

29. LINING

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LINING

Lining (or backing) the adhering of an overall secondary structural support to the primary support of an original work of art or artifact.

29.1 PURPOSE

29.1.1 **To consolidate** a damaged paper support (e.g. artifact with multiple or severe tears.)

29.1.2 **To strengthen** a paper object which is in such a deteriorated or embrittled condition, it would sustain further damage without an additional support.

29.1.3 **To effect certain esthetic considerations** such as flattening or removing of creases.

29.1.4 **To place a barrier** between the art object and an auxiliary support (e.g. retaining an acidic historic support with an alkaline interlining; or to facilitate future removal or to prevent texture imprinting on the primary support).

29.1.5 **To provide for temporary support** during overall conservation treatment.

29.1.6 **To provide a structural support** after removing a poor quality mount (e.g. acidic mounts, historic mounts, strainers).

29.1.7 **To stabilize** dimensional and planar movement of the support or media (e.g. cupping oil paint on a paper support).

29.1.8 **To provide an alkaline reserve** behind an object that can not be made alkaline itself.

29.1.9 **To facilitate the handling**, exhibition and storage of works on paper (e.g. strip lining or false margin technique used at the British Museum).

29.2 FACTORS TO CONSIDER

29.2.1 Necessity of the procedure

A. Structural need for the physical stability of the artifact (e.g. object that is damaged, deteriorated, creased, torn, excessively cockled).

B. The appropriateness of the lining based on historic and artistic integrity of the artifact.

The lining should not lessen the esthetic importance of the object.

C. Alternatives to lining should be considered

1. Provide special housing (such as permanent framing to reduce handling).
2. Provide local treatment or repair.
3. Limit handling and access due to fragility.

29.2.2 **The lining materials and the adhesive should be reversible, when possible.**

A. Consideration must be given for the method of reversibility and the effect of the necessary solvents or mechanical action to remove the lining (e.g: a dry lining on water sensitive media may successfully be applied but needs too much water to be removed; solvents needed for removal of aged non-aqueous adhesives may react with the media; friable objects may be successfully lined face-up, but not able to be turned face-down for future removal).

B. Some synthetic non-aqueous adhesives are not reversible. Long range reversible studies have not been done on many synthetic adhesives.

C. Lining materials, especially fabrics, may leave a texture which is not reversible. Some fabrics, such as silk, do not have good aging properties especially in an alkaline environment.

29.2.3 **Esthetic changes to art object that may result from lining.**

A. **Changes to the media:**

1. Bleeding or penetration of the media to the verso of the sheet due to solubility in adhesive solvent or water.
2. Changes in the opacity and refractive indices of media (e.g.. compacting friable media or regeneration of binder or saturation by dilute paste).
3. Cracking or flaking of media due to expansion/contraction of wet support, or pressure during drying.

B. Changes to the paper support:

1. Changes in the opacity and refractive index of paper (e.g. darkening or greying of paper).
2. Flattening of non-planar areas (e.g. plate marks, embossed marks, impressions from relief and Intaglio processes).
3. Changes to the paper surface, weight, or texture.
4. Planar distortions or curl.
5. Staining of the paper from introduction of water to unwashed object (or limited wash).
6. Movement of sizing or dye within paper.

29.2.4 **The lining should not obscure notations, documentation or other data on the verso of the art object** (See 29.4.7). A compromise is sometimes necessary in order to save the object physically. As transparent a lining tissue as is appropriate to the object should be selected. Some obscured notations etc. may be read after lining using an infra-red viewer. Full photo documentation of any data verso should be made before lining.

29.2.5 **The lining material and adhesive should be compatible with the object.**

A. Expansion and contraction ratios of the object and the lining should be matched to accomplish the specific lining intention and to prevent distortion. When two different papers are lined together with an aqueous adhesive (or subjected to the affects of heat in thermoplastic linings) distortions can result. This is generally due to unequal expansion when wet and thus unequal contraction during drying. The composite of the lining, adhesive, and object will generally curl towards the side which expanded and contracted most. This curling can be minimized or eliminated by matching the expansion and contraction characteristics of the lining paper to the object to be lined, and by controlling the degree of wetting of the lining and object. A good indication of match between the paper object and lining paper would be to take measurements from both papers at three locations along the two directions (with grain, and cross grain) when dry,

fully wet, and dry again. Some general and arbitrary observations of expansion and contraction behavior seen in some types of paper, but not necessarily true consistently, are:

1. Contemporary machine-made papers can have strong expansion and contraction across the paper grain.
2. Degraded papers, can show less dramatic expansions and contractions.
3. Waterleaf paper can show greater expansion but not as much contraction.
4. Fiber type and length influence expansion and contraction. Linen papers show different expansion/contraction than ground wood pulp papers.
5. Japanese papers have a wide variety of characteristics that influence expansion and contraction such as: type of fiber, type of cooking, beating, drying. (See 29.3.1)
6. Cotton and linen fabrics shrink when wetted and expand on drying. Paper has the opposite response, so that fabric lined paper is at war with its lining.

B. Paper Grain: the orientation of the paper fibers in most cases are made to be parallel on both the lining and the object when they are joined. Cross grain orientation can result in severe distortions. However, cross grain linings have been used effectively as primary and secondary linings to counteract severe curl in an object.

C. Strength, weight, and flexibility of the lining paper should compliment the object and not dominate (e.g. a lightweight object generally should have a lightweight lining paper).

D. Opacity and color of the lining paper should be matched, (e.g. a transparent object should not be lined with an opaque paper; a white object should not be lined with a darker paper that darkens the look of the object).

E. Chemical characteristics such as sizing, dyes, overall pH, or any additives need to be considered (e.g. with a low pH object perhaps the lining paper should be buffered; some sizings or

additives in modern papers prevent good adhesion with aqueous solvents; dyes may bleed with water or change color with solvents).

F. Choice of adhesive (aqueous or non-aqueous) and viscosity should be compatible with the object.

1. Aqueous or organic solvents used as diluents of the adhesive should be compatible with the media.

2. Viscosity of the paste (bibliography no. 9, 10). Wheat starch paste as prepared by Japanese scroll mounters is diluted to a wide range of viscosities, each appropriate for certain types of papers and lining procedures. The adhesive properties of the paste are still effective, at very dilute mixtures on appropriate papers. Some general and rather arbitrary observations on different viscosities may be made, but need to be evaluated in conjunction with the application technique:

1. thin paste (skim milk) is better for delicate papers. It also dries faster, (when brushed out over a blotter) which may be appropriate for water sensitive media.

2. medium paste (heavy cream) provides better adhesion to porous, textured or coated papers.

3. thick paste (sour cream) is necessary for adhering heavy boards or paper materials. The physical bulk of thick paste restrains the contraction of the paper and may cause bulges around areas of different paper thicknesses.

G. The drying method should be compatible with the object and the intentions of the lining procedure. (See 28. **Drying**).

1. Friable media may require drying without pressure on the surface.

2. Objects with distortions may need differential drying to help offset the curl.

- a. The side facing out on a drying board (unless humidity is high) will dry faster than the side facing into the screen.

b. A suction table or hair dryer can be applied to specific areas on an object which are drying at a slower rate than the rest of the sheet and so are out of plane. These areas may be contracted by faster drying (local use of hairdryer, etc.) to equal the rest of the object.

3. Hysteresis phenomenon: during the first complete wetting the paper will undergo the most movement and subsequent expansion and contraction will be less dramatic. Lined objects that have undergone considerable expansion in the lining process may eventually flatten better and more safely if first air dried on a felt or blanket before drying under restraint or pressure.

29.3 MATERIALS AND EQUIPMENT

29.3.1 **Japanese Paper.** The nomenclature of Japanese papers is very general and arbitrary. There are often different grades of the same type of paper by the same maker, varying widely in quality. Middlemen may invent names for papers and large distributors may substitute inferior papers without notice. If given specific directions reputable suppliers of scroll mounters' papers are usually reliable. Good quality handmade papers by well known papermakers are more expensive due to the time and care given to every aspect of their making. Generic "Japanese" papers may be machine made and are often made with a mixture of wood pulp, are chemically processed and bleached, and may have additives such as fillers and resins. It is therefore difficult to be specific about types and characteristics of the various papers, and conservators must make their own careful observations aided by an understanding of the ramifications of various factors in manufacturing.

