LD 3.1-85 6470247 0002086 3
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STANDARDS PUBLICATION / NO. LD 3.1

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Performance, Application, Fabrication, and Installation of High-Pressure Decorative Laminates

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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LD 3.1

Performance, Application, Fabrication, and Installation of High-Pressure Decorative Laminates

Published by

National Electrical Manufacturers Association
2101 L Street, NW
Washington, DC 20037
(202) 457-8400

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Foreword

This Standards Publication has been prepared by the Decorative Laminate Section of the National Electrical Manufacturers Association for use by manufacturers and fabricators of high-pressure decorative laminates (HPDL). The performance values presented have been related as closely as possible to end-use applications, and user needs have been considered throughout.

The Decorative Laminate Section has worked (and continues to work) closely with trade organizations and appropriate government agencies in the periodic review and revision of these standards.

These standards are also periodically reviewed by the Decorative Laminate Section for any revisions necessary to keep them up to date with advancing technology. Proposed or recommended revisions should be submitted to:

Manager, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

Standards Publication LD 3.1-1985 revises and supersedes LD 3.1-1980.

LD 3.1-1985 is excerpted from LD 3-1985 and consists of Sections 1, 2, and 4 of that Standards Publication. Omitted from LD 3.1-1985 is Section 3, Test Methods, of LD 3.

The type and thickness of the decorative laminate, the substrate, the adhesive, and the fabricating techniques employed have a definite bearing on the performance of the final product in service. Information on substances, adhesives, fabrication, and installation has been updated and is found in Section 3.

Those who fill out and return the postcard inside the front cover will automatically be notified when LD 3.1-1985 is superseded by a new edition.

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Scope

This Standards Publication covers decorative laminated plastic sheets which consist of papers, fabrics, or other core materials that have been laminated at pressures of more than 500 pounds per square inch (3.45 MPa) using thermosetting condensation resins as binders.

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HIGH PRESSURE DECORATIVE LAMINATES

Section 1

GENERAL

1.1 REFERENCED STANDARDS

In this publication, reference is made to the standards listed below. Copies are available from the indicated source:

National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

LD 3-1985 *NEMA Standard for High-Pressure Decorative Laminates*

1.2 TYPES AND DESCRIPTIONS

The following types and descriptions of high-pressure decorative laminates (HPDL) are covered by these standards: the backs of the sheets shall be sanded or otherwise prepared to be suitable for bonding with adhesives to a base material for mechanical support.

NEMA Standard 11-14-1985.

1.2.1 General-purpose Type

General-purpose type is a high-pressure decorative laminate (HPDL) designed for both horizontal and vertical applications where appearance, durability, resistance to stains, and resistance to heat up to 275°F (135°C) are required.

NEMA Standard 11-14-1985.

1.2.2 Postforming Type

Postforming type is a high-pressure decorative laminate (HPDL) similar to the general-purpose type but is capable of being thermoformed under controlled temperature and pressure in accordance with the laminate manufacturer's recommendations.

NEMA Standard 11-14-1985.

1.2.3 Cabinet-liner Type

Cabinet-liner type is a high-pressure decorative laminate (HPDL) only for use in cabinet interiors.

NEMA Standard 11-14-1985.

1.2.4 Backer Type

Backer type laminate is a high-pressure decorative laminate (HPDL) without a decorative face for use as a balancing sheet in panel construction.

NEMA Standard 11-14-1985.

1.2.5 Specific-purpose Type

Specific-purpose type is a general purpose high-pressure decorative laminate (HPDL) with increased thickness.

NEMA Standard 11-14-85.

1.2.6 High-Wear Type

High-wear type laminate is a general purpose high-pressure decorative laminate (HPDL) with increased surface wear resistance.

NEMA Standard 11-14-1985.

1.2.7 Fire-rated Type

Fire-rated type laminate is a high-pressure decorative laminate (HPDL) but capable of providing lower fire hazard characteristics as determined by the test methods required by the authority having jurisdiction.

NEMA Standard 11-14-1985.

1.2.8 Other Types

Various decorative effects have been developed which meet specific aesthetic requirements. These laminates may have special visual appeal, such as gloss finish, deeply embossed textures, dark colors, and metallic surfaces. They are designed for specific installations and may not be suitable for all applications. For this reason, they are not included in these standards. Information concerning their proper application, properties, and care should be requested from the manufacturer.

Authorized Engineering Information 11-14-1985.

1.3 SQUARENESS

The length and width of high-pressure decorative laminate (HPDL) shall be such that a rectangle of the size specified can be obtained.

NEMA Standard 11-14-1985.

1.4 SURFACE FINISHES

High-pressure decorative laminate (HPDL) shall have finishes which impart various degrees of gloss to the surface. The gloss levels of satin-, furniture-, gloss-, and textured-finish laminates shall be measured in accordance with 3.13 of NEMA Standard LD 3 and shall be within the following values:

	Machine Direction	Cross-machine Direction
Satin finish	15-34	5-19
Furniture finish	35-60	21-35
Gloss finish	70-100	70-100
Textured Finish, low gloss	1-20	1-20
Textured Finish, high gloss	21-40	21-40

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Laminates are normally sanded in the machine direction. Higher gloss readings and pattern direction do not necessarily indicate machine direction.

NEMA Standard 11-14-1985.

Other finishes are available, but because of the nature of the surface texture, no standard test method has yet been developed which adequately characterizes these surfaces.

Authorized Engineering Information 11-14-1985.

Gloss should not be confused with reflectance or apparent reflectance. Gloss is determined by the smoothness of the surface and is measured by the amount of light which is reflected when the angle of incidence is equal to the angle of reflection. Reflectance is the ratio of the total quantity of light reflected from a surface to the total quantity of incident light on the surface regardless of direction. Reflectance is determined by color and shading of the opaque laminate and is independent of surface finish. Apparent reflectance, of which gloss is a special kind, refers to a specified condition of view or reflection.

NEMA Standard 11-14-1985.

1.5 CONFORMANCE WITH FOOD, DRUG, AND COSMETICS ACT

Section 175.300 of the Code of Federal Regulations, Title 21, April 1, 1980 sets forth those resinous and polymeric coatings which may, when used in accordance with the conditions prescribed in that Section, be safely used as food contact surfaces.

Section 175.300 should be consulted to determine which resins commonly used in the manufacture of decorative laminates are safe for use as food contact surfaces.

Authorized Engineering Information 11-14-1985.

1.6 CLEANING AND CARE OF LAMINATES

Resistance to stains of high-pressure decorative laminates (HPDL) is measured by the test method described in 3.9 of NEMA Standard LD 3. However, the procedure described in this test method should not be used to clean laminates. Individual manufacturers should be contacted for recommended procedures for removing stains from their products.

High-pressure decorative laminates are widely used as decorative surfaces for commercial, institutional, and residential applications. Though highly resistant to permanent stains and damage from most cleaning agents, they could be seriously affected by certain harsh chemicals such as acids and bases often found in commercial and household cleaning materials. Refer to Section 4.

Authorized Engineering Information 11-14-1985.

1.7 FIRE RATING

These standards do not specify the fire rating characteristics of individual products. These products are measured and reported in accordance with the procedures established by code-specifying agencies, such as National Fire Protection Association, Building Officials Conference of America, and other local, state, and federal code agencies. The manufacturer should be consulted for a specific fire rating.

High-pressure decorative laminates are surfacing materials which are usually combined with substrate materials. Therefore, the fire rating data should be developed by testing the combined laminate and substrate system and the manufacturer should be consulted.

NEMA Standard 11-14-1985.

1.8 VISUAL INSPECTION

The inspector shall have normal vision, corrected if necessary. No magnification shall be used when viewing the specimens.

NEMA Standard 11-14-1985.

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Section 2
PERFORMANCE PROPERTIES AND VALUES

2.1 The performance properties and values shall be as shown in Table 2-1.

NEMA Standard 11-14-1985.

