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STANDARDS PUBLICATION NO. LD 3

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# High-Pressure Decorative Laminates

NEMA

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

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# LD 3

## *HIGH-PRESSURE DECORATIVE LAMINATES*

(ANSI Approval Date: August 16, 1991)

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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 test methods and performance values presented have been related as closely as possible to end-use applications, and user needs have been considered throughout.

The purpose of this Standards Publication is to provide standard test methods and performance values for high-pressure decorative laminates.

Standards Publication LD 3-1991 revises and supersedes LD 3-1985.

The Decorative Laminate Section works closely with trade organizations and appropriate government agencies in the periodic review and revision of these standards.

The Section's testing laboratory at North Carolina State University has been instrumental over a period of years in developing new test methods and perfecting old test methods, and also is conducting round robins among producer laboratories in proving out the reproducibility of test methods.

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:

Vice President, Engineering Department
National Electrical Manufacturers Association
2101 L Street, NW, Suite 300
Washington, DC 20037

In this 1991 edition of the NEMA Standards Publication for High-Pressure Decorative Laminates, effort has been continued to relate the Standards more closely to the performance expected in their end-use applications. 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 substrates, adhesives, fabrication, and installation has been updated and is found in Section 4.

Metric values for the test procedures and performance standards are included. Where values are given in both metric and U.S. customary units, the U.S. customary units are to be regarded as the standard.

Those who fill out and return the postcard inside the front cover will automatically be notified when LD 3-1991 is superseded by a new edition.

## Scope

This Standards Publication covers high-pressure decorative laminate (HPDL) sheets which consist of papers, fabrics, or other core materials that have been laminated at pressures of more than 750 pounds per square inch (5.17 MPa) using thermosetting condensation resins as binders.



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# HIGH-PRESSURE 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 sources:

**American Society for Testing and Materials**
1916 Race Street
Philadelphia, PA 19103

| | |
|---|---|
| D-523-85 | *Test Method for Specular Gloss* |
| G-53-84 | *Standard Practice for Operating Light and Water Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure to Nonmetallic Materials* |

**National Electrical Manufacturers Association**
2101 L Street, NW, Suite 300
Washington, DC 20037

| | |
|---|---|
| LI 1-1989 | *Industrial Laminated Thermosetting Products* |

**Technology Association of the Pulp & Paper Industry**
Technology Park
P.O. Box 105113
Atlanta, GA 30348

| | |
|---|---|
| Standards T-213-1985 | *Dirt in Pulp* |
| Standards T-437-1985 | *Dirt in Paper and Paperboard* |

### 1.2 TYPES AND DESCRIPTIONS

The following types and descriptions of high-pressure decorative laminate (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) intended 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 intended 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 11-14-1985

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### 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) capable of providing fire-rated characteristics as determined by the test methods required by the authority having jurisdiction.

NEMA Standard 1-30-1991

### 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, 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 1-30-1991

## 1.3 SQUARENESS

The length and width of high-pressure decorative laminates (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 laminates (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 and shall be within the values of Table 1-1.

NEMA Standard 1-30-1991

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

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.

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.

Authorized Engineering Information 11-14-1985

**Table 1-1**
**SURFACE FINISHES**

| | 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 |

## 1.5 CONFORMANCE WITH FOOD, DRUG, AND COSMETICS ACT

Section 175.300 of the Code of Federal Regulations, Title 21, April 1, 1988 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 1-30-1991

## 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. 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 (HPDL) 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 and Appendix A.

Authorized Engineering Information 1-30-1991

## 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.

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## 1.8 VISUAL INSPECTION

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

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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 1-30-1991.

## Table 2-1
## PERFORMANCE PROPERTIES CHART

| | Type Designation | Nominal Thickness* | Thickness Tolerance* | Wear Resistance | Scuff Resistance | Ball 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→ | | | | 3.1 | 3.2 | 3.3 | 3.4 | | 3.5 | 3.6 | 3.7 | 3.8 | 3.9 | | 3.10 | 3.11 | 3.12 | 3.13 | 3.14 | 3.15 |
| Units / Types | | 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 | Rating,† Min. | | 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 | SL | See 1.4 | ... | ... |
| 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 | | SL | | ... | ... |
| General-purpose** | GP 28 | 0.028 (0.711) | ±0.005 (±0.127) | 400 | NE | 20 (508) | 0.7 | 1.2 | NE | SL | 80 | NE | NE | M | SL | | SL | | ... | ... |
| General-purpose** | GP 20 | 0.020 (0.508) | ±0.005 (±0.127) | 400 | NE | 15 (381) | 0.8 | 1.3 | NE | SL | 60 | NE | NE | M | SL | | SL | | ... | ... |
| 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 | | SL | | 5/8 (15.875) | 55 |
| Post-forming** | PF 30 | 0.030 (0.762) | ±0.005 (±0.127) | 400 | NE | 20 (508) | 1.1 | 1.4 | SL | SL | 80 | NE | NE | M | SL | | SL | | 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 | ... | M | | ... | ... |
| Backer | BK 20 | 0.020 (0.508) | ±0.005 (±0.127) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | | ... | ... |
| Backer | BK 30 | 0.030 (0.762) | ±0.005 (±0.127) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | | ... | ... |
| Backer | BK 40 | 0.040 (1.016) | ±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 | SL | | ... | ... |
| 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 | | SL | | ... | ... |
| 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 | | SL | | ... | ... |
| 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 | | SL | | ... | ... |
| 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 | | SL | | ... | ... |
| 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 | | SL | | ... | ... |
| 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 | | SL | | ... | ... |
| Fire-rated†† | FR 32 | 0.032 (0.813) | ±0.005 (±0.127) | 400 | NE | 20 (508) | 0.7 | 1.2 | NE | SL | 50 | ... | NE | M | SL | | SL | | ... | ... |

* See 1.7. † Rating System: NE—No Effect, SL—Slight Effect, M—Moderate Effect. ** Not recommended for all applications; consult the manufacturer for recommended uses.

†† 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 colors to be subject to fugitive changes in appearance and the manufacturer should be consulted.

Notes Approved as Authorized Engineering Information 1-30-1991.

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# Section 3
# TEST METHODS

## 3.1 WEAR RESISTANCE

### 3.1.1 Scope

This test measures the ability of the surface of a high-pressure decorative laminate (HPDL) to maintain its design or color when subjectedto abrasive wear.

NEMA Standard 11-14-1985

### 3.1.2 Test Apparatus

The test apparatus shall include:

1. Abrading machine (Model 503 made by Taber Instruments, A Teledyne Company, North Tonawanda, New York, or the equivalent).
2. Two sets of NEMA Wheels (Taber Instruments Catalog No. S-32, or the equivalent).
3. Supply of zinc plates (such as Taber Instrument Catalog No. S-34, or the equivalent) which are 0.031 inch (0.787 mm) rolled zinc sheet.
4. Sandpaper strips 1/2 inch (12.7 mm) wide in the machine direction by 6 inch (152.4 mm), 180 grit aluminum oxide, open coat, light weight finishing paper, glue bond, or equivalent.
5. Double-faced-adhesive paper tape 1/2 inch (12.7 mm) wide.
6. Analytical balance and weights capable of weighing to the nearest 1 milligram.

NEMA Standard 1-30-1991

### 3.1.3 Test Specimens

The test specimen shall be of the nominal thickness of the material to be tested. It shall be either squares with rounded corners or circular discs. Each specimen shall have a minimum cross-dimension of 4-1/16 inches (103.2 mm) with a 1/4 inch (6.35 mm) diameter hole in the center. A minimum of three specimens shall be tested. All specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.1.4 Preparation of Test Wheels

The test wheels supplied with the abrading machine shall be ready for use in the test except for the application of the sandpaper.

Apply a light dusting of zinc stearate to the rubber rim of the test wheels. Apply the 1/2 inch (12.7 mm) wide strips of pressure-sensitive tape and sandpaper (see 3.1.2, apparatus, nos. 4 and 5) to the periphery of each wheel. Butt join them carefully and avoid contaminating the face of sandpaper. The outside diameter of the finished wheel shall be 2.025 ± 0.025 inches (51.4 ± 0.635 mm).

NEMA Standard 1-30-1991

### 3.1.5 Preparation of Test Apparatus

1. The sandpaper strips shall be placed in an oven for at least 24 hours at 82°F (28°C) to remove any moisture. Upon removing the sandpaper strips from the oven, they shall be stored in a desiccator until used.
2. Set up the abrading machine with the 500-gram plugs in place.
3. Place the test wheels on the arbor and fasten them in position.
4. Connect the vacuum source.

NEMA Standard 1-30-1991

### 3.1.6 Standardization of Abrasive

1. Make up test wheels for each lot of sandpaper received.
2. Using fresh sandpaper, place the abrader wheels on the surface of the zinc plate, turn on the vacuum, and allow the turntable to make 500 revolutions. Wipe the zinc plate clean with a solution of 50:50 volume mixture VM&P naphtha and SD-3A ethyl alcohol, weigh it to the nearest milligram ($W_1$) and then return it to the turntable.
3. Using fresh sandpaper, place the abrader wheels on the surface of the zinc plate, turn on the vacuum, and allow the turntable to make 500 revolutions. Remove the zinc plate, wipe it clean with a solution of 50:50 volume mixture VM&P naphtha and SD-3A ethyl alcohol, reweigh it to the nearest milligram ($W_2$). The weight loss of the zinc plate shall be 130 ± 20 milligrams.
4. Using fresh sandpaper repeat step 3 to obtain $W_3$.
5. If the weight loss, either ($W_1$-$W_2$) or ($W_2$-$W_3$) is out of the specified range, ignore that value and determine another weight loss ($W_3$-$W_4$) using fresh sandpaper from the same lot. If the weight loss ($W_3$-$W_4$) is also out of the specified range, reject that lot of sandpaper.
6. A correction factor for each lot of sandpaper is calculated as follows:

$$\text{Correction factor} = \frac{\text{Sum of the Weight Losses Within Range}}{2 \times 130}$$

NEMA Standard 1-30-1991

### 3.1.7 Test Procedure

1. Clean the surface of the test specimen with a 50:50 volume mixture VM&P naphtha and SD-3A ethyl alcohol and allow it to dry. Weigh to the nearest milligram (W1) if the rate of wear value is desired.

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2. Apply fresh sandpaper to the abrader wheels. Fasten the test specimen to the turntable of the machine and start the abrader.
3. Inspect the specimen every 25 revolutions until the initial wear point (IP) is reached. Record that number of revolutions.

The initial wear point is defined as follows:

Printed patterns - that point at which a clearly recognizable part of the print has been removed in 4 quadrants of the specimen, and the base paper is exposed.

Solid colors - that point at which the color layer is first worn through in 4 quadrants and the sublayer is exposed.

Decorative inclusions in the overlay - that point at which the decorative inclusions are completely removed the full width of the abrading wheel around its entire path.

4. Restart the machine and run it until the final wear point (FP) is reached. Record the number of revolutions. Weigh the specimen to the nearest milligram (W2) if the rate of wear value is desired.

The final wear point is defined as follows:

Printed patterns - that point at which the printed pattern is completely removed, exposing the base paper the full width of the abrading wheel around its entire path.

Solid colors - that point at which the color layer is completely removed, exposing the sublayer the full width of the abrading wheel around its entire path.

Decorative inclusions in the overlay - that point at which the decorative inclusions are completely removed the full width of the abrading wheel around its entire path.

5. Replace the 1/2 inch (12.7 mm) sandpaper strips every 500 revolutions.
6. The wear resistance shall be calculated as follows:

$$\text{Wear Resistance} = \frac{FP + IP}{2} \times \text{Correction factor (see 3.1.6 step 6)}$$

### 3.1.8 Factors Influencing the Accuracy of the Test

1. The abrader wheels should be periodically inspected for rounding of edges, and replaced as necessary.
2. Specimens should be flat or clamped flat on the turntable to ensure total contact across the face of the abrader wheels.
3. Certain solid colors utilize a pigmented sublayer which should be taken into account when determining the end points.

Authorized Engineering Information 1-30-1991

### 3.1.9 Test Report

1. The wear resistance shall be reported as the average of at least three specimens.

NEMA Standard 11-14-1985

2. The rate of wear can be calculated as follows and reported for informational purposes:

$$\text{Rate of wear} = \frac{W_1 - W_2}{\text{Revolutions at FP}} \times 100$$

Authorized Engineering Information 11-14-1985

## 3.2 SCUFF RESISTANCE

### 3.2.1 Scope

This test measures the ability of the surface of high-pressure decorative laminate (HPDL) to maintain its original appearance when exposed to scuffing.

NEMA Standard 11-14-1985

### 3.2.2 Test Apparatus

The test apparatus shall include:

1. Ballistic pendulum as described in Figures 3-1 through 3-3.
   Table 3-1 shall be used in conjunction with Figure 3-1.
2. Scuffing "heel" assembly as shown in Figure 3-4 shall be made of urethane, having a Shore "A" hardness of 85 ± 3.
3. Cleaning solution of 50:50 volume mixture VM&P naphtha and SD-3A ethyl alcohol.
4. Overhead white fluorescent lights with bulb(s) positioned parallel to the line of sight and providing an intensity of 75 to 100 foot-candles (807 to 1076 lux) on the specimen surface.