A. There are three main **Japanese fiber types** from which papers are made.

1. **Kozo papers** have qualities often appropriate for a lining paper. They have the longest fibers and depending on the numerous ways of processing, can be very versatile. Compared to mitsumata and gampi, they are porous, absorbent, and have an uneven surface.

2. **Mitsumata papers** have shorter, weaker fibers than kozo papers; these fibers produce

denser papers which are less absorbent and expand and contract more. They are not often used for lining. However, some mixtures with Kozo can be useful.

3. **Gampi papers** are the shortest fibered and are very responsive to moisture, and expand and contract so strongly that they are rarely used for linings. However, their transparency, smoothness, and strength may make them an appropriate choice in some cases [e.g. tracing papers. They have also been used effectively for secondary linings to reduce curl (L.K.)].

B. The **type of processing** has a major effect on the quality of paper both in terms of behavior and longevity. Reputable suppliers will make this information available on ordering. Variations that produce weaker or stronger papers can be used to advantage, depending on lining requirements:

1. **Cooking** in alkali solutions:

- a. Traditional wood ash (KOH) or (K_2CO_3) is the gentlest and does the least damage to fibers, making papers 'stronger' or more responsive.
- b. Lime ($CaOH_2$) and Soda Ash (Na_2CO_3) are intermediate in strength of cook and breakdown and lightening of fibers.
- c. Caustic Soda (NaOH) is the harshest cook and is used to prepare fiber for bleached papers. It degrades the fibers, which makes a softer, more pliable paper.

2. **Bleaching** is traditionally done in the pulp preparation stage while water washing in the sun, but some pulps are also bleached with harsh chemical bleaches that leave chlorine residues, and degrade the fiber.

3. **Beating** method and degree affect the relative fiber strength and degree of bonding. Compared to Western fiber preparation, the minimal beating of Japanese fibers, along with gentle cooking, accounts for much of its superior aging characteristics.

4. **Drying** can be done on a traditional wooden board that produces a very different paper than one that is dried on heated metal dryers.

a. Board-dried papers generally have a natural tone, rougher surface, but less internal stress, (e.g. there is less expansion with rewetting).

b. Papers dried on heated metal have a smooth, firm, uniform, surface. Quick, forced drying tends to dehydrate and create internal stresses in the sheet so that it will later expand and contract more dramatically. Papers may contain metal (iron) impurities due to the heating surface. These papers should be pre-washed and air-dried to relax the built-in drying stresses.

5. **Fillers** in Japanese papers can be calcium carbonate, clays, or talc. Fillers can impart the following characteristics:

a. Limits the expansion/contraction. Fillers are believed to interfere with fiber bonding and yield a 'weaker' sheet.

b. They act as a 'cushion' due to the bulk.

c. They can act as an alkaline or inert buffer.

C. Evaluation of Japanese Papers. Since precise and reliable specifications about available Japanese lining papers are difficult to obtain, a general idea of an unknown paper's characteristics may be gained by the following subjective tests:

1. **Pre-wash and air-dry the papers** to remove discoloration products, built-in stresses from drying, and to gain a better idea of the overall responsiveness of the paper. [A.D.]

2. **Curl or spring:** feel the spring of a sheet curled over on itself in both directions. A stiffer curl in one direction will reveal grain (usually parallel to the chain lines). A strong spring indicates less processed, denser fibers and possibly higher hemi-cellulose content (i.e. a stronger paper and possibly one that tends to expand and contract).

3. **Snap or rattle:** this may indicate the type of fiber (mitsumata or gampi) and hemi-cellulose content or green bark content, thus more expansion/contraction.

4. **Tear.** Ease of tear indicates relative fiber

length, bonding and overall strength. Difference in tear between the two directions of sheet indicates the grain direction (easiest is parallel to grain). A pronounced difference suggests a machine-made paper.

5. **Wet strength** is an important indicator of lining behavior. Pulling the ends of a wet sample gives a clue to fiber bonding and fiber length and contracting strength.

6. **Fold:** ease and sharpness of repeated folding indicates fiber length and possible fiber damage from processing.

D. Some generic **types of Japanese lining papers** commonly used (bibliography no.8):

1. **Kozo**

a. **Tengujo:** the lightest weight paper that can be handmade (rare) or machine made. Handmade sheets have poor wet strength. They have very little expansion or contraction and can be used for minimal linings and as an interleaf lining.

b. **Misu-gami:** thin, but longer fibers than tengujo (goes through less washing). It has better wet strength and a light calcium filler that controls expansion/contraction and acts as an alkaline buffer.

c. **Mino:** has a range of weights and is a strong, well behaved paper with very little grain and excellent wet strength. Hon-mino, (a specific paper controlled by the government) is a hand beaten high quality paper, has under 5% chemical pulp added for flexibility.

d. **Kizukishi:** a reliable, lightweight paper with moderate expansion or contraction.

e. **Sekishu:** very strong, wet or dry, high quality lining paper. Hand-beaten, long fibers may give slightly uneven fiber distribution. Green bark (containing hemi-cellulose) is usually included and gives a yellowish tone, slight rattle and some expansion.

f. **Uda:** is long fibered, but clay filled which reduces expansion characteristics and imparts alkaline buffering ability.

g. **Mashi:** a medium heavy, natural tone paper available in large sizes. It is difficult to control expansion behavior in the large sheets. If this is critical for a large lining it is better to piece together smaller segments of a well-behaved paper such as Mino. Double linings are often stronger and more cooperative than single heavy linings.

2. **Gampi:** produces transparent papers that expand and contract greatly, are usually brown toned, unless mixed with a percentage of kozo that makes a whiter paper with less expansion characteristics while retaining a transparent quality.

a. "silk" tissue: the thinnest is generally machine made, transparent and expands/contracts greatly. It can be a good choice for tracing paper. Its transparency after lining makes it useful for documents with writing on the reverse which will remain legible.

29.3.2 **Western Papers** are more commonly used for lining in Europe and were also used in earlier centuries. Western papers are occasionally used as a secondary lining, especially when a semi rigid support is needed (See 30. **Mounting**).

A. **Conditions** that might suggest the use of a rigid support are:

1. Useful in simulating original mounts or supports.

2. To provide rigid support for heavily applied media (such as a thick gouache), or for gilded surfaces that might crack on a more flexible support.

3. To provide additional reinforcement for large size objects, or objects with multiple components that are heavy (such as college pieces). Often used for large contemporary objects.

B. **Considerations** for use:

1. Both old papers and new papers (lens tissue, Bodleian, contemporary handmade papers, Arches, etc.) can be used, as appropriate.

2. Use of a Japanese tissue interleaf may be desirable:

a. To consolidate or facilitate handling of the original support prior to reinforcement.

b. To minimize expansion of the original support prior to additional reinforcement.

c. To provide a distinct layer to facilitate later reversibility.

C. Additives and Chemicals

1. Aquapel (alkyl ketene dimer) sizing in Bodleian, Twinrocker, and other modern papers limits water penetration and expansion or contraction.

2. Buffering of lining papers for acidic conditions of artwork.

29.3.3 **Fabrics.** Use of fabric as a lining support is much less common than use of Japanese tissues. Fabrics often provide a more rigid support and greater tooth which helps with the reinforcement of tears. Fabrics are often available in much larger dimensions than most lining papers and this is useful for lining oversize works. Synthetic fabrics are not susceptible to expansion/contraction with humidity fluctuations. Generally, an interleaf should be used between the artifact and a fabric lining to prevent weave impression, deterioration of the fabric and dimensional changes.

A. Natural fibers:

1. Cotton, woven (old muslin linings): absorbs great quantity of adhesive and water between fibers of the threads and between threads in interstices. Contracts when wet and it expands when dry.