Table 2-1
PERFORMANCE PROPERTIES CHART

	Grade Designation	Nominal Thickness*	Thickness Tolerance*	Wear Resistance	Scuff Resistance	Impact Resistance	Dimensional Change		Boiling Water Resistance	High Temperature Resistance	Radiant Heat Resistance	Conductive Heat Resistance	Stain Resistance		Light Resistance††	Appearance	Cleanability	Surface Finish	Postforming	
																			Formability	Blister Resistance
NEMA Test LD 3→				3.01	3.02	3.03	3.04		3.05	3.06	3.07	3.08	3.09		3.10	3.11	3.12	3.13	3.14	3.15
Types \ Units		In. (mm)	In. (mm)	Cycles, Min.	Rating,† Min.	In. (mm), Min.	% MD, Max.	% CD, Max.	Rating,† Min.	Rating,† Min.	Sec., Min.	Rating,† Min.	Reagents 1-23 Rating,† Min.	Reagents 24-29 Rating,† Min.	Rating,† Min.	Defects	Cycles, Max.		In. (mm) Radius, Min.	Sec., Min.
General-purpose	GP 50	0.050 (1.270)	±0.005 (±0.127)	400	NE	50 (1270)	0.5	0.9	NE	SL	125	NE	NE	M	SL	No ABC Defects	25	See LD 3-1.04	...	...
General-purpose	GP 38	0.038 (0.965)	±0.005 (±0.127)	400	NE	35 (889)	0.6	1.0	NE	SL	100	NE	NE	M	SL		25		...	...
General-purpose‡	GP 28	0.028 (0.711)	±0.005 (±0.127)	200	NE	20 (508)	0.7	1.2	NE	SL	80	NE	NE	M	SL		25		...	...
General-purpose‡	GP 20	0.020 (0.508)	±0.005 (±0.127)	200	NE	15 (381)	0.8	1.3	NE	SL	60	NE	NE	M	SL		25		...	...
Post-forming	PF 42	0.042 (1.067)	±0.005 (±0.127)	400	NE	30 (762)	1.1	1.4	SL	SL	100	NE	NE	M	SL		25		5/8 (15.875)	55
Post-forming‡	PF 30	0.030 (0.762)	±0.005 (±0.127)	300	NE	20 (508)	1.1	1.4	SL	SL	80	NE	NE	M	SL		25		1/2 (12.700)	40
Cabinet-liner	CL 20	0.020 (0.508)	±0.005 (±0.127)	50	NE	10 (254)	1.2	2.0	M	M	...	M	M	M	M	...	50		...	...
Backer	BK 20	0.020 (0.508)	±0.005 (±0.127)	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...
Backer	BK 50	0.050 (1.270)	±0.005 (±0.127)	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...
Specific-purpose	SP 125	0.125 (3.175)	±0.008 (±0.203)	400	NE	75 (1905)	0.3	0.7	NE	SL	200	NE	NE	M	SL	No ABC Defects	25		...	...
Specific-purpose	SP 62	0.062 (1.575)	±0.005 (±0.127)	400	NE	55 (1397)	0.5	0.9	NE	SL	150	NE	NE	M	SL		25		...	...
High-wear	HW 120	0.120 (3.048)	±0.008 (±0.203)	3000	NE	75 (1905)	0.3	0.7	NE	SL	200	NE	NE	M	SL		25		...	...
High-wear	HW 80	0.080 (2.032)	±0.008 (±0.203)	3000	NE	40 (1016)	0.4	0.8	NE	SL	175	NE	NE	M	SL		25		...	...
High-wear	HW 62	0.062 (1.575)	±0.005 (±0.127)	3000	NE	35 (889)	0.5	0.9	NE	SL	150	NE	NE	M	SL		25		...	...
Fire-rated**	FR 62	0.062 (1.575)	±0.005 (±0.127)	400	NE	55 (1397)	0.5	0.9	NE	SL	125	...	NE	M	SL		25		...	...
Fire-rated**	FR 50	0.050 (1.270)	±0.005 (±0.127)	400	NE	45 (1143)	0.5	0.9	NE	SL	75	...	NE	M	SL		25		...	...
Fire-rated**	FR 32	0.032 (0.813)	±0.005 (±0.127)	300	NE	20 (508)	0.7	1.2	NE	SL	50	...	NE	M	SL		25		...	...

* See LD 3-1.07.

† Rating System: NE—No Effect, SL—Slight Effect, M—Moderate Effect, X—Severe Effect.

NEMA Standard 12-31-1980.

**Consult the manufacturer for specific fire rating properties since these NEMA Standards do not specify such properties. (See 1.7).

†† Environmental regulations have caused certain changes in appearance and the manufacturer should be consulted.

Authorized Engineering Information 11-14-1985.

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Section 3

APPLICATION, FABRICATION AND INSTALLATION

3.1 INTRODUCTION

The increasing use and application of high-pressure decorative laminates (HPDL) is testimony to their continued reputation for durable performance and good looks.

In recent years, the high-pressure decorative laminate industry has made many technical and aesthetic advances in its products; these are monitored and controlled by up-to-date test methods and improved manufacturing processes.

The aesthetic advances include new patterns and designs and decorative laminates that have sculptured three-dimensional surfaces, metal surfaces, gloss, and dark colors. Some of these may not have the utilitarian latitude of service for horizontal applications that the regular surface finishes have and may be restricted for use (for example, vertical applications only). For recommendations on the use of a particular finish or surface the laminate manufacturer should be consulted.

By using the recommendations in Section 3 as a starting point, users will find much to guide them in obtaining the most appropriate satisfactory installation. However, these recommendations are not intended to assume or replace the responsibility of the user to establish engineering design and practices and procedures best suited to individual job conditions. Section 3 will provide basic information on the fabrication and installation of decorative laminates and a better understanding of the product and its uses.

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3.2 GENERAL DISCUSSION

A high-pressure decorative laminate (HPDL) is used as a surfacing material on counters, desk tops, cabinets, as wall paneling, and on furniture. The physical characteristics of the material should be considered in planning its fabrication and installation.

The properties of the final laminate assembly will be influenced by the choice of laminate type, substrate and adhesive, and by workmanship.

Workmanship in putting the components together encompasses such things as:

a. Proper adhesive spread.
b. Proper cure time for thermosetting and polyvinyl acetate adhesives and proper drying time for contact adhesives.
c. Use of proper bonding pressures.
d. Use of proper fabrication techniques (see 3.6).

Like wood, a high-pressure decorative laminate has a grain direction, and its dimensional behavior is similar to that of wood (see Figure 3-1). When humidity varies, the width of a laminate undergoes greater dimensional changes than the length by a ratio of nearly two to one. Dimensional change is a characteristic found in varying degrees in all cellulosic materials. As humidity decreases, the laminate sheet contracts, and when the humidity increases, the laminate sheet expands. Some properties, such as abrasion and heat resistance, are more or less permanently established in climates when they are manufactured and do not vary greatly with changes in climatic conditions.

NEMA Standard 11-14-1985.

3.3 MATERIALS

Three basic materials are involved in the fabrication and installation of high-pressure decorative laminates (HPDL). These are the laminate, the adhesive, and the substrate or supporting material.

3.3.1 The Decorative High-Pressure Laminate

Laminates are of eight different types:

a. General-purpose
b. Postforming
c. Cabinet-liner
d. Backer
e. Specific-purpose
f. High-wear
g. Fire-rated
h. Other

The different types were engineered to meet specific needs, based on performance, economy, and use. For example, thin general-purpose laminates are suitable for vertical applications such as cabinet doors and panels. Postforming laminates allow simple bends which cover edges and eliminate the need for seams between vertical and horizontal planes such as those found on a sink top or cabinet door. The fire-rated type is tested for the specific fire hazard classification in accordance with local code requirements. Backer sheets are recommended on the reverse side of the panel assembly to control warpage.

The general-purpose-type laminate is the most widely used since it is suitable for many applications and should be considered first. If another type is required, the supplier of the laminate should be consulted for recommen-

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dations as to the type of laminate to be used.

Laminate without a decorative face, such as a backer, is used on the back of panel-assemblies to protect the substrate from humidity changes and to reduce warpage.

See Figure 3-2 for an illustration of some of these types.

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3.3.2 The Adhesive

A variety of adhesives have been found satisfactory for bonding decorative laminates to core materials. The choice of adhesive is based upon the service for which the assembly is intended upon the bonding facilities available. In all cases, the adhesive manufacturer's instructions for use should be closely followed. The following information for the individual types of adhesives is intended only as a supplement to the manufacturer's instructions.

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3.3.2.1 THERMOSETTING TYPES

1. Urea-formaldehyde adhesives are satisfactory for most applications. They can be used for room-temperature bonding or for "hot" bonding. Hot bonding may tend to increase panel warpage, and a backer laminate should be used to control warpage. When hot bonding, the temperature should not exceed 85°C (185°F) for best results.
2. Resorcinol and phenol-resorcinol adhesives are recommended for use when high water resistance and heat resistance are required. They may be used in either hot-pressing or room-temperature bonding. Phenol-resorcinols are sometimes used as a pre-impregnated adhesive sheet in a hot-pressing operation.
3. Casein adhesives are generally satisfactory for room-temperature bonding only. Most caseins have poor

