regenerated cellulose. Cellophane is hygroscopic, becoming quite brittle when dry and quite soft in a humid atmosphere. These

deficiencies are absent in cellulose acetate, which replaced cellophane in the 1950's. A matte acetate film also came into use. Matte cellulose acetate film backing accepts writing, does not reflect light, and is therefore inconspicuous. Rigid and lightly plasticized polyvinylchloride film tape and polyester film tapes are important general-purpose tapes. Another popular all-purpose tape is the biaxially oriented polypropylene film tape. Several adhesive types are used to manufacture polypropylene film tapes including block-copolymer hot melts, natural rubber-tackifying resin adhesives, aqueous acrylic emulsions, and solution acrylic adhesives. (Satas, 1989)

4. **Filament-Reinforced Tapes** - Filament tapes are manufactured by overcoating a thin film with a tacky adhesive layer. The filaments are laid onto the tacky adhesive and the laminate is again coated with the required pressure-sensitive adhesive mass. The use of a biaxially oriented polyethylene film has surpassed the use of polyester film in the U.S.A. and rigid polyvinyl chloride in Europe. Glass filaments are used most often, but polyester and nylon filament reinforced tapes also exist. The tapes are most commonly made with block-copolymer hot melts and natural rubber-tackifying resin adhesives.

5. **Double-Faced Tapes** - Double-faced tapes usually comprise a carrier web, which can either be a film, paper, or fabric, coated on both sides with the pressure-sensitive adhesive. An interleaf keeps the two adhesives layers apart. Lighter weight products, such as those used in the home, are usually based on thin films such as unplasticized polyvinyl chloride, polypropylene, polyester or cellulose acetate. Because natural rubber-based adhesives attach well to many surfaces, they are commonly employed in these double-faced tapes, but acrylic-based adhesives are used in some tape products.

6. **Other Tapes**: Additional tape carrier materials include Teflon, Tyvek or other chlorofluorocarbons.

C. Brand Name Pressure-Sensitive Adhesives: Rubber-Based

1. **Nicomelt P-1585A**: Malcolm Nichol & Co. Easco Technologies. Tan colored pressure-sensitive hot melt adhesive
   Adhesive: styrene butadiene rubber, ethylene/vinyl acetate copolymer*
   Tackifier: hydrogenated rosin*
   (*CCI ARS 2686.1 1988)

D. Brand Name Pressure-Sensitive Adhesive Tapes and Hinges: Rubber-Based

1. **LePage's Biodegradable Tape**: LePage's Inc. Cellophane tape.
   Carrier: cellophane+
   Adhesive: rubber resin+
   (+mfr.,1992)

2. **High Performance Masking Tape #202**: 3M Co.
   Adhesive: rubber resins+
   Carrier: impregnated crepe paper+
   (+mfr., 1992)

3. **Drafting Tape #230**: 3M Co.
   Adhesive: rubber resins+
   Carrier: impregnated crepe paper+
   (+mfr., 1992)

4. **Photographic Tape #235**: 3M Co., black paper tape
   Adhesive: rubber+
   Carrier: black crepe paper+
   (+mfr., 1992)

Note: LePage's, 3M Co., Tesa, and other companies still produce a variety of rubber based adhesive pressure-sensitive tapes, all of which could not be listed here. Please consult product information guides for more information.

15.3.5 Acrylic-Based Pressure-Sensitive Adhesives, Tapes and Hinges

A. Generic Pressure-Sensitive Adhesives: Acrylic-Based
The suitability of polyacrylates for pressure-sensitive

adhesives was recognized as early as 1928. Despite this early work, the polyacrylates were not extensively used for pressure-sensitive adhesives only in the 1950's and secured their present prominent position in the 1960's. Generally, acrylics adhere better to polar surfaces than rubber-based pressure-sensitive adhesives, but correspondingly less well to low energy surfaces. Their tack and adhesion are somewhat less than that of the best rubber-based adhesives. (Skeist, 1977)

Polyacrylates of a particular monomer composition are inherently pressure-sensitive without any compounding. The industry claims that polyacrylates possess some inherent properties superior to many other polymers used for pressure- sensitive adhesives. The polymer is saturated and more resistant to oxidation than rubber-based adhesives. It is water white and yellows less on exposure to sunlight.

Alkyl acrylates and methacrylates of 4 to 17 carbon atoms are suitable monomers for pressure-sensitive adhesives. The most commonly used monomers are 2-ethyhexyl acrylate, butyl acrylate, ethyl acrylate and acrylic acid. Polymer properties can be varied by copolymerization with other monomers. This is a universally used technique as homopolymers are rarely suitable for pressure-sensitive adhesive applications. Polymer flexibility and tackiness increase with increasing side-chain length until a certain chain length is exceeded. Then the chains start to form crystalline regions which cause stiffening of the polymer. Functional groups of the monomers may affect wetting properties and also provide cross-linking sites. Small amounts of such polar co-monomers cause adhesion strengthening with time. For tapes that require clean removal, such as masking tapes, increase in adhesion is undesirable. Acrylic adhesive/tackifier resin blends are used to improve removability of masking tapes exposed to high temperatures.

Cross-linking decreases the free movement of polymer molecules and a decrease in tack is normally observed. Polymers can be cross-linked by multivalent metallic ions such as zirconium and zinc alinate, zinc acetate, zinc ammonium glucinate, titanium compounds, and so on.

Acrylic pressure-sensitive polymers investigated by Donatas Satas (Satas, 1989) were easily soluble in ketones and aromatic solvents. Introduction of ionic bonding changed the solubility behavior considerably. Polymers with significant ionic bonding did not go into solution but only swelled in these solvents. The addition of isopropyl alcohol to the solvent was usually sufficient to negate the effect of the ionic bonding. The result was that the polymers were soluble in solvent blends containing alcohol.

Water-dispersable and water-soluble acrylic pressure-sensitive adhesives can be prepared by incorporating a higher concentration of monomers containing hydrophilic groups. They are important for some medical applications because of their ability to adhere to wet surfaces. These adhesives can absorb water, preventing moisture from accumulating at the skin-adhesive interface and weakening the bond.

Acrylics do not require tackification to provide excellent physical properties, nevertheless, many commercial acrylic pressure-sensitive adhesives contain rosin esters or pure monomer aromatics such as low molecular weight polystyrenes, and copolymers of alpha-methylstyrene or vinyl toluene. Acrylic adhesives may also contain plasticizers, including phthalate and phosphate plasticizers. Fillers such as hydrasperse clay, calcium carbonate, zinc oxide, and colloidal silica, can be used to extend the polymer and to change its properties.

Vinyl acetate/acrylic ester copolymers constitute a special group of acrylic pressure-sensitive adhesives. Such adhesives are less polar. They usually exhibit high tack and may have somewhat poorer aging properties than acrylic adhesives. As with acrylics, adhesive strength increases with time. (Skeist, 1977). Improved adhesion to non-polar surfaces is also obtained by formulating acrylic-based pressure-sensitive adhesives with an ethylene-vinyl acetate copolymer.

B. Generic Pressure-Sensitive Tapes and Hinges: Acrylic-Based

1. **Paper Tapes** - Kraft paper tapes are constructed by extrusion coating the paper with a polyethylene coating. The acrylic adhesive is applied directly to the paper and the back of the tape requires no silicone

release coating. Japanese paper tapes are made of Manila hemp. The reverse side of the backing is overcoated with shellac or synthetic resin and a release coating.

2. **Film Tapes** - Acrylic pressure-sensitive adhesives are often used on plasticized polyvinyl chloride films for various tapes and labels. Plasticized vinyl contains liquid plasticizers (i.e., diisobutyl phthalate, dibutyl phthalate or other phthalate plasticizers) which migrate into the adhesive mass, causing changes in the peel, adhesion and creep resistance of the adhesive. Plasticizer may also accumulate at the film-adhesive interface, or more often at the adhesive surface, causing a loss of tack or adhesion. (Satas, 1989) Biaxially-oriented polypropylene film tapes employ both aqueous acrylic adhesive emulsions and solution acrylic adhesives. These tapes are suitable for various packing applications.

C. **Brand Name Pressure-sensitive Adhesives: Acrylic-Based**

1. **Scotch Brand No. 924 Adhesive Transfer Tape**: 3M Co., transfer tape carrier: none
   Adhesive: unidentified acrylate polymer*
   (*CCI ARS 1844.6 1982)

D. **Brand Name Pressure-Sensitive Tapes and Hinges: Acrylic-Based**

1. **Magic Mending Tape #810**: 3M Co., frosty carrier tape
   Carrier: cellulose acetate+
   Adhesive: acrylic mixture+
   (+mfr.)
   Comment: Since its introduction in 1961, #810 has undergone only minor formulation changes.

2. **Scotch Brand Transparent Film Tape #600**: 3M Co., transparent tape, various widths
   Carrier: Paklon film+
   Adhesive: acrylic+
   (+mfr.)

3. **Scotch Brand #811 Removable Magic Tape**: 3M Co., transparent low tack tape
   Carrier: cellulose acetate+
   Adhesive: acrylic+
   (+mfr.)
   Comment: This tape has the same adhesive as all Post-It system products.

4. **Artists' Tape #285 Adhesive**: 3M Co., tape with white plastic backing
   Carrier: polypropylene carrier filled with titanium white*
   Adhesive: unidentified acrylic resin*
   Comment: last date of manufacture was 1983 (*CCI ARS 2134.1 1983)

5. **Post-It Note Pads**: 3M Co., yellow paper sheets with adhesive strip along top edge
   carrier: paper carrier, neutral pH lignin present,probably wood pulp*
   Adhesive: unidentified acrylate polymer* pre-cross-linked mixture of 6 acrylic polymers+ (*CCI ARS 2238 1984; +mfr., no date)
   Comment: Post-It notes use the same adhesive as the 3M Co. #811 removable transparent tape.

6. **Scotch Brand No. 465 Transfer Tape**: 3M Co., Transfer Tape
   Carrier: polyester film
   Adhesive: unidentified acrylate polymer* (*CCI ARS 1844.8 1982)

7. **Status Security Tape SS1**: 3M Co., single-sided, white plastic book detection strip
   Adhesive: unidentified acrylic polymer* (CCI ARS 1844.10 1982)

8. **Status Security Tape DS2**: 3M Co., double sided, green plastic book detection strip
   Adhesive: unidentified acrylate polymer* (*CCI ARS 1844.9 1982)

9. **Scotch Brand Tape No.415**: 3M Co., double-sided tape
   Carrier:polyester
   film (transfer material coated both sides with adhesive)*
   Adhesive: unidentified acrylate polymer* **Other**: release paper is silicone coated kraft paper*
   (*CCI ARS 1844.5 1982)

10. **Scotch Brand Book Tape No. 845**: 3M Co., Book tape
    Carrier:polypropylene*
    Adhesive: unidentified acrylate polymer*
    (*CCI ARS 1844.7 1982)

(Note: The above list contains only the most common 3M Co. acrylic tape products. Please refer to 3M Co. for technical information on additional products.)

11. **Cellux Invisible Tape**, adhesive tape with clear plastic backing
    Carrier: cellulose acetate*
    Adhesive: unidentified acrylic resin*
    Plasticizer: unidentified phthalate*
    (*CCI ARS 2133.1 1983)

12. **Filmoplast SH**: Filmolux International,adhesive tape with fabric backing
    Carrier: cellulosic fabric*
    Adhesive: mainly poly (2-ethylhexylacrylate)*
    (*CCI ARS 2135.1 1983)

13. **Filmoplast P90**: Filmolux International, 2 cm wide tape with paper backing
    Carrier: unidentified paper*
    Adhesive: mainly poly (2-ethylhexyl acrylate)*
    Plasticizer: unidentified aliphatic plasticizer*
    Filler: calcium carbonate filler (unclear whether this is in carrier or adhesive)*
    (*CCI ARS 1844.1 1982)

14. **Filmoplast P**: Filmolux International, paper backed pressure-sensitive tape
    Adhesive: vinyl acetate probably copolymerized with an acrylate ester.*
    Plasticizer: dibutyl phthalate*

(*CCI ARS 1844.2 1982)
Comment: According to the manufacturers, "Filmoplast" tape is removable with water. It was found on several occasions that water application does nothing to solubilize the adhesive. Acetone and benzine are required to release the substrate from the paper to which it was attached. (PR) (See also AIC/BPG/PCC 46. Adhesives 1989, p. 89)

15. **Filmoplast P90**: Filmolux International, tape with paper carrier
Carrier: unidentified paper*
Adhesive: poly (2-ethylhexyl acrylate), "the same polymer found in CCI ARS 1844.1 (the old Filmoplast P90")*
Plasticizer: "A small amount of colorless liquid was extracted from the adhesive. The IR spectrum of the extract was virtually identical to the extract from ARS 2364.2 (Filmoplast P) The constituents of the extract (likely plasticizer) were not identified. Comparison with 1844.1 indicated a different plasticizer or mixture of plasticizers is present in the new sample."*
Comment: The following information came from David Chandler, a paper conservator at the Art Institute of Chicago: Accelerated aging tests were done in 1981 using a Filmoplast 90 tape attached to pieces of a medium weight Kozo paper. The tests were run by Doug Severson in the photographic conservation lab. Samples were aged in an oven at 45% r.h., 95% r.h., and with no moisture introduced. In all aged samples, the Filmoplast paper substrate was noticeably yellowed although the adhesive remained visually unchanged. In the cases of the 45% and 95% r.h. samples, adhesive reversal became more difficult. (PR)
(*CCI ARS 2364.1 1985)

16. **Filmoplast P Filmolux Inc. Archival tape**: adhesive layer on paper support
Carrier: unidentified paper support*

Adhesive: "The adhesive layer is composed mainly of an acrylic styrene/ copolymer. The adhesive on the old filmoplast P (ARS 1844.2) was primarily polyvinyl acetate (probably copolymerized with an acrylate ester*
Plasticizer: "A small amount of colorless liquid was extracted from the adhesive. The IR spectrum of this extract and the one from ARS 2364.1 were virtually identical. The constituents of the extract (likely plasticizer) were not identified. Comparison with ARS 1844.2 indicated that a different plasticizer or mixture of plasticizers is present in new sample (ARS 2364.2)".*
Other: presence of calcium carbonate (although not reported in which component of the tape)^
(*CCI ARS 2364.2 1985)
(^CAL 4424)

17. **J-LAR**: Permacel New Brunswick, New Jersey, clear pressure-sensitive tape, different widths
Carrier: polypropylene
Adhesive: methacrylate^
(^CAL report 1034)

15.3.6 Heat-Activated Adhesives, Tapes, and Hinges

A. Generic Heat-Activated Adhesives
(See AIC/BPG/PCC 46. Adhesives 1989)

1. **Hotmelt Gun Adhesive** - These adhesives (wax) are used by artists to adhere three-dimensional paper forms. (LP)

B. Generic Heat-Activated Tapes and Hinges
No entries.

C. Brand Name Heat-Activated Adhesives

1. **Scotch Mounting Adhesive No. 567**: White, "gummed" sheet
Carrier: unidentified paper*

Adhesive: poly alkyl acrylate ester*
Tackifier: terpene phenolic resin and an unidentified rosin derivative*
(*CCI ARS 1671 1979)

2. **Kodak Dry Mount Tissue Type 2**: Eastman Kodak Dry Mount Tissue
Carrier: paper*
Adhesive: ethylene-vinyl acetate copolymer blended with a terpene phenolic resin*
(*CCI ARS 1664 1979)

3. **Archivart Adhesive Web**: Process Materials Corporation, adhesive coated polyester web, heat activated
Adhesive: a blend or copolymer of poly(ethylene terephthalate) and poly(tetramethylene terephthalate)*
(*CCI ARS 2259 1984)

D. Brand Name Heat-Activated Tapes and Hinges

1. **Library of Congress Heat Set Tissue**
Carrier: Barcham Green lens tissue
Adhesive: initially a mixture of Rhoplex AC 73 and Plextol B 500. The Plextol B-500 was eventually substituted with Rhoplex AC 234.