NEMA Standard 1-30-1991

### 3.2.3 Test Specimen

Test specimens shall be 5-1/2 x 8 inches (139.7 x 203.2 mm) x thickness. One specimen with the 8 inch (203.2 mm) dimension cut from the machine direction and one with the 8 inch (203.2 mm) dimension cut from the cross machine direction shall be tested. All specimens shall be bonded to 3/4 inch (19 mm), 45 lb/ft$^3$ (720 kg/m$^3$) nominal density particleboard with a contact adhesive in accordance with the adhesive manufacturer's instructions. All bonded specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

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**Table 3-1**
**SCUFF TEST APPARATUS**

| Letter Codes | Part Description and Material | Figure Number | Quantity Required |
|---|---|---|---|
| A | Scuff Tester (Overall View) | 3-1 | N/A |
| A | Vertical Upright Support 4 inch × 4 inch angle iron (101.6 mm × 101.6 mm) $\frac{1}{4}$ inch (6.35 mm) thick | 3-2 | 2 |
| B | Vertical Upright Support Upper Locking Bracket 2 inch (50.8 mm) wide, $\frac{1}{4}$ inch (6.35 mm) thick, flat steel | 3-3 | 1 |
| C | Horizontal Base 8 inch × 2 $\frac{1}{4}$ inch × 42 inch (203.2 mm × 57.15 mm × 1066.8 mm) steel U-Beam | 3-3 | 1 |
| D | Pivot Support and Specimen Plate Holder 10 inch × 7 $\frac{7}{8}$ inch × $\frac{5}{8}$ inch (254 mm × 200.03 mm × 15.8 mm) steel plate machine ground flat | 3-3 | 1 |
| E | Pendulum Support Assembly with Pivot Rod — All Steel $\frac{1}{4}$ inch × 4 inch × 2 inch (6.35 mm × 101.6 mm × 50.8 mm) channel 1 inch (25.4 mm) steel plate | 3-1 | 1 |
| F | Pendulum Pivot Arm Connector 4 $\frac{1}{4}$ inch × 3 inch × 2 inch steel block, 6.4 ± 0.2 pounds (2.9 kg ± 0.09 kg) | 3-1 | 1 |
| G | Pendulum Arm steel drill rod 30 $\frac{3}{8}$ inch (771.5 mm) long, 1 inch (25.4 mm) diameter, 6.5 ± 0.2 pounds (2.95 kg ± 0.09 kg), threaded 2 inch both ends | | |
| H | Heel Assembly 3.5 ± 0.2 pounds (1.59 ± 0.09 kg) 2 $\frac{1}{2}$ inch × 3 inch × 2 inch steel block 2 $\frac{1}{2}$ inch (76.2 mm) diameter heel material | 3-1 | 1 |
| I | Turnbuckle 4 inch (101.6 mm) aluminum | 3-4 | 1 |
| J | Tensile Spring Initial Tension 10 lbs. (4.5 kg), 6 $\frac{3}{4}$ inch (171.45 mm) body length by 1 inch (25.4 mm) diameter | 3-1 | 2 |
| K | Eye Bolt $\frac{1}{4}$ inch (6.35 mm), steel | 3-1 | 2 |
| L | S-Hooks 3 inch (76.2 mm) long $\frac{1}{4}$ inch (6.35 mm) diameter, steel | 3-1 | 2 |
| M | Urethane heel, Shore "A" hardness of 85 ± 3, $\frac{1}{2}$ inch (12.7 mm) thick × 2 $\frac{1}{2}$ inch (63.5 mm) diameter | Where noted | 2 |
| Miscelaneous | 1 $\frac{1}{4}$ inch (31.75 mm) long $\frac{3}{8}$ inch (9.53 mm) — 16 tpi* steel bolts | Where noted | 1 |
| | 2 inch (50.8 mm) long $\frac{3}{8}$ inch (9.53 mm) — 16 tpi* steel bolts | Where noted | 24 |
| | $\frac{3}{4}$ inch (19.05 mm) long 10-32 flat-head screws, steel | Where noted | 2 |
| | | Where noted | 7 |

*Threads per inch

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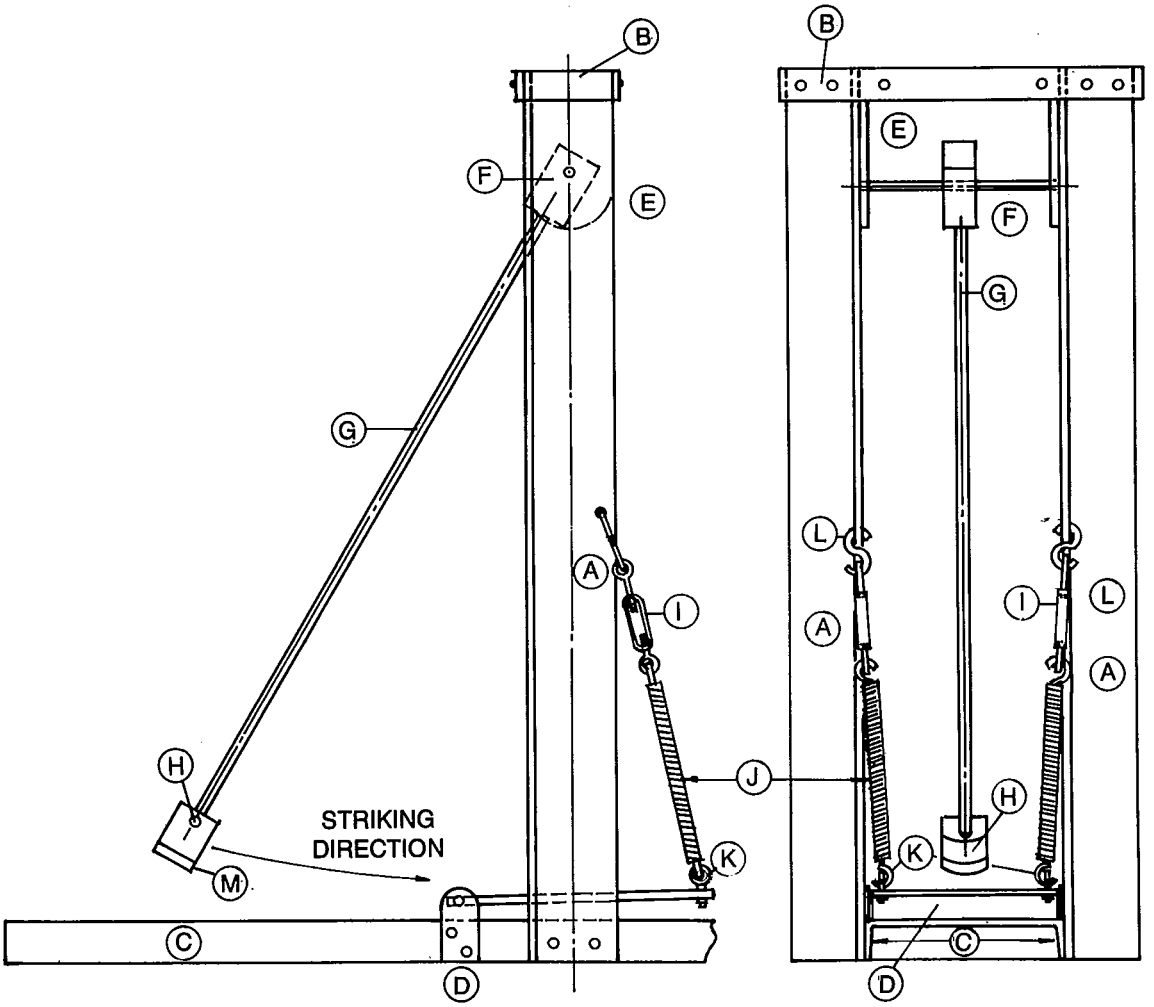



**Figure 3-1**
**SCUFF TEST APPARATUS—OVERALL VIEW**

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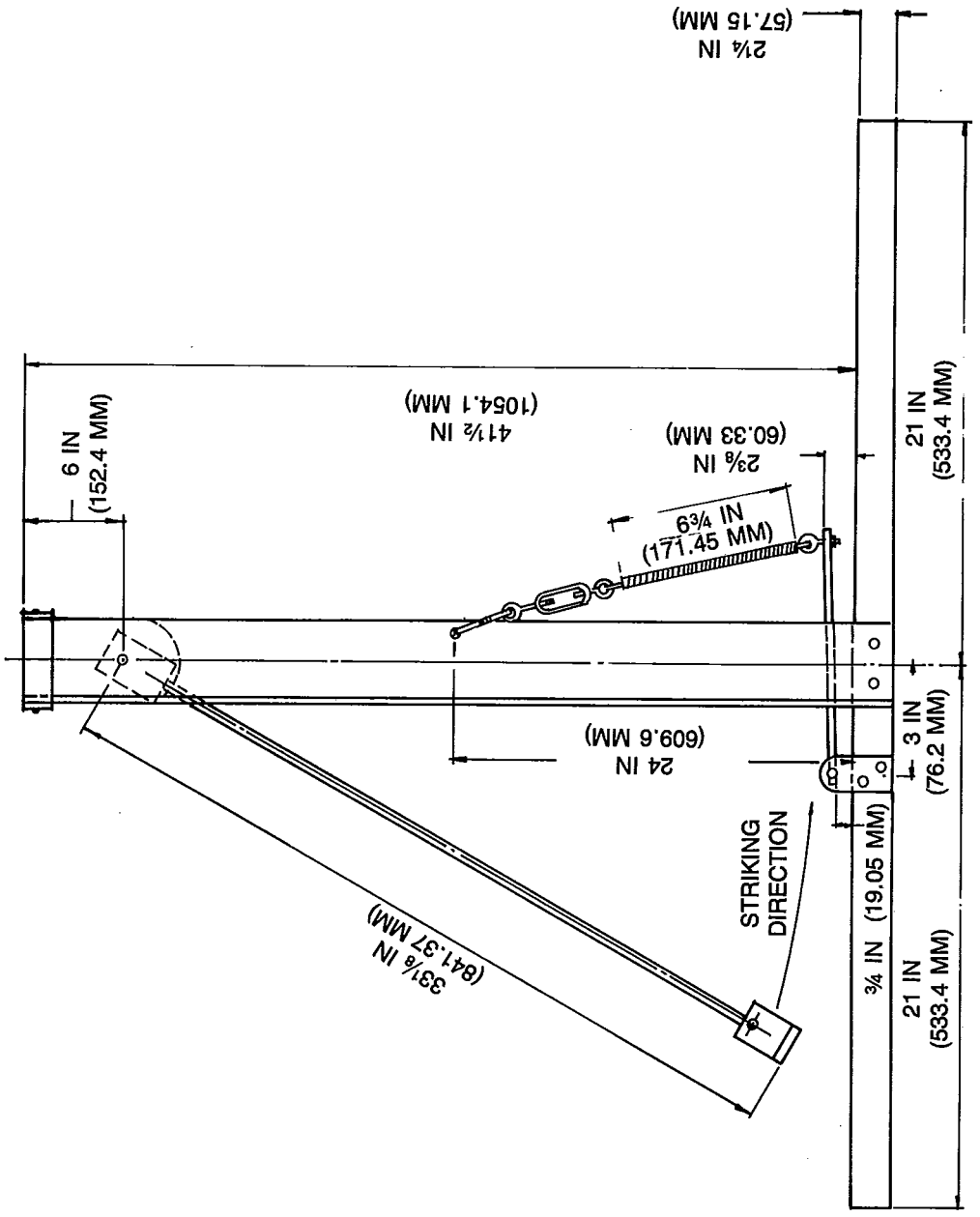



**Figure 3-2**
**VERTICAL UPRIGHT SUPPORT**
**(Not to Scale)**

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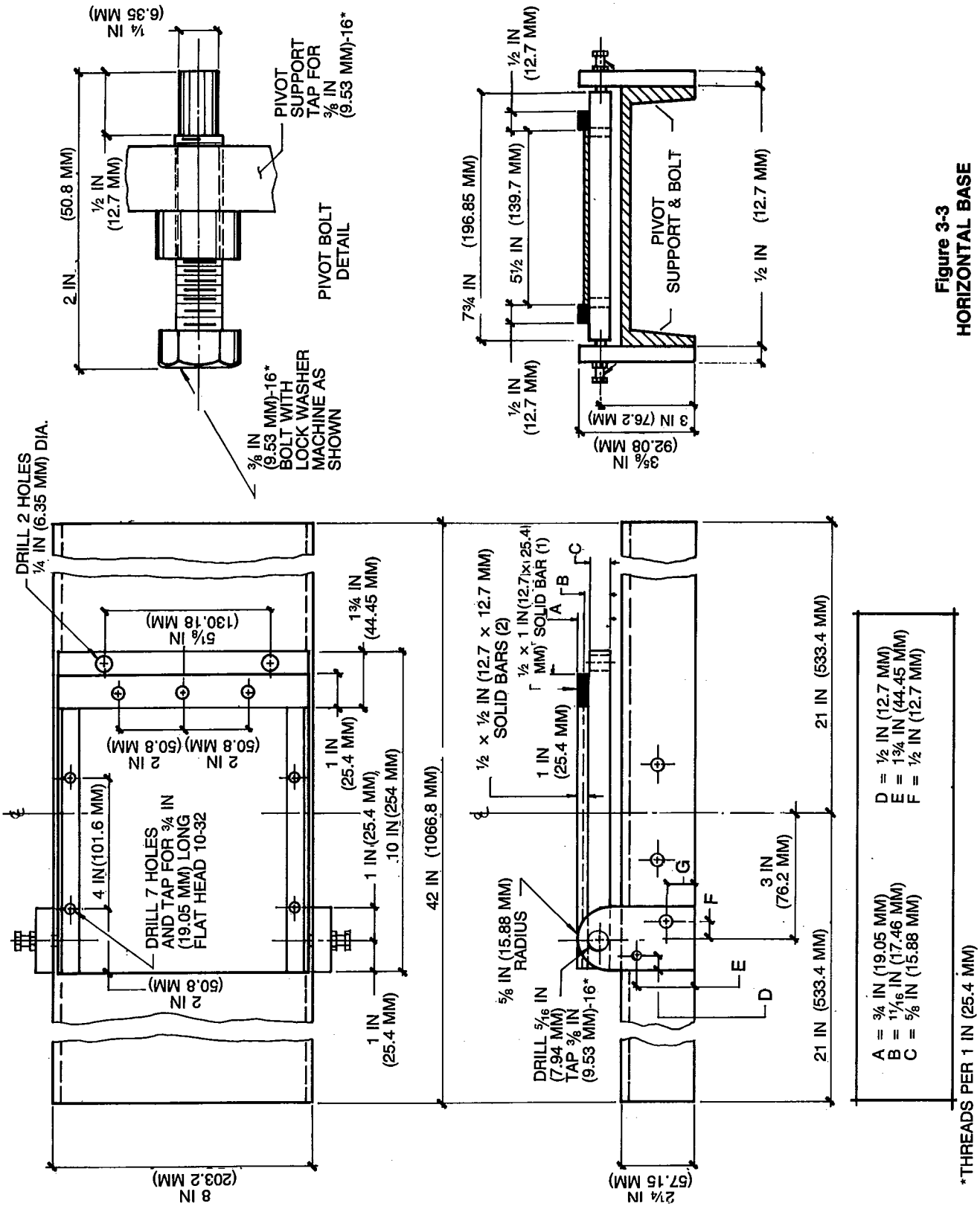