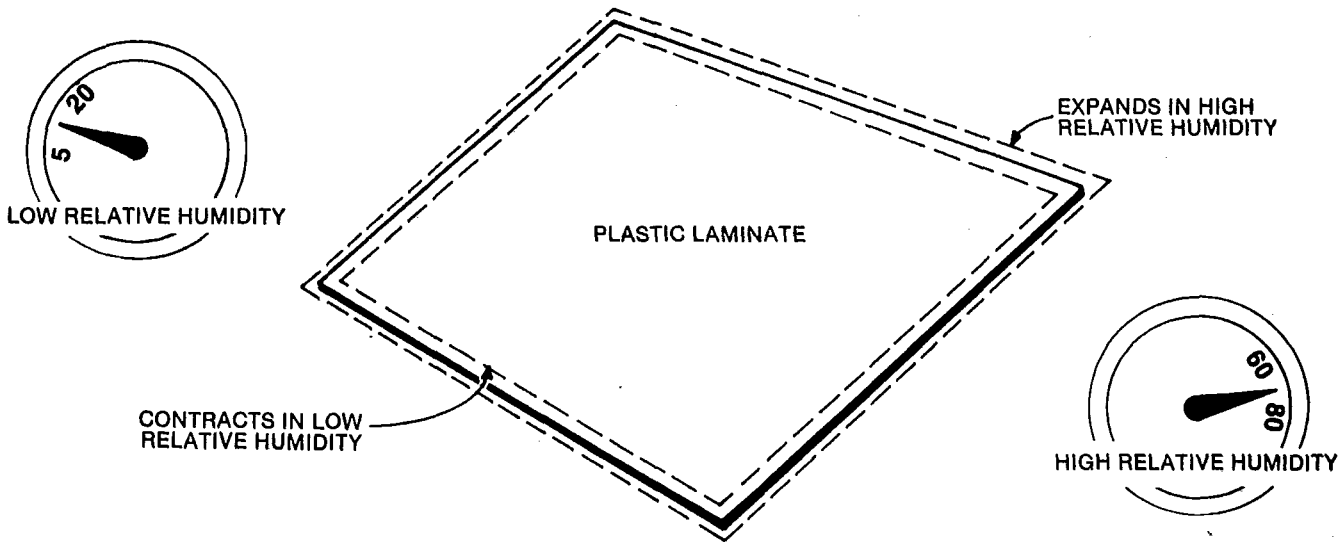


Figure 3-1
HUMIDITY CHANGES

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resistance to fungus growth and should be used only where the end product will be used under relatively dry conditions.

4. Epoxy adhesives are liquids with no volatile components. They have good cap-filling and low-shrinkage properties and are used mainly for bonding laminates to impervious cores (such as steel). They should be catalyzed for use in either hot- or room-temperature bonding operations.

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3.3.2.2 POLYVINYL TYPES (WHITE GLUE)

Polyvinyl acetate (PVA) emulsion adhesives may be used for bonding laminates to wood substrates where resistance to water and high heat are not required in the application (e.g., furniture, kitchen cabinets, and office partitions). They are generally not suitable for sink tops. They are room-temperature-setting adhesives, requiring only that the water in the emulsion be absorbed by the components.

Authorized Engineering Information 11-14-1985.

3.3.2.3 CONTACT TYPES

Contact adhesives may be used for bonding laminates to a variety of cores. They are particularly useful for application to metal or other impervious surfaces. There are two primary types—solvent-based and water-based (water-based adhesives are not suitable for bonding laminates to steel or iron surfaces). The solvent or the water should be evaporated before satisfactory bonding can be accomplished.

Contact adhesives should be uniformly applied to both surfaces to be bonded by a brush, sprayer, paint roller, or notched spreader. Brushing is the least acceptable method because of the difficulty in obtaining uniform application.

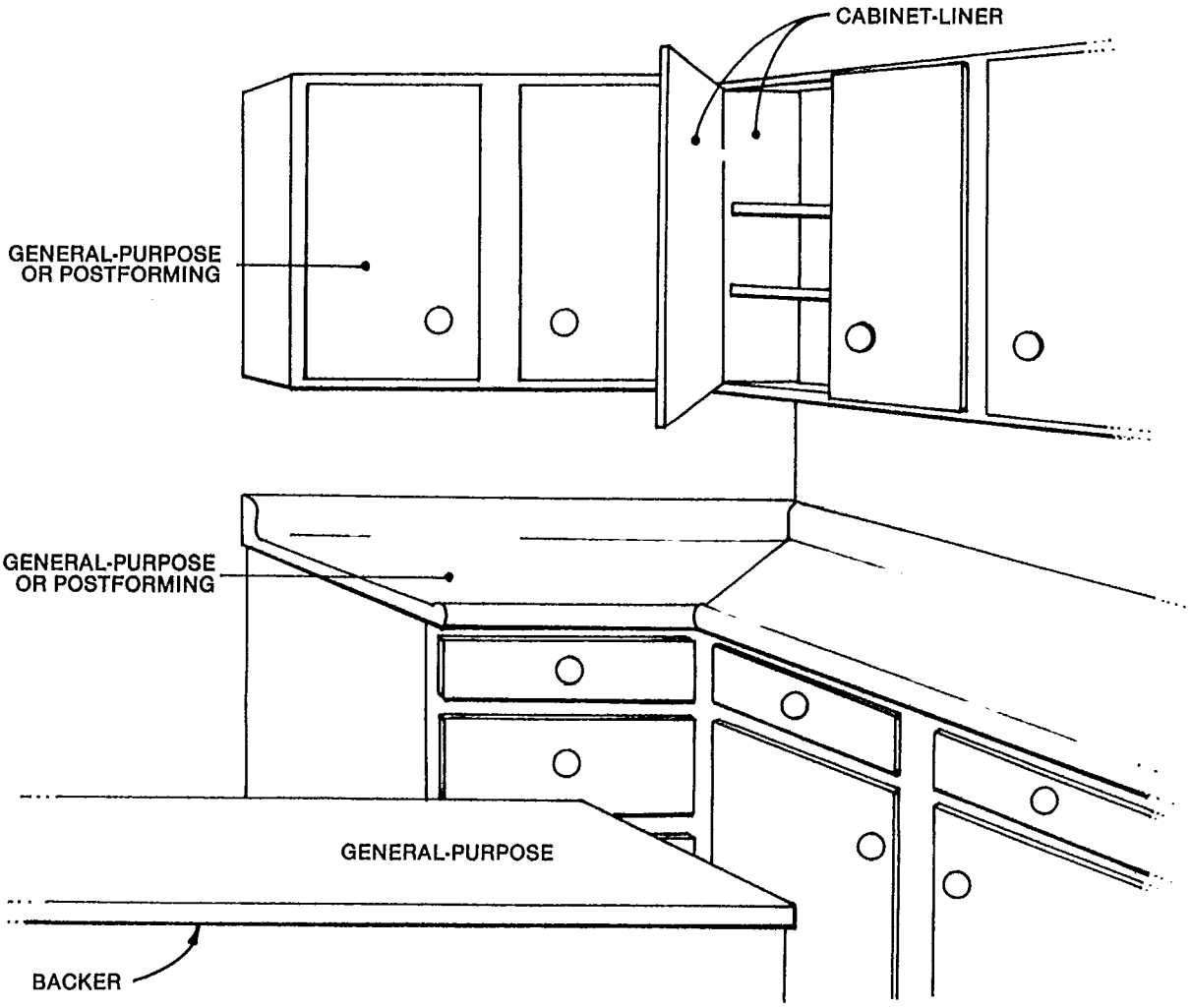


Figure 3-2
TYPES OF LAM'NATE USE

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These adhesives have high immediate bonding strength, and care should be taken when aligning the two surfaces to be bonded. Once contact has been made, the components cannot be realigned.

Contact adhesives do not restrict the movement of the laminate caused by varying humidity conditions to the same extent as thermosetting adhesives. This characteristic should be kept in mind when selecting the adhesive for the application.

Authorized Engineering Information 11-14-1985.

3.3.3 Failures in Bonded Assemblies

Some reasons for bonding failures (as shown in Figure 3-3) and recommendations for avoiding failures are as follows:

1. Improperly prepared or dirty gluing surface—the surfaces should be clean, dry, and free of oils or other contaminants, such as dust, loose paint particles, etc. The adhesive film should have full contact with the surface to which it is applied in order to give maximum adhesion to that surface.
2. Adhesive not agitated or stirred thoroughly—the container of adhesive should always be stirred or agitated before use. This is particularly necessary with the larger containers.
3. Insufficient amount of adhesive on either or both of the surfaces to be bonded—when ready for bonding, the spread film of most contact adhesives will exhibit a uniform semi-gloss appearance over the entire surface of the materials to be bonded. Marked variation in appearance will generally indicate an improper or nonuniform adhesive spread. The substrate can generally be seen more readily through those areas where insufficient adhesive has been applied. If this occurs, recoating the surfaces should achieve a uniform coating.
4. Bonding of surfaces under 21.1°C (70°F)—unless otherwise indicated by the manufacturer, the temperature of the gluing area and all materials should be 21.1°C (70°F) or above.
5. Bonding of surfaces when humidity is too high—experience has shown that when the relative humidity is above 80 percent at temperatures of 21.1°C (70°F) or higher, moisture may condense on the surface during drying (known as "blushing") and will prevent a good bond. Under these conditions, hot spray or forced drying can be used to help retard this condition.