15.3.7 Synthetic Polymer Adhesives, Tapes and Hinges

A. Generic Synthetic Polymer Adhesives
(See AIC/BPG/PCC 46. Adhesives 1989, pp. 47-91.)

B. Generic Synthetic Polymer Tapes and Hinges
No entries.

C. Brand Name Synthetic Polymer Adhesives

1. **Titebond Adhesive**: Franklin Chemical Industries
Adhesive: polyvinyl acetate copolymerized with polyacrylonitrile^
poly vinyl acetate and polyvinyl alcohol*
Other: urea formaldehyde resin (possibly acts as hardener)^

(*CCI ARS 2312.79 1984)
(^CAL 2008 1975)

2. **Slomon's Sobo Glue**: Slomon's Labs, Inc., liquid adhesive
   Adhesive: polyvinyl acetate with polyvinyl alcohol polyvinyl acetate additives, polyacrylate, polyethylene glycol dibenzoate.*
   (*CCI ARS 2312.73 1984)

3. **Slomon's Velverette Craft Glue**: Slomon's Labs, Inc.
   Adhesive: polyvinyl acetate copolymer and additives, polyvinyl alcohol/polyvinyl acetate*
   Plasticizer: phthalate*
   Other: unidentified crystals*
   (*CCI ARS 2312.74 1984)

4. **Wood Repair Glue WRG-2**: Woodhill Permatex, liquid adhesive
   Adhesive: polyvinyl acetate/ polyvinyl copolymer and additives, polyacrylate.*
   (*CCI ARS 2312.28 1984)

5. **Vinamul Polyvinyl Acetate Emulsion**: Vinyl Products Limited, liquid adhesive
   Adhesive: polyvinyl acetate/polyvinyl alcohol copolymer*
   (*CCI ARS 2312.82 1984)

6. **Vinnapas Dispersion EPI**: Henley Chemicals, Limited, liquid adhesive
   Adhesive: polyvinyl acetate 80%/polyethylene copolymer with additives (poly vinyl alcohol)/ polyvinyl acetate with polyvinyl alcohol, polyacrylate and unidentified crystals.*
   (*CCI ARS 2312.83 1984)

7. **Weldbond Presto-Set White Glue**: Weldwood Ltd. (Canada), liquid adhesive
   Adhesive: polyvinyl acetate and additives/polyvinyl alcohol/polyvinyl acetate and polyacrylate*
   (*CCI ARS 2312.85 1984)

8. **Swifts's 2928**: Swift Chemical Limited, liquid adhesive
   Adhesive: polyvinyl acetate/poly vinyl alcohol and polyacrylate*
   (*CCI ARS 2312 1984)

9. **Swifts's 2552 Resin Adhesive**: Swift's Chemical, Ltd., liquid adhesive
   Adhesive: polyvinyl acetate/poly vinyl alcohol with polyamide and possible polyacrylate*
   (*CCI ARS 2312 1984)

10. **Weldbond**: Frank T. Ross & Sons, liquid adhesive
    Adhesive: polyvinyl/poly vinyl propionate copolymer and polyvinyl alcohol/polyvinyl acetate*
    (*CCI ARS 2312 1984)

11. **LePage's Arts and Crafts Glue**: LePages's Inc., white liquid adhesive
    Adhesive: poly vinyl alcohol+
    (+mfr., 1992)

12. **LePage's School Glue**: LePage's Inc., liquid adhesive
    Adhesive: polyvinyl acetate/polyvinyl alcohol copolymer+
    (+mfr., 1992)

D. Brand Name Synthetic Polymer Tapes and Hinges

1. **Archival Aids Document Repair Tape**: Ademco Limited, 2.5 cm wide pressure-sensitive tape
   Carrier: unidentified paper
   Adhesive: vinyl acetate probably copolymerized with an acrylate ester* polyvinyl acetate#
   Plasticizer: diisobutyl phthalate*
   (*CCI ARS 1844.4 1982; #NARA 1985)
   Comment: This tape also comes in 1/2" width called Transparent Mending Tissue, (See also AIC/BPG/PCC 46. Adhesives 1989, p. 90)

2. **Archival Aids Tape AFTI**: Ademco Limited, 2 cm wide pressure-sensitive tape
   Carrier: starch treated paper*

Adhesive: polyvinyl alcohol/polyvinyl acetate copolymer*
(*CCI ARS 1982)

3. **Filmoplast**: Filmolux international Inc., pressure-sensitive tape
Carrier: cellulose*
Adhesive: copolymer of vinyl acetate and dibutyl maleate*
(*CCI ARS 1728 1980)

15.3.8 Miscellaneous

(See AIC/BPG/PCC 46. Adhesives 1989)

A. Cellulose Nitrate

1. **Duco Cement**: Dupont, solvent based adhesive
Adhesive: cellulose nitrate*
Plasticizer: dicyclohexyl phthalate*
(*CCI ARS 1721.1 1980)

2. **H.M.G. Adhesive**: H. Marcel Gueat Limited, solvent-based aculine
Adhesive: cellulose nitrate*
Plasticizer: dibutyl phthalate*
(*CCI ARS 1721.3 1980)

B. Cellulose Acetate

1. **Balsa Model Cement**: Lepage's Limited, solvent-based aculine
Adhesive: cellulose acetate (no plasticizer detected)*
(*CCI ARS 1721.2 1980)

C. Glue Sticks

1. **Pritt Glue Stick**: Henckel, West Germany, glue stick for use with paper
Adhesive: predominantly poly(vinyl pyrrolidone) with some poly(vinyl alcohol). The solvent appears to be water.*

Other: possible presence of an amine or amide contributes to odor of the product.*pH reported as 8.9^
(*CCI ARS 2011 1982)
(^CAL 1033)

2. **UHU Stic Glue Stick**: Faber Castell, white glue stick for use on paper
   Adhesive: predominately poly(vinyl pyrrolidone) with some poly(vinyl alcohol). The solvent appears to be water.*
   Other: possible presence of an amine or amide contributes to odor of the product.*
   (*CCI ARS 2012 1982)

3. **Dennison Glue Stick**: Dennison Manufacturing Company, white glue stick
   Adhesive: poly(vinyl pyrrolidone) with some poly(vinyl alcohol)*
   (*CCI ARS 2017 1982)

15.4 Materials and Equipment Used in Treatment

This section is divided according to the categories of treatment described in Treatment Variations, 15.5. A more detailed description of the use of the equipment or material will be contained in that section if it does not appear here.

15.4.1 Dry Techniques

Hand Tools: scalpel, microspatula, Teflon-coated metal microspatula, bamboo spatula, Teflon spatula, roach carver (a small stainless steel dental tool), tweezers, sand paper, emery paper, polyester film and metal eraser shields for masking, silicone release paper, cotton swabs, brushes, nylon pot scraper (Pancare).

A thin stick of bamboo can be sanded by hand or on a grinding wheel to a rounded tip with a fine and thin edge. The edge of the bamboo tool does not seem to abrade paper as much as a metal spatula when removing adhesive residues.

A Teflon "spatula" can be made by cutting a sheet or tile of Teflon into strips, and then carving and sanding the end to form a thin, smooth,

flexible blade. A tacky adhesive residue does not adhere to the Teflon so the tool is effective on larger masses of tacky adhesive residues.

A piece of double-coated silicone paper, freshly cut so its edges are crisp, is like a Teflon spatula but much thinner. If large enough, it can function simultaneously as a spatula and as a support for the object. The technique is to hold the silicone paper taut between your hands and slide it back and forth under the tape carrier to be removed. Normally this is used with other techniques for softening and swelling the adhesive. This technique is useful if the object and the carrier are stiff or if you need to get under a large area (e.g., part of a collage). It also allows for repeating a softening technique (i.e., direct application of a solvent) without having the object reattach to the adhesive.(CS)

Eraser Materials: crepe squares, and vinyl erasers in pencil, block, and grated form. Rolled up tape with low tack. Electric eraser. Cellulose powder can be used to assist in the removal of tacky adhesive residues. (See AIC/BPG/PCC 14. Surface Cleaning 1992.)

Heat/Hot Air: blow dryer, hot air gun, conservation hot air gun (such as the Leister), slide warming tray (Fisher Scientific), Salton warming tray, tacking iron, metal spatulas, Teflon coated microspatula, heat shielding materials such as blotters, polyester film, thermopapers (Talas). A selection of Thermopaper strips that change color at 10 degree F intervals help indicate the temperature (Paper Thermometer Co, Greenfield, NH 03047; sold by Talas) (KN)

Employing a heated metal spatula is often the easiest method of using heat to remove pressure-sensitive tape carriers from paper surfaces.

A soldering iron can be fitted with a custom-prepared tip for use in lifting some tape carriers, particularly cellophane tapes that still have some tackiness. The initial development of the tool was made by inserting the stem of a metal microspatula into the slit in the tip of a standard soldering iron.

The Transfer Tool in the University Products catalog can be modified as described above, or a modified version of the Transfer Tool is now sold as a kit for removing cellophane tape by University Products as well. The kit includes a soldering iron and a rheostat; the tip is a 3/4" wide, flat spade

which is formed as a dull knife edge. (See 15.5 Treatment Variations for treatment record.)

Note: Always use a rheostat with heat appliances that do not have temperature controls (e.g., tacking irons, heat guns, and simple on/off heating devices.) The rheostat provides a constant voltage which produces heat at a consistent temperature. Thermopapers are used to indicate the temperature of the heated tool. Rheostats are sold by scientific or electrical supply companies.

15.4.2 Aqueous Techniques

Direct Local Application: brushes, cotton swabs, sponges, pipettes and micropipettes (glass & disposable polyethylene), capillary tubes, absorbent tissues and paper, natural sponges and spatulas of various types described above.

Natural sponges can be purchased at cosmetic or drug stores and can be cleaned and reused. They do not tend to leave fibers or other residues.(JG)

Humidification: "Humidification/moisture chambers" made from trays or sinks with covers, ultrasonic humidifiers, Gore-Tex, blotter and/or polyester web for damp packs, various spray tools.(KN) (See also Solvent Vapor in Solvent Treatments below.)

Poulticing: thick solutions of cellulose ethers (i.e. methylcellulose, carboxymethyl cellulose (CMC), hydroxypropyl methylcellulose, (Klucel), cellulose powder (Whatman), agarose gel, starch paste. (See also Poultice Materials for Solvent Techniques below.)

Steaming: steamer (i.e.,"Steamstress" or other clothing steamer), steamer modified for use in conservation (i.e., "Pencil Steam Generator" from University Products), tacking iron, blotters.

Immersion: trays or sinks, nylon or teflon pot scraper (i.e. Pancare), spatulas of various types, stiff bristled brushes, screen, Mylar, or acrylic sheet for support while lifting, hot water source or heated sink. (See AIC/BPG/PCC 16. Washing 1990)

Enzymes: Depending on the chosen application technique, see the appropriate section above. In addition materials to be used in contact with enzymes should not be metallic. Use plastic or

enameled trays, a temperature-controlled bath for immersion, synthetic bristle brushes, and ethanol for rinsing.

Suction Table or Disc: The suction table or disc is normally used for final removal and rinsing. Equipment and tools are described in greater detail below with solvent techniques.

15.4.3 Solvent Techniques

All solvent treatments require consideration of personal safety including use of the following equipment: fume hood or adequate ventilation, personal safety equipment (goggles, gloves designed for solvent work, fitted organic vapor respirator with correct canisters), sleeve protectors, and apron, if desired.

List of Organic Solvents: Solvents which are most practical and safest, assuming use of proper ventilation and protective gear/clothing, include ethanol, isopropanol, acetone, methyl ethyl ketone, ethyl acetate, n-heptane, cyclohexane, benzine, xylene, toluene, VM&P Naptha, mineral spirits and Stoddards' solvent.

Solvents which are used infrequently due to their toxicity include diacetone alcohol, methanol, cellosolve, cyclohexanone, n-hexane, n-dimethylformamide, morpholine, tetrahydrofuran, methylene chloride, 1,1,1-trichlorethane, tricholorethylene

Solvents which appear in the conservation literature but which are strongly not recommended due to high toxicity are benzene, chloroform and pyridine.

Solvent Vapor Chambers: mini-chambers using smaller containers (i.e., beakers, glass jars) with absorbent materials (i.e. cotton, blotters or Plaster of Paris), Gore-Tex (different types), blotters, polyester film for masking out areas or restricting area of treatment.

Direct Local Application: (See Direct Local Application in Aqueous Treatments above.)

Poulticing: Fuller's earth, other diatomaceous earths, cellulose powder, cellulose ethers, agarose gels.

Suction Table and Disc: A suction table or disc can be custom-made for the laboratory or purchased from manufacturers specializing in conservation equipment. The suction tables can be modified by adding a chamber above to add humidification or solvent vapor

treatment to the treatment possibilities. The suction disc is a modification for use in the fume hood, in a custom-built cabinet to be used in front of the fume hood, or on a lab table under an "elephant trunk" fume extractor. One can now obtain a 90 mm diameter glass funnel into which a fritted disc (30-40 micron pore size) has been placed. The disc is flush with the funnel's top surface, and is ready to be inserted into a table top, cabinet or portable surface. (Funnel can be ordered from Microfiltration Systems, 6800 Sierra Court, Dublin, CA 94568/(800) 334-7132)

Additional equipment to be used with the suction table could include a ventilation system (i.e. elephant trunk), ultrasonic humidifier, airbrush/spray gun. Also, one would need to have available blotters or other absorbent paper, polyester web, and the hand tools listed above in Direct Local Application of Aqueous/Solvent Treatment.(MKW)

Immersion: Solvent-resistant trays, solvent-resistant support materials, solvent-resistant masking materials for suction tables, blotters or other absorbent papers, hand tools listed above and a solvent waste disposal system.(MKW)

15.5 Treatment Variations

Description of treatment variations in this section proceeds in the same sequence as a typical treatment, although treatments will vary considerably. In many cases, the same technique may be used for different operations (i.e., poulticing can be used for carrier removal, adhesive removal, and/or stain reduction.) For the sake of continuity, the variations are described in this general order: pre-treatment, tape carrier/hinge material removal, adhesive residue removal, and finally stain reduction. Most conservators generally feel that there is a lower risk in local treatments for the reduction of adhesive and adhesive residues; however, please see "Special Considerations" for further discussion of possible differences in aging between treated and untreated areas.