2. Linen, woven (similar to cotton, see above).

3. "Silking" (See 42. **Lamination and Impregnation**).

B. Synthetic fibers (adhesive is only absorbed

in interstices of fabric and does not swell fabric):

1. nylon, non-woven spun-bonded (Cerex, reacts somewhat with moisture)
2. polyester; non-woven (Pellon, Hollytex, Remy) and woven (Terytex, Dacron/Terylene)

29.3.4 Adhesives (See 46. Adhesives)

A. Water Activated Adhesives from Natural Sources

1. **Starch Pastes.** Starch pastes used in conservation applications are prepared by the separation of gluten and starch from the flour. The starches are composed of two polymer fractions, amylose and amylopectin and each type of starch (corn, wheat, rice, waxy maize, etc.) produces a paste with somewhat different properties of adhesion and reversibility, characterized by a specific percentage of these two polymer fractions. It is the amylose polymer which is responsible for crystallization and retrogradation. It also forms a stronger film when dry than amylopectin. The greater the percent of amylose in a starch, the greater the strength of the film and the greater the chance for crystallization and water resistance.

The most commonly used starches in conservation are wheat and rice. The former contains approximately 18-27% amylose while rice contains approximately 17% amylose. A representative from AYTEXP Wheat Starch (Supplied by Ogilvie Mills, 1060 Kings Hwy. N. Cherry Hill, N.J. 08034), state that their wheat starch consistently has an amylose fraction of 25% and American wheat starches have a consistent range from 23-25%. The 18-27% amylose range reflects world wide variation. It is difficult to know what percentage of amylose Japanese or European wheat starches contain. (K.N.)

Some conservators take advantage of the inherent differences in characteristics of various starches when planning treatment steps. For instance, repairs may be made with wheat starch paste followed by a lining with rice starch. Theoretically this would allow the lining to be applied and possibly removed without disturbing the tear repairs. However,

some conservators feel that mending with rice followed with wheat linings are preferable and the success of each approach depends largely on individual conservator's technique, as well as the amylose content of a particular paste.

Differences in strength and ease of reversibility also explain the practice of mending with starch paste and lining with a starch mixed with methyl cellulose. Considerable variations in working properties, characteristics of reversibility, and strength can be made by modifications through the addition of ingredients such as the cellulose ethers. Pure starch pastes have been used in linings for centuries and have a good record for permanence, aging, and reversibility. Starch paste linings are generally reversible in water.

2. Flour Pastes. This adhesive is not in current use in conservation lining procedures, although frequently referred to in historic references to paper restoration. Recipes for flour pastes for lining vary. Common ingredients include sugar, Karo syrup, or honey and a variety of natural resins.

B. Water Activated Adhesives From Synthetic Sources

1. Cellulose Ethers are made by the esterification of the cellulose molecule. Cellulose ethers are distinguished from one another by different substitutions on the cellulose molecule. The cellulose ethers have limited characteristics of strength and do not adhere well to smooth surfaced papers, limiting their application in lining procedures. Often cellulose ethers are used as lining adhesive additives, providing slip, increased working time, improved film flexibility and greater resolubility. The use of cellulose ethers in conservation is relatively new; they are not time tested, as are the starch pastes. Recent research on artificial aging indicates great differences in aging properties among the cellulose ethers (bibliography no.22,24).

a. Methyl Cellulose. Non-ionic. Prepared by the methylation of alkali cellulose with methyl chloride. It is soluble in cold water; insoluble in hot water. Some conservators feel it does not cause as much curl as starch, others feel it causes more.

It is frequently used to lubricate and allow for movement in the alignment of tears. Methyl cellulose can also be used as a sizing material and to moderate viscosity and strength of starch pastes. Due to limitation in strength, this adhesive is unsuitable for lining of large, heavy, artifacts.

b. **Carboxy Methyl Cellulose.** Ionic. Prepared by treating alkali cellulose with sodium chloroacetate. Soluble in either cold or hot water (in contrast to methyl cellulose) and can be made to have a higher viscosity than methyl cellulose. It has characteristics and uses similar to methyl cellulose.

c. **Hydroxypropyl cellulose (Klucel).** Soluble in water or in polar solvents such as alcohol, and thus adaptable for lining procedures for moisture sensitive paper and media. Recent research reveals a dramatic drop in viscosity indicating reduced chain length upon artificial heat aging (bibliography no.22).

2. **Synthetic Polymer Dispersions.** Dispersions are differentiated from emulsions by the definition: solid particles in liquid vs. true emulsions which are liquid in liquid. Thus most synthetic resin-based adhesives in an aqueous form are dispersions, but they are produced by emulsion polymerization and thus commonly called emulsion adhesives. Various additives and modifiers are necessary in the production of polymeric dispersions including buffers, initiators, emulsifiers, and plasticizers. The long term aging characteristics of synthetic dispersions and the influence of additives and modifiers on aging has only recently been investigated (bibliography no.24). There is some evidence that the highly alkaline and acidic buffers in some of the dispersions can volatilize from the adhesive film into the adherends. The conservator should take this into account when choosing such materials for conservation treatments directly on the work of art. Generally, whenever possible synthetic adhesives are used in the application of a secondary lining, although the conservation treatment of over-sized and non-traditional works typical of contemporary art or moisture sensitive works may necessitate the use of such adhesive directly on the work of art. Synthetic resin dispersions can be used in lining as wet adhesives or as a dry film reactivated by heat

or solvents. Each type of resin is characterized by different melting temperatures, viscosity, and film formation; these characteristics can be modified or tailored for use by the addition of secondary ingredients such as other polymer mixtures, solvents which can act as thickeners, or of cellulose ethers (such as methyl cellulose which may improve the possibility of reversibility).

a. **Acrylic resin dispersions:** are solutions of polymers or copolymers with at least one primary constituent derived from acrylic or methacrylic acids or their esters. The acrylate-methacrylate copolymers are most prevalent in current conservation applications, due to their optimal stability. Acrylic resin dispersions can be used as:

- 1) **wet adhesives**, similar to the way starch paste is applied and used, or
- 2) the dry film may be **reactivated by heat** or by **solvents**. Heat of reactivation varies according to the parent polymers, the percentage of their mixture and the effects of any additives.
- 3) the dry film of some of the acrylic dispersions remains tacky and may be used as a **pressure sensitive adhesive**.

Most acrylic resin dispersions have an alkaline pH when wet, however, extraction of the dry film of some of the dispersions indicates a drop in pH. Most of the acrylic dispersions can be thinned with water, although they are insoluble in water after drying. Manufacturers' specifications suggest that these adhesives are reversible in alcohols, aromatics, esters, ketones, and glycol esters and irreversible in water and benzene. However, artificial aging tests on such adhesives indicate that reversibility may become more difficult on aging, requiring greater polarity solvents to be used for future reactivation of the adhesive.

- 1) **Rhoplex** [Manufacturer: Rohm and Haas Company, Philadelphia PA. Distributed as Primal in Europe]

a) **Rhoplex AC 33.** Aqueous acrylic dispersion based on a mixture of methyl methacrylate, ethyl acrylate and ethyl methacrylate copolymer. 46.5% solids. Similar to acrylic gel medium and the basis for many modern acrylic paints. Supplied as a milky white liquid. Has an alkaline pH of 9.7, possibly due to addition of ammonia. Dries after application to a flexible, water resistant film. Often used as a wet adhesive. Can also be reactivated with heat and solvents.

b) **Rhoplex AC 234.** 46-47% solids. Similar to Rhoplex AC 33 although remains slightly tacky after drying. Natrosol (hydroxy ethyl cellulose) and toluene have been used as a thickening agent for applications in linings where minimal exposure to moisture is necessary. Often used in mixture formulations of heat seal tissues which can be solvent (toluene or alcohol) or heat reactivated. Used also as a wet adhesive and, because it remains slightly tacky upon drying, has possibilities as a very weak pressure sensitive adhesive. Manufacturer states it requires a higher temperature for reactivation than AC 33. It has an alkaline pH of 9 to 10.

c) **Rhoplex N 580.** 54-56% solids, pH of 8. Acrylic dispersion based on polybutyl acrylate which remains tacky after drying. This dry dispersion film can be used as a pressure sensitive adhesive although it forms a relatively weak nap bond as compared to the bond formed when it is reactivated with heat or solvents. Some conservators feel the use of the dispersion in this manner creates a more non-intervention lining as the adhesive does not penetrate the substrate of the adherends or 'flow' as it may with solvents and heat. However, dry mechanical reversal may be difficult on paper artifacts without some damage to primary paper support. Reversal may be aided by solvent reactivation. Some evidence of cross-linking on aging. Similar adhesives with potential for pressure sensitive applications are Rhoplex N619, N1031, LC67.