**Figure 3-3**
**HORIZONTAL BASE**

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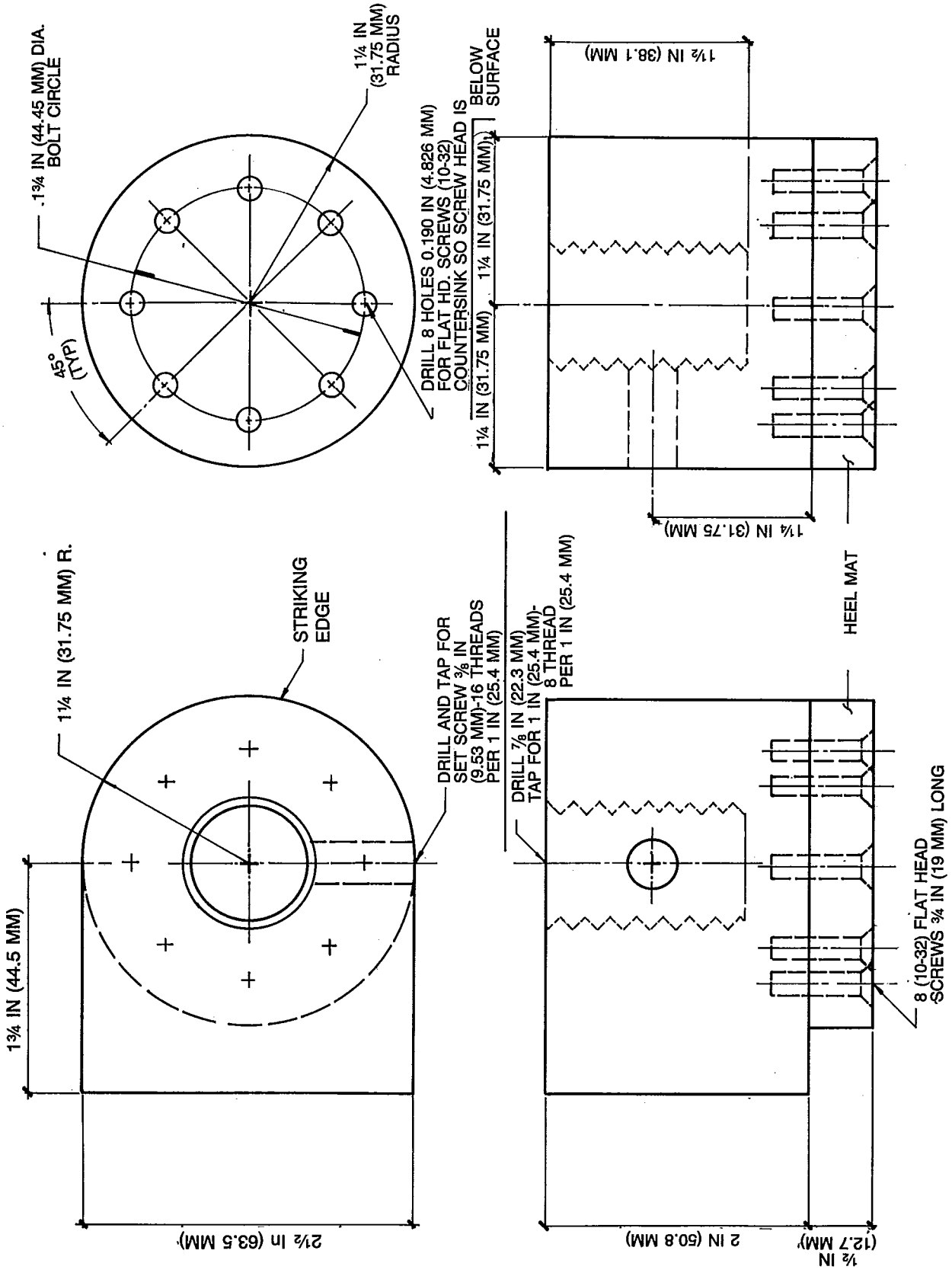



**Figure 3-4**
**HEEL ASSEMBLY**

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### 3.2.4 Test Procedure

1. Clean the surface of the test specimen with the cleaning solution.
2. Fasten the test specimen to the specimen plate holder.
3. Raise the pendulum arm to the prescribed height at an angle of 70° and drop it. This action results in the striking edge of the scuffing "heel" striking the specimen with sufficient force to cause an impact tangential to the surface of the specimen, moving the specimen plate holder assembly downward while continuing to scuff the surface of the specimen. Before the pendulum returns, it shall be caught by hand to prevent it from striking the apparatus.
4. Remove the test specimen after it has been struck once and clean it with the cleaning solution.
5. Examine the cleaned test specimen by placing it without preinspection, on a table and then view it at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914 mm) and at an angle of from approximately 45° to 75° from the horizontal (table surface). The specimen shall be rotated in the plane of the table and viewed from all directions. Direct sunlight or other angle light sources, which will accentuate or minimize the effect, shall be avoided.
6. The same test specimen shall be permitted to be retested by repositioning to ensure striking at a different spot.

NEMA Standard 1-30-1991

### 3.2.5 Test Report

The scuff resistance shall be reported as one of the following:

1. No effect - no visible change,
2. Moderate effect - any change in color, gloss or texture.
3. Severe effect - surface is cracked, torn or ripped.

NEMA Standard 1-30-1991

## 3.3 BALL IMPACT RESISTANCE

### 3.3.1 Scope

This test measures the ability of the high-pressure decorative laminate (HPDL) to resist fractures due to spot impact by a large diameter ball.

NEMA Standard 11-14-1985

### 3.3.2 Test Apparatus

The test apparatus shall include:

1. A free-fall test apparatus of the type shown in Figure 3-5, or the equivalent.
2. A polished stainless steel ball weighing 224 ± 3 grams, measuring 1-1/2 inches (38.1 mm) in diameter and having no damaged or flattened surface.
3. Clamping jig capable of holding the test specimen flat. See Figure 3-6, or the equivalent.
4. Overhead white fluorescent light with bulb(s) positioned parallel to the line of sight, and providing 75 to 100 foot-candles (807 to 1076 lux) on the specimen surface.

NEMA Standard 1-30-1991

### 3.3.3 Test Specimen

1. The test specimen shall be no larger than 12 x 12 inches (304.8 x 304.8 mm) x thickness. It shall be bonded to 3/4 inch (19 mm) 45 lb/ft$^3$(720 kg/m$^3$) nominal density particleboard with a contact adhesive in accordance with the adhesive manufacturer's instructions. The bonded test specimen shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.3.4 Test Procedure

1. Clamp the test specimen in the clamping jig and place it on the solid base of the free-fall test apparatus.
2. Adjust the height scale so that it touches the face of the test specimen.
3. Position the electromagnet at any arbitrary height above the test specimen.
4. Place the ball on the electromagnet and drop the ball. Catch the ball on the first rebound so that multiple impacts do not occur. Impact positions shall be at least 1 inch (25.4 mm) apart and 2 inches (50.8 mm) from the edge of the specimen.
5. Examine the impact spot for cracks and determine the result. Decision shall not be based on the use of stains, dyes, or magnification. Raise or lower the electromagnet height if necessary and repeat step 4 and step 5 until the maximum height at which no cracking occurs is determined.
6. Drop the ball from the height determined in step 5 two times in different locations on the test specimen. If either drop fails, reduce the height by 1 inch (25.4 mm) and continue testing until a total of three successful results have been obtained at that height.

NEMA Standard 1-30-1991

### 3.3.5 Factors Influencing Accuracy of Test

1. Damaged or flattened balls should never be used.
2. The test specimen and clamping jig should be completely supported on the solid base. Warped specimens or lack of support can affect results by as much as 100 percent.
3. The fall path of the ball should be precisely perpendicular to the specimen's surface.

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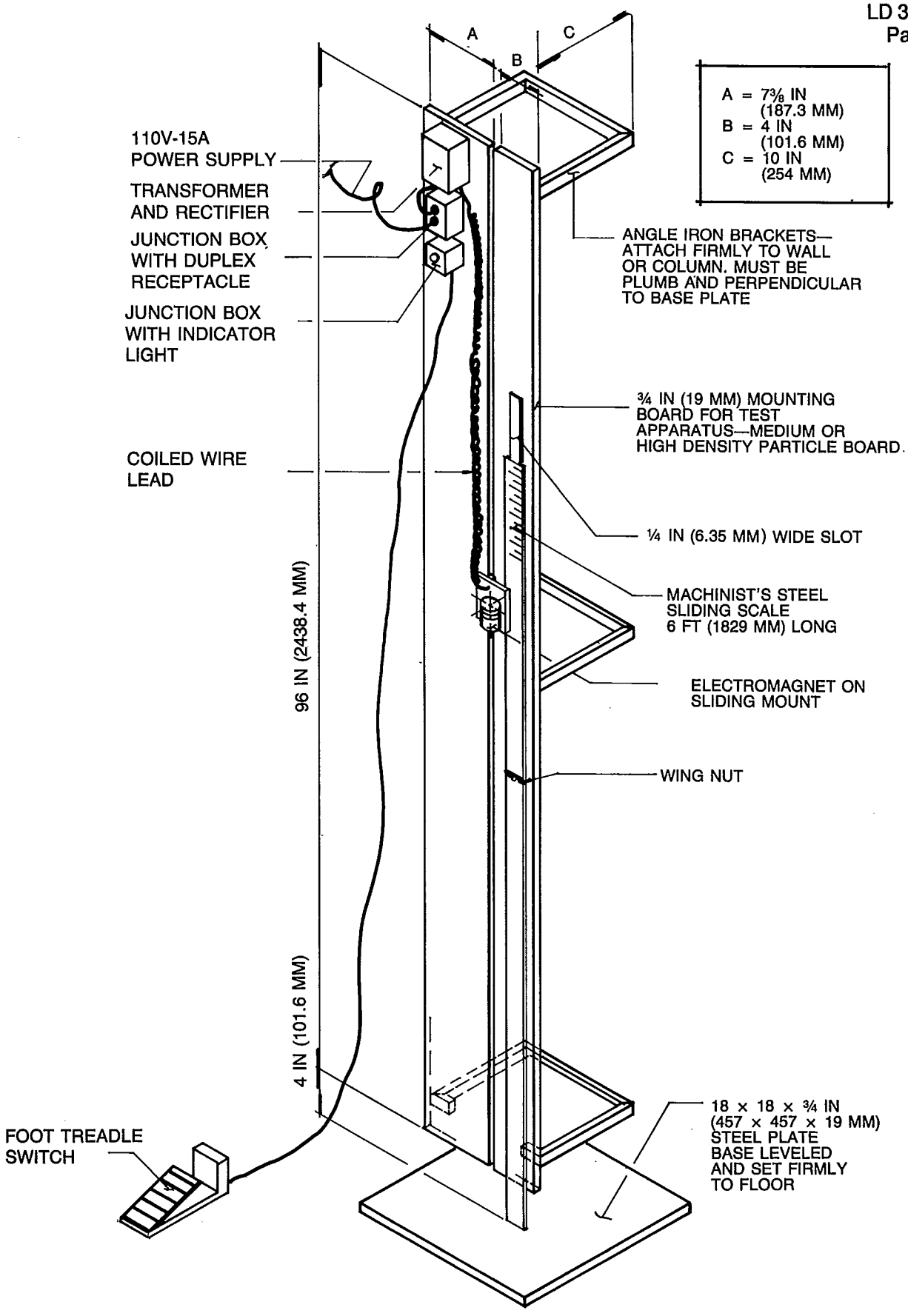



**Figure 3-5**
**FREE FALL**
**IMPACT TEST UNIT**

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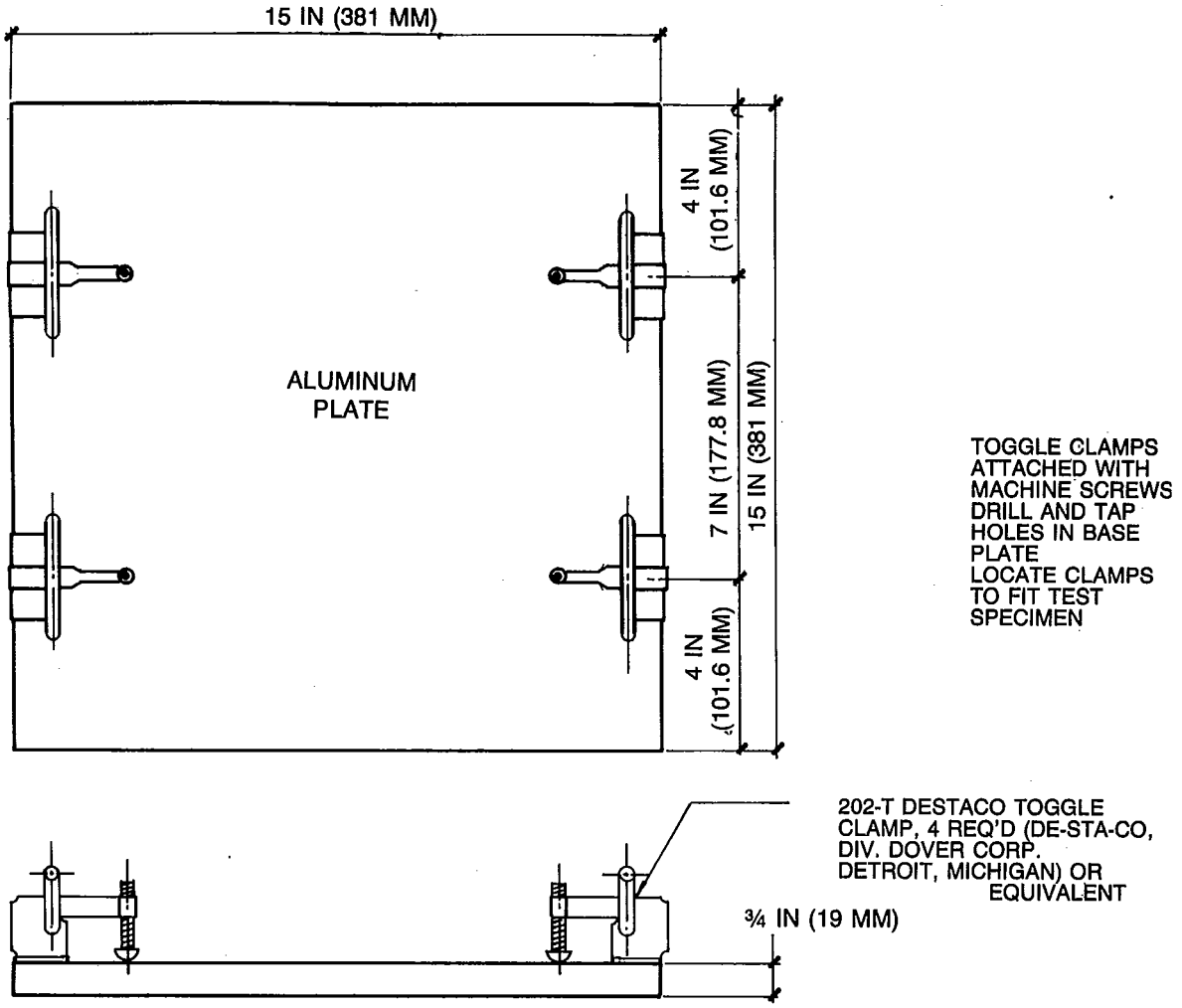



**Figure 3-6**
**CLAMPING JIG**

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4. Improperly conditioned test specimens can affect results drastically.

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### 3.3.6 Test Report

The test report shall indicate the actual height of impact resistance.

NEMA Standard 1-30-1991

## 3.4 DIMENSIONAL CHANGE

### 3.4.1 Scope

This test measures the dimensional changes of high-pressure decorative laminate (HPDL) over an extreme range of relative humidities.

NEMA Standard 11-14-1985

### 3.4.2 Test Apparatus

The test apparatus shall include:

1. Circulating air oven capable of maintaining a temperature of 158° ± 3.6°F (70° ± 2°C).
2. Humidity chamber capable of maintaining a relative humidity from 95 to 100 percent at a temperature of 100.4° ± 3.6°F (38° ± 2°C).
3. Mounted dial gauge with suitable bed plate.
4. Desiccator of suitable size, with desiccant such as calcium chloride.
5. Fixture for holding test specimens in straight non-warped position. See Figure 3-7.
6. Rigid shims, 5-3/8 inch x 1/2 inch x 0.025 inch (136.5 mm x 12.7 mm x 0.6 mm).