When testing and deciding on a course of treatment, one should be aware that more than one adhesive may have been used, for example the tape used around the edges may vary from a tape used on the back of an object. Also test each tape in several locations, e.g., at edge and in center. The treatment requirements may vary when more than just edges are tested.(CS)

Certain mechanical manipulations are useful when removing tape carriers after adhesive has been softened either by local applications of moisture or solvents, or by using humidification or solvent vapor mini-chambers. By applying the tip of a honed microspatula to the top surface of the paper tape carrier and moving it with an almost imperceptible circular motion often the carrier can be coaxed free of the object.(NA) Care should be taken to watch for areas that may already be delaminated or have weaknesses from tears.

15.5.1 Dry Techniques

Many conservators prefer to use dry techniques for adhesive and adhesive residue removal, using solvents and chemicals minimally or only as a last resort. This is due to the possible long-term damage from introducing solvents, enzymes, bleaches, etc.

In a case where there is a minimal amount of pressure-sensitive adhesive residue embedded in the fibers, it may be desirable to simply counteract the tackiness and control future deterioration. For example, a modern lithograph on Japanese paper had been attached to a back mat with double-sided tape. The residue was removed using a solvent chamber and picking off the residue with tweezers. Some tackiness from adhesive residue embedded in the soft fibers remained. Cellulose powder was sprinkled over these areas and burnished in place.(EW) One conservator reported difficulty in removing rubber-based pressure-sensitive tape adhesive onto which cellulose powder had been sprinkled. In this case, the adhesive mass had not been reduced following removal of the tape carrier. After one and one-half years, the residue had become extremely hard and brittle, causing the paper around the perimeter of the adhesive mass to crack. (KL) A powder of calcium carbonate could also be used to buffer the area against future deterioration caused by the adhesive residue.

In some cases it may be preferable to abrade some paper fibers from the reverse of the object rather than subject it to the greater risks of local aqueous or organic solvent treatments. (MKW) For example with an acrylic tape on a very thin fibrous Japanese paper, it may be impossible to completely remove all the adhesive without removing a few paper fibers. In this case one may decide to remove the bulk of the tape and adhesive residue now rather than be faced later on with an aged, discolored, pressure-sensitive adhesive that causes staining and deterioration of the object.(EB)

Many "dry" techniques for removal of adhesive and adhesive residues function as pre-treatment actions. Peeling, sanding, scraping or scoring of a tape carrier often precedes aqueous or solvent removal techniques. Some pressure-sensitive tapes and adhesive residues can be removed entirely by dry techniques. Adhesives found in binding structures can often be removed largely with "dry" techniques.(BMJ)

When trying to hold a sheet of paper for either tape removal or for adhesive reduction, strips of flexible metal or plastic magnets will secure the item to a metal work surface. The magnets will hold the paper,

allowing for more control by the conservator, especially on delicate paper.(BM)

Adhesive reduction, after removal of the tape carrier, by scraping or erasing with a crepe square or vinyl eraser is sometimes all that is necessary if the adhesive is still sticky and has not penetrated the support. (FZ) This technique works best if the surface of the support is compact and smooth.

A. Simple Removal, Peeling Off, or Delaminating the Tape Carrier

A bamboo or Teflon tool can be inserted under areas of paper tapes where the adhesive has become desiccated, allowing the tape to be separated from the paper surface.(EW) Some acrylic tape carriers can be peeled off objects with smooth, compact surfaces such as calendared or coated papers. A slow steady pulling of the carrier will sometimes remove the adhesive mass as well. Using an angle of almost 180 degrees to release the tape will prevent distortion of the object, although sometimes an angle closer to 90 degrees will remove more adhesive. The carrier may be easily removed from pressure-sensitive tapes that have cross-linked adhesives, particularly aged rubber-based adhesives.

Delamination is also useful on paper tapes, glassine tape, paper patches, etc. Delamination of some kinds of white paper tape and, in some cases, masking tape can be accomplished by dry peeling or by humidification with a damp swab and gentle scraping with a microspatula. The success of this method will depend on the age of the tape and

adhesive and, possibly, the hardening of the adhesive in the paper fibers.

B. Scoring

Plastic tape carriers can be scored lightly with a scalpel to increase their flexibility. Masking tapes and other crepe paper carrier tapes often respond well to scoring across the grain direction. This breaks up the stiffness of the carrier and also aids penetration of solvents.

One treatment method is to score the carrier of frosted tape at 1/4" intervals. The carrier can then be removed in sections. If a crepe square or vinyl eraser is used to remove the exposed adhesive mass, then the adjoining intact tape can act as a support to the object while the mechanical manipulation of the crepe square or eraser is performed.

C. Scraping

An embrittled adhesive may be scraped with a dull scalpel, a shaped "Fisher" knife, shaped sculptor's spatula blade or other similar blade to remove additional adhesive. Looking through a stereobinocular microscope or other magnification device allows the conservator to observe the layers and avoid removing fibers.(FZ)

The advantages of scraping away excess adhesive residues for pretreatment include:

1. Scraping the carrier of a tape or hinge will allow better penetration by solvents or enzymes. This technique is useful for glassine, linen, kraft, masking and white paper tapes.(PR)

2. Scraping to minimize the amount of adhesive mass will decrease time spent on other removal procedures, e.g., the suction table, or contact with solvent vapor chambers, etc. With commercial PVA adhesives (e.g., Elmer's), scraping as much adhesive off as possible makes it possible for the solvent to work more efficiently. Testing with a solvent chamber will indicate if the adhesive can be softened and mechanically picked off. Rolling the area with a moist swab

followed by a dry swab to pick up residues also may help to reduce PVA-type adhesive residues (EW) (See solvent combinations section for choice of solvents.)

3. Scraping will minimize the adhesive available to penetrate the sheet or to travel laterally through the sheet during solvent treatment, thus reducing the risk of lateral wicking and tide lines.

4. In the case of electrical or other tapes with colored carriers, it is helpful to remove most of the carrier before applying solvents. This may prevent soluble dyes from moving into and staining the paper. (CS)

D. Sanding

Sanding with a very fine grained sandpaper may help to reduce an embrittled adhesive residue. Sandpaper of different grades can be used to abrade the surface of carriers and hinges to increase susceptibility to solvents. Sanding can be done with emery paper glued at the bevelled surface of a wooden dowel for precise control. This technique works well with hard surfaced or calendared and coated paper carriers, and when large quantities of tape are involved. A metal eraser shield or heavy weight polyester film can protect the surface of the object adjacent to the tape during sanding. Sanding may not be a suitable technique on a paper which has a fibrous or unsized surface which will "hold" adhesive dust.

E. Erasers

Crepe rubber squares and other eraser materials are very useful in picking up adhesive residues that still have some tackiness. The eraser techniques are usually more successful when treating tapes on papers with a medium to hard surface. Soft, fibrous paper surfaces, such as Japanese papers, may be damaged by the mechanical action needed with these methods. In addition if the media is friable or susceptible to erasure, this technique is not appropriate.

1. A crepe rubber square can be cut and fashioned to prepare a shape suitable to the area of adhesive to be removed. To erase in very small areas, e.g., within lettering or design, cut a small piece of eraser and hold it by tweezers. (CS) Care must be taken to clean

the crepe as the residue accumulates on it. Slight fiber loss is possible due to the elastic, abrasive action of crepe rubber on some papers. (EKS) In many instances it is advisable to do this work using a microscope. It may help to lightly swab the adhesive residue with solvent and then begin using the crepe eraser while the residue is still moist. (KL) Alternatively, heat can be used to soften adhesive before removal. Sometimes a "ball" of the accumulated eraser crumbs and adhesive residue works better than a crepe eraser used alone.(KL)

2. Vinyl erasers are less tacky and therefore may be less likely to damage the surface of a paper. The vinyl eraser is prepared (a blunt chisel is a good edge) and is used to push or ball up the adhesive residue. A vinyl eraser may work more efficiently on tacky adhesive residues if used with a light dusting of cellulose powder. Cellulose powder is particularly useful on adhesives that seem to become more tacky when manipulated with an eraser. The cellulose powder acts as a binder and will also pick up residues of the eraser. Vinyl erasers in "pencil" form are also good for this technique.(EO'L)

Many vinyl erasers contain a plasticizer, usually a phthalate. These plasticizers have the ability to soften and swell some adhesive residues. "Magic Rub" vinyl erasers contain 1/3 dioctyl phthalate, which has a Teas Chart location almost identical to methylene chloride." (Nicholson, Catherine. "Notes from Washington Conservation Guild Meeting, January 1991" Newsletter.) Because the dioctyl phthalate plasticizer is readily volatilized, it may be helpful to cut away the eraser surface to expose a fresh plasticizer-saturated edge. It may also be useful to use heat simultaneously with the "Magic Rub" eraser on very cross-linked rubber-based pressure-sensitive tape adhesive residues.

One should note that hard-surfaced, glossy or coated papers can be abraded by the fine abrasives ($CaCO_3$) in vinyl erasers. Also, the phthalate plasticizer can react with some media, especially ballpoint pen inks, grease pencils, wax crayons, stamp pad inks, and felt

markers. Magic Rub can also interfere with later techniques (i.e. poulticing) by becoming embedded in paper fibers.(EB)

3. Groom Stick is very tacky rubber-based, kneadable eraser and therefore the possibility of it damaging surface fibers is great. However, it can be a very effective dry method of adhesive removal on heavily sized, calendared or clay or plastic-coated papers. In one case, a kneaded eraser was particularly useful in removing 3M Co. 415 tape from a drawing on "frosted" mylar. (FB) All kneaded erasers must be handled carefully so that dirt and oils will not be transferred to the object.

4. At times, the tape itself can be used as a "pick up" eraser, i.e., Magic Mending Tape can be pounced repeatedly in area where there is an adhesive residue of Magic Mending Tape (VBH)

F. Heat

Heat is often useful if a pressure-sensitive tape adhesive is still in a tacky state. Heat can be used to release a pressure-sensitive tape carrier, or soften the adhesive sufficiently to enable the residue to be removed mechanically with a crepe eraser or following exposure to a solvent chamber. Heat applied using both hot air and heated spatulas has been found to be useful with frosted tapes, double-sided tapes, masking tapes, etc., particularly when they have been applied fairly recently.(EW) Dry mount adhesives (i.e. Fusion 4000) can often be removed by heating the adhesive, removing the carrier tissue, and subsequently lifting the residue with a crepe square. (JG)

1. **Heat Applied Locally with Heated Tool**
A metal spatula is heated by contact with a tacking iron or by hot air from a heat gun. It can be heated before insertion between the carrier and the adhesive, or heated in situ with a stream of hot air, often from a small hand-held hair dryer. If the adhesive is allowed to cool it will normally resolidify and resist removal, so a technique which allows for a continuous source of gentle heat is preferable.

In using the modified soldering iron, or the Transfer Tool the custom-made tip is heated until it is just warm enough to lift the tape carrier, thus leaving the residue to be removed either with a crepe rubber square, eraser or solvents. More than 4000 inches of tape from two church register books were removed by this method, which was both efficient and cost-effective. In addition, because the heat is concentrated at a narrow line rather than heating a larger area, there is less opportunity for the adhesive to penetrate the paper. (BM)

An additional technique using a combination of moisture and heat involves the removal of kraft paper tape using moistened blotter squares applied with a hot tacking iron to the tape carrier. This softens the adhesive long enough to pull away the carrier either in one piece, or in strips. The carrier can be scored lightly for removal of a large piece. (See 15.5.2 Aqueous Techniques)

2. **Heat Applied Overall**

Heat can be applied using a hand-held hair dryer. This warms a larger area, and may provide a gentler source of heat than that of a heated tool. It has been observed that there are fewer problems with residues becoming less solvent-soluble and therefore harder to rework, with the use of hot air than with the heated metal spatulas.(KL) (See 15.5.1.F.3 below)

The object must be secured and protected from the force of the blown air and it can be difficult to handle the hand-held dryer and the necessary tools unless the dryer is placed in some kind of holder.

Another indirect method for applying heat is use of a warming tray (i.e. Salton warming tray, or a slide-preparation tray) to mobilize larger areas of adhesive. The softened adhesive mass can be gathered up into cellulose powder using a microspatula, an eraser, or the finger tips, and scraped away with a microspatula. This procedure can be repeated several times for optimum removal. (EO'L)

3. Cautions in Using Heat

In particular, when considering the use of a hot air gun to remove masking tape, test the solubility of the adhesive before and after a test application of heat to the same area. Heat can change the solubility of masking tape adhesive, making it less soluble or even insoluble in the same solvents effective previously. This can complicate the removal of the adhesive residues left after removal of the tape carrier.

This change in solubility occurred during the treatment of a lithograph by Jean Arp which had masking tape on the edges of the reverse. The tape adhesive was still tacky before treatment, although it appeared to be partially embedded in the paper. The adhesive was initially soluble in petroleum benzine according to tests. Hot air was chosen to minimize potential staining of the immaculate, white recto of the Arp. Following removal of the tape carrier and some of the adhesive residue using a hot air gun, the petroleum benzine no longer dissolved the residual adhesive; it had become soluble only in toluene and acetone.(EB)

The change in solubility may have been due to one or a combination of the following phenomena: the plasticizer may have been evaporated off by the heat, leaving an adhesive residue with more polar solubility parameters; the plasticizer, tackifier or even elastomer may have been driven into the paper, making the residue less accessible and more resistant to solvation; tackifier resins have a low molecular weight relative to the elastomer (however, tackifiers also have a higher glass transition temperature than most elastomers); the adhesive residue may have been oxidized and/or cross-linked by the heat, thus requiring a more polar solvent combination for removal (LS;EO'L)

Polypropylene carriers can deform at relatively low temperatures. The hot air gun, or any uncontrolled heat source, can actually melt these carriers and drive them into the paper to which the tape is affixed.(EO'L)

G. Freezing

Dry ice has been successfully used on Leroy Neimann prints to release adhesive from lacquer-based inks.(SD)

An experiment was performed to freeze a tape to embrittle the adhesive. Through the use of dry ice, the tape was chilled to about -20 degrees F with the paper protected by a sheet of polyester film. This method did not seem to work well. An attempt was also made to use something similar to liquid nitrogen to embrittle the adhesive. Experimentation was discontinued because the idea of using heat seemed more easily controlled and probably safer.(BM)

The technique was found to be somewhat useful for pressure-sensitive tape, but the embrittlement and removal of degraded fibers remained a concern.(EM)

15.5.2 Aqueous Techniques

Removal of attachments with water-soluble adhesives can appear to be a fairly simple, straightforward procedure. Often, however, the most precious items (for example, a collection of old master prints, or a rare book) have had repeated applications of adhesive either with hinges, or labels, or, in the case of a book, guards and spine adhesives. The conservator may be faced with a stiff accumulation of adhesive layers and paper remnants. The paper beneath may be more severely abraded than is initially apparent and may be extremely fragile, making treatment very difficult. Techniques for removal in such cases must be extremely delicate and controlled.

A. Local Treatments

Recto and verso should be inspected before, and frequently during treatment using normal, raking and transmitted light to avoid alterations in the paper surface as much as possible.