2) **Lascaux Products** [Manufactured in Switzerland by Alois K. Diethelm, AG CH-8306 Bruttellen]. Similar to Plextol products in Europe.

a) **Lascaux 498HV**. Acrylic resin dispersion based on butyl acrylate, thickened with polymethacrylic acid. Initially thinned with water. Resoluble in alcohols, aromatics, esters, ketones, and glycol esters. Insoluble in benzene. Glass transition temperature approximately 26 C. May be used as a wet adhesive and also as a reactivated dry film using heat (approximately 76 C) or toluene and xylene. Manufacturer suggests mixing Lascaux 360HV to lower reactivation temperature (approximately 55-60 C).

b) **Lascaux 360HV**. Similar to 498HV but with lower glass transition temperature (-8 C). More flexible than 498HV. Heat and solvent (toluene or alcohol) reactivated. Heat of reactivation is lower than 498HV (approximately 43-49 C). Some conservators have used this as a heat seal tissue although dried film remains slightly tacky at room temperature. Used also as pressure sensitive adhesive but has very weak pressure sensitive adhesive qualities (see bibliography no. 25). Has been used as an additive to cellulose ether adhesives to improve their adhesion.

c) **Lascaux 498 20X**. Similar to 498 HV although prethickened with 20% xylene for increased viscosity and less watery solution. Primarily used in painting conservation.

3) **Mixtures**: Heat Seal tissues made with mixtures of acrylic dispersions.

a) The Library of Congress heat seal tissue has primarily been used for repair although some adaptations have been used in applications to lining procedures. (bibliography no. 17). The mixture initially described in the L.C. publication was Rhoplex AC 73, and Plextol B 500. The conservator can use a mixture of other dispersions to create a heat seal tissue for an individual treatment.

b. Polyvinyl Acetate Resin Dispersions: These are adhesives formulated by the polymerization of vinyl acetate as the primary monomer. Usually supplied as a copolymer with internal plasticizers. Dispersion additives such as defoamers, preservatives, initiators, etc. are also present. These dispersions are often acidic in pH. Not in current favor for use in lining procedures due to problems with solubility, acidity and discoloration upon aging (bibliography no. 18 and no. 19). Occasionally used as an additive to starch paste lining for added strength although this may affect reversibility.

- 1) **Jade 403.** [Supplier: Jade Adhesives, 2929 Campbell Ave., Chicago, Ill. Distributed in Europe (Hoechst) as Mowolith DM5, DMVI].

c. Vinyl Acetate/Vinyl Ethylene Copolymer Dispersions. Produced by the copolymerization of vinyl acetate and ethylene polymers. Not in general use in conservation as a lining adhesive for paper artifacts, although tests by DeWitte et al. (bibliography no.24) showed favorable aging results on the product Vinamul 3252. This retained a neutral pH, favorable heat reactivation and little change in tensile strength or color even after prolonged periods of artificial aging. This information suggests testing of this material for adaptation procedures in lining.

- 1) **Elvace 40-704 (Formerly Elvace 1874)**
[Manufactured by Riechhold Chemicals, Inc. Dover, Delaware. Distributed as Vinamul 3252 in U.K.]. 54-55% solids.
- 2) **Beva D-8.** [Manufactured by Conservator's Products Co. P.O. Box 411, Chatham N.J. 07928]. Non-ionic, high viscosity adhesive similar to Beva 371. Some problems with adherence to smooth surfaces. Used as a wet adhesive as well as dried and reactivated by heat (approximately 75 C) or solvents (toluene or xylene).

C. Solvent Adhesive Systems: Unlike the dispersions the solvent adhesives contain virtually no water. These adhesives would be employed for works on paper when exposure to any aqueous adhesives poses a risk to the object.

1. **Polyvinyl Acetate Series: AYAA, AYAC, AYAF, AYAT.** [Distributed in Europe as Mowilith 20, 30, 40 by Fabwerke Hoechst, AG Frankfurt]. These resins are manufactured by the presence of a vinyl radical. The resins are differentiated by increasing average molecular weight from AYAA to AYAT. Tensile strength and elongation increases with viscosity grade. Soluble in acetone or toluene. These adhesives have good initial flexibility, varying bond strength and a range of softening points. Varying the mixtures in this series can change the softening point (m.p.) or bond strength. Primarily used as dry film which is heat or solvent (acetone or toluene) activated (bibliography no.11). There is some question as to the cross-linking and reversibility characteristics of this type of lining adhesive upon aging. Glass transition temperatures are: AYAA 21 C; AYAB 17 C; AYAC 16 C; AYAF 24 C; AYAT 26 C.

2. Mixtures

a. **Beva 371** [Manufactured by Conservator's Products Co. P.O. Box 411, Chatham, N.J. 07928] (Note: Recent copyright enforcement no longer permits the ethylene vinyl acetate adhesive produced by Adams Chemical to be referred to as 'Beva 371'). The mixture contains ethylene vinyl acetate, resins such as Ketone resin N and a small percentage of wax. The adhesive is available as a pre-cast film or in gel form which may be thinned into solution with petroleum solvents or toluene or xylene. For applications to paper, when used in solution Beva is often applied by spraying under high pressure to create a 'flocked' layer of adhesive. The solvent basically evaporates before the spray hits the adherend. This reduces the risk of staining which could occur with brush applications. Can be used with heat (approximately 145 F/63 C) or solvent reactivation.

b. **Bernie Rabin heat set formula** composed of equal portions of AYAA and AYAC in toluene with very small percentage microcrystalline wax (bibliography no.16). Not in general use as a lining adhesive for paper artifacts.

29.3.5 Adhesive Preparation Tools

A. Paste

1. Strainer (rounded wooden hoops fitted over the top with horsehair for thick paste, or silk for aged paste.
2. Blenders
3. Salton sauce maker (automatic stirring and adjustable temperature)
4. double boiler

B. Synthetic Adhesives

1. Silicone release paper
2. Tacking iron, hot air blower
3. Aerosol gun or compressor
4. Nylon film membrane (Dartex)

29.3.6 Application Tools and Materials

A. Brushes

1. Water brush (mizubake)
2. Paste brush (tsukemawashi, noribake, shigoke, uwabake)
3. Smoothing brushes; hard (nadebake) smooth (uwabake)
4. Pounding brushes (uchibake, and nadebake)
5. Flat edge painter's brushes
6. Sponge brushes (don't last long)

B. Rollers, Sprayers

C. Fabric Screen can be used to apply paste through to give an even coating on thin papers and as a support for application.

D. Supports for application of Lining Tissue

1. Wooden strips or glass or plastic rods
2. Polyester film or other flexible sheeting

29.3.7 Supports for Lining Surfaces

A. Drying board or **karibari** (a wooden lattice frame covered with numerous layers of Japanese handmade paper. The surface is coated with fermented persimmon juice or synthetic resin for waterproofing). Advantages: responds to moisture when object is applied, removal is facilitated because the karibari surface is pressed in rather than having to lift edge of object; there is no bowing as with Plexi; lightweight; can be built in large size or connected with others to accommodate large object. Disadvantages: accumulation of old edge strips and residual adhesive from previous linings can interfere with objects placed over them later.

- B. Plywood
- C. Sanded Plexiglas
- D. Table top
- E. Synthetic Fabric stretched over Plexi
- F. Mylar stretched onto table or level surface:
allows for slip during drying, if necessary.

