Kodak Approval Digital Color Imaging System

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Lamination Techniques for Packaging

*Preparing **Kodak Approval** System Proofs on Packaging Substrates*

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Kodak

Purpose

Background

With continuing innovation in packaging methods, materials, and flexographic printing techniques, more and more printing is done on plastic, foil, and other non-paper substrates. Among the ways the **Kodak Approval** digital imaging system is keeping pace with these changes is through its capability of generating proofs onto many types of packaging substrates. Using the **Kodak Approval** system, prepress customers can present their clients with true halftone proofs imaged on the same substrate used in packaging the final product. This gives the proof the look and feel of the end product and helps customers to minimize guesswork in early stages of printing operations. Packaging customers can even create a mock-up or prototype of the final printed package.

With its unique formulation of colorants and films, **Kodak Approval** digital proofing media adapt to both conventional paper substrates and many types of non-paper substrates such as those used in food, cosmetic, beverage, and healthcare product packaging. However, non-paper substrates can have a wide range of physical properties, including some that can be incompatible with standard lamination techniques used for the **Kodak Approval** system.

About this Document

To meet the need for lamination onto different substrate types, including those initially thought to be prohibitively difficult, various techniques have been developed by **Kodak**'s Technical Applications Group working with existing customers in the printing and packaging industry. This document is intended to share useful information about the lamination process and materials with customers working in the packaging industry, and to make both newly developed and time-tested techniques more accessible to these customers.

The Lamination Process: An Overview

In order to use lamination more effectively, it is helpful to have a good working knowledge of the materials used, their key properties, and the overall lamination process. Figures 1, 2, and 3 show the key components and steps in the **Kodak Approval** system's lamination process, from start to finish. The cross-sectional callouts in these figures are not drawn to scale, but exaggerate the thicknesses of various film layers to help make clear what happens at each stage of proof preparation. A summary description of each step follows.

Figure 1 shows imaged intermediate from the **Kodak Approval** digital color imaging system. In the writing process performed on the **Kodak Approval** system, a sheet of intermediate receiver is wrapped around a vacuum drum. One at a time, successive sheets of thermal color donor (typically cyan, magenta, yellow, black, and other special colors) are then overlaid on top of the intermediate. Laser energy transfers dye colorant from the donor layer of each overlaid sheet, forming the **imaged intermediate**, a reversed intermediate of the final image written onto the intermediate receiver sheet.

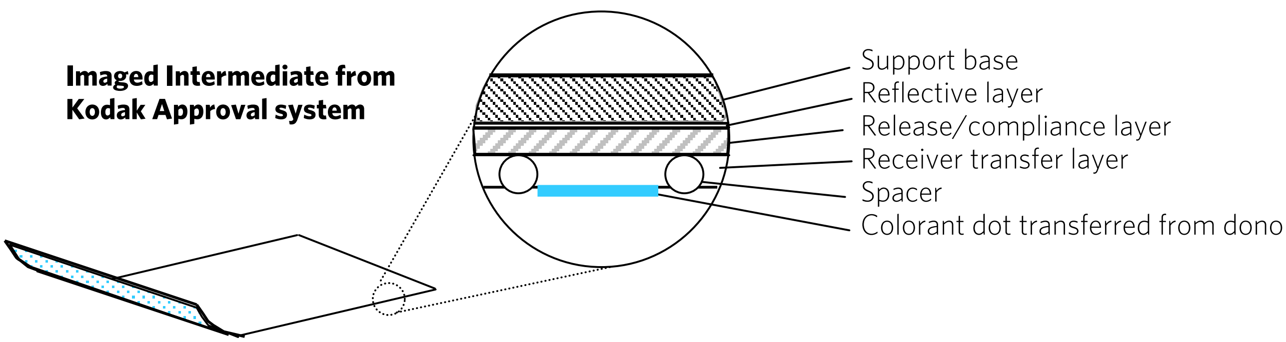


*Figure 1. Output from the **Approval** system*

The imaged intermediate receiver sheet has a number of layers, as shown enlarged in Figure 1. The **support base**, **reflective layer,** and **release/compliance layer** are needed only to support the writing and transfer operations and do not become part of the finished proof.

In the lamination of the finished proof, the imaged intermediate sheet separates between the **release/compliance layer** and the **receiver transfer layer**. A **receiver transfer layer** does the work of image transfer.