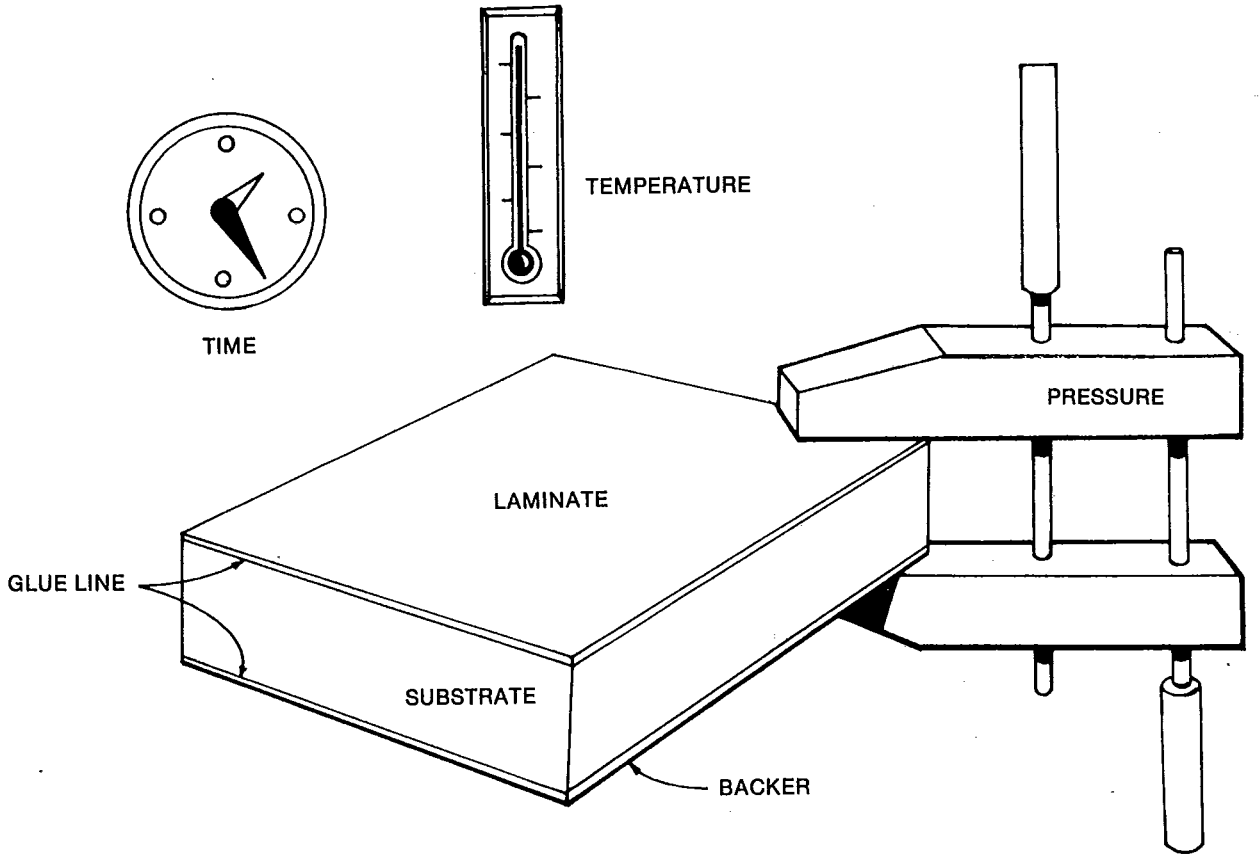


Figure 3-3
FAILURES IN BONDED ASSEMBLIES

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6. Bonding when surfaces are over-dry or under-dry—care should be taken to follow the manufacturer's recommendations concerning the allowable tack range of the adhesive. If assembly is made before the adhesive is dry or after the allowable open time is exceeded, unsatisfactory bond may result.
7. Bonding without sufficient pressure—to ensure the intimate contact necessary for an adequate bond, sufficient pressure should be applied over the entire area using as much pressure as possible without damaging the assembly. Pinch rollers (rotary press) and heavy weighted rollers are ideal, but hand pressure rolling is adequate provided the operator exerts maximum pressure by means of a two-handled or single long-handle roller. The rollers should be of steel or hard solid rubber (50-80 durometer) not over 3 inches (76.2 mm) wide. Hand rolling should be done from the center to the edges to ensure the removal of all air bubbles. The edges should be rolled twice. Double coating edges with adhesive is advisable because of the porosity of the substrate.
8. Field bonding of oversized sheets—it is recommended that the maximum sheet size used for vertical field application be limited to 2 × 8 feet (609.6 × 2438.4 mm). If larger panels are required, these should be shop-fabricated.

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3.3.4 The Substrate

Good quality plywood, particleboards, and medium- and high-density fiberboards are satisfactory for use as substrates since they supply the degree of rigidity needed to support the laminate and offer a suitable face for bonding.

The face of the substrate should be sanded smooth and be free from grease, wax, dust, or other contaminants which would interfere with adhesion. It should also be free of chips or other foreign matter which might show through the decorative surface after bonding.

Many particleboards are engineered for flatness. These boards have, for example, strata of varying chip size with the finer chips at the surface. Plywood resists warping because the grain direction of each ply is at right angles. However, both particleboards and plywood should be properly handled and stored so that they will maintain their flatness. See 3.4 and 3.6. It should be noted that certain properties of the assembly are influenced by the density of the substrate. For example, thinner laminates will require higher density substrates to achieve equivalent end properties as compared to thicker laminates on lower density boards. Plaster board, gypsum board, plaster, and similar materials are not recommended because their internal bond strength is not sufficient for this service.

Authorized Engineering Information 11-14-1985.

3.4 CONDITIONING AND STORAGE OF MATERIALS PRIOR TO FABRICATION

Materials should be properly conditioned before they are used.

Conditioning should make allowances for the geographical location in which fabrication or installation takes place. For example, end products which are produced and used in the Southeastern United States are not as susceptible to shrinkage of the laminate with its attendant problems, as are articles used in northern climates. This is due to the fact that in the Southeast, the average yearly humidity is higher and the temperature does not vary as widely. Similarly, installations in the Southwest, which normally has low humidity, are not as likely to be affected by changes in the length and width of the laminate after fabrication. In these areas, normal conditioning of the component parts for 48 hours prior to fabrication at the prevailing climatic conditions is usually sufficient for the satisfactory fabrication and installation.

However, end products are now frequently fabricated in one area of the country and marketed in a distant area. For example, a wardrobe may be fabricated in a location where temperature and humidity are both high and then be shipped into an area where they are both low. The laminate will tend to reach moisture equilibrium with the new environment and shrink. In such cases, it is advisable to dry the components before fabrication of the end product, and the use of a thermosetting adhesive is highly recommended.

Stored laminate stock should be rotated so that older sheets will be used before new ones.

The following general information about conditioning should be noted:

a. Most problems which arise after fabrication and installation are due to differentials in expansion or contraction between the laminate and substrate (see Figure 3-4). It is recommended that both the laminate and the substrate be brought to an equilibrium condition of moisture by storing them for a suitable period of time (normally 48 hours) at room temperature (approximately 23.9°C [75°F]) and at relative humidity of 45 to 55 percent. Provision should be made for the circulation of air around the components.

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b. Warp in the plastic sheet prior to bonding is not a cause of warp in the finished panel. Warped laminate sheets can be used unless they are so warped that they cannot be fed properly through glue spreading or bonding equipment.

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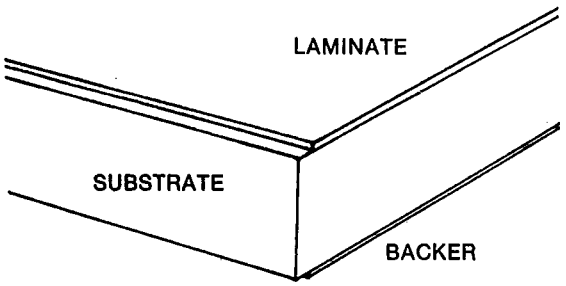


Figure 3-4
CONTRACTION OF LAMINATE

3.5 FABRICATION TOOLING

The proper type of tools for fabricating decorative laminates can be obtained from many local manufacturers. The following information is intended only as a supplement to their recommendations.

3.5.1 Sawing

To avoid chipping, it is important that the saw blade teeth cut into the decorative face.

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3.5.2 Band Sawing

Band sawing is recommended for curved or straight cuts where smooth edges and close tolerances are not required. For smooth edges on curved cuts, it is customary to saw the part oversize and finish it by routing, filing, or sanding.

Equipment: a woodworking or metal cutting band saw can be used.