29.3.8 **Vacuum Suction Table**

29.3.9 **Vacuum Hot Table**

29.3.10 **Glass beads** used to burnish reverse side of object after drying to reduce stiffness or curl.

29.4 **TREATMENT**

Expansion/contraction ratios of the art and the lining paper are always matched as closely as possible. The grain direction of the lining is usually applied parallel to the grain direction of the art.

29.4.1 **Wet Lining (Basic Lining Technique)** The techniques used in this traditional method are adapted and modified for individual needs of the artwork, but are based on the premise that the artwork can be wet during treatment. The lining can be undertaken after all phases of aqueous treatment or the piece can be wetted just prior to lining.

A. **Preparation of the Art**

1. The art object is placed face down on a smooth flexible surface (materials often chosen are polyester film (Mylar), wet strength tissue, parafilm or pellen). A flexible sheeting is recommended as a support to facilitate handling during treatment and also to act as a buffer between the artwork and table top in case paste from the lining migrates to the front of the artwork.

2. Water is introduced into the object to the extent the medium will allow. The amount of water introduced is usually controlled by method of application, i.e. water immersion, brush wetting, spraying, misting, humidification chambers and ultra-sonic humidifiers. The art is relaxed, the paper fibers are expanded, grain or machine direction is noted. (see 29.2.5)

3. Tears, if any, are aligned and adjusted.

B. **Preparation of the Lining**

1. Choice of the lining material depends upon compatibility with the artwork and the intentions of the lining treatment.

2. The dimensions of the lining tissue are larger than those of the art by 1 inch or more on all sides. This facilitates placement by allowing for any slight misalignment: literally a "margin or error". Lining margins may also be used for pasting during a screen drying or used later for hinging and attachment to matboard.

3. Remove any irregularities in the tissue such as knots, slubs, or debris by wetting area and pulling out with tweezers.

4. Note side of tissue to be placed next to artwork and to be pasted (some tissues have a rougher or smoother side).

5. The lining is wetted by:

a. **Brushing** with a Japanese water brush (mizubake). The more the tissue is brushed the greater the mechanical pull and the greater the lateral expansion on the tissue.

b. **Immersion** in water to completely wet. (wetting and air drying reduces mechanical pull greatly and also removes impurities in Japanese tissues. Tissue can then be re-wet)

c. **Spraying**. Relaxes tissue without saturating with water (can be placed between plastic to allow moisture to equalize throughout sheet).

6. Prepare and have ready several extra lining tissues in case tissue becomes damaged before application.

C. Adhesive Application

1. Starch paste is traditionally diluted to the consistency of light cream or skim milk. The type of starch and the viscosity vary with conservator. Many conservators prefer to dilute the paste for greater flexibility, for prevention of curl, for better reversibility and because paste linings hold with very little paste. Degree of tack and viscosity are obtained through aging and dilution of the paste with water.

2. The paste is generally applied with a Japanese paste brush to the rough side of the

tissue beginning at the center and working the paste out toward the margins. There are some alternative solutions to avoid stretching out the lining sheet at this stage:

a. Spray applications for very dilute paste solutions.

b. Off-set paste application: texture a Mylar sheet with sandpaper, then apply paste to Mylar. Lining tissue is next spray misted to moisten. The tissue is then dropped onto pasted Mylar and a second sheet of Mylar is placed on top. The sandwich is rolled with a rubber roller to transfer the adhesive to the tissue. The underlying Mylar is removed and the second Mylar sheet is now used as a carrier to place the tissue on the object's verso. To further prevent "pull" on lining tissue, avoid smoothing brush and use vacuum suction table to achieve contact application of paste. rather Can only be done if paper is structurally sound. Backing sheet is laid onto pasted object and brushed into contact. (Keiko Keyes, lecture: Oxford)

c. Apply starch through a thin fabric screen, this assures a thin even layer and can be used on thin tissues. Also aids in transporting tissue to artwork.

d. Paste application to smooth side may result in less disturbance of fibers.

D. Placement and Attachment Procedure

1. The lining is applied with the grain direction parallel to the grain direction of the artwork.

2. The pasted lining is lifted by hand beginning at a short edge, a wooden stick is slipped beneath the lifted edge. Using the stick as support the tissue is lifted and carried to the art object. A second stick is often in the ready to be used on the opposite end of the tissue. One end of the tissue is positioned so that the entire lining once lowered will overlap the art evenly on all sides. The tissue is slowly lowered onto the art. (An alternate method for lifting and supporting the lining tissue is to wet and paste the tissue on a clear, flexible support such as Mylar, position as described above and slowly lower beginning at one end.)

3. Once in place uniform contact is ensured by a smoothing brush beginning in the center and working out. If Mylar is used, contact is ensured between lining tissue and object by smoothing with brush, hand or roller.

4. Remove Mylar film (if used) by lifting a corner and rolling the film onto itself, taking care the edges of the lining tissue are not lifted in the rolling. Smooth lining out and insure contact with smoothing brush.

5. Pounding the two papers together with an uchibake is optional, few Western conservators are employing this step because of the potential danger to the artwork. This technique was developed to integrate lining to lining, not lining to original.

E. Drying (See 28. Drying)

1. **Unrestrained drying:** object is air dried.

2. **Minimal restraint:** object is dried under felts.

3. **Pressure drying:** the lined object is sandwiched between blotters, felts, glass and weights applied; blotters changed until all moisture removed. Sometimes an interleaf (wet strength tissue, polyester web) is used between art and blotters.

4. **Restrained drying:** using a drying board (karibari) or other surface the lining is carried out as described above. Instead of sandwiching object between felts or blotters and weights, a small amount of paste is applied to the edges of the lining tissue and it is adhered to the drying board or other rigid surface. The object may be dried face out or face in. The object may also be allowed to air dry first and then be slightly and evenly re-wetted and then restrained for a second drying. This avoids excessive contraction and minimizes chance for any separation of tears.

29.4.2 **Dry Paste Version** This lining technique is adapted for artwork that is sensitive to moisture. The artwork is not wetted and the tissue and paste are blotted to remove any excess moisture.

A. Preparation of the Art

1. The art is lightly sprayed with a fine mist of water on both sides or,
2. The art is humidified until it is thoroughly relaxed.

B. Preparation of the Lining (see 29.4.1 B)

C. Adhesive Application

1. A fairly thin starch paste is brushed out onto the lining paper. The pasted lining paper is then lifted and transferred to a blotter, paste side up. The pasted lining paper is then lightly brushed with a damp paste brush to insure that the blotter absorbs the excess moisture.
2. Another method is to apply paste to lining paper that is placed on Mylar. Then place a thin piece of Mylar on the pasted surface. Flip the package over and remove the Mylar on the back and blot the lining paper from the verso. Cover again with dry Mylar to flip the package over and remove the thin Mylar from the pasted surface.
3. A third alternative is to paste out tissue over a thick blotter which is pasted to glass or Plexi or adhered with double stick tape, (the blotter absorbs moisture of the paste).

D. Placement and Attachment of Lining to Artwork

1. The art object is now removed from the humidity chamber and placed face down on a piece of polyester web.
2. The lining paper is then lifted from the blotter and brushed down over the verso of the art.

E. Drying (See 28. Drying)

1. The lined art is sandwiched between polyester web and blotters.
2. Attach to screen (restrained drying)
3. Suction Table (restrained drying)

29.4.3 Linings which Employ Restraint During Drying. The object is face out: this is designed for delicate watercolors or pastels with sensitive surfaces, it can obviate the need for blotters on the surface during drying. These linings are also useful for works with

multiple tears in which alignment from the front takes place during lining. The advantages of this technique are: the conservator can see the face of the object during tear alignment, transmitted light may be used during tear alignment, and the object does not have to be thoroughly wetted, it can be humidified only. Disadvantages are: potential flattening of surfaces, not recommended for works with deep plate marks or relief impressions, discolorations may migrate to the recto surface, adhesive may come through tears to recto.