The **release/compliance laye**r is not only designed to allow this separation at final lamination, but also provides the cushioning that allows the **receiver transfer layer** to conform very closely to the surface of the substrate, on a microscopic scale, so that the gloss of the finished proof mimics the gloss of the substrate.

The receiver transfer layer includes tiny **spacer beads** used in the writing process. These spacer beads accompany the **receiver transfer layer** and are thus incorporated into the final image that is formed on the proof.

For reasons described in more detail subsequently, the customer's **substrate** is prepared for image transfer by prelamination, as shown in Figure 2. In prelamination, a sheet of Kodak Approval prelaminate material is laminated onto the substrate. This transfers a very thin **prelaminate transfer layer** onto the surface of the substrate.

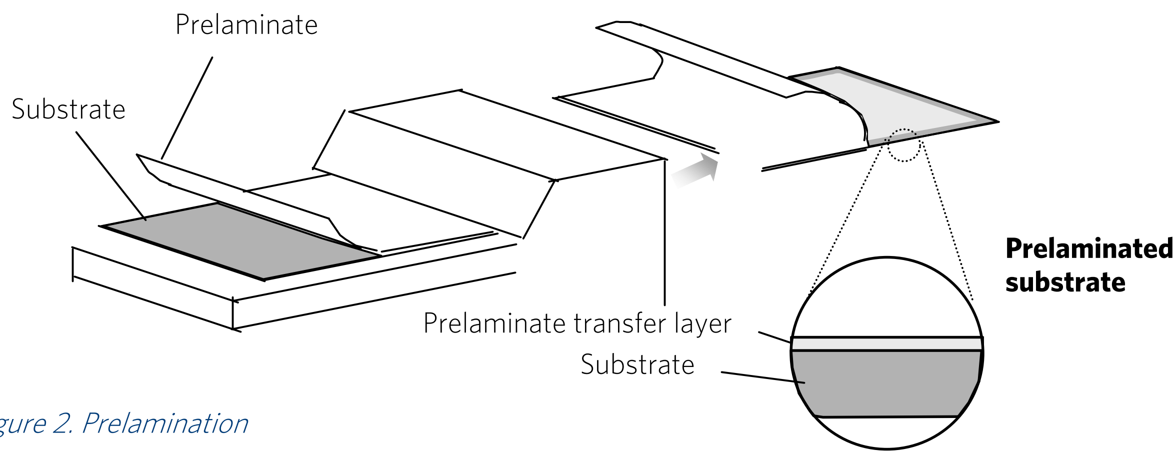


Figure 2. Prelamination

Final steps in proof lamination are shown in Figure 3. Here, the **prelaminated substrate** from the prelamination procedures of Figure 2 is fed back into the Kodak Approval laminator along with the **imaged intermediate** shown in Figure 1. This final lamination operation transfers the **transfer layer** of the **imaged intermediate** onto the **prelaminated substrate** surface. With this process, then, the **complete imaged proof** is provided on the customer's custom substrate, which has both the additional **prelaminate layer** and the image-bearing **transfer layer** affixed to it.