The surface on which the object is placed is important. For example, when the object is placed face-down, glassine or glass may be required to protect the media. Such highly smooth surfaces, however, can allow local burnishing of the paper surface during hinge removal. The use of polyester web and blotters below hinge areas during treatment can limit burnishing.(NA) Glassine placed over a 1/8" felt may provide a softer surface for local treatment.(BMJ)

Residues of water-soluble adhesives, especially from old hinges at corners, which are not completely removed can often contract and distort the paper. If one cannot entirely remove the adhesive residue without damaging the paper surface, humidification followed by friction drying using Japanese paper will sometimes even out the contraction.(VBH) The object could also be sandwiched between polyester web, with the polyester web stretched taut and taped over the edges of a board, using a felt between the polyester sandwich and the board for padding. The object is then allowed to dry. (BMJ) See also AIC/BPG/PCC 22. Humidification 1984 for additional stretch-drying techniques.

1. **Direct Application of Water Locally**
   Applying water locally to a hinge, tape carrier and/or adhesive residue with a brush or swab allows the conservator to observe the reaction of the treatment area and the adhesive to the moisture. The moist paper remnant or tape often can act as a poultice to soften the adhesive.(FZ) Ideally, the adhesive wets up, softens or gels before the object's surface absorbs moisture. Concerns include abrading, thinning or otherwise changing the surface character of the paper through wet or dry manipulations, causing wetting out and subsequent movement of discoloration products or adhesive to the recto of the paper.

   Manipulations are often needed to remove the adhesive residues. These manipulations include:

   a. Applying water with a fine brush and rolling with a dry swab.

   b. Rolling alternately with damp swab and dry swab, using both hands if possible. Swabs are changed frequently.

   c. Applying water on with a fine brush and blotting with blotter or Japanese tissue.

   d. Applying water through Japanese tissue onto the surface and allowing the adhesive residue to be absorbed into the Japanese tissue.

The area should be checked frequently with extreme raking light to confirm that adhesive sheen or adhesive tidelines have been eliminated and that the paper surface is not being disturbed. Dextrin adhesives have a characteristic odor and the swabs may be checked to determine that these adhesives have been reduced sufficiently.

These same techniques may be used to eliminate residues of paste or methylcellulose poultices.

Natural sponges make it easier to control the amount of water delivered to a specific area and can be reused after cleaning. The natural sponge also does not get caught in residual adhesive as does cotton or tissue paper.(JG)

Variations:

Slightly warmed or alkaline waters (containing either calcium or ammonia at pH 8-9) will sometimes swell and soften resistant water-soluble adhesives, particularly protein or protein/starch mixtures.(EW, JG)

Glassine tape can be more successfully removed with a direct application of warm water brushed onto an intact or "abraded" glassine tape carrier.(NA)

Marination - The tape carrier or hinge is wet out with a local application of water or other solvent and placed between two pieces of Mylar under weight. Given sufficient time, the adhesive may soften enough to remove the carrier and the adhesive residue mechanically. Caution: this technique may produce tidelines.(MKW)

A slanted board may be used as the support for removal of old guards, or other long strips of paper. Gravity assists in keeping the direct

application of water along the desired adhesive edge.(BMJ)

2. **Poultice**

Poultices and other similar techniques for indirect application of moisture can be used for removal of tape carrier/hinge material/adhesive residues as well as for reduction of associated staining.

Note: Conservators should be careful not to inhale particulates such as Fuller's Earth, cellulose powders or other similar poultice materials.

a. Blotters, chromatography paper and other absorbent papers

Absorbent papers such as blotters, chromatography paper, and wet strength paper can be used by dampening or saturating a piece with water, or a mixture of water and ethanol, and applying this to the paper tape carrier, hinge or guard. A barrier to prevent evaporation, such as a polyester or polyethylene film, can be placed over the absorbent paper and may be lightly weighted. The softening and release of the carrier is checked frequently, as well as any tendency to form tidelines. It is usually easier to "feather out" a tideline while it is still wet than to wait until it dries before attempting removal. More moisture can be added to the blotter if needed. Absorbent papers can be used in conjunction with Gore-Tex to limit the transfer of moisture to the object.

Blotters may be used with polyester web between them if adhesive staining is the problem. The blotter is used to remove the adhesive residue and cleanse the paper support. The degree of wetness of the blotter will depend on the possibility of creating tidelines. If the object can't be washed then tidelines should be avoided. A piece of Mylar on top of a moist blotter slows down evaporation.(EW)

A heavy-weight high-quality paper (i.e. Kalamazoo Hand Made Paper made by Tim Barrett) has been found to be a useful tool in poulticing. If it is burnished, it can be used as a smooth absorbent surface for poulticing.(BMJ)

Cotton linters and cotton pulp can also be used as a poulticing material for some of the reasons outlined above and in a similar way to absorbent papers.(KL)

b. Cellulose ethers

Water and ethanol/water mixtures, in cellulose ethers such as methyl cellulose can be used to soften hygroscopic adhesives.

For Oriental papers or other papers with little or no sizing, or fibrous surfaces, use a layer of Japanese tissue between poultice, swabbing, etc. to minimize loss or abrasion of paper.(KL)

An application of thick methyl cellulose may be used to remove paper tapes, glassine, kraft, Japanese paper and linen hinges, animal glue and old guards in book conservation. The methylcellulose is spread liberally on the carrier or adhesive residue with a spatula or "bright" tip brush restricting it to the surface of the carrier or adhesive. After the adhesive swells and softens, the methylcellulose and adhesive may be removed together using a spatula or tweezers. Using methylcellulose may leave the bulk of the adhesive on the object. The adhesive residue can be removed with a blunt tool, preferably while it is still moist. Moist swabs may be used, followed by dry swabs to remove the final layers. Final swabbing with a mixture of water and ethanol may help to remove the "shininess" of any adhesive residues.(EW)

A methylcellulose poultice may be used to remove the paper tape carrier or hinge and

then the thick residual adhesive is removed by applying a ball of cotton slightly moistened with hot water to the remaining adhesive and blotting with dry cotton.(MKW)

For removing linen tape hinges, apply methyl cellulose in a gel thick enough to stay within the hinge edges without flowing beyond the edge and wetting paper. Leave the poultice undisturbed five to ten minutes or more until the tape adhesive has become softened and swollen. The carrier can then be teased away and the residual adhesive "balled" up and removed cleanly with the tip of a honed microspatula without becoming embedded in most papers. If this moment is missed, some of the adhesive inevitably becomes embedded in the paper and resists removal.(NA) The same technique is useful for removing hide glue from the spines of books, and may be preferable to using wheat starch paste because it is more controllable.(BMJ)

Kraft paper may have a tendency to come off in layers and may require multiple applications of methylcellulose.(EW)

It is also possible to add solvents or enzymes to the cellulose ethers to locally treat staining caused by adhesives.

Cautions:

Care must be taken not to leave MC on the object for too long. The tape/hinge adhesive may be solubilized and driven into the paper, requiring subsequent suction table treatment (FZ).

Cellulose ethers can leave a residue that is difficult to remove. It may be better to use a piece of lens or Japanese tissue as an interlayer between the adhesive and the cellulose ether poultice.

In some cases, using a cellulose ether may result in more planar distortion of the object.(EW)

c. Cellulose powders, cotton linters or cotton pulp

Cellulose powders can be used with water or water/ethanol mixtures, in much the same way as Fuller's Earth can be used with solvents. They are absorbent, high-alpha cellulose, and very white, a feature which can be used to detect discoloration. They are, however, also expensive.(JG) In addition, they don't leave the grayish haze of Fuller's Earth. (CS)

d. Starch paste

Wheat starch paste, either cooked or precooked, can be used to poultice water soluble adhesive residues. They can be mixed to any consistency and applied directly or through Japanese paper or polyester web.

The starch paste is used in a consistency thick enough so it will stay within the boundaries of the tape or hinges to be removed; in this way, the paper will not get wet and tidelines are avoided. The starch paste poultice is left for one to two minutes. The carrier will need to be removed before the starch paste dries. Most of the time, the adhesive residue will be left behind on the paper. A second layer of thick starch paste poultice will help the adhesive to soften and be ready for scraping with the bamboo tool.(LP)

Starch paste can also be used when the adhesive is animal glue. Book conservators have traditionally used starch paste as a poultice to clean the spines of the books that will receive treatment. The starch paste poultice is applied and removed several times until the spine is clean and the signatures can be separated

without difficulty. (MLS) (See discussion of methylcellulose poultices above, as well.)

e. Agarose gel

Agarose gels can be used in the same way as cellulose ether poultices to soften and swell water-soluble adhesives including gelatin in the spine of vellum books. The agarose gel may be easier to use because it is prepared and formed into a solid block. However, agarose can adhere so firmly that it is difficult to remove after treatment. It is therefore advisable to cover the area of the hinge first with a piece of thin Japanese paper before placing the agarose gel.(CMG) Agarose should also be watched carefully -- it is often wetter than it appears. (SD)

3. Local Application of Steam

Steaming is most effective on proteinaceous adhesives or on combinations of protein with another water soluble adhesive.

a. Direct application of steam

The direct application of steam is usually accomplished by using a clothes steamer in either a vertical or horizontal format, depending on the construction of the steamer. The amount of steam delivered can be controlled by plugging off the holes on the bottom with a kneaded eraser. The steamer can be used with distilled water and a bit of salt or baking soda. A blotter or paper towel wrapped around the bottom of the steamer reduces the risk of condensation dropping onto the object. Blotter paper squares should be kept close at hand, to pick up water drops. (CS) Using wooden or Teflon tools during adhesive removal with steam helps to eliminate the possibility of moisture forming on a tool while it is used.

Removal of the top surface of the hinge or attachment allows quicker, more even penetration of the steam.(LG) By wetting the tape or adhesive first with a damp swab or cotton ball, the length of time that the object is exposed to hot steam can be reduced.(CMG, JG)

b. Local application of steam through an intermediate layer

The sensitivity of the object and media to heat needs to be considered when using this approach (i.e., swelling paint layers, staining, or the possibility of forcing adhesive further into paper fibers, etc.). This technique has been used for old master drawings with delicate media.

Generally if the object has to be treated face up, the media should be protected with a barrier of Hollytex or a plastic film. An absorbent layer or layers may also be required to insure that the warm vapor does not condense on the edge of the barrier material.

A tacking iron applied to moist blotters may be used to introduce steam into a smaller area, for example in an area which may have sensitive media. Using alkaline pH water can speed the dissolution of the adhesive and by limiting the initial dampness of the blotter, tidelines can be avoided. The heat setting and treatment time may vary or repeated applications may be required. The adhesive should dissolve and hopefully will become absorbed into the blotter itself.(EW,JG)

With thick residues of gelatin or animal glue, filter paper, lens tissue, Japanese tissue, or tableaux paper (cheaper bast-fibered paper) can be used to absorb the adhesive as it is dissolved by steaming.(LP) The dry filter paper or Japanese tissue is applied to the adhesive and

the back of the paper or tissue is then steamed. The process may be enhanced by first steaming the adhesive residue alone. Once the filter paper is saturated with dissolved adhesive it can be gently rolled off with the fingertips. The Japanese tissue can be gently lifted with the aid of a microspatula if necessary.(JG)

This method may be most effective on fairly thin paper mends (i.e., brown kraft paper) and not nearly as effective on thick paper mends.(PR)

4. **Enzymes**

Criteria for the use of enzymes in removal of tapes, hinges, or adhesive residues include the state of degradation of the adhesive, the fragility of the object and the vulnerability of any media which may be involved. There are specific enzymes which might prove useful for dissolving glue, paste and oil stains, depending on the nature of the original staining material. There are times when the specific nature of the enzyme reactions can be an asset. For example, an object repaired in the image area with silk crepeline, attached with starch adhesive, could be a better candidate for enzyme removal than for immersion and/or physical manipulation.

Enzymes have been used effectively on Japanese prints, applied locally to the adhesive residue. The enzymes should be applied to the adhesive only to the extent possible. The enzyme solution can be rolled onto the adhesive with a swab or brushed or sprayed on. Cover the local enzyme application with a piece of plastic film to retain the moisture. Working on a light box can provide a source of warmth to increase the effectiveness of the enzyme solution, and allows the conservator to ensure that there is no thinning of the paper during adhesive removal. Alternatives include placing the object on a sheet of Plexiglas, over a tray of warm water. Some conservators denature the enzymes with ethanol. If the object is water sensitive, the local area may not necessarily be rinsed with water prior to denaturing.(JG)

A glassine tape which did not respond to removal in water or water/ethanol was successfully removed by local application of a solution of proteolytic enzyme which has a small amount of alpha amylase as an impurity. This enzyme, formerly called"milezyme" (Miles Laboratories) is now called HT-Proteolytic and is available from Solvay Enzymes (1-800-487-4704.) (EO'L)

Some conservators feel that enzymes should be used only as a last resort due to the number of unknowns in the reaction processes between enzymes and various components of paper and media. Other more traditional methods, such as using hot water, poultices (methylcellulose, agarose, etc.) might be sufficiently effective although more time consuming.

5. Reduction of Tidelines

One of the major risks in treating tape, hinge and adhesive removal locally is the possibility of forming tidelines in the original paper support. Tidelines may be formed from the movement of the original colored components of the paper, or colored residues of the adhesive or components of the carrier.

A suction table or suction disc may be used with local application of water or water/ethanol mixtures to reduce the tidelines. Caution must be used to ensure that the area is not "overcleaned" and does not appear lighter in color than the surrounding paper.

The tidelines can be treated, if the media is stable to water, by spraying the paper support overall, or placing the object in a humidification/ moisture chamber and reducing the tide lines on the suction table.

In one variation the object is placed on a blotter on the suction table or disc and tidelines are reduced by gently wafting ultrasonic mist onto the tideline through a hose or tube with a very small aperture or opening. This works well, even on old colored papers and is gentle enough for many works with fragile media

although care must be taken and a light touch used.(MKW, EKS)

B. Overall Treatments

1. Humidification

Humidification involves making the object moist or damp by the introduction of water in either the vapor phase or the liquid phase. Vapor phase methods include placing the object in an environment that contains a high level of either cool or warm water vapor, or water vapor introduced through a membrane such as Gore-Tex. Liquid phase methods include spraying, placing the object next to a damp blotter, and some forms of humidification chambers. Some controversy exists about the exact form of water that is delivered by some of the systems described below. All forms of introducing water to the object require careful monitoring.

a. Gore-Tex

Gore-Tex is very useful to introduce moisture in a slow and controlled fashion. The material used consists of a thin moisture-permeable Teflon membrane that may or may not be felted on one side. Gore-Tex is now available in a wide range of types that may be useful (i.e. teflon tape is available in hardware stores in the plumbing section. This material has been used to remove paper tapes). The plain membrane, without felting seems to allow faster penetration of the water vapor, but may also be less controllable. Typically, paper conservators have used the type that has felting on one side.(EW)

It has been observed that when using Gore-Tex, more adhesive seems to remain on the carrier than on the object. This seems to cause less planar distortion to the object, requiring only local instead of overall flattening. (EW)

The degree of moistness/dampness of the blotters is a critical factor when using Gore-Tex. The amount of moisture in the blotters may vary from slightly damp to wet, and may be used in different amounts on each side of the object as necessary. This allows for a gradual increase in the amount of moisture in the blotters for maximum control of the humidification process. The blotter may be custom cut to the shape/size of the paper tape or hinge, or may be allowed to overlap the edge. Gore-Tex rectangles cut larger than the area to be treated are used when the adhesive is best softened by being "surrounded" by the humid environment. It is often helpful if the Gore-Tex and moisture source are applied to both sides of the paper.(EW/HM)

1) The object is placed on Hollytex and a blotter. The Gore-Tex is applied with the membrane sides against the object. A damp blotter is placed against the other side of the Teflon membrane. Light weight (a felt and Plexiglas or glass rectangle) can be applied to hold the moisture in the package and to keep the layers in close contact. If the area being treated is distorted and can't be weighted safety, laying a piece of plastic loosely over the object will work. (CS) An incandescent light placed over the set-up to warm the area may speed up the humidification process. After a period of time (possibly a prolonged period) the adhesive will be gently swelled and/or softened and the paper tape or hinge can be lifted from the paper.(EW)

2) Cautions in using Gore-Tex:

Gore-Tex packages need to be checked periodically in order to ensure the safety of media and the paper support. There is the possibility of over-wetting the paper

with this technique which may soften and swell media. The Teflon surface of the Gore-Tex should protect against offsetting, unless the media becomes so soft that it dissolves.(EW)

Gore-Tex should be stored flat or rolled so that wrinkles and creases are not introduced into its surface. These kinds of distortions may cause cracks in the Teflon membrane that will permit leakage and allow for uneven moisture distribution during treatment.

b. Humidification/Moisture Chamber

A humidification/moisture chamber can be used to soften some hygroscopic adhesives such as animal glues and mucilages. This can be used as a pre-treatment to mechanical removal or other local treatments. Generally, this method is slow, but could be incorporated in treatments of a large group of objects where a "cycle" in the treatment would allow for sufficient exposure time.