A. British Museum Method: Lining Tissue Stretched on a Solid Support.

1. Preparation of Art

- a. The art object is wetted or humidified.
- b. If torn, no repairs are made on the verso.

2. Preparation of Lining

- a. see 29.4.1 B
- b. The lining tissue is thoroughly wetted and expanded onto a wooden, glass or Plexiglas sheet, the edges are secured to the surface with tape and the tissue dries very taut.

3. Adhesive Application

- a. The adhesive usually selected for this method if there are numerous tears, is methyl cellulose or carboxy methyl cellulose or a mixture of starch paste and cellulose ethers, because of their "slip" quality which allows more time for alignment and manipulation once the object is placed.
- b. The starch pastes will not allow for as much manipulation, but they have been used successfully with this technique.
- c. The adhesive is applied evenly with a brush to the stretched lining tissue.
- d. An alternative method is to substitute up to 80% of water with ethanol when preparing methyl cellulose for very sensitive media and to limit expansion of art work. (S.R.)

4. Placement and Attachment of Lining

- a. The art object is carried, face up, to the stretched and pasted tissue, if there are tears

a rigid support may be used to transport the art.

b. The object is slowly shifted onto the tissue.

c. Tears are aligned. If lining tissue is stretched onto Plexiglas, transmitted light may be used to aid alignment by placing materials on top of a light box.

d. When placement is satisfactory, secure contact by placing polyester tissue over the surface and using light application of pressure. Brayer or roller also sometimes used with discretion. Allow object to dry in this manner for several days.

B. Lining Tissue Stretched on Temporary Support:

Dacron or Terylene. This method of lining allows a long working time in which to align tears and also insures that the object dries flat. This technique works best if the object is able to be completely wet during the treatment. Consideration must be made of the potentially undesirable effect of flattening an object (platemarks, etc) and of the strain on fragile or highly expansive papers, and the strain imposed upon the art as Dacron is removed. A paste layer remains on the reverse of the lining which may be undesirable.

1. Preparation of the Art

a. The object to be lined is wetted face down onto Mylar.

b. Tears and loose pieces aligned as much as possible.

c. The Mylar may be used as a carrier when placing the object onto the lining.

2. Preparation of the Lining and Adhesive Application.

a. Prepare a sheet of Plexiglas by sanding to give the surface tooth.

b. Apply paste to the Plexiglas and place dacron fabric onto the pasted Plexiglas and smooth out.

c. Apply paste to the surface of the Dacron or Terylene and place the lining paper onto this surface.

d. Apply paste to the lining paper (see 29.4.1 B)

3. Placement and Attachment of Artwork

a. Carry art, face in, on the Mylar support to the prepared lining, determine placement.

b. Attach by lowering Mylar onto pasted lining paper.

c. Remove Mylar by rolling it onto itself.

d. Do final tear adjustments and alignments.

4. Drying

a. Allow to dry for a least two days.

b. Separate Dacron from the Plexiglas.

c. Now separate lined art from the Dacron.

Variation I:

1. Preparation of Art

same as above 29.4.3.B.1

2. Preparation of Lining

same as above 29.4.3.B.2, except step C: do not apply paste to entire surface of Dacron, but only to borders so that lining tissue will be attached to fabric only at the edges.

3. Placement and Attachment

same as above 29.4.3.B

4. Drying

same as above 29.4.3B.4, except the need to 'peel' lined art from Dacron is eliminated.

Variation II: for objects requiring a minimum of moisture:

1. Original object may be given a thin preliminary dry lining to mend tears and facilitate handling, and to minimize penetration or adhesive from lining assembly to original object. Methyl cellulose added to starch paste can assist in minimizing water content.

2. Prepare lining by pasting up Dacron and paper being sure to apply paste layer to top of paper

(acts as size for rewetting) and allow to dry.

3. Apply paste to lining assembly and lay down humidified object.

C. Lining Using Restraints: Vacuum Suction Table.

This procedure is designed to allow the lining of works on paper which have a surface so fragile or friable as to not allow for any of the manipulation or pressing of the surface as is described in 29.4.3 A or 29.4.3 B (see bibliography no. 14). With the table, suction is solely responsible for ensuring contact between the art and the lining tissue initially and during drying. Type of suction table (perpendicular or transverse flow) can make a difference in the rate and evenness of drying in the lined object. With transverse flow air is introduced beneath the table as well as drawn from the surface - thus drying time might be shortened. Disadvantages of this technique are: the prolonged suctioning of air through paper as is often needed to dry an object on the suction table, risks "dirtying" the paper by pulling into the surface fibers airborne dust and dirt. White chalks and finely divided pastel pigments, particularly when wetted or humidified, have been known to "sink" into paper fibers during suction table treatment.

1. Preparation of Art

a. The object is humidified, face up supported on a sheet of Japanese tissue or polyester web. Humidification either by use of an enclosed container, spraying/misting or ultra-sonic vapor must be sufficient to thoroughly relax and expand art object.

2. Preparation of Lining

a. Several layers of blotters with a sheet of Japanese tissue or polyester web on top are placed over a prepared opening on the surface of the vacuum suction table, the rest of the table is covered to pull a vacuum. (Having a Japanese tissue or polyester web interleaf between the lining tissue and the blotters provides a support when changing the blotters is necessary and acts as a barrier to prevent any adhesion of lining tissue to blotter caused by migration of the lining paste).

b. The tissue/blotter pile is thoroughly wetted until soaked.

c. The lining tissue is placed over the wetted tissue and blotters on the suction table and smoothed into contact.

3. Adhesive Application

a. Paste, diluted to the appropriate consistency is brushed onto the lining tissue beginning at the center and working out.

b. The tissue/blotters beneath the lining tissue should be wet enough not to draw or pull the diluted paste through the lining tissue.

c. Raking light aids to ensure an even application of adhesive on the lining paper.

4. Placement and Attachment

a. The art is transported to the prepared lining tissue, supported on Japanese tissue or polyester web.

b. At this time the art must be relaxed and relatively flat.

c. The art is slowly slipped off the tissue support and onto the lining, depending on dimensions of the object, this step may require two people.

d. Once in place, minimal suction is activated. It is at this point the conservator will know how much manipulation is necessary to avoid creating air pockets, draws and wrinkles. The art work may react to the moisture contributed by the lining and blotters. It may be helpful to have ready a fine sprayer (Dahlia) or humidifier with hose attachment in case further humidification is necessary.

e. Suction is increased to create good overall contact between the art and lining.

5. Drying

a. Once even contact is achieved, the vacuum may be decreased enough to allow the lined art, supported by the interleaf to be removed from the table long enough to replace the wet blotters with dry ones. (Difficulties, such as creases, have been encountered if suction is not low enough when replacing blotters).

b. Suction is returned to medium once lined object is in place.

c. Complete drying on the table may not be necessary or even desirable as noted under "Disadvantages". Once adhesion between art and lining is secured, e.g. pressure is not longer necessary, the lined object can be removed from the table and placed on a drying board or other method of restrained drying.

Variation: Use of a moisture chamber placed directly on the suction table has been described in the literature (bibliography no.14, no.26). Any covering on the surface of the vacuum suction table must be designed to have an air intake opening to prevent implosion. **Advantages** of the moisture chambers are: a greater degree of control over the moisture content in the object during all phases of the treatment thus reducing the need for re-wetting due to unwanted drying in the object. **Disadvantages** are: the conservator may find it difficult to immediately reach a particular side or area of the object, even with access holes.

1. Preparation of the Art

a. Two openings, slightly larger than the object are prepared on the surface of the suction table, side by side (one to be closed while the other is used). The rest of the table is masked to pull a vacuum.

b. The moisture chamber is positioned on the suction table. This chamber has a port for the entry of ultra-sonic vapor.

c. The art object is placed face up on a sheet of Japanese tissue or polyester web over a dry blotter.

d. The art, tissue, blotter are placed over one of the openings on the table.

e. The ultra-sonic vapor is activated. The amount of water content and volume of vapor is selected.

f. The object is allowed to become thoroughly relaxed and moistened.

g. If ultra-sonic vapor alone does not flatten object, the suction table may be activated on low setting to achieve this.