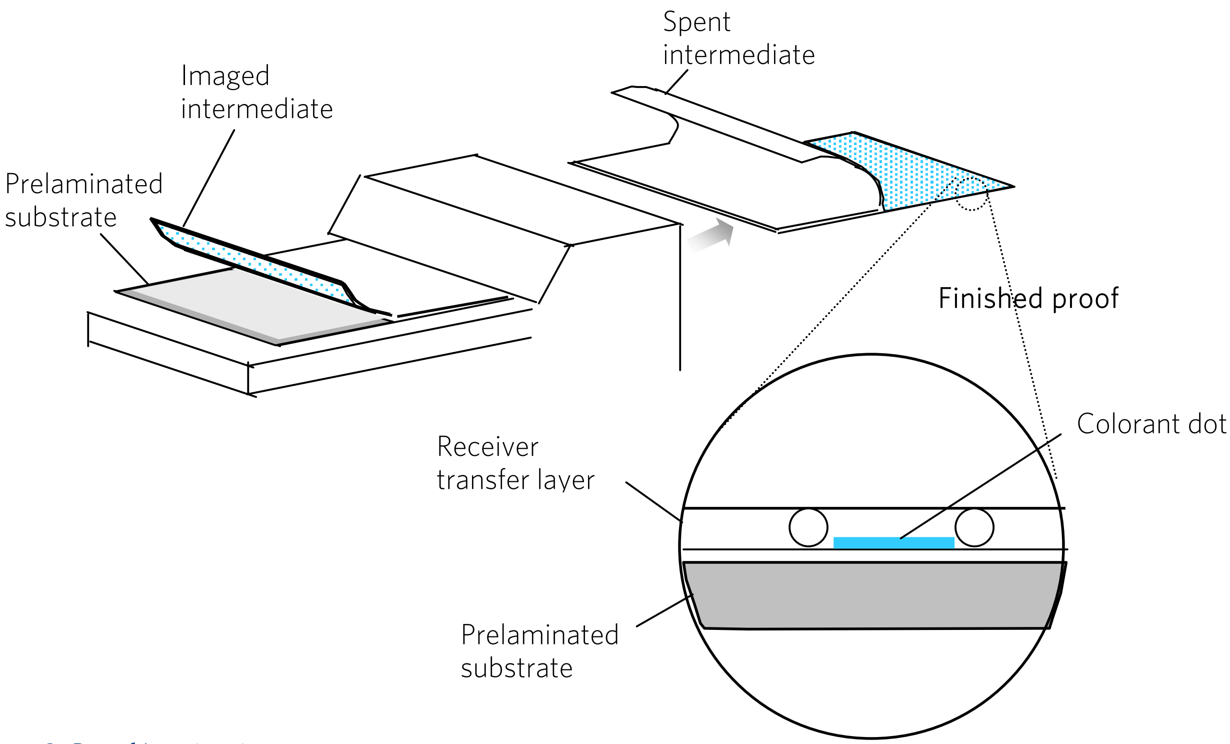


Figure 3. Proof Lamination

The basic sequence of Figures 1, 2, and 3 is familiar to customers who have been preparing Kodak Approval system proofs on conventional paper print stock. When using most conventional paper stocks, little attention needs to be paid to materials and variables in the proof lamination process. However, in order to prepare proofs on plastics, foils, and other print substrates used for packaging, it is more important for customers to know about the lamination materials, about laminator settings, and about requirements for laminating onto their own non-paper substrates.

Laminator Controls and Settings

Lamination temperature and speed are factors in achieving successful image transfer to a substrate. The **Kodak Approval** laminator control panel, shown in Figure 4, has operator controls for adjusting these settings.

Speed

The speed switch control has a High and Low speed toggle switch, with each setting of the switch having a corresponding speed control dial. The toggle simply switches laminator speed to the setting on the corresponding speed control dial. These speed dial settings are factory preset, with typical values as shown below.

Toggle Switch Position	Default Speed Dial Setting	Inches/Min.
High (rabbit)	55	27
Low (turtle)	30	15

Note: A specific customer site can have settings that differ significantly from the preset values shown above.

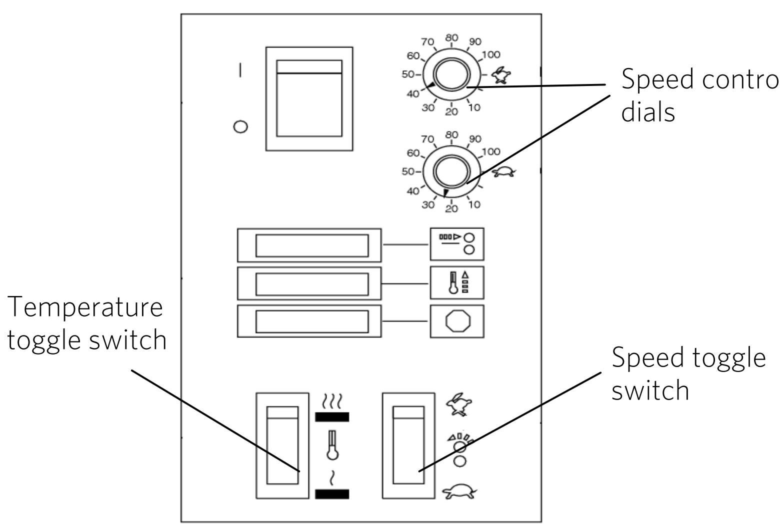
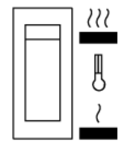


Figure 4. Laminator Control Panel

Documentation provided with the laminator describes how to determine the optimum speed settings for prelamination and image transfer onto the prelaminated substrate. The same procedures that are followed for finding optimum speed settings with paper stocks also apply when using other types of non-paper media.