Note: If a higher level of humidity is desired when using a humidifier it may be necessary to bypass an automatic shut-off that operates when a certain level of humidity has been achieved. It is possible to locate the automatic shut-off device and turn it off (CS)

2. Immersion

Immersion is the most efficient method for removing water-soluble tapes, hinges and adhesive residues, if the media and paper are not water-sensitive. Often the tape carrier or hinge will float off of the paper surface during immersion and the adhesive residues can be gently brushed while the object remains in the bath.

a. If testing results indicate that immersion of an object is possible, the decision to proceed might

be based on one or more of the following criteria: when immersion may be more efficient and effective for removal of large quantities of water-soluble tapes/hinges/adhesives on an individual object, particularly where tidelines may be a problem; when the paper surface is problematic and extensive manipulation should be avoided; or, because enzymes are more efficiently applied in solutions as pH and temperature can be closely monitored for optimal enzyme action. (See discussion of local treatments with enzymes in 15.5.2 Aqueous Techniques)

b. Water baths may be made more effective by introducing alkaline compounds (i.e., ammonium hydroxide). Raising the pH level with ammonia is especially helpful when the adhesive is proteinaceous.(KL)

c. Consideration should be given to pre-treatments before immersion.

Opaque tapes or hinges, can be probed, using a scalpel or microspatula, to locate and evaluate/identify any media which may not be visible. Care should be taken to avoid disturbing the surface of the object itself, i.e., periodic examination under magnification.

Pre-treatment could include techniques to increase permeability of the tape carrier or hinge material. Removal of tape carriers or layers of hinge material using dry techniques will ease removal of the adhesive mass. Thick deposits of adhesive residue can be reduced by pre-treatment techniques as well. (See 15.5.1, Dry Techniques).

3. **Moisture Chamber/Suction Table/Ultrasonic Humidifier System (MKW)**
The following techniques can be applied to the removal of stains associated with hinges, tapes or adhesive residues.

This system makes feasible the treatment of works with very soluble colors and unstable media such as unfixed pastels, charcoal drawings, works with textured paper supports, and three dimensional works such as collage---without applying any covering material to the surface of the work.

When a moisture chamber is placed over the suction table during treatment it is possible to control the moisture and maintain a desired moisture level in the object during subsequent, often lengthy treatments.

The chamber is built of clear plexiglas into which openings are placed to allow the conservator to work on the object without removing it from the chamber. The interior space of the chamber is large enough so that the conservator can conduct treatments under controlled moisture conditions.

The moisture is introduced into the chamber by means of an ultrasonic mist humidifier. The humidifier uses extremely high frequency sound waves to break water into a super-fine cool mist. The cool mist does not condense on the ceiling of walls of the chamber as it might with a steam generated system. The moisture level within the chamber can be maintained at a predetermined relative humidity or increased until the object is thoroughly wetted.

If the moisture chamber is placed over a suction table the wetted object can be slowly dried by withdrawing the moisture from the chamber through the suction table. As the moisture level within the chamber is slowly reduced the normal humidity of the surrounding room atmosphere is achieved and complete drying and flattening of the object can be carried out on the

suction table, if necessary, or combined with more traditional flattening techniques.

The air entering the system is filtered through openings in the sides of the chamber thus assuring clean air passing through the paper support of the object. Alternatively, the system can be used in a "clean room."

15.5.3 Solvent Techniques

A. Choice of Solvent

There may be many solvents which will satisfy the most important criterion of performing the required treatment action. However, there are additional factors which should be considered in the selection of a solvent or mixture of solvents for removal of the tape, hinge, adhesive residues and staining that is often associated with deteriorated adhesives.

1. Physical Properties

a. Solubility parameters (including polarity, London dispersion forces, and hydrogen bonding)

In 1967 C.M. Hansen defined solvent properties in terms of three types of cohesive energy forces: London dispersion forces, polarity, and hydrogen bonding. The cumulative effect of these forces defines the solubility parameter of solvents (Hansen 1967).

Teas Triangular Solubility Chart - In 1968 Jean P. Teas plotted on a triangular coordinate graph, 88 solvents with respect to the quantitative contribution of the three types of cohesive energy forces--dispersion, polarity, and hydrogen bonding.(Teas, 1968) The effect of these forces determines the reactions of the solvents with other materials (i.e. adhesives) and this graphic representation is useful for planning solvent choice in treatment.

Prior to treatment, one usually begins testing with solvents of low polarity, using increasingly polar solvents until an effective solvent is found.

Solvents can be chosen using their locations on the Teas chart by initially finding a solvent that begins to soften or swell the adhesive and then choosing solvents near the original solvent on the chart to achieve the desired effect for removal. Often the conservator may chose to soften and swell the adhesive without dissolving it so that the adhesive does not move through the paper with the solvent. It may also be possible to chose combinations of solvents from the Teas chart that are effective, but perhaps less toxic or less prone to leave behind staining or overcleaning.

A solvent combination can be created by mixing two solvents which are known to soften, swell or solubilize the adhesive. Similarly, by drawing a line in a Teas chart between two solvents that effectively soften an adhesive, one can locate other solvents which may be desirable because they are less toxic (i.e., because of a higher TLV or slower evaporation rate) or because they have a more favorable working characteristic (i.e., solubilize the adhesive more quickly, will penetrate the paper more or less readily, or evaporate more quickly or slowly). A solvent mixture that is commonly used in place of MEK is acetone and ethyl acetate). (KN)

The dissolved adhesive has a solubility parameter as well and therefore alters the solubility parameter of the solvent/solvent mixture. (Hansen, 1967)

Caution: Solvents with high polarity (such as acetone or MEK) may overclean, resulting in tidelines or a mottled appearance on more sensitive discolored paper. Although often very subtle, this effect should be avoided and can be

extremely difficult, if not impossible, to remove.(FZ) Ethanol (and water) may also overclean the paper without substantially reducing the adhesive residue or stain.(SD)

b. Evaporation Rate

Solvent testing should also begin with the rapidly evaporating solvents because if the adhesive being tested is readily soluble, the movement of the dissolved adhesive into the surrounding paper fibers may be avoided or diminished. Generally the solvent which evaporates the most rapidly and also removes the adhesive will cause fewer complications to the object (e.g., fewer tidelines and less movement of discoloration and fillers. (JG,KL)

Solvents with a rapid evaporation rate (such as methylene chloride) can be used to diminish lateral wicking and tideline formation in sensitive papers.

Due to the high evaporation rate, methylene chloride will form ice crystals on the brush when used in the strong draft of a fume hood. A related slightly dark area may also form on the paper.(FZ) The ice crystals can form water tidelines in paper if they are not allowed to disperse between applications. Too much solvent used too soon may work on the stain but leave water tidelines. (KL)

Solvents which evaporate more slowly, with low-polar forces [i.e., VM&P naphtha, mineral spirits, or Stoddard's solvent (a non-polar hydrocarbon mixture which may or may not contain aromatic hydrocarbons.)] can be used as "barrier" solvents to contain lateral movement and tidelines caused by solvents with higher polarity. The "barrier" solvent is applied to the paper surrounding the tape or adhesive residue which is then treated with the solvent

which solubilizes and removes the adhesive.(FZ)

c. Solvent Grade/Purity:

Solvents are available in various "grades." The grade is an indicator of purity, but some names of grades may be unique to the specific manufacturer or supplier. Specifications for certain grades, including "technical," "purified," "practical," and "reagent grade," may be different for each company, but some generalizations about the grades are helpful.

The grades can be distinguished by the quality of the raw material, by the type of purification processing, and by the amount and type of chemical analysis received. A "guarantee" of higher grades of purity results in a more expensive product.

"Technical grade" is tested the least, and is the most economical. It may contain unacceptably high levels of impurities, such as iron. These solvents also may contain colored components from impurities.

"Purified grade" and "practical grade" are somewhat more purified than technical grade, and have received more testing. However, these grades also may contain impurities undesirable for paper conservation.

To ensure that the undesirable impurities fall within acceptable limits, one must purchase chemicals that have been analyzed for those specific impurities. The impurities may be reported on the label as "guaranteed" to be less than a certain maximum limit, or as passing a specific test, with or without a numerical limit.

"Reagent" and "A.C.S." grades meet or fall below the maximum impurity levels allowed by the American Chemical Society, and are

acceptable for most chemical analyses and conservation treatments. (See the current edition of "Reagent Chemicals: American Chemical Society Specifications" for specific tests and impurity limits for each solvent and chemical.) "Reagent grade" may or may not meet ACS specifications, but is generally considered sufficiently purified for conservation treatments. Some companies have other special grades of high purity organic chemicals and solvents, which may be acceptable for conservation use.

More expensive grades have an actual lot analysis for each batch of chemical, with more precise impurity levels listed. High purity grades labelled with actual lot analyses cost extra and are not necessary in conservation treatment. Also, "ultrapure" grades and specialty grades, such as "U.S.P." (a pharmaceutical grade) and "H.P.L.C.", have purity levels in excess of conservation needs. (KT)

d. Miscibility

Any mixture of substances which is homogenous down to the molecular level is considered a solution. Two liquids are miscible if they can combine to form a solution. Ethanol and water are miscible, while toluene and water are not.

The thermal effect on mixing or solution is the difference between the cohesive energy of the mixture and that of the individual pure components. A negative heat of mixing favors solubility and a positive heat of mixing favors immiscibility. In common times, "like dissolves like."

2. Toxicity

The issue of levels of toxicity is also one of the major considerations in solvent choice for treatment. If a solvent or solvent mixture of lower toxicity can be used, it should be used, rather than risking exposure to

one of the solvents considered more toxic. For this reason, it is best to become familiar with the toxicity characteristics of all of the solvents in the laboratory. Many laboratories now keep a limited range of solvents available that are all within "acceptable limits" of toxicity. This remains a matter of personal discretion.

The chemical company supplying the solvent should/must also provide available "material safety data sheets" upon request.
Note: Some solvents have not been thoroughly tested and information may be incomplete). The Center for Occupational Hazards will also provide advice and information for a small donation to cover mailing costs, etc. upon request. The Center will also send "material safety data sheets," a hand chart entitled "Common Solvents and Their Hazards" as well as a "Glove Selection Chart" to help choose the appropriate gloves for solvents that can be absorbed through the skin.

3. **Safe Handling Requirements**
A major safety issue with the use of solvents is flammability and the potential for explosions. Note in particular, that ethers exposed to oxygen in the atmosphere may form peroxides which present an explosion hazard in an unvented space.(FZ)

All solvents should be dated upon arrival and regularly tested with peroxide test strips (Quantofix is one brand name to look for) to measure peroxide formation. Solvents should be disposed of properly when the limit for peroxides is reached.(FZ)

To improve safety in solvent storage, transfer remaining quantities of the solvent into smaller containers as the solvent is used, to minimize air space above the solvent (CS)

Pour small amount of water through the suction disk prior to and following solvent work to minimize the potential of explosions.(SD)

4. Disposal Requirements

Treatment and removal of large amounts of tape, hinge and adhesive residues can generate significant quantities of organic solvent waste. Disposal regulations vary in different regions, but one factor that appears to be a constant is high cost. Certification by local authorities and preparation of a contract for disposal is expensive and needs to be factored into the overall treatment cost.(EO'L)

For relatively small amounts of solvent it may be safer to use pieces of blotter (12" by 12") to soak up solvent. The blotters can be placed in the fume hood and allowed to evaporate.(PR)

5. Solvents of Choice for Specific Adhesives

The following solvents are commonly found to be effective on the specified pressure-sensitive tape adhesives:

Rubber-based:

Induction Stage -- Hexane, cyclohexane, benzine, ethanol

Oxidized Stage -- Toluene, xylene, cyclohexane + toluene, ethanol + toluene

Cross-linked Stage -- Ethyl acetate, acetone, methyl ethyl ketone, ethyl acetate + acetone, tetrahydrofuran, n, n-dimethylformamide, methylene chloride

3M #810 ("Magic Mending"): Ethyl acetate, ethanol, toluene, ethyl acetate + toluene, toluene + acetone, methyl ethyl ketone

Filmoplast P & P90: Benzine, toluene, xylene, acetone (with difficulty)

Document Repair Tape (Archival Aids): Cyclohexane, toluene, xylene

3M #415 & #924: Ethanol, ethyl acetate, acetone, tetrahydrofuran

6. Solvent Mixtures

The solubility parameter of two or more solvents is the mean (average) of the solubility parameters of the mixture. Therefore, removal of an adhesive or stain may be achieved by combining two or more solvents which are not effective individually.