1. *Saws*
   Nineteen- to twenty-gauge carbon-steel band saw blades or hardened steel blades with soft backs should be used. Teeth range from 16 to 18 points per inch. For contour cutting, the blade should be ¼ to ½ inch (6.35 to 12.7 mm) wide. For straight cutting, the blade should be 1 to 1 ¾ inches (25.4 to 44.45 mm) wide. Teeth should have a medium set for straight cuts and a heavy set for contour cuts. The amount of set depends upon the radius of the cut required. Teeth should be kept sharp at all times.
2. *Speed*
   Saw speeds from 5000 to 8000 surface feet (1524 to 2438 surface meters) per minute are satisfactory.
3. *Feed*
   Feed the work into the blade only as fast as it will cut without forcing the saw.

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3.5.3 Circular Sawing

Equipment:

1. Floor or bench saws can be used. Material should be supported near the point of blade contact to avoid vibration.
2. Powered circular hand saws with 60 carbide-tipped teeth may be used for rough cutting. If used, the teeth should cut into the face of the laminate in order to avoid excessive chipping. This means the laminate should be cut in the face-down position.
3. Blades
   In general, the blades illustrated in Figure 3-5 and meeting the conditions of Table 3-1 have been found to be satisfactory.

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3.5.4 Routing

Routing may be done with electric or air-powered routers. Cutters should be carbide-tipped. The speeds recommended are the same as those used in standard woodworking practices. It is important to use a router having adequate horsepower to maintain cutting speeds (based on the type and amount of material to be cut). For special edge trimming, very high-speed routers are available which produce smooth-edge chip-free work.

Sharpness of the router cutters should be maintained.

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3.5.5 Sanding

Belt-type portable hand sanders may be used to flush the self-edge before the laminate top is applied. However, care should be taken to direct the sanding operation away from or parallel to the decorative surface.

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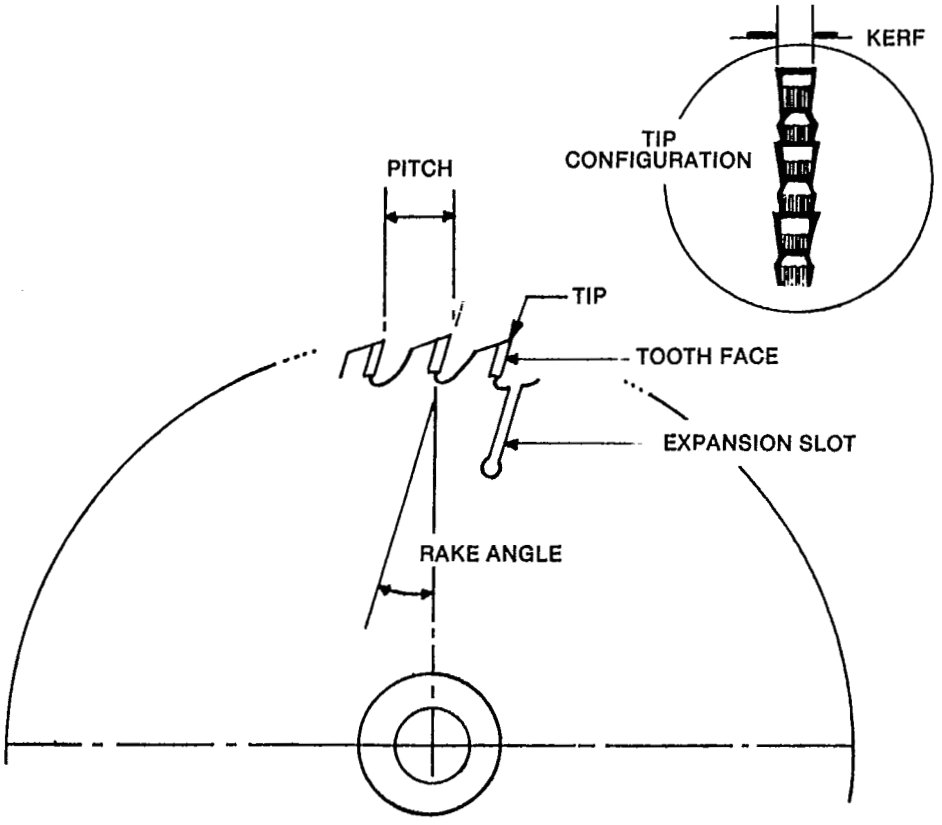


Figure 3-5
SAW BLADES

Table 3-1
TYPICAL BLADES

	Unbonded Laminate	Bonded Panel $^{3}/_{4}$ in (19 mm)
Diameter	8 to 14 in (203.2 to 355.6 mm)	8 to 14 in (203.2 to 355.6 mm)
Speed per minute	8000 to 15000 ft (2438 to 4572)	8000 to 15000 ft (2438 to 4572 m)
Pitch	0.417 in or less (10.59 mm or less)	0.520 in or less (13.21 mm or less)
Rake angle	10 to 15 degrees	10 to 15 degrees
Kerf	0.084 to 0.110 in (2.13 to 2.79 mm)	0.094 to 0.135 in (2.39 to 3.43 mm)

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3.5.6 Drilling

To drill decorative laminate, a standard drill with dubbed tip to provide sufficient clearance is recommended. The drill flute should be ground flat approximately $\frac{3}{32}$ inch (2.38 mm) back from the cutting edge for a 1 inch (25.44 mm) drill. A double-angle drill point has proven successful in preventing breakout on the back side. For production work, drill speeds as high as 10,000 rpm with tungsten-carbide-tipped drills provide excellent results.

Regardless of the diameter of the hole, all material being drilled should be backed with wood to prevent breakout at the bottom of the drilled hole.

For machine drilling (drill press), the diameter of the drill selected should be 0.002 inch (0.05 mm) larger than the specified diameter of the hole. Straight-shank high-speed twist drills are satisfactory.

For hand drilling, a brace and bit, regular auger bits, or a bit stock drill can be used. Large holes can be cut by using a trepan, hole saw, or fly cutter. For very large holes, a router and template should be used.

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3.6 GENERAL RULES FOR FABRICATION AND INSTALLATION

3.6.1 Fabrication and Installation in the Shop and on the Job

The fabrication and installation of laminates can be subdivided into three broad categories and can be done in the shop or on the job:

a. Horizontal
b. Vertical
c. Postforming

There are some general rules which should be followed for all categories.

1. A primary consideration of the fabricator should be the proper storage and conditioning of component materials. Both the laminate and the substrate should be conditioned for 48 hours at a temperature between 21.1° to 24°C (70° to 75°F) and a relative humidity of 45 to 55 percent (see Figure 3-6) prior to bonding.
2. Control of the glue line is another consideration, and its thickness and uniformity of spread should be given constant attention. The substrate (and, in the case of contact adhesives, the laminate) should be coated with adhesive over all of the area where contact will be made. Spot bonding should never be used (See 3.3.2).
3. Some method of applying controlled uniform pressure over the entire sandwiched construction—by pinch rolls, for example—should also be considered. Lack of proper pressure in bonding and improper conditioning are among the greatest causes of problems arising after fabrication. The pressure applied should be between 50 and 75 pounds per linear inch (0.89 and 1.34 kilograms per linear millimeter) of roll when contact adhesive is used. Polyvinyl acetate, urea, resorcinol, and similar adhesives generally require at least 20 pounds per square inch (137.9 kPa). Proper pressing should produce a tiny head of adhesive all the way around the edge of the glue line. If excessive pressure is used, objectionable telegraphing of the substrate structure may occur.

   A stable fabricated assembly may be achieved by bonding it under pressure at room temperature for an extended period of time (e.g., a quantity of table tops which have been baled and allowed to stand for 24 hours under pressure exerted by clamps as shown in Figure 3-7).

   Specific conditions are recommended by each adhesive manufacturer and should be followed.
4. Care should be taken when cutting the laminate—whether it is unsupported or bonded to a substrate—to prevent edge chipping, hairline cracks, or overcutting at inside corners. Otherwise, the laminate will be weakened and may be the cause of problems later.
5. When making any cutout (as for electrical outlets, ranges, sinks grills, windows, chopping blocks, "L" shaped counter tops, etc.), all inside corners should be smoothly rounded using a minimum corner radius of $\frac{1}{8}$ inch (3.17 mm). A router is an ideal tool for making cutouts (see Figure 3-8).
6. When removing large areas from a sheet of laminate (e.g., a sink cutout), the connecting strips between the remaining areas should be left as wide as possible.
7. Factory-trimmed sheet edges and saw-cut edges should be routed or filed. Original edges on factory-cut laminates are not finished edges since oversized laminates are supplied to allow for proper fabrication.
8. All chips, saw marks, and hairline cracks should be removed from cuts by filing, sanding, or routing. Saws and routers with carbide-tipped-blades are recommended to ensure chip-free edges and adequate tool life.
9. Cove areas on countertops which are exposed to spilled water or other fluids should be waterproofed to assure a tight seal. Rabbet-and-groove construction with a water-proofing adhesive or a receiving-type molding with a caulking compound should provide satisfactory protection.
10. When laminate is bonded to a substrate, precaution should be taken to prevent warping of the assembly.