Temperature

The temperature control is a toggle switch having lower and higher heat positions. This control is mainly for use with varying substrate thicknesses. For some thin substrates used in packaging, the melting temperature of the substrate can be of particular concern. The nominal temperatures to which the substrate material is exposed are in the following range:



- High temperature setting: 130° C
- Low temperature setting: 125° C

In general, the thickness of the substrate is a key variable for determining the best temperature and speed settings for both prelamination and image transfer. The higher temperature setting and slower speed times work best where the substrate material is relatively thick or has high thermal mass. Both temperature and speed settings are primarily intended to allow for this variability in thickness dimension or thermal absorption variability.

While temperature and speed settings control key transfer parameters, there is more to lamination than heat and speed. For reasons described later in this document, some substrate surfaces may not be suitable for lamination unless they are treated. For such surfaces, none of the available temperature or speed settings will be suitable for obtaining good prelaminate adhesion or image transfer.

Excessive temperatures or speeds that are too slow are **not** desirable, since this can cause some unwanted migration of the thermal colorant, and might even cause some small amount of colorant to leach back onto the intermediate release layer. Adversely, using temperatures that are too low or speeds that are too fast can result in incomplete transfer. When working with new substrate materials, it is best to allow some time for experimentation so that the best settings for speed and temperature can be determined.

As a rule of thumb, laminate at the lowest temperature setting
and fastest speed setting that works for the substrate you are using.

Reminders When Cleaning Laminator Belts

It may be necessary to clean portions of the moving components of the laminator for best performance or if a substrate melts onto the belt material. Detailed instructions for this procedure are given in the laminator documentation. There are a few highlights of particular importance with packaging materials:

- Use a general-purpose, streak-free cleaner or soap and water and a clean, damp cloth. Apply cleaner or soap solution **to the cloth**, then wipe down the belts.
- **DO NOT** use tools or abrasive cleaners that might scratch or degrade the belt or its coating.
- **DO NOT** use cleaners containing alcohol or acetone for cleaning the belt, since these chemicals can damage the belt surface.

See the laminator documentation for full cleaning details.

About the Lamination Materials

As the sequence illustrated in Figures 1, 2, and 3 shows, a number of the materials used to generate a proof are support materials that do not form part of the completed proof. For the most part, detailed information on these supporting materials is unnecessary for the end-user. However, some amount of technical information about those materials that are transferred is useful, particularly for customers who work with plastic, foil, and other packaging substrates.

Intermediate Receiver

The intermediate receiver has layers of materials that support the functions of writing and lamination, but are then discarded, namely, a PET (polyethylene terephthalate) support base, a thin reflective layer, and a release/compliance layer. The working layer of interest for the completed proof is the **receiver transfer layer**.

The following table lists key transfer layer characteristics.

Receiver Transfer Layer Characteristics

Material	Thickness	Softening Temperature
Butvar B-76 polyvinyl butyral (PVB), with spacers	8 microns (nominal)	62 – 72° C

Prelaminate Material

The prelaminate material also has a PET support base, with a thin **prelaminate transfer layer** that transfers to the customer's substrate. The support base is discarded after prelamination. The following table lists key prelaminate layer characteristics.

Prelaminate Transfer Layer Characteristics

Material	Thickness	Softening Temperature	Surface Energy (see p.10 for more information)
Butvar B-76 polyvinyl butyral (PVB), with spacers	3 microns (nominal)	62 – 72° C (nominal)	Using dyne pen approximation: 36 – 38 dynes/cm (nominal)

Why Prelamination is Required

As Figure 5 shows, the donor colorant that transfers is “sandwiched” between two layers of polyvinyl butyral, one from the receiver transfer layer, the other from the prelaminate transfer layer. This arrangement is most important for accurate color, colorant stability, and overall image stability. These encasing transfer layers are designed to be thick enough to provide a protective environment for the colorant dots, but thin enough to allow conformance to the substrate surface.