NEMA Standard 1-30-1991

### 3.4.3 Test Specimens

1. Test specimens shall be 5-1/2 x 1/2 inch (139.7 x 12.7 mm) x thickness.
2. One set of specimens (three cut from the machine direction and three from the cross machine direction) is required for the high-humidity test and one set for the low-humidity test (a total of 12 specimens).
3. Test specimens shall be cut in such a way as to have smooth edges and ends free from nicks, chips, or cracks.
4. The test specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.4.4 Test Procedure

1. Place each test specimen in the holding fixture. Shim if necessary to prevent bowing, and measure its length to the nearest 0.001 inch (0.025 mm). Record all measurements.
2. Preheat the oven to 158°F ± 3.6°F (70° ± 2°C) and place one set of specimens in it for 24 hours.
3. Remove the test specimens from the oven and cool them in a desiccator for 1 hour.
4. Within 1 minute after its removal from the desiccator, put each cooled test specimen in the holding fixture and measure its length to the nearest 0.001 inch (0.025 mm). The specimen shall be located in the same position in the fixture as when the first measurements were made. Record these second measurements.
5. Preset the high-humidity chamber from 95 to 100 percent relative humidity at 100.4° ± 3.6°F (38° ± 2°C) and place the second set of specimens in it for 7 days.
6. Remove the test specimens from the chamber and wipe them free of surface water.
7. Within 1 minute of its removal from the chamber, place each test specimen in the holding figure (3.4.2, part 5) and measure its length. The specimen shall be located in the same position in the fixture as when the first measurements were made. Record these second measurements.

NEMA Standard 1-30-1991

### 3.4.5 Calculation

The gross dimensional change is defined as the algebraic difference of the average dimensional changes in the low- and high-humidity tests.

The percentage of dimensional change, expressed, as a positive or negative, shall be calculated on the basis of the original dimension for each corresponding direction of the laminated sheet.

NEMA Standard 11-14-1985

*Example*

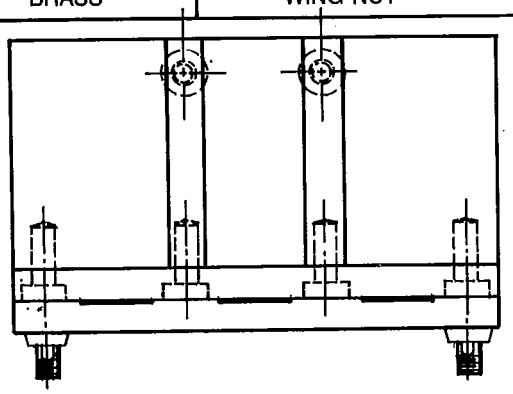
| | |
|---|---|
| Original length of test specimen | 5.523 in (140.28 mm) |
| Length of specimen after low-humidity conditioning | 5.505 in (139.83 mm) |
| Dimensional change (139.83 from 140.28 mm) | -0.018 in (-0.45 mm) |
| Percent dimensional change (-0.45 mm/140.28 mm) x 100 | -0.3% |
| Original length of second specimen | 5.595 in (142.11 mm) |
| Length of specimen after high-humidity conditioning | 5.625 in (142.87 mm) |
| Dimensional change (142.87 from 142.11 mm) | +0.030 in (+0.76 mm) |
| Percent dimensional change (+0.76 mm/142.11 mm) x 100 | +0.5% |
| Percent gross dimensional change (+0.5 to (-0.3)) | 0.8% |

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**BILL OF MATERIAL**

| ITEM | MATERIAL | NAME | SIZE IN (MM) | NO. REQUIRED |
|---|---|---|---|---|
| 1 | STAINLESS STEEL | FACE PLATE | ¼ × 3¾ × 5⅜ (6.35 × 95.25 × 136.53) | 1 |
| 2 | STAINLESS STEEL | BACK PLATE | ¼ × 3¾ × 5⅜ (6.35 × 95.25 × 136.53) | 1 |
| 3 | STAINLESS STEEL | BRACE | ¼ × 1¾ × 5 (6.35 × 44.5 × 127.0) | 2 |
| 4 | STAINLESS STEEL | BASE | ½ × 1¾ × 3¾ (12.70 × 44.5 × 95.25) | 1 |
| 5 | BRASS | SOCKET-HD. SCREW | 0.190-32* × ⅜ LONG (4.83-32* × 9.53 LONG) | 10 |
| 6 | BRASS | ROUND-HD SCREW | ¼-20* × 1 (6.33-20* × 25.4) | 2 |
| 7 | BRASS | WING NUT | ¼-20* (6.35-20*) | 2 |



A = 17/32 IN (13.49 MM)
B = 9/16 IN (14.29 MM)
C = ½ IN (12.7 MM)

*THREADS PER 1 IN (25.4 MM)

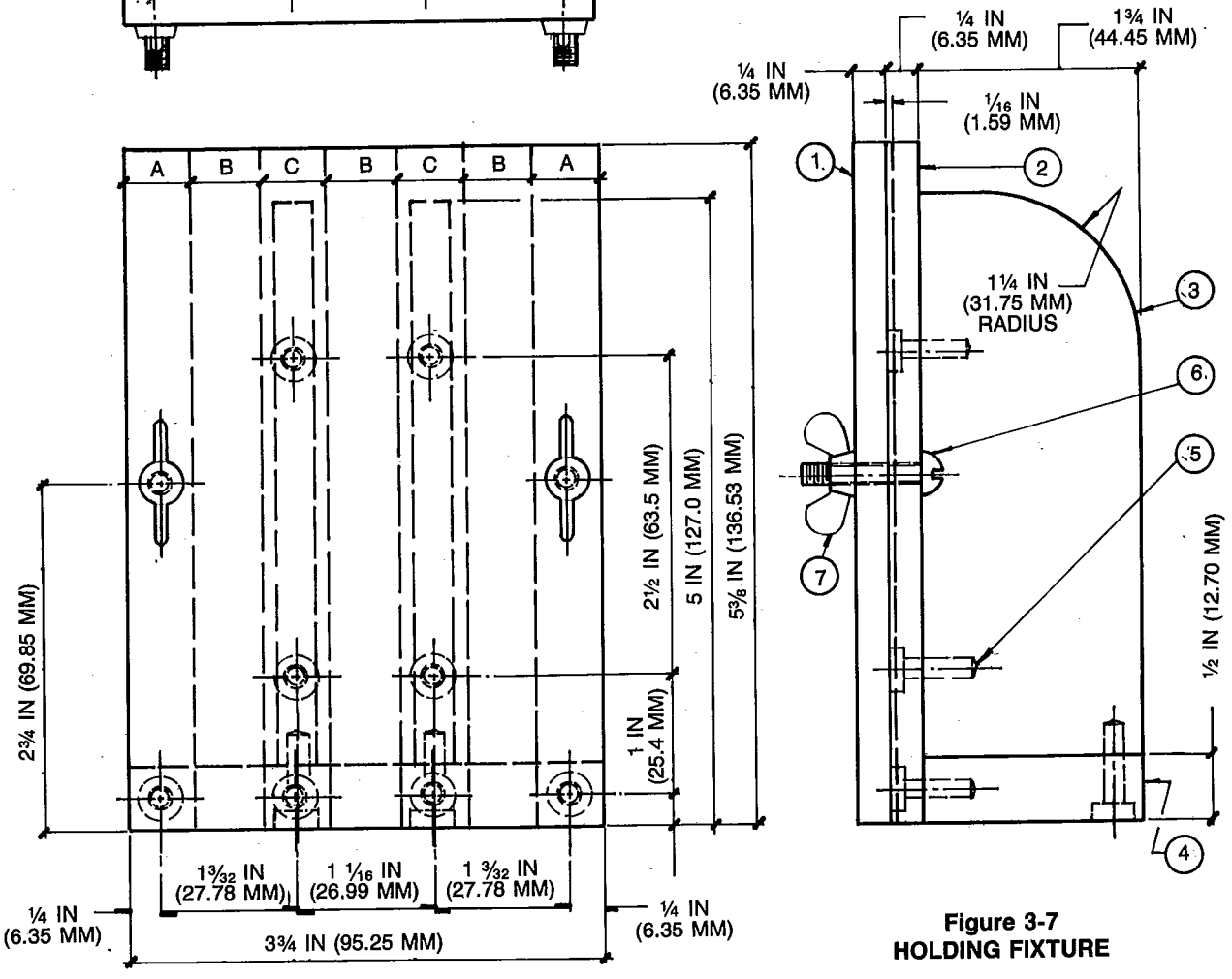



**Figure 3-7**
**HOLDING FIXTURE**

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### 3.4.6 Test Report

The test report shall include the following:

1. Gross dimensional change in machine direction in percent (average of three specimens at each condition).
2. Gross dimensional change in cross-machine direction in percent (average of three specimens at each condition).

NEMA Standard 11-14-1985

## 3.5 BOILING WATER RESISTANCE

### 3.5.1 Scope

This test measures the ability of the surface of high-pressure decorative laminate (HPDL) to maintain its color and surface texture when subjected to boiling water.

NEMA Standard 11-14-1985

### 3.5.2 Test Apparatus

The test apparatus shall include:

1. A flat-bottom heating vessel in accordance with Figure 3-8.
2. Hot plate or equivalent.
3. Tongs to lift heating vessel.
4. Overhead white fluorescent lights with bulb(s) positioned parallel to the line of sight and providing an intensity of 75 to 100 foot-candles (807 to 1076 lux) on the specimen surface.

NEMA Standard 1-30-1991

### 3.5.3 Test Specimens

Test specimens shall be 8 x 8 inches (203.2 x 203.2 mm) x thickness. They shall be bonded to 3/4 inch (19 mm) thick 45 lb/ft$^3$ (720 kg/m$^3$) nominal density particleboard using a contact adhesive in accordance with the adhesive manufacturer's instructions. Bonded test specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.5.4 Test Procedure

1. Fill the heating vessel to 1/2 inch (12.7 mm) from the rim with water and heat it until the water boils vigorously.
2. Examine the test specimen carefully prior to the test and note the conditions of the color and surface texture.
3. Pour approximately 10 ml of boiling water on the horizontal surface of the test specimen and set the vessel containing the remainder of the boiling water in this puddle.
4. Allow the vessel to remain in place for 20 minutes.
5. Remove the vessel with the tongs. Wipe the specimen to remove any residual contaminants and dry thoroughly, and allow it to stabilize at room temperature conditions for at least 24 hours.
6. Examine the conditioned test specimen by placing it, without preinspection, on a table and then view it at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914.4 mm) and at an angle of approximately 45° to 75° from the horizontal (table surface). The specimen shall be rotated in the plane of the table and viewed from all directions. Direct sunlight or other angle light sources, which will accentuate or minimize the effect, shall be avoided.

NEMA Standard 1-30-1991

### 3.5.5 Test Report

The specimen shall be examined for blisters, crazing, delamination, whitening or cracking.

The resistance to boiling water shall be reported as:

1. No effect - no change in color or surface texture.
2. Slight effect - a change in color or surface texture only visible at certain angles or directions,
3. Moderate effect - a change in color or surface texture visible from all angles and directions, but does not appreciably alter the original condition of the specimen.
4. Severe effect - a change in color or surface texture which obviously and markedly alters the original condition of the specimen.

NEMA Standard 1-30-1991

## 3.6 HIGH-TEMPERATURE RESISTANCE

### 3.6.1 Scope

This test measures the ability of the surface of high-pressure decorative laminate (HPDL) to maintain its color and surface texture when subjected to a high temperature.

NEMA Standard 11-14-1985

### 3.6.2 Test Apparatus

The test apparatus shall include:

1. A flat-bottom heating vessel in accordance with Figure 3-8.
2. Hot plate or equivalent.
3. Bath wax.
4. Dial thermometer reading from 212° to 482°F (100° to 250°C) in 2° gradations, or the equivalent. Mercury-filled glass thermometers shall not be used.
5. Tongs to lift heating vessel.
6. Overhead white fluorescent lights with bulb(s) positioned parallel to the line of sight and providing an intensity of 75 to 100 foot-candles (807 to 1076 lux) on the specimen surface.

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### 3.6.3 Test Specimens

Test specimens shall be at least 8 x 8 inches (203.2 x 203.2 mm) X thickness. They shall be bonded to 3/4 inch

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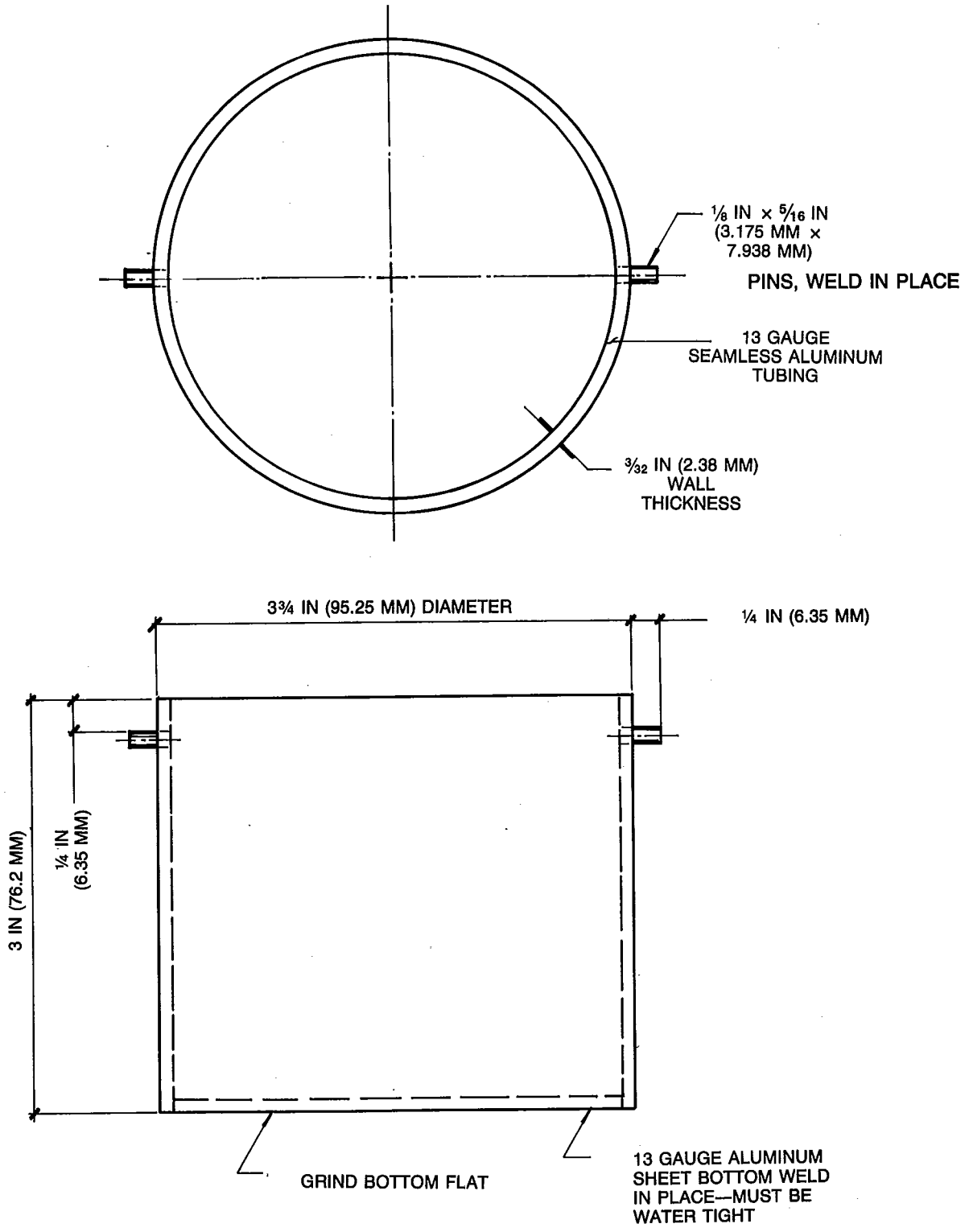



**Figure 3-8**
**HEATING VESSEL**

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(19 mm) thick 45lb/ft$^3$ (720 kg/m$^3$) nominal density particleboard using a contact adhesive in accordance with the adhesive manufacturer's instructions. Bonded test specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.6.4 Test Procedure

1. Examine the test specimen prior to the test and note the condition of the color and surface texture.
2. Fill the heating vessel to 1/2 inch (12.7 mm) from the rim with bath wax. Heat the wax until it reaches a temperature of 365°F (185°C). Do not overheat as fire can result. Using the tongs, remove the vessel from the hotplate and allow the wax to cool to 356° ± 1.8°F (180° ± 1°C). Then place the vessel, using the tongs, on the test specimen and allow it to remain in place for 20 minutes.
3. Remove the vessel with the tongs and allow the test specimen to stabilize at room temperature for at least 24 hours.
4. Wipe the specimen with VM&P naphtha and SD-3A ethyl alcohol to remove residual wax. Examine the conditioned test specimen by placing it, without preinspection, on a table and then view it at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914.4 mm) and at an angle of approximately 45° to 75° from the horizontal (table surface). The specimen shall be rotated in the plane of the table and viewed from all directions. Direct sunlight or other angle light sources, which will accentuate or minimize the effect, shall be avoided.
5. Record observations.