2. **Preparation of the Lining**
(see 29.4.3 C.2 above)

3. **Adhesive Application**
(see 29.4.3 C.3 above)

4. **Placement and Attachment**
(see 29.4.C.4 above)

5. **Drying:** Type of air flow in the table influences this step. The transverse (parallel flow) tables aid in drying blotters from below so there may be less or no need for blotter changes during drying. (Some conservators find that these tables dry unevenly from one edge).

a. If necessary to change blotters, dry blotters may be placed over first opening vacated by the art. (see 1a. above)

b. The lined art, on the interleaf, is lifted onto the dry blotters. (It will probably be necessary to reduce suction slightly while shifting art to dry blotters). Suction is increased as needed once art is positioned.

c. Remove wet blotters and cover second opening with plastic.

d. Humidification continues in order to keep the top surface of the object damp while moisture is being removed from below.

e. Once the blotters beneath the object do not appear to be absorbing further moisture, the mist can be decreased gradually until no further moisture is entering the chamber. [Caution: again, air must be allowed to enter chamber through an opening anytime suction is activated.]

f. If necessary, to prevent irregular drying at edges of the art, place polyester web strips up to or slightly over the outer edges of the object and weigh with glass or Plexiglas.

g. The object is taken to dryness or partial dryness while under the suction pressure as described in 29.4.3 C.5 above.

D. Lining Using Restraints-Object is Face In: This method is useful for oversize objects which cannot be easily lifted to a drying board or onto a pasted lining tissue. **Advantages are:** once the object is

wetted it doesn't have to be moved again and this allows very large objects to be lined flat, eliminating trying to dry the entire object with changes of blotters. **Disadvantages are:** the conservator cannot see recto of the object once lining begins; inks on recto may blanch against Mylar if moisture isn't completely drawn from verso; the conservator can manipulate the amount of tension created during this lining, the more expanded the art and lining tissue when joined, the greater the tension created. Misjudgement could cause tears.

1. Preparation of Art

- a. The Mylar (approximately 3 mil.) should be pre-cut to the dimension of the object when dry.
- b. Wet the art object into smooth contact with sheet of polyester film
- c. When fully relaxed, blot the object of all excess moisture and allow for some contraction (object should not be fully expanded when lined).

2. Preparation of the Lining (see 29.4.1 B)

- a. Wet lining tissue (or tissues if object is oversized) on 3 mil. Mylar using water brush and sprayer.
- b. The tissue or tissues have been cut so as to overlap the edges of the art object by a least 1-2 inches on all sides.

3. Adhesive Application (see 29.4.1 C)

4. Placement and Attachment of Artwork

- a. Align and place lining tissue onto back of object, smoothing lining into contact with both the art and, where it extends beyond the art, the table surface.
- b. When lining tissues are in place, blot off excess moisture.
- c. The edges of the lining tissue which are pasted to the table top surface are further secured in place by strips of masking or linen tape. This prevents the lining from pulling away from the table. Some blotting may be done from the top side.

5. **Drying:** Allow object to dry under tension for at least two days.

Variation: Follow all steps outlined above in 29.4.3 D, but under Preparation of Art #b, cut Mylar several inches larger than the object on each side; and under Placement and Attachment, instead of smoothing the lining tissue into contact with the table top, the tissue which extends beyond the art is smoothed into contact with the Mylar. The Mylar provides a "slip". Should the tension created during drying become too great the lining tissue is likely to release at the contact point with the Mylar rather than tearing or pulling elsewhere to relieve tension.

29.4.4 Double Linings: Purpose

- A. To provide additional/extraordinary reinforcement of weak objects.
- B. To facilitate the mending of torn objects or lining objects with planar distortions.
- C. To incorporate or simulate original linings of cloth, paper or mounts.
- D. To reinforce objects with a sensitivity to moisture.

1. **Procedure:** Reinforce tears by lining instead of individual mends. After object is fully expanded and tears are registered, apply lining. After drying (between felts) adjust tears as necessary by local applications of water, repositioning and drying. Tears with extreme cupping can be additionally reinforced with mending strips applied to lining verso. After trimming away edges of first lining, relax object by humidification or wetting with a water brush or sprayer. Place object face down on clean Plexi with a sheet of non-woven polyester (slightly larger than the object) protecting the surface. Lay down pasted lining which is several inches larger on all sides than the object and smooth down. Allow to dry partially and while object is still fairly relaxed, paste down edges of second lining to Plexi. Can be dried face up to facilitate inpainting or face down to have drying occur through the back. Edges can be dried with hair dryer to avoid peeling from Plexi. Object is already reinforced so separation will not occur at tears. Planar distortions will be removed to maximum extent during drying (good for lining objects made of more than one overlapping sheet).

Object can also dry unrestrained and be flattened later in a similar fashion.

2. **Variation:** For objects which are sensitive to moisture, first apply a dry lining (see 29.4.2) with Japanese tissue. The first lining acts as a barrier, controlling penetration of moisture from the paste of the 2nd lining to the object. Dry art face down after checking surface for moisture penetration.

B. Japanese tissue-Western paper linings: This procedure is useful for heavy works which require a stiff, but not necessarily solid, support.

1. Object can be lined in a conventional fashion with Japanese paper (serving as an interleaf or to mend tears) then to Western paper. Dry and flatten under weights or by stretching.

Variation: also particularly good for large or heavier objects. Prepare western lining paper cut several inches larger than the object, by wetting and allowing to dry evenly until desired dimension is reached. Place on clean, sanded Plexi and paste surface. Japanese paper is now laid down onto the western paper and pasted also. Relaxed object is laid down onto pasted surface. Edges of western paper are pasted down to Plexi only in areas which extend beyond edges of object. Contact is insured by smoothing with soft brayer over barrier sheet. After drying, western paper is trimmed to edge of object. Lightly sand edges of western paper to reduce sharpness.

C. Japanese tissue-fabric linings: This procedure is useful for works composed of several printed sections which require an extremely large support surface in order to be pieced together as a whole, e.g. large lithographic posters and billboards.

1. **Procedure:**

Object is already lined with Japanese tissue in manner described in 29.4.1. The object is wetted face down onto Mylar. Cotton canvas or or Irish linen is pre-washed with hot water to remove size. It is then stretched onto a strainer, dampened, and re-stretched very taut. Fresh dilute starch paste is applied to the verso of the Japanese tissue lined object. The object and Mylar are lifted and placed onto the stretched fabric. Good contact is assured.

2. Variation:

Use pre-washed cloth in similar fashion to Dacron, as in 29.4.3.B.2. Paste cloth down to Plexi only at edges beyond original object. Paste surface of cloth and smooth out Japanese paper onto cloth. Apply paste to surface of paper. Apply humidified object. Allow to dry face up.

3. Advantages

- a. The strainer can be positioned vertically, so air circulation is encouraged from both sides; this also allows the conservator to manipulate wet/dry areas on objects with inherently uneven expansion/contraction ratios, i.e. heavily inked areas vs. un-inked areas (posters, lithos.)
- b. Cloth can provide a good reinforcement for tears and good hanging weight and the option of mounting onto stretcher.

4. Disadvantages

- a. Paper and fabric have different reactions to moisture.
- b. A weave impression from the fabric could be impressed into the paper, even with a Japanese tissue primary lining.
- c. Limited strength of starch paste with linen.

29.4.5 Non-aqueous lining methods

Non-aqueous adhesive in lining works on paper have occasionally been used when the condition of an art object demands a lining support but the nature of the medium or paper precludes the use of water soluble adhesives such as starch pastes or methyl cellulose. In these cases the non-aqueous adhesive is in direct contact with the art object.

Since none of the synthetic, non-aqueous adhesives have stood the test of time as have the starch pastes, their selection in conservation treatments is usually made only after judicious review of any possible aqueous alternatives. When it is necessary to use a non-aqueous adhesive, selection may be based on the object's ability to undergo heat, and the temperature range; and the effect of various solvents used as diluents in the

adhesive and which may need to be employed later for reversing the treatment.