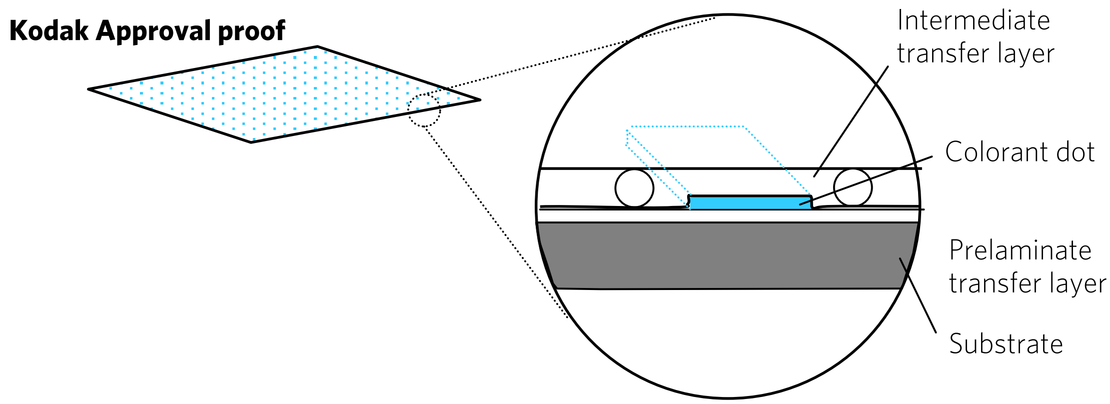


Figure 5. Colorant Dot Encased Between Transfer Layers

Without prelaminate protection, image quality can be adversely affected. Interactions with the substrate, with various types of coatings, plasticizers, and other chemical additives or with various types of surface treatments could degrade the colorant material or its dot structure.

The donor colorant is specifically formulated to have the intended color when colorant dots are themselves wrapped or encased in the polyvinyl butyral material. While it may be possible to affix the receiver transfer layer to materials other than the prelaminate transfer layer, this can compromise the color accuracy of the finished proof. The color may “look okay” to the laminator operator, but not satisfy the high colorimetric standards expected from **Kodak Approval** system proofs.

Substrate Requirements for Compatibility

There are a number of substrate characteristics that are important when considering lamination to unconventional print substrates. These include surface energy characteristics and the presence of various chemical additives and agents that can inhibit proper adhesion, as described below.

Surface Energy Requirements

The surface chemistry underlying successful lamination requires that the substrate have sufficient surface energy to properly bond to the prelaminate transfer layer. This is related to the commonly recognized phenomenon sometimes called "wetting" and is another factor in substrate compatibility with the Kodak Approval system. Surface energy information helps to determine which substrates are compatible with lamination and which other substrates are not compatible unless they can be appropriately treated.

Surface energy of a substrate is measured in terms of dynes per centimeter, expressed as dynes/cm. Optimal wetting of a surface is needed in order to provide the maximum surface contact, which means the best binding of an ink, a laminate, or other overlaid material, to the surface. In order for suitable "wetting" of a substrate surface to allow printing, lamination, or other type of coating, the surface energy of the substrate must exceed the surface energy of the applied ink or laminate coating. For use with Kodak Approval media, this means that the surface energy of the substrate must be **greater than** the surface energy of the prelaminate material.

In the printing world, substrates vary widely in surface energy. Conventional printing papers and paperboard substrates typically exhibit very high surface energy and, unless specifically treated otherwise, are well suited to ink or laminate application. However, coatings, laminates, additives, and other treatments can appreciably reduce the surface energy of a paper substrate, making it unsuitable for printing or lamination. For this reason, a small subset of very smooth and low surface-energy paper types have not been suitable for Kodak Approval system proofs.

Plastic and foil substrates, typically used in packaging applications, are more problematic for this reason. Many types of plastics exhibit low surface energy levels due to plasticizers or antioxidants that are added to enhance flexibility and other useful characteristics. These plasticizers or antioxidants can continually migrate to the surface of the plastic substrate, compounding the problem of printing or lamination to such surfaces.

To reiterate, the surface energy of the substrate must be **greater than** the surface energy of the prelaminate material. Where this requirement is not met, some additional type of surface preparation is needed to allow lamination. The threshold value of interest for lamination is the surface energy of the prelaminate layer, given as 36 - 38 dynes/cm (nominal) in the table on page 8. To allow lamination, then, the surface energy of the substrate must be **greater than** 36 - 38 dynes/cm.