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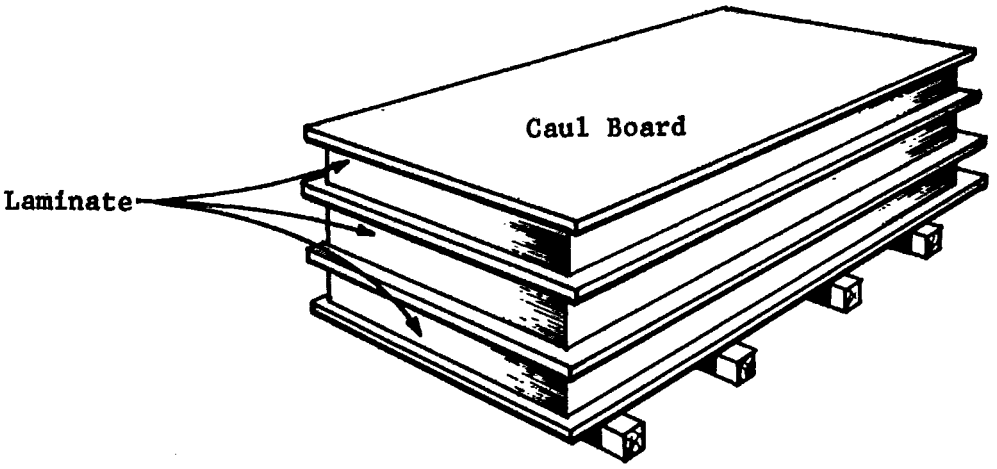


Figure 3-6
CONDITIONING OF LAMINATE

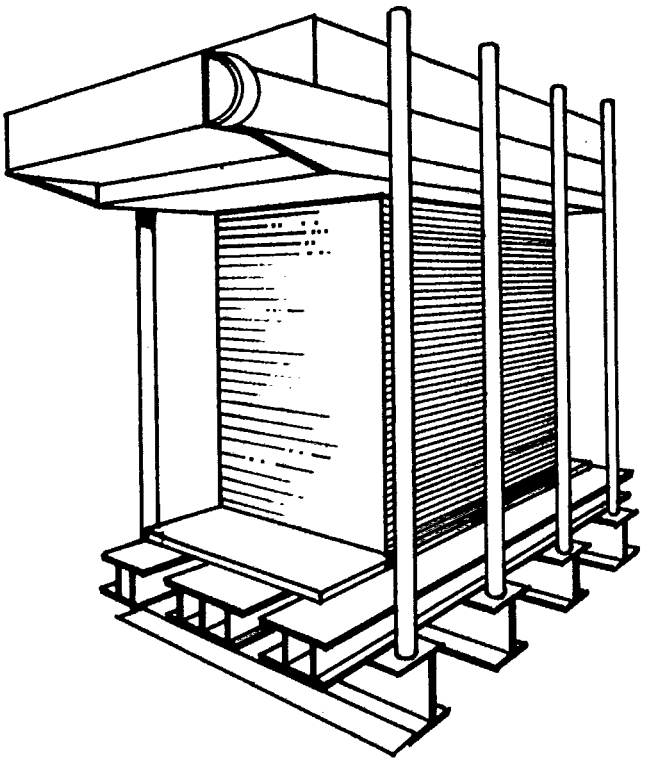


Figure 3-7
PRESSURE CLAMPS

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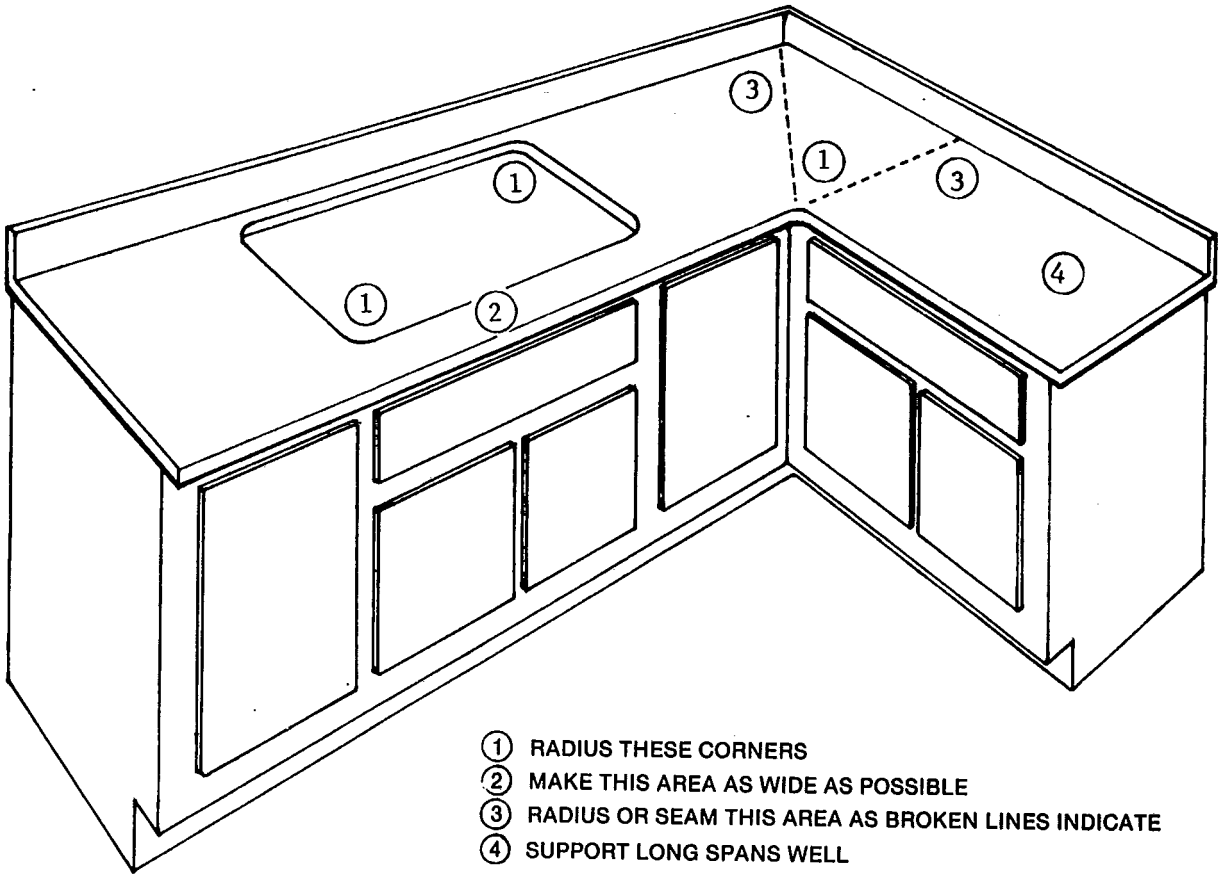


Figure 3-8
LAMINATE CUTOUTS

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Laminates used on shelves or in long unsupported spans should make use of a backer. A thick backer (approximately the same thickness as the face sheet) can provide more stability than a thin backer. Thicker laminates can offer better dimensional stability and resistance to stress (corner) cracking.

11. Before using nails or screws, oversized holes should be drilled through the laminate with a sharp drill bit.

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3.6.2 Installation on the Job (See 3.4)

Some major applications of laminates are in the construction of new buildings and the upgrading of old ones. As a final step before occupancy, counters which have been installed by the builder may be surfaced with laminates. Normally the material to be covered probably will be plywood or particleboard of good quality and should have a minimum number of seams. Contact adhesive should be used to bond the laminate to the substrate.

On-the-job installation of laminates usually involves inside corners, outside corners, and cutouts. The fabricator is once again cautioned to observe the general rules listed in 3.6 for working laminates and should follow them implicitly.

The importance of pressure when using contact adhesives cannot be over-emphasized. A pressure of 50 pounds per linear inch (0.89 kilograms per linear millimeter) should be necessary. Pinch rollers should not be used for on-the-job applications. However, a long-handled rubber roller 2 to 3 inches (50.8 to 76.2 mm) in diameter and 3 inches (76.2 mm) long, commonly called a "J" roller, can be used satisfactorily (see Figure 3-9).

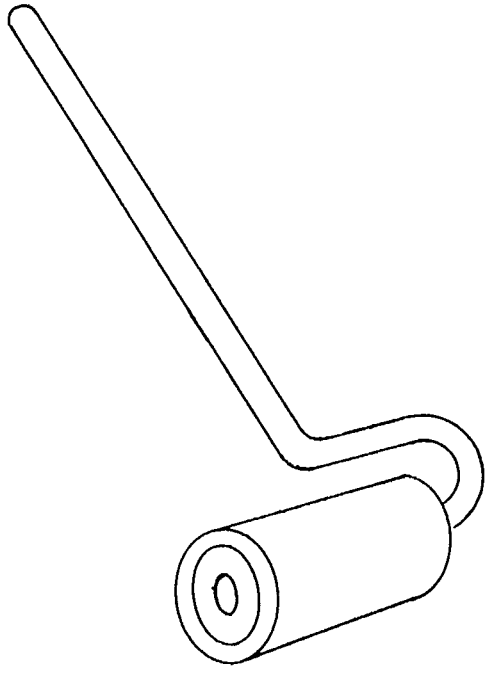


Figure 3-9
"J" ROLLER

Pressure should first be applied to the center of the sheet, working toward the edges to avoid trapping air which can cause surface bubbles or blisters.