NEMA Standard 1-30-1991

### 3.6.5 Test Report

The specimen shall be examined for blisters, crazing, delamination, whitening or cracking.

The resistance to high temperature shall be reported as one of the following:

1. No effect- no change in color or surface texture.
2. Slight effect - a change in color or surface texture only visible at certain angles or directions.
3. Moderate effect - a change in color or surface texture visible from all angles and directions, but does not appreciably alter the original condition of the specimen.
4. Severe effect - a change in color or surface texture which obviously and markedly alters the original condition of the specimen.

NEMA Standard 1-30-1991

## 3.7 RADIANT HEAT RESISTANCE

### 3.7.1 Scope

This test measures the ability of the surface of high-pressure decorative laminate (HPDL) to resist spot damage when subjected to a radiant heat source.

NEMA Standard 11-14-1985

### 3.7.2 Test Apparatus

The test apparatus shall include:

1. Resistor heating element with silver-soldered copper lead lugs as shown in Figure 3-9 and wired in accordance with Figure 3-10.
2. Draft-excluding enclosure having:
   a. Approximate inside dimensions as follows:
      Width - 13 inches (330 mm)
      Length - 16 inches (406 mm)
      Height - 10 inches (254 mm)
   b. Open bottom, or equally convenient arrangement.
   c. Means for visually inspecting the test specimen while it is under test.
3. Stop watch or other suitable timer.
4. Constant current heater control as shown in Figure 3-10.
5. Radiation calibration block in accordance with Figure 3-11.
6. A suitable temperature measuring device.
7. A spotlight directed on the test area to observe effects.
8. A candle to blacken the metal calibration disc.

NEMA Standard 11-14-1985

### 3.7.3 Test Specimen

The test specimen shall be 9 x 9 inches (228.6 x 228.6 mm) x thickness. It shall be bonded to 3/4 inch (19 mm) thick 45 lb/ft$^3$ (720 kg/m$^3$) nominal density particleboard using a contact adhesive in accordance with the adhesive manufacturer's instructions. The bonded test specimen shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.7.4 Calibration Steps

1. Place the heating element on the calibration block, making certain that the unit is located against the guides and is flat against the top of the calibration block. This will locate the heating element directly over the metal disc.
2. Adjust the height of the heating element so that the distance between the disc and the resistance coil is 0.313 ± 0.003 inch (7.95 ± 0.08 mm).
3. Remove the heating element from the calibration block for a preliminary heating period. Adjust the

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BILL OF MATERIAL

| Item | Material | Name | Size | Number Required |
|---|---|---|---|---|
| 1 | Grade G-5 | Cap | Diameter—1 in (25.4 mm); Length—1 in (25.4 mm) | 1 |
| 2 | Grade G-5 | Mounting Plate | 1/4 in (6.35 mm) diameter × 2 in (50.8 mm) × 5 in (127 mm) | 1 |
| 3 | Grade G-5 | Mounting Plate | 1 × 2 × 3 in (25.4 × 50.8 × 76.2 mm) | 1 |
| 4 | ... | Heater element | ... | 1 |
| 5 | Copper | Mesh wire | Length—About 4 in (101.6 mm) | 2 |
| 6 | Brass | Sleeve | Outside diameter—3/4 in (19 mm); Length—1-1/4 in (31.75 mm) | 1 |
| 7 | Brass | Nut | Outside diameter—1 in (25.4 mm); Thickness—3/16 in (4.76 mm) | 1 |
| 8 | Metal | Screw | 10-32 × 3/4 in (19 mm) long | 4 |
| 9 | Copper | Lead lug | ... | 1 |
| 10 | Copper | Lead lug | ... | 1 |

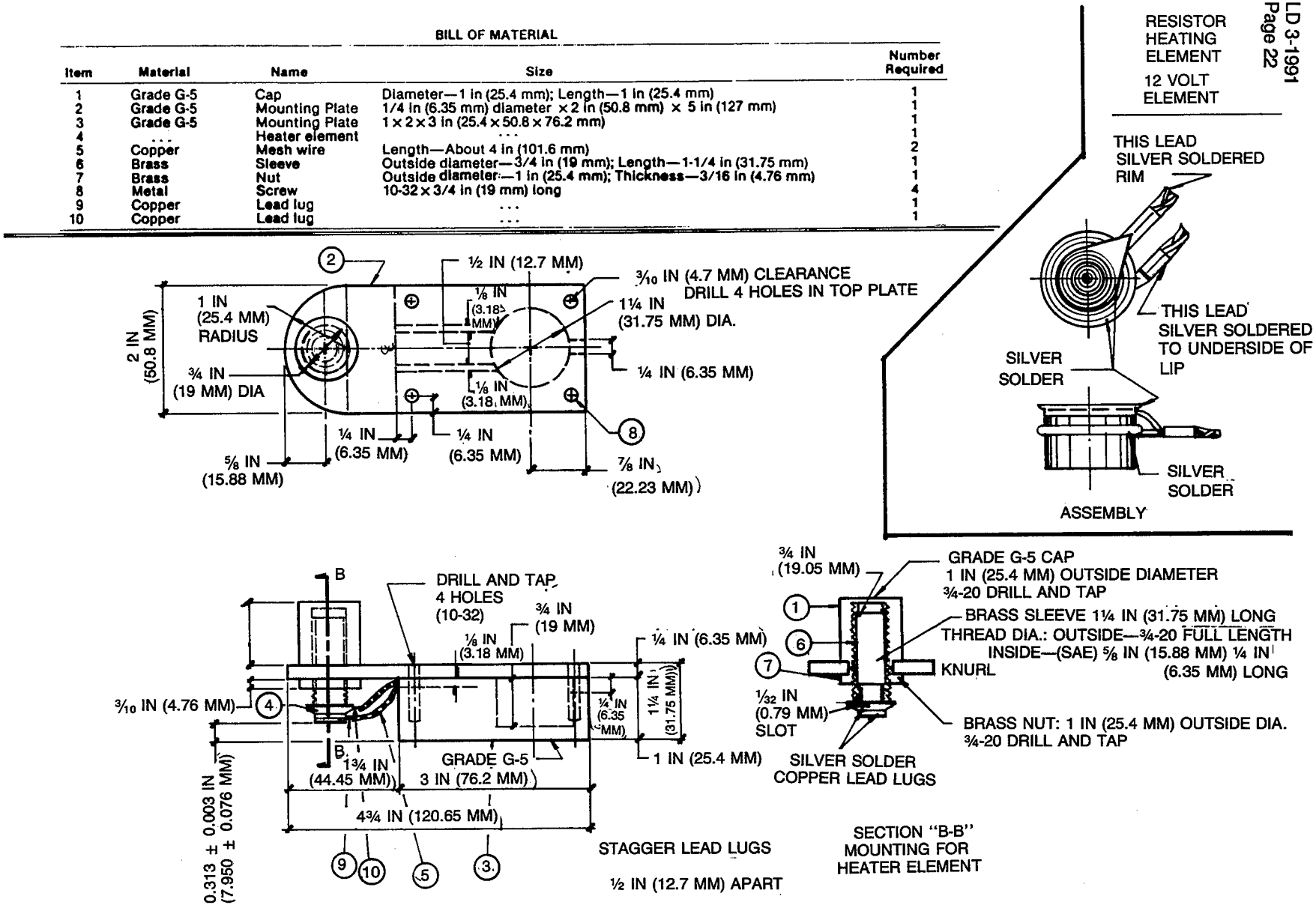



**Figure 3-9**
**CONSTRUCTION OF RESISTOR HEATING ELEMENT ASSEMBLY**

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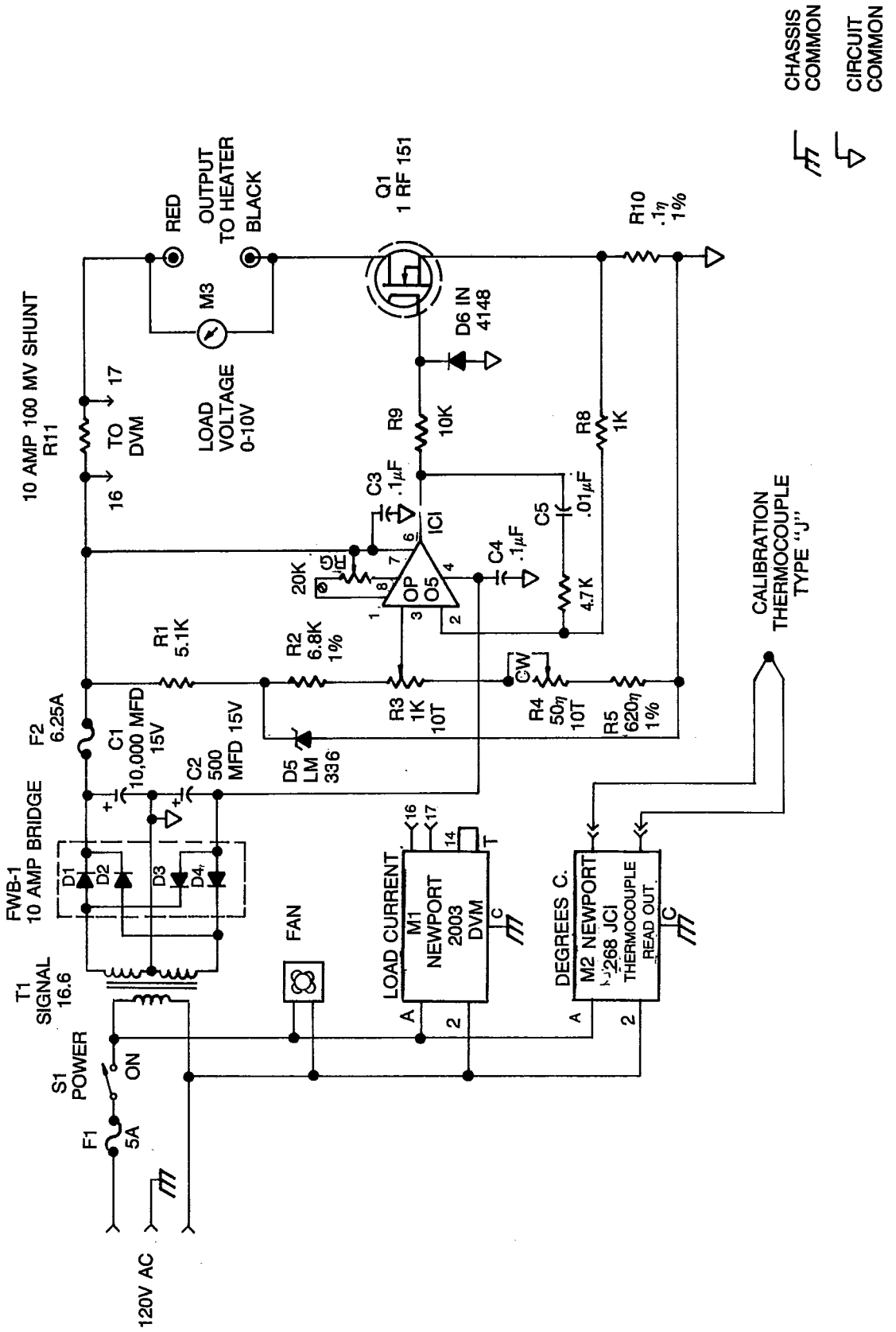