Surface Energies for Typical Substrates

Typical examples of substrate surface energy measured for some commonly used packaging materials are as follows (all values nominal):

- Clay coated board: 100 dynes/cm
- Aluminum foil: 45 dynes/cm
- Polyester: 43 dynes/cm
- Polyvinyl chloride: 38 - 43 dynes/cm
- Polystyrene: 33 - 35 dynes/cm
- Polypropylene: 31 dynes/cm
- Polyethylene film: 31 dynes/cm

Using the threshold 36 - 38 dynes/cm value given above, it appears that some of these materials just listed would be acceptable substrates for lamination using Kodak Approval media. Clay coated board, aluminum foil, and polyester with these measurements would be compatible with surface energy requirements. Polyvinyl chloride also appears a likely candidate, although there may be borderline formulations. Polystyrene, polypropylene, and polyethylene films do not hold much promise as acceptable substrates, however, unless otherwise treated as is described later under **Techniques with Difficult Substrates**.

Measuring Surface Energy for Compatibility with the Kodak Approval System

Given these considerations, a first step in assessing compatibility of a particular substrate with the Kodak Approval system is to measure the surface energy, in dynes/cm, of the substrate. This is conventionally done using a tool called the dyne pen. Dyne pens are typically sold in sets, with each pen in the set rated at a nominal dyne/cm value. A typical 8-pen set may have dyne/cm values of 30, 32, 34, 36, 38, 40, 42, and 44 dynes/cm.

To find the surface energy of a sample, a tester marks the surface with a dyne pen of a given dynes/cm value. On a sample substrate with a higher surface energy, this dyne pen will wet the surface, showing no "beading" effect within a few moments of application. Conversely, on a sample substrate having a lower surface energy than this given dynes/cm value, wetting does not occur; instead, the applied liquid from the dyne pen "beads up" on the surface. If it has a surface energy value within the range of the dyne pen set, a surface measurement can be made by working through the range. The surface is marked using successive dyne pen values until a lower value pen wets the surface and the next higher value beads on the surface.

Be aware that the dyne pen is not a precision measuring instrument, because it requires some amount of subjective visual assessment by the tester. However, the dyne pen does provide a useful *relative* measurement of surface energy. By measuring the surface energy of the substrate relative to the prelaminate media, a customer may be able to quickly assess whether or not the substrate is suitable for lamination.

It is also important to note that a compatible dyne pen rating, of itself, may not necessarily mean that a substrate can be used. There can be chemical components of the substrate that prevent lamination even where surface energy measurements would otherwise indicate acceptability.

Dyne pen measurement is subjective.

Another Factor: Chemical Additives

Packaging materials may include various chemical constituents that can migrate to the surface or otherwise act to confound attempts at lamination. As noted earlier, plasticizers and antioxidants are sometimes used to complement other characteristics of a material. Release agents and silicone compounds are among yet other types of additives that might prevent adhesion, even where surface energies appear to be compatible.

The next section describes some of the methods that can be used to overcome at least some of the obstacles presented by incompatible surface characteristics.

Techniques with Difficult Substrates

Because of the broad range of materials that can be used for packaging and because of continuing innovation in the packaging industry, it would not be feasible to test all possible materials in all potential thicknesses, along with additives that might be used in combination with them. However, thanks to considerable field experience and input, a number of strategies have been devised for working with more difficult substrate materials, as outlined in this section.

The support team for the **Kodak Approval** system has developed a number of techniques for working with packaging substrates, where the conventional rules and procedures for lamination need to be slightly modified. A brief listing of some of the more useful time-tested techniques follows.

Laminating to thin or fragile substrates. Lamination has been successfully performed onto a number of wrapping materials thinner than about 1 - 2mm. These materials may require special handling because otherwise they can tend to soften and wrap themselves around laminator surfaces, eventually sticking, crumpling, or causing other problems.