Advantages of non-aqueous lining are: the ability to add an overall structural support when needed to an object sensitive to water or a work so oversized as to preclude the use of moisture; the elimination of most problems with expansion/contraction matching between art and lining (although heat can also cause some curl and distortion); the ease of placement of the art, particularly oversize works when neither art nor lining is wetted; and, if the adhesive used is heat activated, placement and adjustment of the art onto the lining may be made with less difficulty than with already tacky adhesives such as starch pastes and emulsions.

Disadvantages are: the lack of information on the long term aging characteristics of these adhesives: i.e. their ability to remain reversible and, the possibility they may permanently alter the physical and chemical structure of the art object through deterioration and migration. Additionally, dispersion adhesives also contain modifiers, initiators, plasticizers, surface active agents and buffers. The effect of these variables is not fully known. The use of solvents and/or heat usually involved in non-aqueous linings may have long term effects upon the medium or paper. Immediate effects should be known before attempting use of any of these adhesives.

- A. **Supports used in non-aqueous linings** are as variable as those selected for aqueous linings and are chosen appropriate to the needs of the object. Japanese tissue papers, natural and synthetic fabrics have been used. (see 29.3.1-3)
- B. **Adhesives** (see 29.3.4) Many of the non-aqueous adhesives offer a variety in their method of bonding: 1) heat activated, 2) solvent activated, 3) contact pressure, or 4) wet application, similar to the way starch paste is applied. Examples of adhesives often activated by heat are: a) acrylic resin dispersions (Lascaux and Rhoplex) and b) thermoplastic resin solvent systems (Beva 371, PVA resins, Rabins Hot Melt). Examples of adhesives activated by solvent application are most of the above and hydroxy propyl cellulose (Klucel) - rather than apply heat to activate the resins an appropriate solvent is applied. Examples of adhesives which can be used as pressure sensitive are a) acrylic resin dispersions (Rhoplex N580 and Lascaux 360 HV)

and b) silicone polymers (these have not been tested for use in paper conservation). Adhesives may be applied to the two adherends (e.g. verso of the art and surface of lining material) or the adhesive may be applied to both sides of an interleaf material used between the art and the lining. Adhesives can be manipulated to the conservator's needs by the method of application (brush, spray or offset); degree of application (thick vs dilute) and method and degree of heating (hand held hot air gun, vacuum hot table, hand ironing). Most conservators attempt to achieve bonding between the art and the lining material using the least amount of adhesive necessary and to keep the adhesion on the top surface fibers, avoiding penetration or flow of the adhesive into the art.

C. **Examples of non-aqueous lining treatments.** The following are generic descriptions of non-aqueous and synthetic adhesives used in linings. These generic descriptions are followed by examples of specific treatments published in the conservation literature.

1. **Heat Activated:**

a. **Preparation of art**

1. All dry cleaning and repairs are made prior to lining.
2. Cockling or major distortions should be flattened as much as possible.

b. **Preparation of lining**

1. The lining material (natural or synthetic fabric or Japanese or western paper) cut slightly larger than the dimensions of the art, is temporarily stretched or restrained. Wooden stretchers are often used but stapling or pinning lining material to a non-absorbing rigid support works also.

c. **Adhesive application**

1. The adhesive is applied either as a liquid or as dry pre-cast film or on a carrier as a heat seal tissue. If in liquid form it may be applied by spraying or brushing onto the verso of the art and/or onto the lining material. It is

thought that spray application, if manipulated properly (high pressure and rapid evaporator diluents), can disperse the adhesive onto the surface of the adherends in a stringy, cobweb-like layer which creates multiple sites for nap-like bonding. This is as opposed to the even overall layer achieved with brush applications which tend to "fill" air pockets and voids in a surface as the adhesive flows to create an even overall layer for attachment. In either case the liquid adhesive is given adequate time to form a dry film. The adhesive can also be applied as a pre-cast dry film either without a carrier e.g. Beva 371 film, or supported on a carrier such as lens tissue, pellow, or thin Japanese tissue.

d. Placement and Attachment:

1. The lining is positioned on the surface of either a vacuum suction table or a vacuum hot table.
2. if neither of the above pieces of equipment are available, the lining material is placed upon silicone release paper on a smooth surface.
3. The art is positioned on the lining material.
4. An appropriate cover or release paper is placed over the art and lining material (unless the vacuum suction table is used).
5. Pressure or suction is activated: a) with vacuum tables or b) hand pressure created by ironing, to insure contact.
6. Heat is applied either by hand (tacking iron or hot air blower) or from source in vacuum table. The degree of heat necessary to apply is a function of the adhesive selection.
7. Pressure or suction continues as the heat source, having activated the adhesive, is removed and cooling begins. (Examples: see bibliography entries 11, 12, 13)

2. Solvent Activated

- a. Preparation of art (see above)
- b. Preparation of lining (see above)
- c. Adhesive application (same as above)
- d. **Placement and attachment:** Before the art and the lining are positioned together and pressure applied, the adhesive is reactivated by application of an appropriate solvent. Once the adhesive is activated, the two adherends are positioned and joined into contact using either vacuum suction or pressure. Suction or pressure on the object should continue until all solvents have evaporated and the adhesive has become a dry film. (Examples: see bibliography entries 20, 21 and 23).

3. Contact Activated

This method is little reported in the conservation literature. Some of the acrylic resin dispersions remain tacky at room temperature (see 29.3.2.) and can be used as pressure sensitive adhesives. The bond formed using these adhesives is relatively weak and may therefore be more easily reversible in the future. By not employing heat or solvents the adhesive layer (at least initially) is less inclined to penetrate the surface of the adherends. Rhoplex N580 and Lascaux 360 HV can be used as pressure sensitive adhesives.

4. Wet Application

Some of the acrylic dispersions have been used wet in the manner in which paste is applied. This is particularly useful for works with a slick surface or artist's prepared papers where starch paste would probably not adhere a slick surfaced paper to a lining support. Rhoplex AC-33 and 234 and Lascaux 498 HV have been used this way. The cellulose ethers are also used in this way. Contact of pressure must be ensured until the adhesive becomes a dry film.

29.4.6 Composite linings

These are linings which combine aqueous and non-aqueous lining systems within the treatment. Technically, these are double linings or, if the second lining is a rigid support, this procedure could be termed mounting. This procedure is, in fact, most often used to line the

work of art to a good quality, rigid support either for structural or esthetic reasons. When this is the main consideration, a traditional lining (though usually using the dry version: 29.4.2) is employed which acts as a buffer between the art and the non-aqueous adhesive.

Aqueous linings also prepare the art by flattening distortions. Advantages of composite linings using two different adhesive systems are: ease of separation should reversal become necessary, e.g. heat or certain organic solvents will release the non-aqueous layer without disturbing the aqueous layer. Should mechanical removal be necessary, the lining tissue will protect the surface of the art from abrasion.

Most of the adhesives listed in 29.4.5 would be used with these linings. Lining supports may also include the following solid supports:

- ragboard
- ragboard mounted to aluminum honeycomb panel
- ragboard mounted onto a wooden stretcher
- ragboard faced to archival corrugated board (**Process**)
- ragboard mounted to paper honeycomb panels (**Tycore**)
- archival paper honeycomb panels (**Tycore**)
- Karibari panels

(see related articles following bibliography)

29.4.7 Special Considerations

A. Lining with a window: This procedure is used for objects which have important information verso which must be viewed, but the object is so fragile it must be lined.

1. **Preparation of art** (same as 29.4.1A) with the addition that Mylar is placed over the area to remain visible after lining.
2. **Preparation of lining** (same as 29.4.1.B)
3. **Adhesive application** (same as 29.4.1.C)
4. **Placement and attachment** (same as 29.4.1.D) with the addition the lining material is blocked from attaching to the art in the area covered by the Mylar insert.
5. **Drying** (same as 29.4.1.E). Once object is dry, the lining is cut around the Mylar and removed, or the lining is cut on three sides forming a flap. The flap may be folded back into place and opened only when necessary to view information beneath.

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