**Figure 3-10**
**SCHEMATIC DIAGRAM**
**FOR RADIANT HEAT TEST**

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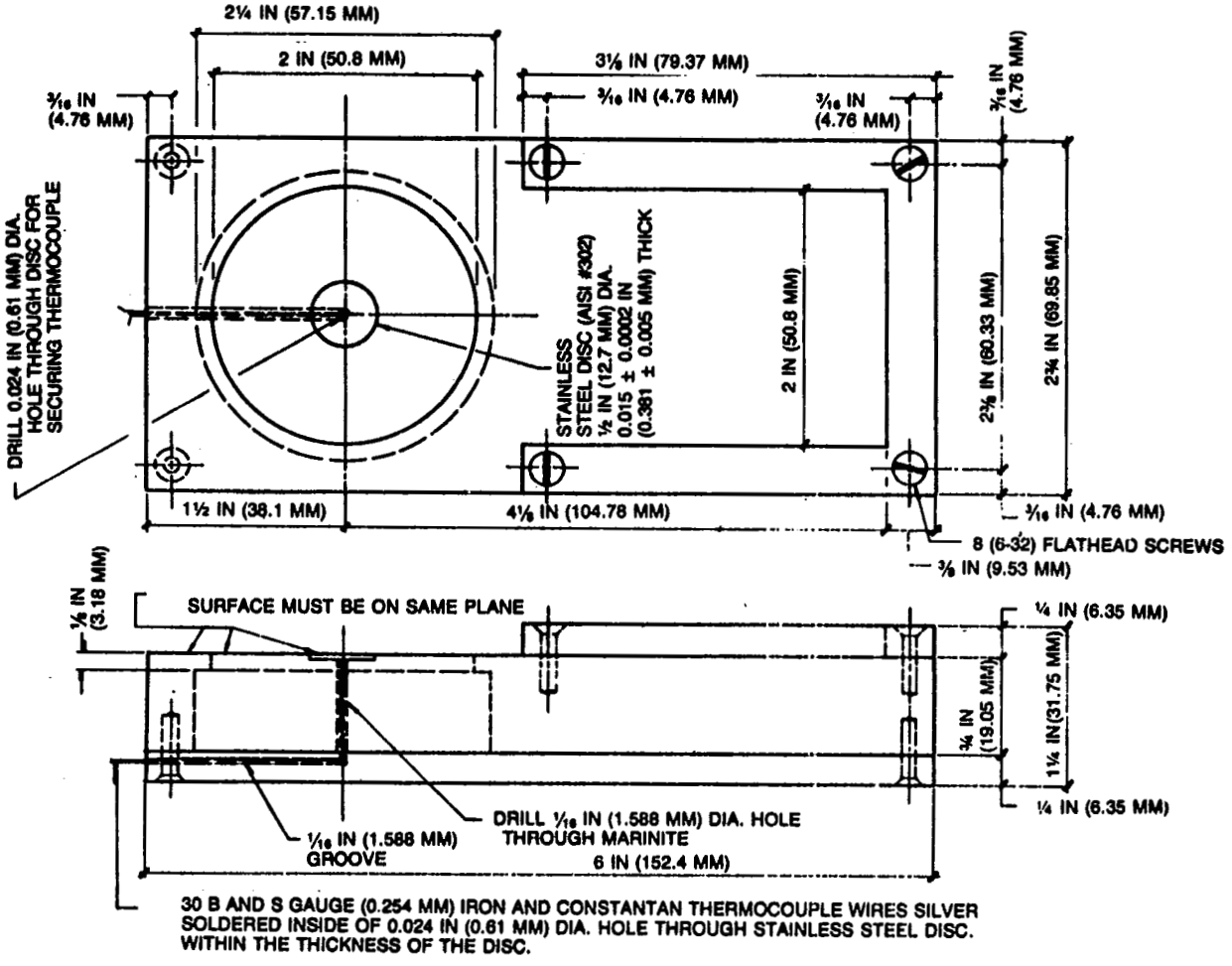



**Figure 3-11**
**RADIATION CALIBRATION BLOCK**

The main body of the block should be constructed of NEMA Grade G-5 or G-9 laminated material as designated in NEMA Standards Publication LI 1-1989.

The thermocouple wires are first silver soldered from the front surface of the 0.015 inch (0.581mm) thick stainless steel disc and inside of the 0.024 inch (0.0610 mm) hole with a minimum of silver solder to effect a good contact. The wires should be No. 30 B & S gauge (0.254 mm) iron and constantan, insulated with glass fiber. The front surface of the disc should be polished by first removing the excess length of thermocouple wires, sanding to produce a smooth surface and then polishing with a crocus cloth.

The portion of the block immediately surrounding the disc should be a low-density heat-resistant insulating material having a density of approximately 36 pounds per cubic foot (577 kg/m$^3$) and sanded on both surfaces. This insulating material should be coated with linseed oil primer.



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current input to the heating element to approximately 3.5 amperes and allow the element to heat for 15 minutes.

4. Blacken the metal disc with the carbon from the flame of the candle which is mounted vertically and shielded from all drafts. Hold the calibration block so that the disc is halfway down in the bright yellow portion of the flame. Avoid the lower or darker portion of the flame as it consists of partially unburned wax which produces an undesirable waxy carbon deposit. Allow the carbon to deposit on the disc for 30 seconds and then remove the calibration block from the flame.
5. Replace the heating element over the black disc and cover the assembly to prevent cooling from drafts. Allow 15 minutes for the calibration disc to heat up with no temperature being determined. Adjust current input as necessary so that the final observed temperature is between 552.2° – 561.2°F (289° – 294°C).
6. After the necessary adjustments are made, proceed with the test in accordance with 3.7.6.

NEMA Standard 11-14-1985

### 3.7.5 Test Procedure

1. Position the heater on the test specimen so that the resistance coil is at least 1-1/2 inches (38.1 mm) in from any edge, start the timer at this instant, cover the assembly with the enclosure within 2 seconds, and continue until the specimen fails or for 600 seconds.
2. The second test shall be made at a location at least 4 inches (91.6 mm) from the first test, and the third test shall be made at a location of at least 4 inches (91.6 mm) from both previous tests. The heater block shall not rest on an area of the test specimen which has been previously subjected to test.

NEMA Standard 11-14-1985

### 3.7.6 Factors Influencing Accuracy of Test

Four important factors which affect the accuracy of the test are:

1. Accuracy of distance between the calibration disc and resistance coil 0.313 ± 0.003 inch (7.95 ± 0.08 mm).
2. Accuracy of distance between the surface of the test specimen and the resistance coil. Their planes should be parallel and 0.313 ± 0.003 inch (7.95 ± 0.08 mm) apart.
3. Effects of drafts during calibration or during test. The heater element, calibration block, and test specimen should be shielded on top and all four sides during calibration and test.
4. Temperature of test specimen.

Authorized Engineering Information 1-30-1991

### 3.7.7 Test Report

The radiant heating resistance shall be recorded as the average time of failure in seconds, of the three tests on any one specimen. Failure is evidenced by blistering, charring, permanent discoloration, or crazing. If failure does not occur, record as 600 seconds plus.

NEMA Standard 11-14-1985

## 3.8 CONDUCTIVE HEAT RESISTANCE

### 3.8.1 Scope

This test measures the resistance of high-pressure decorative laminate (HPDL) to conductive heat.

NEMA Standard 11-14-1985

### 3.8.2 Test Apparatus

The test apparatus shall include:

1. A 750-watt, 115-volt, 60-hertz heater capable of maintaining a temperature of 350.6° ± 5.4°F (177° ± 3°C).
2. A variable output transformer.
3. A 200 gram brass weight approximately 1-3/4 inches in diameter x 5/8 inch high (44.45 mm in diameter x 15.8 mm high).
4. A 4-5/8 x 4-5/8 x 1/2 inch (117.5 x 117.5 x 12.7 mm) aluminum alloy 6061 plate.
5. A thermocouple disc consisting of a brass disc 1-3/4 inches in diameter x 1-1/16 inch (44.45 mm in diameter x 1.59 mm) thick with glass coated thermocouple wires flush mounted by means of silver solder.
6. A temperature measuring device suitable for use with the thermocouple.
7. A wind screen enclosure (Figure 3-12) approximately 6 inches wide x 6 inches deep x 12 inches high (152 mm wide x 152 mm deep x 305 mm high).
8. Stop watch or suitable timer.
9. Overhead white fluorescent lights with bulb(s) positioned parallel to the line of sight and providing an intensity of 75 to 100-foot candles (807 to 1076 lux) on the specimen surface.

NEMA Standard 1-30-1991

### 3.8.3 Test Specimen

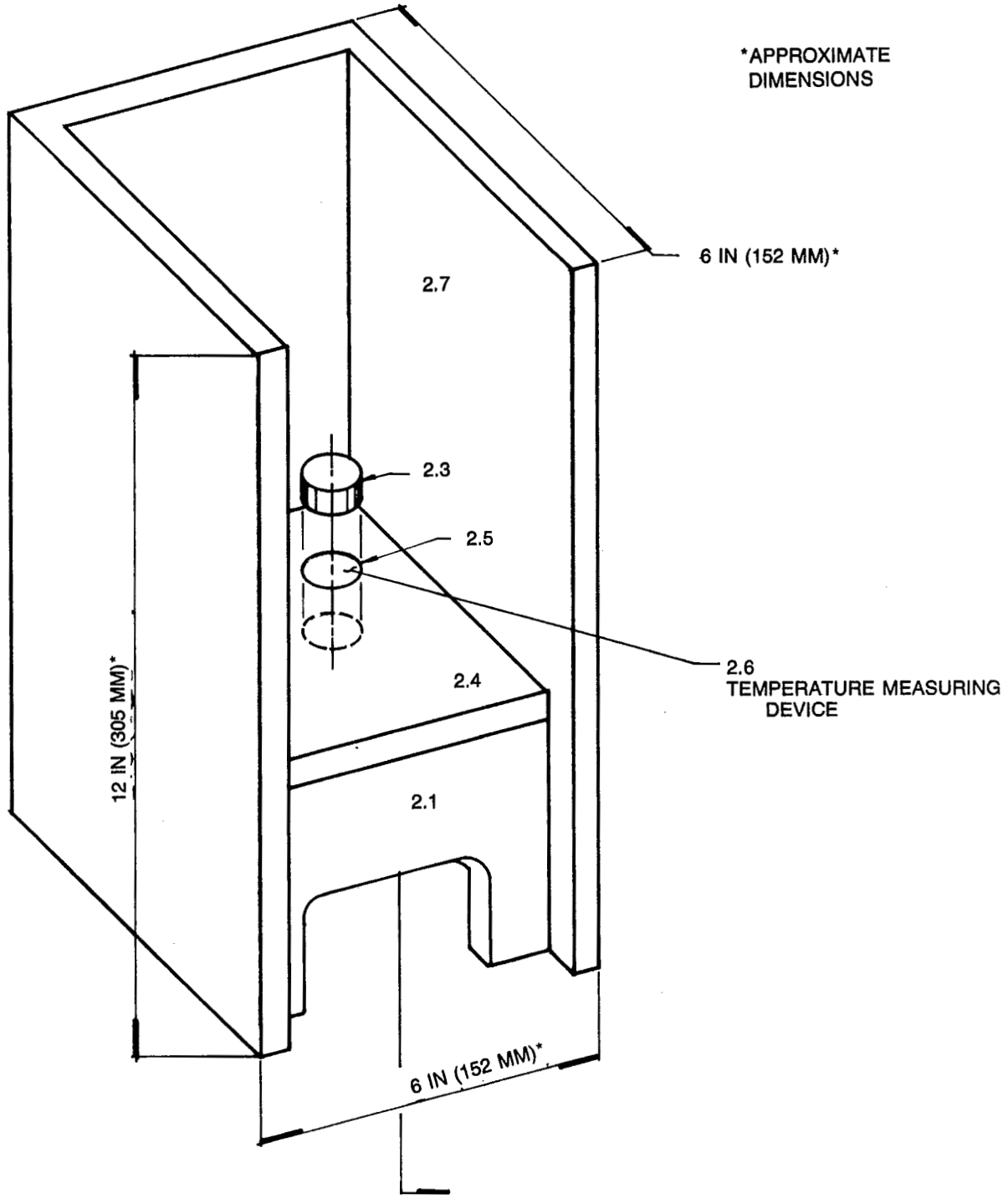
The test specimen shall be 1 x 2 inches (25.4 x 50.8 mm) x thickness and of uniform coloration. The test specimen shall be cut into two 1 inch (25.4 mm) squares, conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

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### 3.8.4 Test Procedure

1. Place the electric heater with the aluminum plate on top of it in the wind screen enclosure and heat for at least 15 minutes.

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MATERIALS:
- 2.1) HEATER
- 2.2) VARIABLE TRANSFORMER
- 2.3) WEIGHT
- 2.4) PLATE
- 2.5) DISC
- 2.6) TEMP. MEAS. DEVICE
- 2.7) WIND SCREEN ENCLOSURE

**Figure 3-12**

**CONDUCTIVE HEAT RESISTANCE TEST APPARATUS**

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2. Put the brass weight on the heated aluminum plate with the brass thermocouple disc between them.
3. Attach the thermocouple leads to the temperature measuring device and measure the temperature. Adjust the variable transformer until the aluminum plate and brass weight stabilize and maintain a temperature of 350.6° ± 5.4°F (177° ± 3°C).
4. Wipe the surface of both test specimens with a solution of 50:50 volume mixture VM&P naphtha and SD-3A ethyl alcohol and allow to dry. One square shall be tested and the other retained for comparison.
5. Lift the heated brass weight and place the test specimen, decorative face down, on the heated aluminum plate. Start the stopwatch immediately and quickly place the heated brass weight on top of the test specimen to ensure intimate contact between the test specimen and the face of the heated aluminum plate.
6. After a 5 minute contact period, remove the test specimen and allow it to remain at ambient conditions for at least 24 hours.
7. Examine the test specimen by placing it, without preinspection, on a table adjacent to its mate, taking care that both specimens are in the original orientation as cut from the sheet. View at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914.4 mm) and at an angle of approximately 45° to 75° from the horizontal (table surface). The specimens shall be rotated in the plane of the table and viewed from all directions, maintaining the original orientation. Direct sunlight or other angle light sources, which will accentuate or minimize the effect, shall be avoided.

NEMAStandard 1-30-1991

### 3.8.5 Factors Influencing Accuracy of Test

1. Color variations in the pattern.
2. Cleanliness of the aluminum plate.

Authorized Engineering Information 11-14-1985

### 3.8.6 Test Report

The conductive heat resistance shall be reported as one of the following:

1. No effect - no change in color or surface texture which can be seen.
2. Slight effect - a slight change in color or surface texture only visible at certain angles or directions.
3. Moderate effect - a slight change in color or surface texture visible at all angles and directions.
4. Severe effect - blistering, crazing or other permanent damage.

NEMA Standard 1-30-1991

## 3.9 STAIN RESISTANCE

### 3.9.1 Scope

This test measures the ability of the surface of high-pressure decorative laminate (HPDL) to resist staining by substances which may be encountered in common household service.

NEMA Standard 11-14-1985

### 3.9.2 Test Apparatus

The test apparatus shall include:

1. Concave glass covers, one for each test material, with flat fire-polished rims, 1 inch (25.4 mm) in diameter.
2. A cleaning solution of 50:50 volume mixture of VM&P naphtha and SD-3A ethyl alcohol.
3. A 5 ± 0.5 percent solution of sodium hypochlorite (bleach solution).
4. A liquid non-abrasive household detergent.
5. A clean, soft, white cloth.
6. A mild abrasive cleaner (mild abrasive soap and water).
7. A stiff nylon bristle brush, such as a nail brush.
8. Cotton balls.
9. Overhead white fluorescent light with bulb(s) positioned parallel to the line of sight and providing 75 to 100 foot-candles (807 to 1076 lux) on the table surface.