One technique that has been used successfully with these materials is to form a sleeve for encasing the thin substrate as it passes through the laminator. Within the sleeve "pocket," the surfaces that come in contact with the substrate should have high gloss (that is, having a very low surface energy). A high gloss surface can be formed, for example, by using sheets of spent intermediate. A thicker sleeve surface can be formed by laminating two prelaminate sheets together, with the prelaminate sides face-to-face. Repeat this process to form each side of the sleeve. For a very stiff sleeve portion, a suitably large sheet of cardboard can be sandwiched between prelaminate sheets, with the prelaminate backing not removed.

Some temperature-sensitive substrates can be used to form **Kodak Approval** system proofs by careful employment of sleeves. However, there are no hard-and-fast rules for speeds or heat settings and some experimentation may be necessary.

Sleeving techniques can be helpful for some fragile substrates.

Laminating to very thick substrates. Using high heat and/or slow speed settings on the laminator is recommended where substrates are relatively thick.

How to tell if prelaminate transfers successfully. The prelaminate transfer layer is extremely thin. With some substrates, it can be difficult to determine whether or not transfer actually occurred under given conditions. One simple test for prelaminate transfer is to mark a small corner of the prelaminate material sheet surface on the transfer side, using a permanent fine-line marker (such as a **Sharpie** pen) or other writing instrument. Then laminate the substrate with the marked prelaminate. When successful transfer occurs, the mark will be visible on the substrate with no mark on the spent prelaminate support material. Otherwise, the mark, or some portion of it, will remain on the prelaminate material sheet.

Adjustments to gloss. The same gloss level adjustments that are available with paper printing stocks also apply when using packaging substrates. To add gloss, use a second pass through the laminator, with the image against the reverse (shiny) side of the intermediate support. A faster speed is recommended, since small dots in particular can be compromised by excessive heat. For a matte finish, use the matte laminate ML01 instead of the P02 prelaminate.

Running test samples. Remember that the laminator allows you to run a small proof with compatible materials. To test a substrate for suitability, for example, cut a small 6 x 8 inch section of the substrate with a correspondingly sized section of prelaminate material and run this through the laminator.

Working with smaller samples. In some cases, it is easier to work with smaller sized portions of a proof. This can be helpful, for example, when working with thin or heat-sensitive substrates, preventing bubbles from being formed as the substrate softens during lamination.

Using Surface Coating Materials

Under some circumstances, precoating a substrate may be acceptable for surface preparation and allow lamination for the **Kodak Approval** system. For this method, an adhesion sheet can be applied to the substrate. This may be suitable, for example, where surface energy measures too low or where additives in the substrate prevent successful lamination.

There are a variety of commercially available precoating materials that can be compatible with the polyvinyl butyral substrate of **Kodak Approval** prelaminate material. In addition to providing good adhesion, other general requirements for acceptability of a recoating include relatively high transparency, minimal thickness, and minimal impact on the final look and feel of the end product. To prevent unwanted chemical interaction of the precoating with the substrate on one side or with the prelaminate material on the other, any precoating material used should be acid-free.

As one surface coating option, **Kodak Matchprint** Digital Halftone GT prep sheets can provide a suitable precoat on some surfaces, particularly metals. This relatively thick material produces a proof having high gloss.

Another precoating material that has been successfully used is the Preview Precoat adhesive film (product number COA200), manufactured by Xyron, Inc. (Scottsdale, AZ) and marketed primarily to creative professionals for image transfer applications. The fairly adhesive transfer layer of this material can be readily laminated to many types of substrate, providing a good bonding surface for subsequent prelaminate film lamination.

Applying Surface Treatments

Printers, coaters, and converters use a number of different surface treatments for materials that have relatively low surface energy that otherwise prevents proper adhesion of inks or laminates. These same types of surface treatments can also be used to condition a surface for **Approval** system proof lamination. While there are no set guidelines for any specific material, the general principles and requirements for lamination that are outlined in the section entitled **Surface Energy Requirements** apply. Briefly, a surface treatment may be suitable if it effectively increases the surface energy of the substrate to sufficient levels for lamination.

Among surface treatments widely used for packaging substrates are the following:

Corona Discharge Treatment (CDT). Corona treatment increases the surface energy of plastic films and paper to improve adhesion for lamination and printing. In corona treatment, high frequency power is applied near the surface of a material, creating a corona effect that increases the surface tension of the substrate. The effects of this energy transformation can vary from one material to another. For best results, converters often apply CDT treatment at the time of extrusion (production) and again prior to conversion (printing, coating, or lamination). Thus, it may be difficult to duplicate exact conditions of a substrate during prepress procedure. CDT effects may decay with time, so that it may be necessary to work with more recently treated material.