There are several reasons for using solvent mixtures, rather than a single solvent, in removing adhesives and associated stains. According to Hansen's theory of solubility, a solvent or solvent mixture with solubility parameters that closely match those of a substance to be removed will result in its dissolving. A mixture of solvents has resultant parameters that are intermediate to those of the individual solvents, allowing the conservator to customize the parameters to match those of an aged, degraded or difficult to dissolve substance. Thus, solvent mixtures may result in improved solubility of such a substance by better matching its solubility parameters than any one solvent might. Conversely, a substance that is extremely soluble and threatens to strike through or wick out and stain adjacent areas could be treated with a solvent mixture designed to give slow and/or partial solubility. In addition, solvents can be chosen that have other desired properties, such as a slower evaporation rate, which allows a more prolonged action and thus improved solubility of difficult to remove stains. The varying rates of evaporation of solvents in a mixture may act to create a moving sweep of shifting solubility parameters that permits solubilizing more adhesive degradation products that may be present in an aged stain. Last but not least, because solvent mixtures can be customized to give optimal solubility parameters for the specific task, the conservator can choose less toxic solvents which when mixed have equal or greater solvent action than a more toxic solvent. (KN)

Many conservators have developed, through experience, mixtures of solvents that have been effective for either a wide range of tape or synthetic adhesives, or specific known adhesives. Often it is necessary to test solvents alone and then in combination, to ensure that there are no adverse effects of the solvent on media, in particular.

a. In 1976, a solvent combination was developed which has been effective for various uses. The formula is: 10 ml. alcohol, 10 ml. distilled water, 10 ml. acetone, and 2 ml. benzyl alcohol. The solution should be freshly made for each use and placed in a closed container, since the more volatile solvents will evaporate quickly, changing the effect of the mixture. It is sometimes effective on pressure-sensitive adhesives or PVA emulsion residues. The mixture is used to remove adhesive without softening the substrate and is useful in cases where water is effective but harmful to the paper or media. It may be used to soften a single layer of adhesive residue when the layer below is water-sensitive, such as when glue has been applied over watercolor, or when watercolor inpainting needs to be reduced over an original layer of watercolor. The solution is usually applied by brush, given a moment to work, then the softened portion of the adhesive residue is scraped or swabbed away. The limiting effect of the various components means that the action is relatively slow, and thus, controllable. Check first for staining, as when using any solvent or solvent mixture. (KGE)

b. A solvent mixture of 50:50 ethanol:toluene has been a useful mixture for various tape adhesives.(EW/JG)

c. A solvent combination whose action is similar to MEK, but without the toxicity or possible bleaching effects is a 50:50 acetone:ethyl acetate.(JG/EW)

d. PVA adhesives sometimes respond well to solvent combinations containing water, acetone, and THF in varying proportions. The adhesive should become white and softly granular and responsive to mechanical removal.(KGE)

e. One conservator reported having to remove Band-Aids and found a mixture of toluene and hexane to be useful.(EM)

7. Cautions for Use of Solvents in Treatments

The history of the use of a particular solvent for conservation treatment is one consideration in solvent choice. Published reports of use and results can be very helpful. In addition there has been some research into the effects of solvents on the paper support, but controversy still exists on this subject. (See 15.6 Special Considerations)

a. Avoid using acetone on transparent tape carriers--the carrier may dissolve into the paper object.(JG)

b. Many modern or contemporary papers contain components (i.e., dyes, fillers, or "blueing" or fluorescing agents) which may move with organic solvents. (JG) Solvents such as MEK, THF or DMF, especially used alone, will move fillers in paper.(EW)

c. The use of THF may leave peroxides in the paper support. Following local use of this solvent, the area may be rinsed with deionized water to avoid localized oxidation of the sheet.(LS)

d. Examination with ultraviolet light often shows changes to the object in areas of local solvent treatment that may not be visible to the unaided eye. These appear as dark (UV absorbing) patches in areas of solvent application and exaggeration of tidelines or areas of overcleaning which are only faintly visible in normal light.(FZ) It has also been

observed that this effect is diminished by humidification following solvent treatment. This may or may not indicate a long-term effect and supports the concerns some conservators have regarding solvent treatments.(KL) See 15.6 Special Considerations.

B. Choice of Method

1. Usually a very small drop of solvent is applied on the opposite side of the object from the attachment at a corner, to determine whether the carrier releases easily, and whether the adhesive swells, becomes sticky, or dissolves.(PR) Be sure to repeat the test and to allow sufficient time. Sometimes, a solvent needs to be in contact with the adhesive for a longer period of time for the reaction to begin.(CS)

2. In general, it is preferable to start out with the least invasive procedure (solvent vapor), progress to direct application with rapidly evaporating solvents, and then to use of the suction table (for slow evaporating solvents) and finally to overall immersion.

3. In addition, the pretreatment of tapes and adhesive residues by exposure to solvent vapors can increase the effectiveness and decrease the amount of time needed for later local removal. This is especially true for pressure-sensitive tape residues which have oxidized and crosslinked. Solvent vapors can also swell acrylic-based adhesives which may assist in mechanical removal.(SD,KL)

4. Overall immersion in water after solvent work may eliminate solvent tidelines, if media and other paper components are stable.(KL)

5. It may be possible to bathe the object first in deionized water/slightly alkaline water to reduce overall discoloration in the paper. This may reduce the potential for tidelines caused by the use of solvents. Generally the carrier is first mechanically removed (i.e., with dry techniques, but no solvents); as much adhesive residue as possible is removed with dry

techniques, leaving the adhesive residues embedded in the fibers until after bathing is completed.(EW) It is possible that immersion in water may allow water-soluble components in the adhesive residues to move deeper into the paper.

6. Complete removal of adhesive residues is usually indicated primarily by visual means. If all translucency and discoloration have been removed it is assumed that most of the adhesive residue has been removed.(PR)

The feel of the paper may also be an indicator of residues remaining.(EM) Adhesive residues sometimes leave a stiffness or are somewhat sticky or greasy.(PR)

C. Treatment Methods for Local and Overall Solvent Treatment

1. Solvent Vapor Mini-Chambers

Solvent vapor mini-chambers can be made by placing solvent-soaked absorbent material (e.g. blotters, cotton balls, etc.) into a small container made of an inert material. Containers that have been found useful include glass baby food jars, dome watch- glasses, or small beakers. Mylar can also be folded and shaped into a container.(KL)

An additional technique for a more stable mini-chamber is to partially fill a container with plaster of Paris which is allowed to dry. This then becomes the absorbent material for the solvent of choice and many different sizes or shapes of containers can be used (i.e., a butter dish cover for long pieces of tape).(VBH)

Solvent vapor mini-chambers provide a gentle method of softening and swelling adhesive residues so that they can be removed mechanically with a crepe eraser or with one of the other solvent techniques which follow. The solvent vapor mini-chamber is effective when used as a pre-treatment before inserting a warmed metal microspatula between a tape carrier and an adhesive mass. It is most useful for relatively new applications of tape or adhesive. This technique

may be especially useful on brittle or fragmented papers where the dry manipulations may be too harsh if the adhesive is not softened first.(SD)

In one instance an object had a very solvent-sensitive yellow color, probably gamboge. Pressure-sensitive tape had been used to repair numerous tears. Adhesive on the reverse behind the area with the yellow pigment could not be swabbed off with a liquid solvent or solvents used with the suction table in this area without dissolving and moving the yellow pigment. A solvent vapor chamber on the reverse softened the adhesive so it could be creped off and the gamboge did not move or fade. Staining in areas of the gamboge pigment was left untreated.(EW)

Cautions in the use of solvent vapor chambers include that the chamber not be left on too long. The adhesive may be driven into the paper, even to the opposite side, creating staining or tidelines where it may be more difficult to remove them. This is especially true for thin and absorbent papers.

Also be sure that the rim of your container is clean and smooth. Adhesive residues tend to accumulate on the edge and can transfer to the object.(VBH) A collar made from a blotter for the base of the glass container will absorb any excess solvent that may be released from above.

2. **Solvent Vapor Treatment Using Gore-Tex Fabric**
Use of Gore-Tex fabric can allow solvent vapors to be used in a highly concentrated form for effective softening of adhesives. A Gore-Tex sandwich using the appropriate solvent in blotters will sometimes soften adhesive more effectively than solvent mini-chambers or even large solvent vapor chambers. The vapor is concentrated enough to provide the desired effect without "wetting" the object. Care must be taken not to apply too much solvent to the blotter as liquid can indeed pass through the Gore-Tex fabric. Organic solvent passes through much more quickly than water. One must be cautious about the degree of "wetness"

of the blotters and tolerance to solvents of the art work in question. (SRA) (See Bibliography for manufacturer's address.)

a. Example: Treatment of a Henry O. Tanner (American, 1859-1937) black chalk drawing mounted overall to an acidic gray board with a highly yellowed synthetic adhesive, possibly rubber cement or cellulose nitrate.

Since the medium showed minimal friability, the object was placed face-down on glass or polyester film to prevent evaporation of solvent in that direction. A layer of Japanese paper was placed over the adhesive to absorb some of it when it softened and to protect the Gore-Tex from the softened adhesive. The Gore-Tex fabric was placed with the Teflon side over the Japanese tissue. A blotter was dipped in acetone, which was allowed to evaporate until the sheen left the surface and then was placed over the felted side of the Gore-Tex. A glass rectangle was placed over these layers to limit the evaporation and provide light weight to ensure contact. After 5-10 minutes the adhesive gelled and could be scraped away. In most cases none of the adhesive penetrated to the recto. With very thick adhesive areas this step had to be repeated. After treatment a very thin adhesive layer still remained on the verso and could not be scraped away. By inverting a solvent vapor chamber over the thin layer of smeared adhesive, it softened enough for removal with a crepe eraser. The adhesive staining on the recto then was removed on the suction table.(NA)

A variation on this technique can be done with the object face up. In one particular case, an object was mounted with dabs of thick adhesive to a dense acidic cardboard. Pieces of Gore-Tex were placed Teflon side down over the areas attached with the adhesive. A blotter wetted with acetone was placed over the Gore-Tex and

weighted with glass. After 10 or 15 minutes a flexible spatula could be inserted to separate the object and the board. Additional treatment was carried out as described above. Generally, the adhesive did not penetrate to the front of the object. Where it did move, it was reduced on the suction table, or by immersion. (NA)

b. Example 2: A variation of the Gore-Tex treatment was used to remove a rubber-based transparent tape carrier on an embrittled hard-sized paper, where there was a tendency for the paper to delaminate. The adhesive appeared to be cross-linked and difficult to swell or remove. The Gore-Tex and a solvent-saturated blotter were placed on the reverse of the object so that the solvent vapors were penetrating the paper from below and not inhibited by the tape carrier. The membrane side of the Gore-Tex was placed against the reverse of the paper below the region with the tape. The blotter was cut to the same size as the piece of tape and placed against the felt side of the Gore-Tex. The object, Gore-Tex, and blotter were sandwiched between polyester film and the whole was weighted. To remove the tape carrier, a corner of the upper sheet of polyester was lifted to work locally, leaving the other areas undisturbed. (LS)

c. A note on the disposal of Gore-Tex with adhesive residues: Pieces used for treatments such as those described above should subsequently be used only for similar treatments, if at all. Softened or dissolved adhesive residues can indeed stick to the Teflon surface and may damage the Teflon or the object. Excess adhesive can be swabbed off the surface of the Gore-Tex membrane, but extensive bathing in the solvent is needed for more complete adhesive removal. (NA)

3. **Dry Poultice Materials Used with Solvents**
Poulticing can be a controllable and precise technique for the removal of pressure-sensitive tape adhesive residues and some staining. Poulticing works best on residues which need more time to solubilize or soften. Often the technique will need to be repeated more than once and/or some cleaning of the surrounding area will need to be carried out.

Usually the tape carrier and as much of the adhesive residue as possible are removed with the assistance of dry techniques or solvent vapor chambers before poulticing is begun.

It is generally best to poultice from the same side on which the adhesive residue is found. However, if the adhesive stain appears on the recto, it may be inappropriate to use a poultice due to some difficulty in controlling the technique and the inability to monitor the process.

Before putting a poultice on the object, test a small representative area with the poultice material to be sure it can be removed from the paper without leaving a disfiguring residue.

To test the efficacy of using a poultice with a particular solvent, begin by placing Mylar under the test area to ensure that evaporation of the solvent takes place from the poultice side. Place a one cm. diameter pile of the dry poultice material on the adhesive residue or stain. Flatten the top of the pile to receive the solvent. Place a droplet of the chosen solvent or solvent mixture onto the pile. To slow the solvent evaporation rate, Mylar can also be placed over the poultice and a Plexiglas rectangle may be used to hold the Mylar in place. The poultice is allowed to dry and checked by brushing away the dried poultice to see if the test was effective. The poulticing tests may proceed using increasingly larger poultice applications, keeping in mind that the increased quantity of solvent increases the solvent concentration and ability to dissolve larger quantities of the adhesive residue. The desire is always to maintain control of the

solvent and dissolved adhesive residue within the poultice material so that the "drawing" capabilities of the poultice can assist the action of the solvents.

If the pressure-sensitive adhesive residues are on the verso, place the object face down on a blotter with a surface below that is inert to solvents (i.e. Mylar). The treatment should be set up in a fume hood or well-ventilated area with weights on the edge to hold the object in place. Test the adhesive residue to determine the most appropriate solvent or solvent mixture.

As with any other solvent technique, test all of the media on the front in the nearby region of the adhesive thoroughly with the solvent chosen, to ensure that they will not be harmed by the treatment. Remember that solvents tend to travel laterally through the fiber network and the effects may be seen a long way from the application site. The solvent choice may depend on media solubility as well as effectiveness in removal. The addition of petroleum benzine will slow the evaporation of more volatile solvents and allow additional preparation time as well as working time when the poultice is in place.

The following describes a series of steps used for a Fuller's earth poultice on an adhesive residue. Conservators will vary the techniques for providing a barrier around the wet poulticing material, the materials placed above and below the poultice area and the time, however the following is a compilation of many contributors techniques to form one series of steps, with some variations noted under the appropriate poultice material.(EB,JG,KL,LS)

After testing, and choosing the most appropriate solvent to remove the adhesive, add the appropriate solvents to poulticing material. The poultice should be wet but be able to retain a shape so that it can be accurately placed on the adhesive residue.

Some conservators place some of the dry poultice material beneath the object in the areas corresponding

to the adhesive residues to help to draw any of the solvent with dissolved adhesive that may wick to the front. One would not do this if the media on the obverse would be affected by the dry poultice material.

Place the wet poultice material over the adhesive residue and then surround the area with a ring of dry poultice or a ring of a slower evaporating solvent (i.e. petroleum benzine) that does not interact with the adhesive. The dry poultice material around the wet prevents the formation of tidelines and "feathers" the transition between the treated area and the rest of the paper. Check the poultice after a while for dryness and for tidelines that may appear. The drying period for the poultice will depend on the solvent(s) used. Repeat applications as needed. If necessary, the poulticing can be alternated from recto to verso, which may help to reduce tidelines.

Covering the treatment area with polyester web, blotters, thin Mylar, and a conforming weight will slow the evaporation time.

After adhesive reduction is complete, clean the poultice residue from the paper by brushing with a soft brush or tamping with a kneaded eraser, depending on the paper surface, and proceed with stain removal, if needed.

Variations:

One can also begin by surrounding the adhesive residue with the dry poultice material and pouring a wetter slurry of the poultice mix onto the adhesive residue stain and allowing it to dry, as above.(KDL)

The adhesive residue can be placed face-down on a "bed" of the dry poultice material on blotter. The object is pressed slightly to ensure close contact between the paper surface and the flattened surface of the dry poultice material. The solvent is applied to fully wet the paper support in the area with the adhesive residue and is then covered with Mylar. and left to be checked at regular intervals until dry. More

solvent can be applied as necessary. When it appears that the poulticing material has become saturated with the adhesive residues, it should be replaced with new, dry poulticing material. The "bed" of dry poulticing material should extend outside the area to which the solvent is applied, to prevent the formation of tidelines.(PR)

a. Poulticing Materials

1) Fuller's Earth

Fuller's Earth is a diatomaceous earth that has a surprisingly effective ability to absorb moisture and solvents. It can be purchased in two basic shades: beige and a whiter version from chemical supply houses or sometimes, drugstores (it is also used for "beauty masks").