NEMA Standard 1-30-1991

### 3.9.3 Test Specimen

1. The test specimen shall have an area sufficient to permit placing all of the test materials on its surface. A 24 inch x 24 inch (609.6 x 609.6 mm) specimen is adequate.
2. The test specimen shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.9.4 Test Materials

Materials shall be kept in closed containers to avoid change in concentration and shall include the following:

1. Tap water
2. A 50:50 volume solution of SD-3A ethyl alcohol and water
3. A 70 percent solution of isopropyl alcohol
4. A cleaning solution of 50:50 volume mixture of VM&P naphtha and SD3-A ethyl alcohol
5. Non-oily nail polish remover
6. Acetone

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7. Household soap solution (water containing 5 percent bar soap)
8. Household detergent solution (water containing 5 percent detergent).
9. Household ammonia (non-sudsing)
10. Tomato catsup
11. Vegetable cooking oil
12. Trisodium phosphate solution (water containing 1 percent trisodium phosphate by weight)
13. Freshly prepared coffee (one teaspoon of instant coffee per 6 ounces of water)
14. Freshly prepared tea (one teaspoon of instant tea per 6 ounces of water)
15. Fresh whole milk
16. Citric acid solution (water containing 10 percent citric acid)
17. Plain prepared mustard
18. Distilled vinegar
19. Lipstick - red
20. Ink - washable blue
21. Grape juice
22. Red food dye
23. Beet juice
24. Merthiolate (water/alcohol solution containing 0.1 percent merthiolate)
25. Wax crayon-black
26. Shoe polish-black paste
27. Ink, ball point pen - blue
28. Ink, felt pen, non permanent - black
29. Ink, supermarket stamp ink - purple

NEMA Standard 11-14-1985

### 3.9.5 Test Procedure

1. Using the mild abrasive cleaner and water, clean the surface of the test specimen with a clean, soft, white cloth. Rinse well and dry using another clean, soft, white cloth. Allow to dry completely at a temperature of 73.4° ± 3.6°F (23° ± 2°C).
2. Position the test specimen on a flat, level, horizontal surface (table or bench) and tape or weigh it down so there will not be any variation from the horizontal plane.
3. With the test materials at ambient room temperature take one at a time and place a 1/4 to 1/2 inch (6.35 to 12.7 mm) spot upon the surface of the test specimen. As each individual test material is deposited, place one of the glass covers, concave side down, over the test material. Next, move the glass cover gently while in contact with the surface of the material undergoing testing until the test material is both under and outside the glass cover. Make certain that the entire circular rim of the glass cover has been wetted by the test material. Each area so prepared on the test specimen shall be marked in some manner so that the test material can be identified at the end of the test period.
4. Allow the prepared test specimen to stand undisturbed for 16 to 24 hours. Remove the glass covers and subject the decorative surface to the following procedures described below to remove the staining material. At any point where the staining material has obviously been removed, the procedure shall be terminated.
   a. Flush the surface liberally with tap water to remove excess material. Rinse well with water and wipe dry using a clean, soft, white cloth. The remaining residue of staining material shall be washed with a mixture of VM&P naphtha and SD-3A ethyl alcohol. If the surface is covered with dried or crusted materials, use liberal amounts to dissolve them. Once more rinse well with water and wipe dry using a clean, white, soft cloth.
   b. Wash the surface liberally with a household detergent solution. Rinse well with water and wipe dry with a clean, soft, white cloth.
   c. Use a cotton ball and place it over remaining stain; saturate with full strength bleach solution and allow to remain for two minutes. Rinse well with water and wipe dry with a clean, soft, white cloth.
   d. If any residue from staining material still remains, wet the bar of mild abrasive soap and the stiff nylon brush, and rub the brush on the soap until the bristles hold a reasonable amount of soap. Immediately scrub the spot with the bristles where staining material residue can still be observed.

      Do not rub in such a manner as to permanently mar the decorative surface finish. Additional soap may be applied to the brush if the action seems desirable or necessary.
   e. When scrubbing has accomplished the objective or failed, rinse and dry as described in previous steps.
   f. Repeat any of the previous steps (a through d) if necessary.
   g. Allow the test specimen to condition at ambient room temperature for at least 16 hours before examination.
   h. Examine the conditioned test specimen by placing it, without preinspection, on a table and then view it at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914.4 mm) and at an angle of approximately 45° to 75° from the horizontal (table surface), The specimen shall be rotated in the plane of the table and viewed from all directions. Direct sunlight

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or other angle light sources, which will accentuate or minimize the effect, shall be avoided.

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### 3.9.6 Test Report

The stain resistance shall be reported as one of the following:

1. No effect - all stain materials removed with no impairment to surface appearance. Any change in gloss due to the cleaning procedure (a and d of step 4 in 3.9.5) is permitted.
2. Moderate effect - a difficult to perceive stain visible from all angles and directions. Any change in gloss due to cleaning procedure (a and d of step 4 in 3.9.5) is permitted.
3. Severe effect - any easy to perceive stain or disturbed surface visible from all angles and directions.
4. List the material(s) which caused moderate or severe effect.

NEMA Standard 11-14-1985

## 3.10 LIGHT RESISTANCE

The fluorescent lamp or the carbon-arc fading lamp method shall be used for this test.

### 3.10.1 Scope

These tests measure the ability of the high pressure decorative laminate (HPDL) to retain its color when exposed to a light source having a frequency range approximating sunlight.

NEMA Standard 1-30-1991

It is not intended to show the resistance to continuous exposure to outdoor weathering conditions.

Authorized Engineering Information 11 14-1985

### 3.10.2 Fluorescent Lamp Method

#### 3.10.2.1 Test Apparatus

The test apparatus shall include a light source consisting of a commercial fluorescent lamp (UVA-340) whose dosage of radiant energy emitted shall be such that it will produce a condition approximating sunlight.

1. The test chamber shall be as described in Section 6 of ASTM Standard G53-84 Standard Practice for Operating Light and Water Exposure Apparatus (Fluorescent UV Condensation Type) for Exposure to Nonmetallic Materials.
2. Specimen holders - constructed to permit masking a portion of the specimen during exposure and mounted at a fixed distance from the lamps.
3. Overhead white fluorescent lights with bulb(s) positioned parallel to the line of sight, and providing 75 to 100-foot candles (807 to 1076 lux) on the specimen surface.

NEMA Standard 1-30-1991

#### 3.10.2.2 Test Specimens

The test specimens shall be 3 inch x 6 inch (76.2 mm x 152.4 mm) with the long dimension in the machine direction. The test specimen shall be conditioned for 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

#### 3.10.2.3 Test Procedure

1. Mount the test specimen in a masking holder vertically within the specimen face placed inward in the test chamber so that approximately one-half of the specimen will be exposed to the light source.
2. The test chamber shall be operated with 100 percent light and 0 percent condensation.
3. The air temperature surrounding the specimen shall be maintained at 158°F ± 5.4°F (70°C ± 3°C).
4. The specimen shall be exposed to the light source for 24 hours.
5. At the conclusion of the exposure period, remove the test specimen from the masking holder and allow it to condition at ambient room temperature for 24 hours.
6. Examine the conditioned test specimen within 4 hours by placing it, without preinspection, on a table and then view it at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914.4 mm) and at an angle of approximately 45° to 75° from horizontal (table surface). The specimen shall be rotated in the plane of the table and viewed from all directions. Direct sunlight or other angle light sources, which will accentuate or minimize the effect, shall be avoided.

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If a difference in appearance occurs between the masked and the exposed areas of the test specimen, coat the specimen with a thin uniform film of white petroleum jelly and re-examine it. If the difference persists, report it as a color change; if it disappears, report it as a change in surface texture.

Authorized Engineering Information 1-30-1991

#### 3.10.2.4 Factors Influencing the Accuracy of the Test

1. The lamps should be rotated every 400 hours of operation, replacing the two oldest.
2. The lamp replacement schedule method recommended by the manufacturer of the test chamber should be followed to ensure uniform light output.
3. All specimen holders should be filled with test specimens or blanks to ensure that the same air flow conditions exist for each testing period.

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### 3.10.3 Carbon-Arc Fading Lamp Method

#### 3.10.3.1 Test Apparatus

The test apparatus shall include a suitable commercial carbon-arc fading lamp whose dosage of radiant energy emitted shall be such that it will produce a condition approximating sunlight.

1. Specimen supports of the cylindrical framework type for mounting the test specimens perpendicular to and at a fixed radial distance from the center of the light source.
2. Ventilating fan capable of maintaining the black-panel temperature at 145.4° ± 5.4°F (63° ± 3°C). This ventilating fan shall be an integral part of the light source apparatus.
3. Black-panel thermometer - A unit which can be mounted in the position of test specimen to determine the temperature of the air surrounding the specimen.
4. Overhead white fluorescent lights with bulb(s) positioned parallel to the line of sight, and providing an intensity of 75 to 100-foot candles (807 to 1076 lux) on the specimen surface.

NEMA Standard 1-30-1991

#### 3.10.3.2 Test Specimens

The test specimens shall be of the size required by the test apparatus (3.10.2). used. Test specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

#### 3.10.3.3 Test Procedure

1. Mount the test specimen in a masking holder so that approximately one-half of the specimen will be exposed to the light source, the other half being covered by the masking holder.
2. Expose the mounted specimen to the light source for 48 hours.
3. Maintain the temperature of the air surrounding the test specimen at 145.4° ± 5.4°F (63° ± 3°C).
4. At the conclusion of the exposure period, remove the test specimen from the masking holder and allow it to condition at ambient room temperature for 24 hours.
5. Examine the conditioned test specimen within 4 hours by placing it, without pre-inspection, on a table and then view it at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914.4 mm) and at an angle of approximately 45° to 75° from horizontal (table surface). The specimen shall be rotated in the plane of the table and viewed from all directions. Direct sunlight or other angle light sources, which will accentuate or minimize the effect, shall be avoided.

NEMA Standard 1-30-1991

If a difference in appearance occurs between the masked and exposed areas of the test specimen, coat the specimen with a thin uniform film of white petroleum jelly and re-examine it. If the difference persists, report it as a color change; if it disappears, report it as a change in surface texture.

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#### 3.10.3.4 Factors Influencing the Accuracy of the Test

1. The thermometer should be mounted on a black panel to obtain the correct temperature reading.
2. The humidity in the unit should be as constant as possible.
3. All specimen holders should be filled with test specimens or blanks to ensure that the same air flow conditions exist for each testing period.

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### 3.10.4 Test Report

The light resistance shall be reported as one of the following:

1. No effect - no change in color or surface texture.
2. Slight effect - a change in color or surface texture only visible at certain angles and directions.
3. Moderate effect - a change in color or surface texture visible at all angles and directions but does not appreciably alter the original condition of the specimen.
4. Severe effect - a change in color or surface texture which markedly alters the original condition of the specimen.

NEMA Standard 11-14-1985

Environmental regulations have caused certain colors to be subject to fugitive changes in appearance and the manufacturer should be consulted.

Authorized Engineering Information 1-30-1991

## 3.11 APPEARANCE

### 3.11.1 Scope

This test measures the visual quality of the surface of high-pressure decorative laminate (HPDL).

NEMA Standard 11-14-1985

### 3.11.2 Test Apparatus

The test apparatus shall include:

1. Flat level horizontal surface (bench or table) approximately 30 inches (762 mm) high.
2. Overhead white fluorescent lights with bulb(s) positioned parallel to the line of sight, and providing an intensity of 75 to 100-foot candles (807 to 1076 lux) on the specimen surface.

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3. Dirt estimation chart based on TAPPI Standards T-213 and T-437.

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### 3.11.3 Test Specimen

The test specimen shall be an entire sheet and shall not be conditioned prior to the test.

NEMA Standard 11-14-1985

### 3.11.4 Test Procedure

1. Place the test specimen on the horizontal support, The surface shall be washed with a 50:50 volume mixture VM&P naphtha and SD-3A ethyl alcohol, and allowed to dry.
2. Examine the test specimen by viewing it at an eye-to-specimen distance of approximately 30 to 36 inches (772 to 914.4 mm) and at an angle of approximately 45° to 75° from the horizontal (table surface). The specimen shall be rotated in the plane of the table and viewed from all directions. Direct sunlight or other angle light sources, which will accentuate or minimize the effect, shall be avoided.
3. Inspect the specimen for the following defects:
   a. Type A defects - smudges, smears, fingerprints or streaks.
   b. Type B defects - any foreign particle which has an area of 0.60 square millimeter or larger and which is visible at the viewing distance.
   c. Type C defects - any group of three or more foreign particles, each having an area of 0.30 square millimeter or more, which occur within a 12 inch (304.8 mm) diameter circle and which are visible at the viewing distance. If only two foreign particles occur within the prescribed circle, each particle shall be judged separately according to the criteria for Type B defects.

NEMA Standard 1-30-1991

### 3.11.5 Test Report

The test report shall list all Type A, B, and C defects.

NEMA Standard 11-14-1985

## 3.12 CLEANABILITY OF SURFACE

### 3.12.1 Scope

This test measures the ability of the surface of high-pressure decorative laminate (HPDL) to be cleaned.

NEMA Standard 11-14-1985

### 3.12.2 Test Apparatus

The test apparatus shall include:

1. Straight-line washability and abrasion machine.
2. Cellulose sponge 3 x 4 x 1-3/4 inches (76.2 x 101.6 x 44.5 mm)
3. Spray cleaning solution
4. Masking tape 2 inches (50.3 mm) wide
5. Two 3 inch (76.2 mm) "C" clamps
6. A clean, soft white cloth,
7. Soiling agent

NEMA Standard 1-30-1991

For instructions on the preparation of the soiling agent, see Appendix B.

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### 3.12.3 Test Specimen

The test specimen shall be of a size to fit the test apparatus and bonded to a suitable substrate with a contact adhesive in accordance with the adhesive manufacturer's instructions.

The bonded test specimen shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.12.4 Test Procedure

1. Thoroughly mix 1 part of soiling agent with 2 to 3 parts of tap water by weight to form a paste.
2. Apply two strips of masking tape to cover 4 inches (101.6 mm) of each end of the test specimen, leaving an exposed area of 8 x 8 inches (203.2 x 203.2 mm).
3. Apply 5 grams of the soiling agent paste to the exposed area of the test specimen, covering it smoothly and completely. Allow the specimen to dry at least 24 hours.
4. After drying, wipe off the soiling agent paste using a clean, soft, white, dry cloth, and rinse the test specimen lightly under running tap water. (If the test specimen is clean after this rinsing, stop the test and report the result as "no effect.")
5. Mount the test specimen in the test machine using the "C" clamps to hold it in place.
6. Moisten the cellulose sponge with 4 grams of cleaning solution and mount the sponge on the machine.
7. Set the stroke counter at zero and start the machine. Scrub the test specimen for 10 strokes, rinse and examine it. If the specimen is not clean, add another 4 grams of cleaning solution, scrub the specimen for another 15 strokes and rinse it. If the specimen is still not clean, add another 4 grams of cleaning solution, scrub the specimen for an additional 25 strokes, rinse it and remove the masking tape. If the specimen requires more than 50 strokes to come clean, the test shall be stopped.

NEMA Standard 1-30-1991

### 3.12.5 Test Report

Compare the "cleaned" test area with the masked original surface and report the cleanability as one of the following:

1. No effect - 0 to 10 scrubbing strokes; clean as original; no change in appearance.
2. Slight effect - 11 to 25 strokes; clean as original; no change in appearance.

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3. Moderate effect - 26 to 50 strokes; clean as original; no change in appearance.
4. Severe effect - more than 50 strokes.

NEMA Standard 11-14 1985

## 3.13 SURFACE FINISH

### 3.13.1 Scope

This test measures the gloss level of the surface of high-pressure decorative laminate (HPDL).

NEMA Standard 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.

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.

Authorized Engineering Information 11-14-1985

### 3.13.2 Test Apparatus

The test apparatus shall include:

1. Portable 60-degree gloss meter
2. Black glass high-gloss standard with a rating of 94 ± 1 unit
3. The test apparatus shall be in accordance with the ASTM D-523 except that the primary working standard shall have a value of 94 ± 1 unit.
4. A clean, soft, white cloth.