To sum up, on-the-job installations should provide for proper conditioning of the laminate, proper application of the adhesive, and close conformance with the general rules given in 3.5 and 3.6.

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3.7 POSTFORMING LAMINATES

Each laminate supplier knows the inherent properties of his postforming-type materials and should be consulted. However, all forming materials have certain basic characteristics.

Postforming laminates are made by incorporating modified thermosetting resins and by pressing techniques which somewhat inhibit their ability to take a permanent set. When exposed to elevated temperatures, the laminate softens momentarily, allowing a straight-line bend to be made. This bend should be achieved quickly and uniformly when the proper temperature is reached. The reaction is a final one: the laminate cannot be reformed by reheating. Thus, proper forming machines and close attention to detail are recommended in this type of shop fabrication.

Some postforming fabricators maintain a list of each laminate by pattern along with the conditions of time and temperature which yield the most satisfactory results. Such data is most helpful when fabricators and laminate suppliers find it necessary to discuss technical problems.

A suitable postforming machine may be needed when working with postforming-type laminates. Because such items as postformed sink tops are secured to a framework from beneath, a backer is rarely used (see Figure 3-10). Postformed cabinet doors (see Figure 3-11) generally need a backer or decorative laminate to minimize warpage. However, the material should be properly conditioned, and all of the rules previously listed should be applied to this type of installation.

Woods used for bull-nose moldings, cove moldings, and back-splash moldings should present straight parallel surfaces so that the postforming material can be bent uniformly. One should not attempt to draw the laminate into compound radiused shapes.

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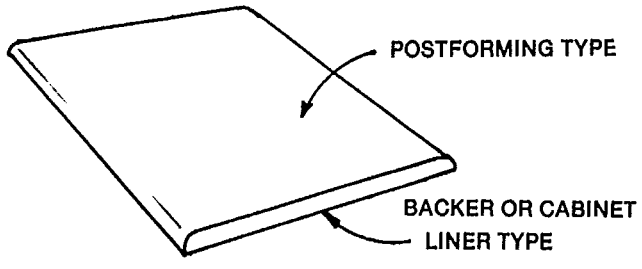


Figure 3-11
CABINET DOOR

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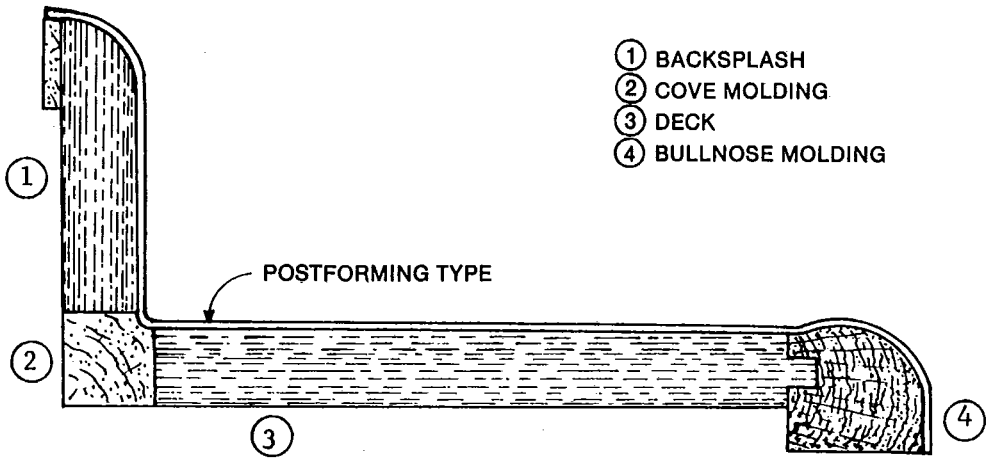


Figure 3-10
TYPICAL POSTFORMED TOP

3.8 FIELD WORKING OF BONDED ASSEMBLIES

Bonded laminated decorative material may be sawed, routed, filed, drilled, and otherwise worked and fitted in the field. The tools used may be hand- or power-operated. Since decorative laminates dull tools more rapidly than wood, it may be necessary to sharpen tools frequently as dull tools may cause chipping. Carbide-tipped tools are recommended.

The following suggestions should be followed:

1. Chamfer all exposed edges of decorative laminates by filing to prevent possible damage by chipping.
2. When using splines, install them so that the tongue of the spline stays at least $\frac{1}{16}$ inch (1.6 mm) away from the bottom of the groove. This should permit some movement and should tend to prevent warping in the event of panel movement.
3. Seal exposed core edges with metal moldings, by self-banding with laminate, or by waterproofing compounds, etc., where they are exposed to water or continually high humidity.
4. This is particularly applicable to joints in work tops, counters, bars, sink tops, baths, shower areas, etc.
5. Avoid making miter joints at 45-degree angles for outside corners of wall paneling, applied edges of tops, etc. A miter joint is particularly vulnerable to damage from sharp blows.
6. Avoid using systems to join two or more sections of horizontal work surfaces which tend to weaken the structural rigidity of the joint. An example of a good system is the use of mechanical metal fasteners which permit accurate alignment and increase the strength at the joint.
7. Avoid making cutouts having sharp corners and rough edges. All cutouts should be routed or filed to ensure smooth edges. A radius of $\frac{1}{8}$ inch (3.175 mm) or larger in the corners is recommended to minimize corner cracking. The largest radius practical should be used.

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3.9 TYPICAL PROBLEMS—CAUSES AND PREVENTION

Some of the problems which may arise after laminates have been fabricated and installed are the following:

1. Cracking of the laminate at corners and around cutouts (see Figure 3-12) may be caused by improper conditioning, improper bonding and, sometimes, poor planning, or any combination of these reasons. Cracking may be caused by shrinkage; conditioning helps prevent it. Rough edges, inside corners which have not been rounded, and forced fits can contribute to cracking.

   If the seams are properly placed in the layout of the laminate, stresses can be minimized.

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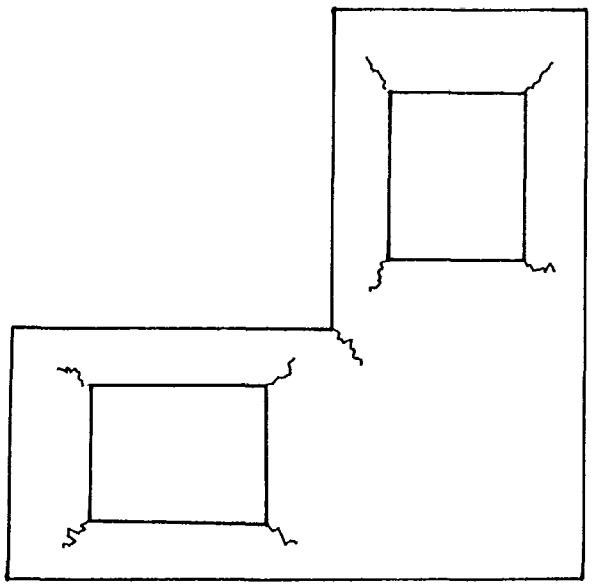


Figure 3-12
CRACKING OF LAMINATE

2. Opening of joints or seams (see Figure 3-13) may be caused by improper conditioning and bonding. Allowance should be made for some movement of the laminate.

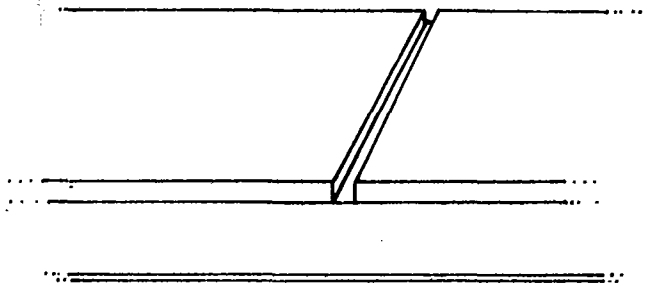


Figure 3-13
OPENING OF JOINTS OR SEAMS

3. Separation of the laminate from the substrate (see Figure 3-14) may generally be caused by a poor adhesive bond. The bonding procedure should be reviewed with close attention to uniform glue line, uniform pressure, cleanliness of mating surfaces, and the eight itemized precautions listed for adhesives in 3.3.3. If the edges fail to bond, extra adhesive may be applied and the product reclamped. Contact adhesives can often be reactivated by heat and rebonded by adequate pressure if the glue line is not starved.