Calcium carbonate powder may also be added to the Fuller's earth without compromising the effectiveness. The Fuller's earth and calcium carbonate can be blended to match the color of the paper support to minimize "hazing" after treatment, caused by poultice material embedded in the paper fibers (EB,KGE)

The dry poultice materials may also make the media appear lighter and more matte particularly if the media is softened by the solvent treatment. The media should be protected with a shield if the poultice material is nearby.

It should be noted that removal of the dry poultice material with a kneaded eraser, while more effective possibly than brushing, may leave a residue and may also remove media that has been weakened by the solvent.

If a slight residue of calcium carbonate remains, it may slightly alkalize the paper locally. This may, or may not be perceived as an advantage.(EB)

Do not reuse Fuller's Earth as adhesive residues from the first use may redeposit or tideline out.(KL)

2) Dry wheat starch paste powder

Dry wheat starch paste can be used as a poultice material. Non-polar solvents do not mix as evenly in this material, but a suitable consistency can be achieved. If any particles remain in the paper they may be less visible than the Fullers earth. It is used in the same way as Fuller's earth.(EW)

3) Blotters, chromatography paper

Blotters, or other absorbent papers may also be used with solvents to help draw the dissolved adhesive residue away from the paper support. In a technique similar to the second variation described above, the object can be placed face-down with the adhesive residue in contact with the blotter surface, the solvent applied from the opposite side and covered with Mylar, so that the draw is from the side with the blotters.(SD)

It should be noted that some blotters have blueing which moves laterally in the paper and forms noticeable blue rings, particularly when acetone is used. It has been noted that this blueing has not been deposited on other objects, but should be checked before use with absorbent objects and large volumes of solvent.(KL)

4) Agarose

The use of solvent gels in a sandwich of polyester film may act like a localized solvent

chamber. Place the polyester film over the gel to slow down evaporation.(LP)

5) Combination Solvent Poultices

For PVA adhesive residues, which are notoriously difficult to remove, a mixed poultice using a thick methyl cellulose gel with acetone added often softens the adhesive residue and allows much of it to be scraped away.(NA)

A solvent combination useful for may pressure-sensitive tapes, including aged masking tape, is toluene or ethanol in a poultice followed by ethanol applied locally on the disc. (See discussion of using the suction disk for removal of adhesive residues below, 15.5.4.b.) Ethyl acetate and acetone in a poultice followed by acetone on the disk has been useful for similar types of tape. (SD)

An Audubon print with hand-applied watercolor had several types of pressure-sensitive tape attachments, including "Scotch" tape on the obverse, and masking tape and a black colored tape on the reverse. The black tape included a paper carrier similar to masking tape and was probably intended for use in masking slides. The adhesive was also tinted black. The black tape presented the most problems because as the adhesive was softened from the solvent applied to remove the carrier, the black colorant also stained the primary support. A poultice of Fuller's Earth, alternating applications of ethyl acetate and xylene was most successful in drawing out both adhesive residue and colorant from the object. (PR)

4. Direct Local Application of Solvents

The solvent can be applied with a brush, a pipette or micropipette, cotton balls, cotton linters, or blotters. The key to success is the ability to carefully control the amount of solvent delivered regardless of means of

application to reduce the risk of lateral movement of the dissolved adhesive through the paper support.

This technique allows for close observation of the reaction of the adhesive, as in testing, and also allows the adhesive to be removed in stages, approaching the front surface of the paper support.

For example, to remove acrylic-based tape adhesive residues from a medium to heavy weight, cohesive Japanese paper, apply the solvent directly to the adhesive residue with a fine sable brush. When the adhesive residue whitens and swells, the rounded edge of a dull scalpel blade can be used to carefully scrape the adhesive and gradually lift it away from the paper support. For a very thin Japanese paper, apply the solvent as described above, and with the point of a sharp scalpel blade, the adhesive residue can be coaxed gently away from the paper support.(EB)

Often these direct local applications are combined with the use of suction because of the possibility of lateral wicking of the dissolved adhesive into the paper.

In many instances, combining application techniques can be more effective than using a single application technique. For example, solvent applied by brush followed by spray from an air brush reduces the adhesive and helps to disperse any tidelines or lateral movement.

a. Brush or pipette application

Various types of tools can be used to apply the solvent. The desirable qualities include control, and the ability to hold sufficient quantities of the solvent to keep the adhesive wetted out. Many types of brushes are useful, but should have unpainted handles, or a finish that is solvent resistant. Pipettes, micropipettes and disposable micropipettes that are solvent-resistant are useful. A solvent feed-tube can be made from a solvent-resistant tube

packed with cotton and placed on top of adhesive. The solvent is added to the top of the tube and will be pulled by gravity through the cotton onto the adhesive residue. Swabs, cotton balls and wads of cotton linter can also be used. For a wider application of the solvent, an airbrush can be used, but the solvent will evaporate more quickly, and there will be more solvent in the surrounding area.

b. Use of the suction table or the suction disc

A suction table or suction disk can be used to help draw the solvent through the paper support, carrying with it the dissolved adhesive residue or stain. Small, discrete tests can be carried out to see if the draw of the vacuum is sufficient to prevent the lateral spread of the solvent, and solvent application techniques can be varied depending on the type of suction that is available.

If the draw on the suction table/disc is insufficient to draw out the solubilized adhesive, the adhesive residue can become more embedded or the solubilized adhesive can move laterally, extending the adhesive (and any discoloration) beyond the original application. This will necessitate treating a larger area of the paper with solvents, which may be especially problematic when there are solvent soluble, colored components in the paper.

Make sure that the vacuum is "explosion-proof" as most home-type vacuums are not built for this use, and a spark in the motor could ignite solvent fumes.

There was a problem involving a suction table in which the charcoal filter had become saturated with MEK and was no longer able to absorb any solvents. When the table was turned on the lab filled with MEK vapors. (AW) Check charcoal and fiber filters frequently and

on a regular schedule to ensure that they are able to function correctly.

A suction disc provides more localized strong suction for treatment of dense or thick paper and can be positioned inside a fume hood for safer use of toxic solvents. The vacuum motor can be kept out of the hood. If your vacuum motor is not explosion proof, it is recommended to put a "solvent trap" in the hose running from the disc to the pump. A drawing of a "solvent trap" is included at the end of this chapter. (FZ)

The opening for a suction table can be reduced to a very small size by using a "mask" made from a polyester film, or other impermeable plastic on the surface of the table. This will increase the draw achieved on the suction table.(MKW)

Because more solvent appears to evaporate from the surface of the suction table than is actually drawn through, it may be possible to modify the table, if it has a moisture chamber or other chamber fitted over the table. One can cut a hole into the side of the moisture chamber/cover and fit it with a flexible hose connected to an "explosion-proof" exhaust fan that leads to the outside. This allows space to work on the object and contains the fumes so that they can be efficiently exhausted.(MKW) Otherwise, the table should have a nearby exhaust hose (i.e. "elephant trunk") or be very well ventilated, and the conservator is advised to wear an organic vapor respirator.

Normally, a layer of thin blotter, or other absorbent paper is placed between the object and the opening of the suction disc/table. This will provide a layer of absorbent material to receive the solubilized adhesive residue and also prevent the texture and edges of the disc or "mask" from becoming impressed on the

object. This impression can be very difficult to remove. The blotter or absorbent material used should be changed whenever saturated, or more frequently, as needed. It is a good way to monitor the effectiveness of the treatment.

An effective technique involves the use of "marination" with the suction table. Pieces of polyester film are placed on either side of the adhesive residue, which is placed over the opening in the "mask" on the suction table. The opening is covered with a blotter and polyester web. The appropriate solvent is brushed or sprayed onto the adhesive residue, covered with the polyester film and the object is allowed to "marinate" in the sandwich. After sufficient time for the adhesive residue or stain to be dissolved, the bottom piece of polyester film is removed and the vacuum suction is turned on. At this time additional solvent can be brushed over the area, and the blotters can be replaced with clean blotters, until no more discoloration is removed. If tide lines have developed the object can be sprayed overall, if media and other components in the paper allow, with solvent while the suction table is on.(MKW)

5. Immersion

If the media and paper are unaffected by the chosen solvent, immersion is a practical technique for removal of dry mount tissue residues, or an abundance of tape, adhesive, or staining.(JG) Immersion is faster and more effective, with fewer risks for tidelines, particularly on thick paper objects.(PR) Immersion also seems to minimize the risk of leaving tidelines, or stains from adhesive residues, but also places all of the media, and paper components at greater risk. Careful testing should, of course, precede immersion.

Use shallow solvent baths to allow easy access to the immersed object, and so that there is less "waste" solvent to dispose of after the procedure. (JG/KL) If the solvent is allowed to evaporate the residue may

be examined to give additional information about unknown adhesives.

Shallow trays can be made of 3 or 4 mil. polyester film, folded up on the sides and stapled at the corners. For lifting, it can be supported with a rigid board or cookie sheet (HM) The polyester tray can be thrown away after treatment.

Make sure that the object is fully immersed and gently agitate the bath to minimize the possibility of tide line formation. Repeat with clean solvent until no more adhesive or stain is present.(VBH) Multiple shallow baths may be good for delicate objects that cannot withstand mechanical action.

A technique that is especially good for cellulose acetate delamination, but may also be effective for large quantities of transparent tape adhesive residues is 4 to 7 "baths" in acetone with a final "bath" in ethanol to "rinse" before aqueous treatment. (SD)

Note: It is necessary to remove cellulose acetate tape carriers prior to immersion in acetone, as the solvent will otherwise dissolve the transparent film into the paper to which the tape is adhered.

The problems with immersion include the possibility that the adhesive can be spread throughout the entire paper support. Even repeated baths may not necessarily completely remove all residue of the adhesive which may be trapped in and on the paper fibers. (MKW)

Solvent immersion treatments also include the inherent danger of flammability, the cost of disposal of waste and the need for sufficient ventilation and protective respirators, gloves and clothing for the conservator.

6. Combination of Techniques

A combination of techniques may work more quickly and/or thoroughly than a particular technique done individually and repeatedly. Some combinations have

been included under the main headings for Treatment Variations above.

15.6 Special Considerations

A. Possible Disadvantages of Local Treatment of Adhesive Residues

Areas that have received local treatment with water, show altered fluorescence, or absorption, when observed after treatment with ultraviolet light. This observation has lead to a discussion of the possible disadvantages of local treatment.

There is a concern that local aqueous treatment, even humidification, to remove water-soluble adhesives can cause the paper support in areas of local wetting to age differentially. The acidic by-products of deterioration may be solubilized and removed from the paper. At some later time the object may differentially age or discolor in areas that did or did not receive treatment. It is speculated that this may be prevented with uniform introduction of water, or at least overall humidification.(LP)

When using steam to remove water-soluble hinges and/or adhesives, there is the possibility that tidelines that are not visible immediately after treatment may appear with the aging of the object. It may be advisable, when the media allows, to float the entire sheet of paper on water after the hinges and adhesive have been removed to remove this effect of local treatment.(CMG)

It is sometimes argued that immersion may be a safer, gentler approach to hinge removal, as normally the manipulations of the surface are reduced and mechanical damage is avoided, but also avoiding the possible local alterations that may be indicated by the observation above. This approach must, of course, be weighed against the possibility of overall alterations in paper and print or drawing media from this method.(NA)

Examination using ultraviolet light when removing pressure-sensitive tapes and adhesives produced the following observations. When the area with the adhesive is viewed before and after treatment, an alteration is visible, often extending well beyond the area where the tape was adhered. This may result from lateral wicking of the solvent with the adhesive or other dissolved paper components, or from the use of solvents in ever-widening rings to chase tidelines. The altered fluorescence or absorption of ultraviolet light may indicate any of a variety of changes, but the implications for future

ageing are not clear. Often adhesive is moved laterally during solvent treatment, but seemingly cannot be entirely removed. Probably sizing, fillers, coloring agents or degradation products are also moved or altered. Some solvents may be held by the paper for a prolonged period of time or may have a dehydrating effect. The concern is, again, that the treated area may age differently from the rest of the paper.(NA)

If solvent is used locally as the only treatment (no wash, etc.) it may help to humidify the object after the solvent has evaporated. It appears that this may reduce the altered fluorescence and may also improve the handling qualities, restoring flexibility to a dehydrated region in the paper support.(KL)

B. The Effect of Organic Solvents on Paper/Cellulose

The effect of organic solvent treatment on paper was investigated by Lynn Brostoff and Timothy Vitale. The research studied the effects of solvents on the water vapor absorptive sites, measured by moisture regain; on the stiffness, measured by ultrasonic modulus measurements; and permanent weight loss by controlled weighing. These papers were evaluated - two without sizing and one with alum-rosin sizing. The papers were tested before and after immersion in methanol, acetone, toluene, and deionized water.

Description of Procedure:
Increases in moisture regain measurements indicate that the surface area available for water vapor absorption in the test material has increased. For paper this would include the amorphous regions within the fibers and the outer surface area of the fiber. Stiffness was measured using ultrasonic energy by the material's structure -- the more open the structure, the more slowly the energy travels and the lower the modulus -- corresponding to a decrease in stiffness. Permanent weight loss is measured by controlled weighing (in bone-dry conditions) before immersion and after immersion and drying. Permanent weight loss indicates either changes due to the solvation and removal of soluble material, or the removal of small, loose fragments or components of the paper. The residue can be analyzed using other techniques to identify the content.

Results:
Generally, the work demonstrates the effects of solvents on paper, including the increasing loss of stiffness (ultrasonic modulus) and increase in moisture regain. Methanol was close in effect to water, with acetone's effects falling between those of methanol and toluene.

Permanent weight loss in the sized paper correlates with the ability of the solvent to solubilize and remove the alum-rosin size from the paper. Methanol was the most efficient at removal, followed by acetone and toluene. Solvents had no effects on the permanent weight of the unsized papers. Water caused permanent weight loss to all samples, and the residue was carbohydrate, as determined by FTIR analysis. (Brostoff and Vitale 1986, unpublished)

In 1980, Jonathan Arney and L.B. Pollack explored the retention of organic solvents (i.e., ethanol, methanol, acetone, ethyl ether, methylene chloride, chloroform, carbon tetrachloride, and toluene) in solvent-treated papers (i.e., Whatman, newsprint, rag paper) using gas chromatography. The results suggested that moisture in the atmosphere will displace retained solvents completely in a few hours under ordinary environmental conditions of 50% RH and 20° C. A related study of the sorption of thymol vapors by paper indicated that thymol also is not retained permanently in paper.(Arney and Pollack 1980)

In 1972, Katherine Eirk evaluated the following solvents: methylene chloride, tetrachloroethylene, xylene, pyridine, hexane, toluene, acetone, dimethylformamide, petroleum benzine, and methanol. (KGE) (Eirk 1972)

C. Further Discussion of Degradation of Rubber-Based Tapes and Adhesives

The aging behavior of rubber cement and rubber-based transparent mending tape was investigated by Dr. Robert Feller. The research demonstrated that deterioration of these materials involves the formation of hydroperoxide intermediates, thus the adhesives pass through a sequence of stages in the course of aging. The first is a period of relatively little change (the induction time), the end of which is signalled by a soft, sticky condition. Beyond this point, as the rubber becomes further oxidized, one finds that solvents of increasing polarity are needed to remove it. Finally, the material becomes hard, brittle, discolored and may be resistant to dissolution in solvents. During the sticky stage the small molecules which result from the chemical breakdown of the adhesive often migrate into the paper or other substrate upon which the tape is affixed, resulting in deeply penetrating stains. Feller's research also indicates that the translucency of the taped area appears well ahead of the marked discoloration. The continued presence of tack/stickiness, and the first indication of migration are indicators that the adhesive may be removable in a solvent like acetone at this stage, whereas

considerable difficulty can be expected when the adhesive has reached a hard and highly discolored condition. (Feller 1982)

The rubber-based adhesive materials break down into volatile oxidation products including carbon dioxide, water, formaldehyde, formic acid, and other small fragments of the original chemical substances. Some of the degraded adhesive material may be cross-linked, while other components are known to be acidic. (Kemp, Bishop, et al. 1931; Farmer and Sundralingam 1943). A treatment to reduce the acidity of the paper to which the tape was attached might be considered.