Plasma treatment. This treatment method also uses electrical ionization of a gas, but at much lower electrical voltage levels than CDT. For this type of treatment, a plasma (glow) discharge creates ion bombardment of the surface, at energy levels greater than that available with CDT methods. This causes an etching effect and results in stronger bonding attributes for the treated substrate. Plasma treatment is advantaged over CDT treatment for use on thicker substrates and on materials that may not respond well to corona treatment. Plasma effects generally decay less quickly than the alternative CDT method.

Flame plasma surface treatment. This treatment is similar to atmospheric plasma treatment and may be used particularly for aluminum foils and other specialized surfaces. It slightly modifies the surface chemistry, increases the oxygen content ratio, and provides considerable improvement in bonding strength. Customers interested in using any of these surface treatments need to work closely with their converter or other supplier to optimize the substrate for their process. Customers who regularly use particular materials for printing and packaging applications often have advanced in-house expertise available to them. Prepress personnel are encouraged to work closely with their own materials experts when substrates need additional treatment to allow prelamination.

The surface energy of the substrate must be
greater than the surface energy of the prelaminate material.

Points to Remember

Image stability

As was shown in Figure 5, the transferred donor color is intended to be sandwiched between the prelaminate transfer layer and the receiver transfer layer, both of which are of the same material. This arrangement effectively seals the donor in its optimal environment for color-keeping and prevents migration or spreading of the colorant into the substrate. For this reason, the prelamination step is a requirement.

Prelamination is required.

Laminator settings

The temperature and speed settings of the laminator cannot compensate for incompatibility of surface energies between the substrate and the prelaminate material. That is, adding heat or slowing lamination speed will not help if the surface energy of a substrate is simply too low for adhesion. Other steps need to be taken to treat the surface of such materials.

See **Applying Surface Treatments** on p. 14.

Melt Transition Temperature of the Substrate

The melt transition temperature of some plastic film materials is close to the temperatures that are maintained at the Laminator nip. For this reason, it can be useful to consider the techniques for thin or fragile substrates given in **Techniques with Difficult Substrates**.

Thermal colorant transfer

The colorants are transferred from the imaged intermediate using a thermal process. Lamination at excessive temperatures or over excessive time periods can soften materials and degrade dot structure and should be avoided. Use of sleeving, as described in **Techniques with Difficult Substrates**, can help to prevent unwanted softening of colorant in some situations.

Questions and Answers

Q: What if my dyne pen measurements give me slightly different values for prelaminate than those shown here?

A. Dyne pens require some amount of subjective judgment and are not intended to give precision surface energy measurements. Dyne pens themselves may not be exact and there can be variations between sets made by two different manufacturers. Dyne pen sets also vary with age and have a limited shelf life. Fortunately, exact values for surface energy are not required, only relative values are needed. The important principle is that the substrate must have a higher surface energy than the prelaminate layer. Measure both the prelaminate material (correct side up, that is, with notches on the left or towards you) and your substrate to determine if this surface energy relationship holds.

Q: What if colorant transfer seems to work well enough without prelamination? Why should I take that extra step?

A. It is possible to adhere the transfer layer of the imaged proof to some unlaminated surfaces. However, there are good reasons for taking the time to prelaminate a substrate used with this system. Based on its particular formulation, the donor colorant of the **Kodak Approval** proof has the best color keeping and provides optimal imaging when it is encased by the **Butvar** material. The prelaminate also prevents the colorant from migrating and spreading into the substrate, with consequent loss of color or unintended mixing or spreading of the colorant over time, compromising dot structure. Therefore, the use of **Kodak Approval** prelaminate material is highly recommended, even where the difference may not be clearly obvious.

Q: Do I need to purchase a set of dyne pens simply to determine if my substrate is compatible?

A. No. The dyne pens merely provide a convenient measurement that is relative and subjective. You can quickly test a substrate simply by attempting prelamination. If prelamination succeeds, lamination of the imaged intermediate receiver will also work. If necessary, use the marking test described earlier in the **Techniques with Difficult Substrates** section to determine whether or not the prelaminate transfer layer successfully transferred.