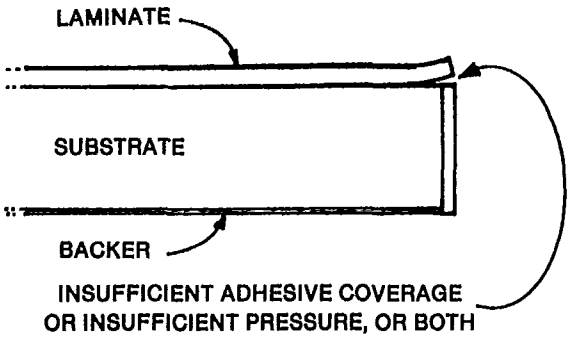


Figure 3-14
(TITLE)

4. Blistering or bubbling of the laminate surface away from the substrate (see Figure 3-15) can be caused by starved glue line, improper conditioning, and inadequate pressure or drying. When contact cement is used, the condition can sometimes be corrected by applying heat and pressure. But uniform glue lines and pressure over clean conditioned laminates and substrate might have prevented the problem.

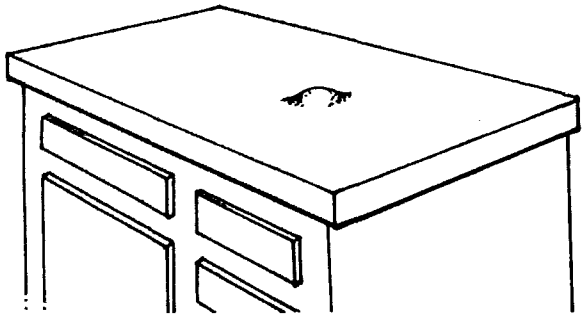


Figure 3-15
LAMINATE BLISTERING OR BUBBLING

5. The forming of a blister or bubble over a small area, often accompanied by a darkening of the laminate (see Figure 3-16), can be caused by continual exposure to a source of heat. Electrical appliances which produce heat and light bulbs should not be placed in contact with or close proximity to laminate surfaces. Repeated heating may cause the laminate and adhesive to react and finally deteriorate after continual exposure to temperatures above 65.6°C (150°F).

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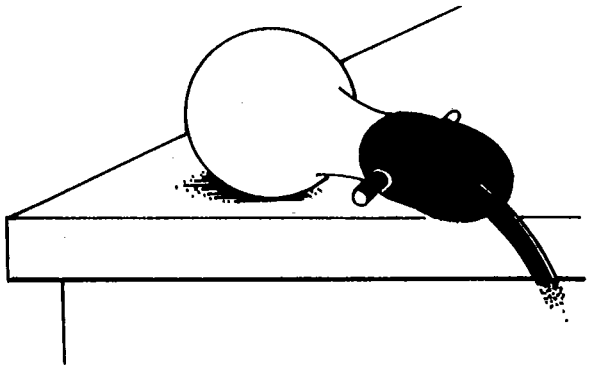


Figure 3-16
EXPOSURE TO HEAT SOURCE

6. Cracking of the laminate in the center of the sheet (see Figure 3-17) may be caused by flexing of the substrate when it covers a wide span or by spot gluing. Wide spans call for sturdy framework, and special attention should be given to the uniformity of glue lines and gluing pressures. Also, care should be taken to avoid trapping foreign objects between the laminate and the substrate.

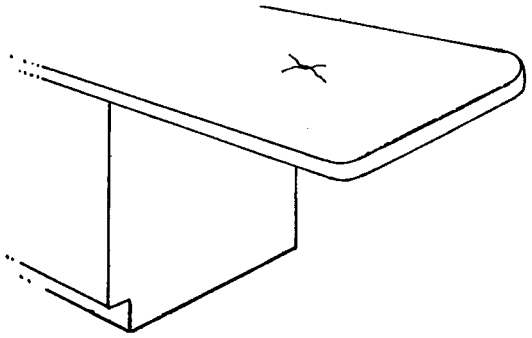


Figure 3-17
LAMINATE CRACKING

7. Warping of the assembly (see Figure 3-18) may be generally caused by unbalanced construction or unbalanced glue lines. Proper backer sheets should be chosen and aligned so that their grain direction is parallel to that of the laminate. Proper gluing is also important. If the substrate is secured to a framework, the framework should be designed to hold the assembly to a flat plane. Conditioning is also helpful.

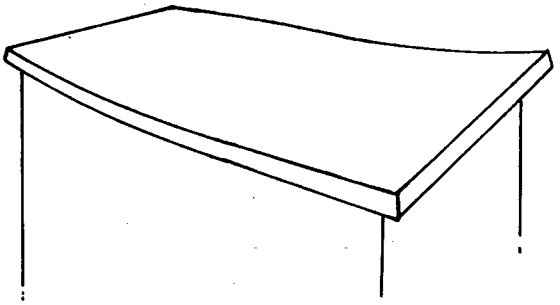


Figure 3-18
LAMINATE WARPING

8. Staining or etching of the surface of the laminate may be caused by certain harsh chemicals (acids and bases) to be found in commercial cleaning products intended for sinks, ovens, stoves, tiles, bricks, toilet bowls, stainless steel, ceramics, and similar items.

   Laminates should be protected from such materials. Accidental contact should be immediately followed by a thorough washing with water since exposure time is important. The longer the contact, the worse the etching or discoloration.

   Agents containing hydrogen peroxide, hydrochloric acid, sulfuric acid, nitric acid, phosphoric acid, lye, sodium bisulfate, potassium permanganate, or other materials known to be strongly acid or alkaline in nature should not be permitted to remain in contact with the laminate surface. They should be immediately washed off. If the nature of agent is unknown, the chemical manufacturer should be consulted.

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3.10 CARE AND MAINTENANCE OF LAMINATE SURFACE

High-pressure decorative laminate (HPDL) surfaces are highly resistant to wear, scratching, boiling water, food acids, alcohol, oil, grease, and ordinary household chemicals.

The high-pressure decorative laminate surface can keep its original pleasing appearance for many years. The following simple precautions should be followed:

1. Wash regularly with mild soap and water. Dry the surface with a clean cloth or soft paper towel to prevent soap streaks from appearing.

   Liquid cleaners without abrasive materials in their formulation are also very effective on decorative laminate surfaces for the removal of superficial stains which may not come off with soap and water.

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Some of the liquid "cleaners and polishers" provide a thin protective film of wax on the surface. The individual laminate manufacturer should be consulted for suggestions of products to be used on laminate surfaces.

2. Avoid gritty or abrasive liquid cleaners and cleansing powders.
3. Avoid the use of bleaching compounds or solutions.
4. Use a wooden cutting board when chopping or slicing.
5. Use a trivet or hot pad underneath hot skillets, casseroles, and appliances.
6. Select a rubber mat, if desired, that permits air circulation underneath.
7. Do not use your decorative laminate as an ironing board surface.

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3.11 CLEANSER SUITABILITY

The suitability of a cleanser for use on high pressure decorative laminate (HPDL) is evaluated in two parts: rubbing and staining.

For the rubbing evaluation, a straight line washability and abrasion machine, a cellulose sponge 3 × 4 × 1¾ inches (76.2 × 44.45 mm), and a gloss laminate bonded to a suitable substrate and cut to fit the machine, should be used.

The laminate should be placed into the holder and the cellulose sponge moistened with water and any excess squeezed out. The cleanser manufacturer's recommendations should be followed. However, if there are not any instructions provided, any liquids, sprays, etc., should be used at full strength. Any solid cleanser should be prepared at a one-to-one mixture by weight with water.

The cleanser should be applied to the sponge until it is saturated or coated, and the sponge mounted on the machine. The travel path of the sponge on the laminate should next be wetted or coated with the cleanser.

The counter should be set at zero, the machine started, and the laminate scrubbed for 200 cycles. The cleanser should be removed from the laminate with water, and the laminate dried and examined. If there is any loss of gloss experienced, the cleanser should not be recommended for use with the laminate.

For the staining evaluation, a concave glass cover with flat fire polished rim, and a gloss laminate should be used. The laminate should be placed on a flat level horizontal surface and taped or weighted down.

A ¼ to ½ inch (6.35 to 12.7 mm) spot cleanser should be placed on the laminate surface. If a dry cleanser is used, an equal amount of water should be added. The glass cover concave side down should be placed over the spot. The cover should stand undisturbed for 16 hours after which it is removed and the laminate washed with water and dried.

Then the laminate should be examined under normal light conditions. The cleanser should not have created any surface disturbance, stain, or whitening on the surface of the laminate.

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September 1984

NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

(Bylaw—Art. V, Sec. 1)

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Bylaw—Art. V, Sec. 2, Subsection A)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

(NEMA Policy Memorandum 84-2, dated June 7, 1984)

Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Bylaw—Art. V, Sec. 2, Subsection B)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design.

(Bylaw—Art. V, Sec. 6, 1st Sentence)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment and/or approval.

(Bylaw—Art. V, Sec. 4, Subsection A)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

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