D. Stain Reduction Following Adhesive Removal

When a discolored stain remains following adhesive removal and the aesthetic value is impaired, bleaching may be considered. The state of degradation of the object must be considered, and the possible limitations in effectiveness of the treatment caused by embedded adhesive residues. There are conservators who feel that the stained paper may already be significantly degraded due to the presence of the adhesive, and could be dangerously weakened by application of a chemical bleach solution.(PR)

A number of conservators report limited success with bleaching of adhesive stains.(EM)

E. Treatment Reports on Objects with Intrinsically Important Tape

1. Treatment of a collage with masking tape included marking the exact location of the tape pieces and then removing them intact. The residual adhesive was reduced as much as possible. The staining caused by the masking tape was removed from the support and/or the collage elements to the extent possible. The adhesive on the tape carrier was reduced and the carrier was lined with Japanese paper and wheat starch paste. The lined tape was attached in the original location with wheat starch paste. The tape also can be reattached with Japanese paper hinges and wheat starch paste but in some instances the additional thickness is not aesthetically acceptable.(EKS)

2. A drawing by Claes Oldenburg on tracing paper was attached to a secondary support by the artist, with several pieces of masking tape. The secondary support also bore the artist's signature. After noting the exact location of the various

elements, the tape carrier was carefully removed intact, and the adhesive residue was removed from both the paper carrier and the object. The tape carrier was reinforced with Japanese paper. A poly vinyl acetate resin was applied to the reinforced tape carrier and allowed to dry. The resin was then reactivated with solvent and the tape carrier was reapplied in the original positions. (PR)

F. Rehousing as an Alternative to Treatment

1. Instead of slitting a hinge to remove an object from one mat for placement in a new mat, release the part of the hinge that is attached to the back mat by gentle application of moisture delivered through a Gore-Tex membrane, poultice or swab, while protecting the object from the moisture application. This part of the hinge then can be reattached to the new back mat. (MS)

2. When an exhibition requires that a matted work be placed into a new mat, it may be possible to leave the work hinged to the back mat, use a larger front mat for the exhibition, and reuse the original mat after the exhibition. This system was created to reduce the handling and manipulation of the objects for exhibition and can be more cost-effective.

   If the exhibition requires a smaller dimension for the new mat the C-sink mat may be used. (See drawing at the end of this chapter.) To make a C-sink mat: a) Remove the original window (front mat), b) Determine outer dimensions for new mat, c) Cut new window mat, d) Place new window mat in correct position on top of the work and lightly mark the outside dimensions on the back mat (fig. 2), e) Cut the back mat following the marked lines using the C pattern (fig. 3). The two pieces removed need to be retained with markings for organization to avoid later confusion. f) Hinge the new face mat to the original, cut-down back mat for exhibition purposes. The pieces retained from cutting down the original backmat are then attached to a new support. Cut a piece of 2-ply or 4-ply rag board, depending on the support required, to the size of the original back mat. Attach the C-shaped piece to the new support using 3M 415 double-sided tape. Do not tape the right-hand strip onto the backing board at this point. Following the exhibition, remove the window mat from the original backmat and place the mounted object into the

C-shaped sink created with the pieces. Attach the remaining right-hand strip to the backing with the 3M 415 double-sided tape (fig. 4). Place linen tape around the seams in the mat to hold the mounted art work in place (fig. 5). (ES,HM,PG,SW)

G. Rehousing to Avoid the Future Need for Hinge Removal

Hinge fragile objects onto a 2-ply acid-free, lignin-free, buffered backmat when they are treated if it is likely that they will be exhibited. The backmat then can be hinged or photo-cornered into the exhibition mat and, if necessary, replaced into its original mat following the exhibition. This will reduce the risk of damage from additional handling or manipulation. (See AIC/BPG/PCC 40. Matting and Framing 1988)

Another option, in cases when mat changes can be expected to occur, is to attach a piece of Japanese paper to the reverse areas of an object that will receive hinges. Care must be taken to ensure that the Japanese paper and its adhesive are chosen so they do not create distortions on the front of the object. Hinges then can be changed repeatedly without the adhesive contacting the reverse surface of the object.(CS)

15.7 Time Line

1837 - First reports of gums used as adhesives on postage stamps
1845 - Natural rubber first used for medical tapes (Day)
1902 - Minnesota Mining and Manufacturing Co.(3M Co.) founded
1905 - First glassine paper introduced to U.S.
1908 - Cellophane invented (first extrusion of xanthate)
1909 - First kraft paper manufactured in U.S.
1918 - Beginning of use of styrene-butadiene as elastomer
1924 - Celanese USA produces first cellulose acetate
1928 - 3M Co. introduces first masking tape
1930 - 3M Co. introduces first "Scotch" brand cellophane tape
1932 - Borden invents first tape dispenser (3M Co.)
1939 - Polyisobutylene developed as an elastomer
1950's - Cellulose acetate begins to replace cellophane
1959 - First U.S. patent for polyacrylates as pressure-sensitive adhesives
Late 1950's - Terpene resins introduced as tackifiers in pressure-sensitive tapes
1960 - LePage's changes from gum to modified starch in its mucilage products; still sold as "mucilage"
1961 - 3M Co. introduces Magic Mending #810 frosty and #800 clear tapes
1965 - Block co-polymers first appear on pressure-sensitive market
1966 - Hercules J-Lar polypropylene tape first introduced
1969 - Petroleum resins introduced as tackifiers
1970's - Styrene-butadiene latex invented
1970's - Document Repair Tape developed at British Library
1980 - Introduction of Post-It Notes by 3M Co.
1984 - Filmoplast P & P90 first buffered with calcium carbonate

15.8 Glossary

(Based on ASTM D907-74, Horie, and other sources)

adhesive: see AIC/BPG/PCC 46.Adhesives 1989, Glossary, page 126.

adherend: the surface/object onto which an adhesive is intended to stick.

adhesion: "the state in which two surfaces are held together by interfacial forces which may consist of valence forces or interlocking action, or both" ASTM (from Skeist xi 1977)

blocking: "an undesired adhesion between touching layers of a material, such as occurs under moderate pressure during storage or use" ASTM (from Skeist xiii 1977).

bond strength: an expression, usually in units, which relates relative strength of an adhesive/adherend bond.

cohesion: the ability of a material to stay united with itself under stress.

contact adhesive: examples of these are "contact" cements used to laminate materials such as plywood and phenolic resin plastics (Formica) in the building trades.

creep, cold flow: the ability of a material to move under ambient conditions. This property is related to glass transition temperature (Tg).

elastomer: a material which can deform at room temperature and reform under the same condition with no change in its properties.

extender: In adhesive use, a material used to increase the volume of an adhesive. Calcium carbonate, hydrated alumina are examples. See also Filler.

plasticizer: a liquid or soft solid at room temperature that makes the elastomer softer and more conformable to the surface to which the adhesive is applied.

pressure-sensitive adhesive: an adhesive system that is activated by slight pressure, as in applied by the fingertips, and is not temperature dependent.

primer: a coating put onto tape carrier material to enable an adhesive mass to stick to the carrier.

solids content: the percentage content of elastomer or synthetic polymer in an adhesive. Solids content decreases with addition of fillers, pigments, tackifiers, and other additives.

substrate: also called the "adherend", the surface onto which a tape is applied.

tack: the relative stickiness of an adhesive. The effectiveness of adhesive is evaluated by measurable expression of the strength of the adherend/adhesion bond; "tack" is the property measured in the assessment.

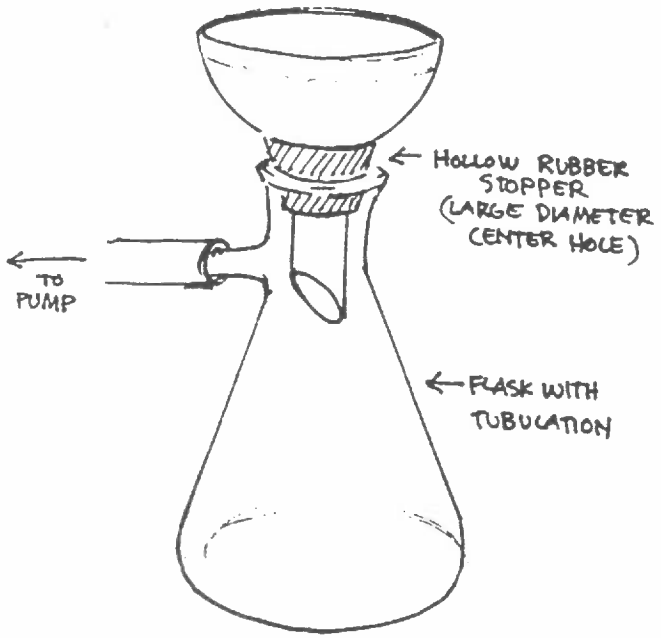
tackifier: a material added to an adhesive system to control the stickiness of the adhesive. In rubber-based adhesives, resins are nearly always used.

thermoplastic: See AIC/BPG/PCC 46. Adhesives 1989, Glossary, pg. 126.

vulcanization: "a chemical reaction in which the physical properties of rubber are changed in the direction of decreased plastic flow, less surface tackiness, and increased tensile strength by reacting it with sulfur or other suitable agents." ASTM (from Skeist, pg. xviii, 1977).

15.9 Illustrations

A. Solvent Trap



A solvent trap is a glass flask with tubulation, which holds the disk, using a hollow rubber stopper as a cushioning gasket. Solvent and adhesive residue accumulates in the flask, diminishing the amount traveling down the tube toward the pump. Although the suction pulls the disk/stopper/flask system into intimate contact, it is sometimes also necessary to apply slight physical pressure to the disk. The system is placed under a fomecor platform with a hole in the top surface to reveal the disk.

15.9 Illustrations

B. C-Sink

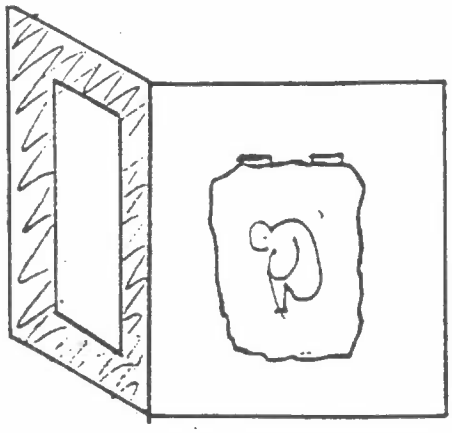


Figure 1
Art work in its original housing (standard size mat)

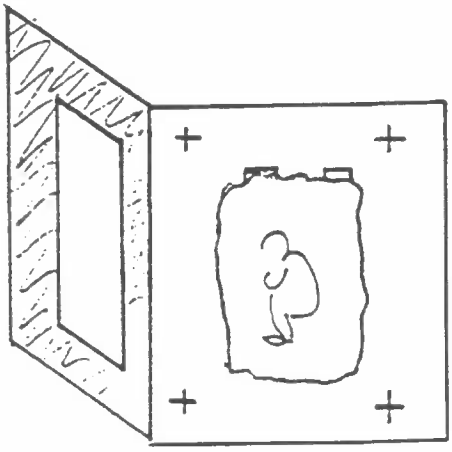


Figure 2
Pencil marks indicating outer dimensions for new mat

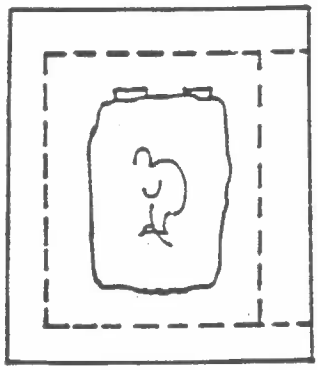


Figure 3
Cut backmat in this pattern

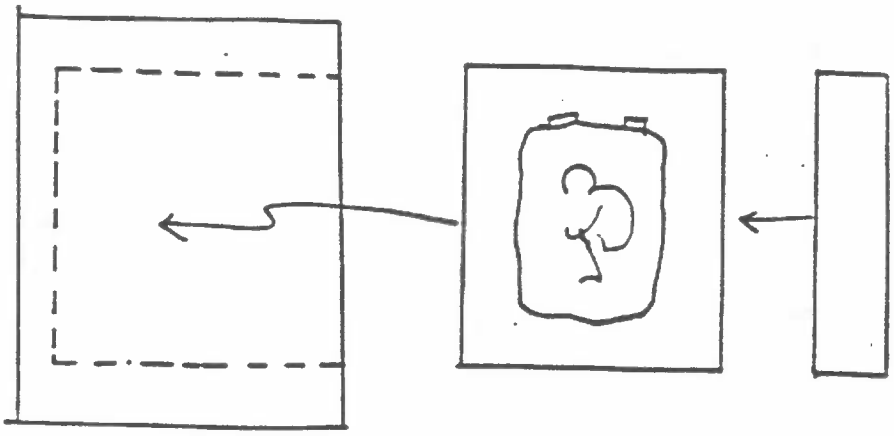


Figure 4
Mounted art work is placed into "C-Sink."
Then right hand strip is attached in place
with 4-15 double-sided tape.

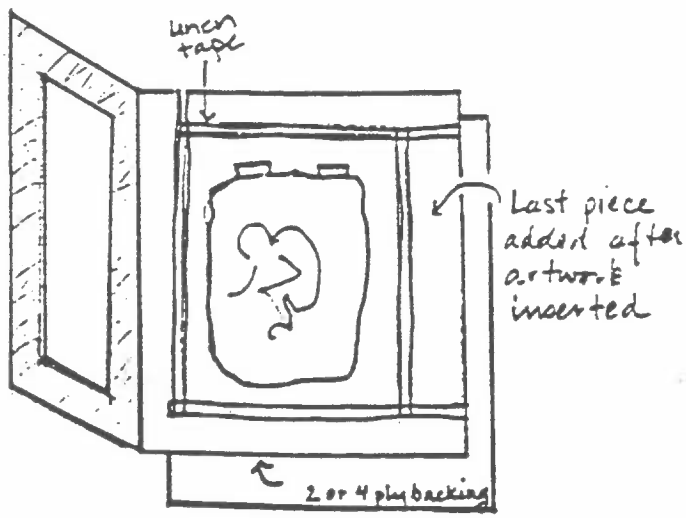


Figure 5
Re-assembled
"C-sink"

15.10 Bibliography

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15. Hinge, Tape, and Adhesive Removal, page 102

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