NEMA Standard 1-30-1991

### 3.13.3 Test Specimen

The test area of each specimen shall be at least 6 inches (154.2 mm) square and shall represent, if possible, the four corners and geometric center of the full-size production sheet.

The test specimens shall not be conditioned prior to the test.

NEMA Standard 11-14-1985

### 3.13.4 Calibration

Adjust the gloss meter to indicate 82 units when calibrated against the primary working standard.

NEMA Standard 1-30-1991

Do not use the white standard. (The calibration to 82 on the gloss standard is necessary to bring the value for high gloss finishes within the range of some of the meter scales.)

Glossometers which have been manufactured to electronically calibrate to A.S.T.M. 523 may be used to determine the gloss level of high pressure decorative laminates. However, as gloss levels approach the high gloss range, the electronically calibrated glossometer values will tend to be about 8 to 12 units higher than those instruments adjusted to 82 units; therefore, gloss values greater than 100 units may occur when measuring high gloss laminate. Please consult the laminate manufacturers for assistance.

Authorized Engineering Information 1-30-1991

### 3.13.5 Test Procedure

1. Wipe the specimen with a clean, soft, white cloth.
2. Place the calibrated gloss meter on the first sample in the machine direction of the laminate, aligning the opening in the bottom of the instrument with the center of the test area. Take and record the gloss meter reading.
3. Place the calibrated gloss meter on the first sample in the cross-machine direction of the laminate, aligning the opening in the bottom of the instrument with the center of the test area. Take and record the gloss meter reading.
4. Repeat steps 1 and 2 for all other test areas of full-size panels or individual test specimens.

NEMA Standard 1-30-1991

### 3.13.6 Test Report

The test report shall include:

1. The average of all readings taken in the machine-direction.
2. The average of all readings taken in the cross-machine direction.

NEMA Standard 11-14-1985

## 3.14 FORMABILITY

### 3.14.1 Scope

This test measures the ability of postforming type high-pressure-decorative laminate (HPDL) to be formed.

NEMA Standard 11-14-1985

### 3.14.2 Test Apparatus

The test apparatus shall include:

1. One two-element radiant electric heater, 120 volts, 1600 watts, or equivalent, mounted in a suitable metal-lined trough. See Figure 3-13.
2. A variable output transformer.
3. Temperature indicator crayons rated 275° to 375°F (135.0° to 190.6°C) or an infrared thermometer.
4. A stop watch or other timer.
5. A machinist's micrometer.
6. A wind screen such as shown in Figure 3-14, or equivalent.
7. Calibration strips of solid-color white laminate (General Purpose type) 2 x 8 x 0.045 ± 0.002 inch

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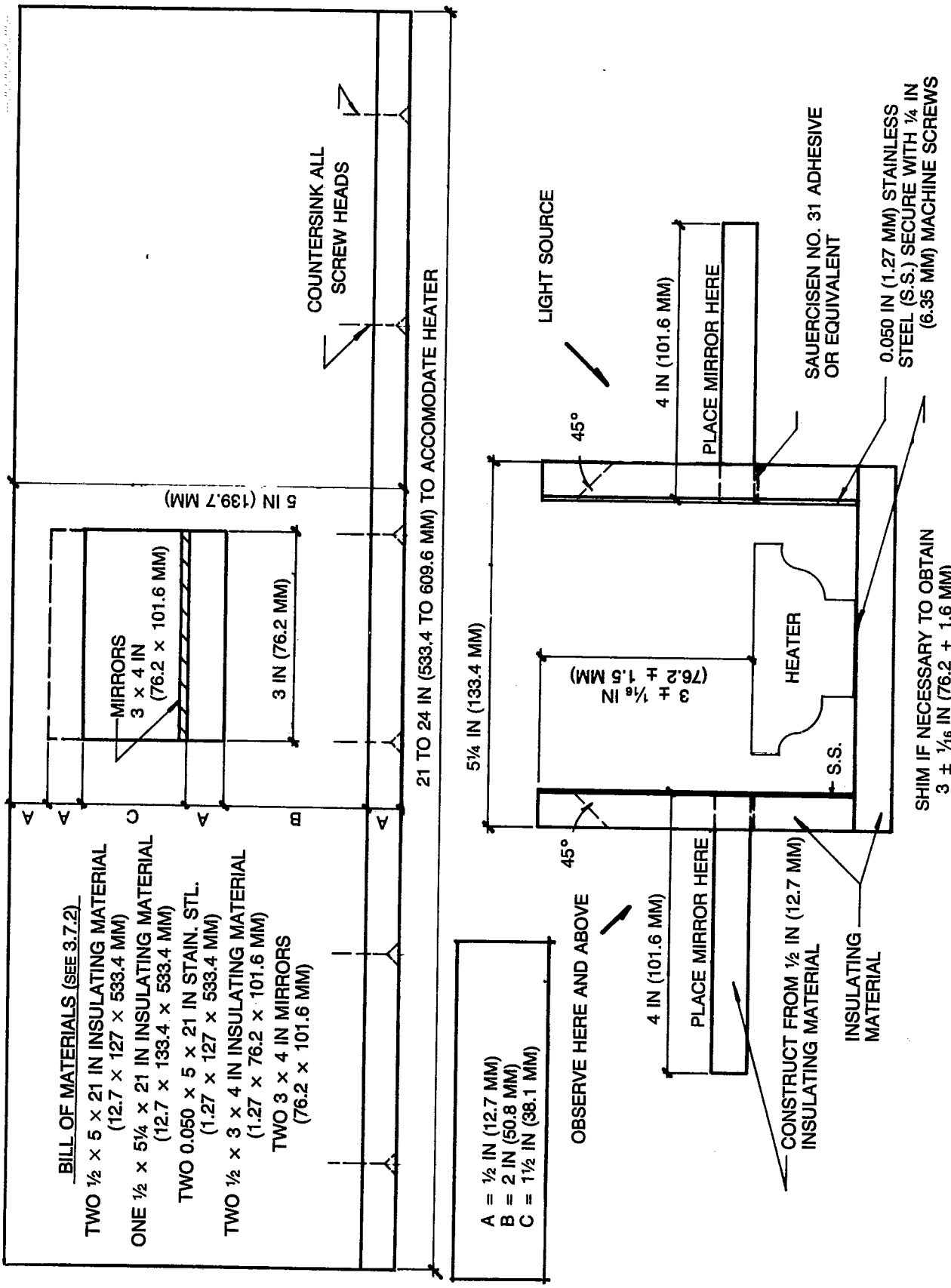



**Figure 3-13**
**HEATING APPARATUS**

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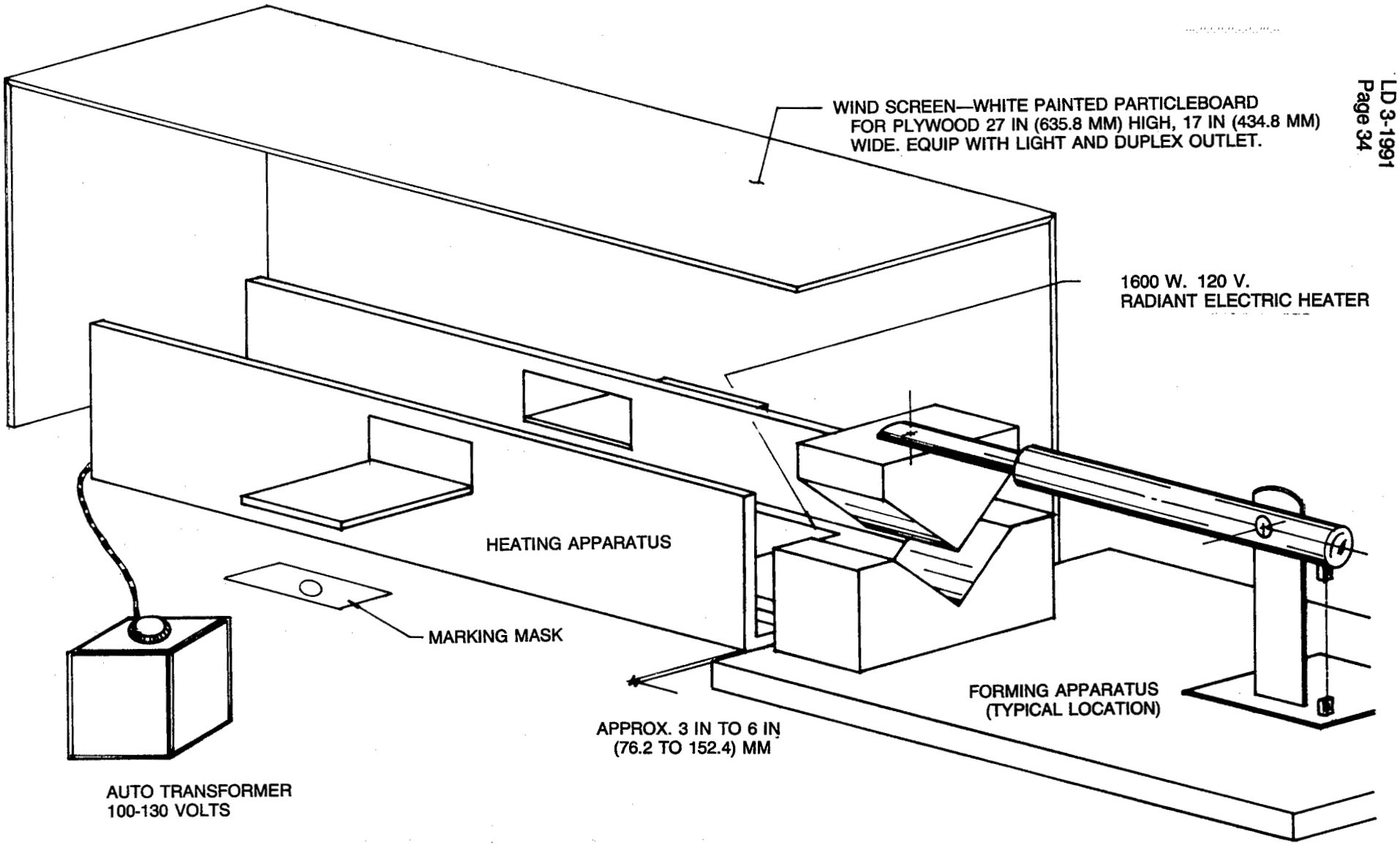



**Figure 3-14**
**FORMABILITY AND BLISTER RESISTANCE APPARATUS**
**Not to Scale**

NEMA LD*3 91 ■ 6470247 0500027 5 ■

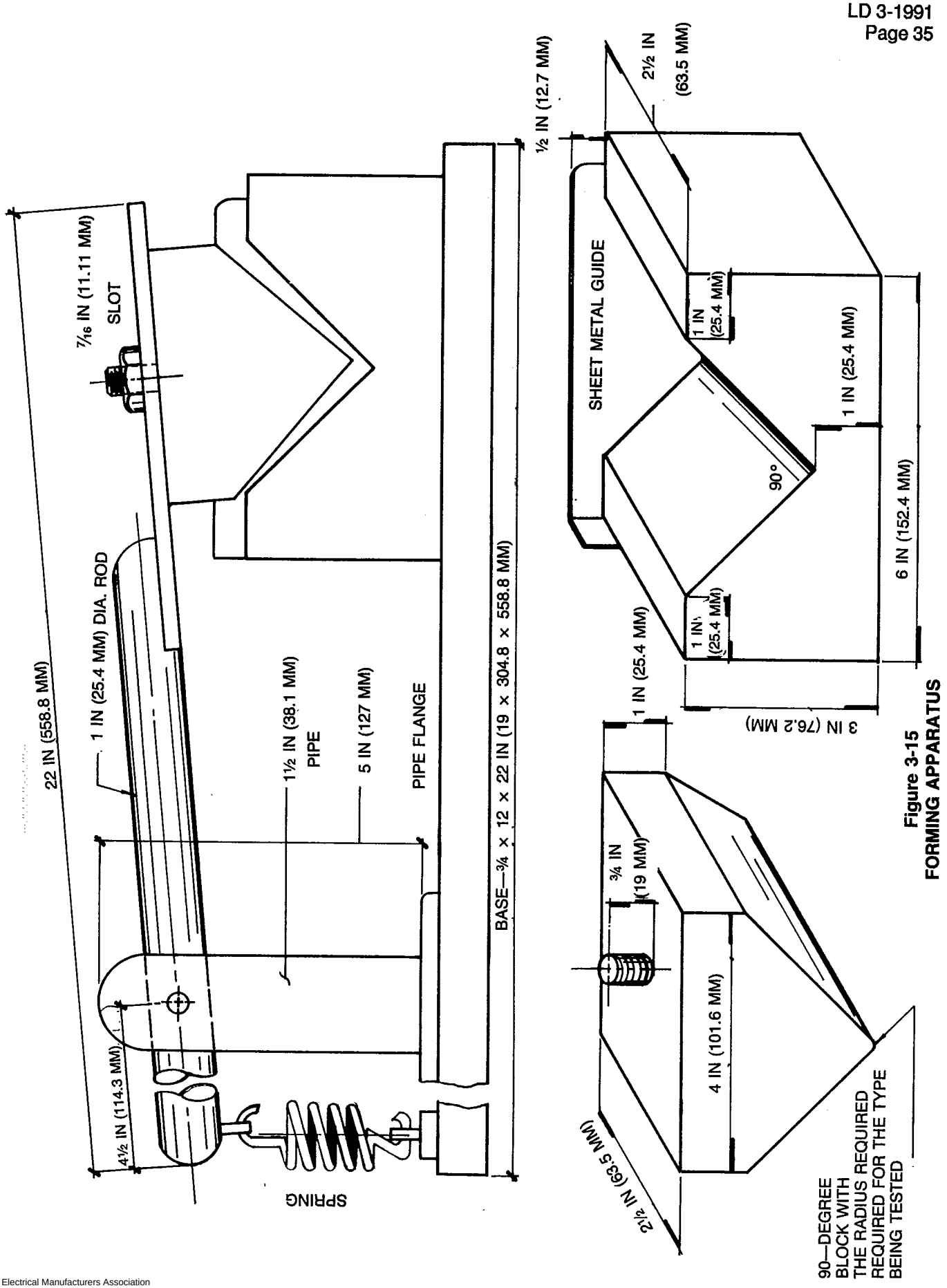



**Figure 3-15**
**FORMING APPARATUS**

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(50.8 x 203.2 x 1.14 ± 0.05 mm) with the 8 inch (203.2 mm) dimension cut parallel with the machine direction of the laminate. The backs of the strips shall be sanded to obtain the specified thickness.

8. Radiused male forming blocks 1/2 and 5/8 inch (12.7 and 15.9 mm) and female forming blocks shall be machined from C grade industrial laminate, hard maple or similar close-grained wood species. See Figure 3-15.
9. Forming apparatus (see Figures 3-15 and 3-15A). The manufacturer should be consulted when using the forming apparatus shown in Figure 3-15A.

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10. The parts of the test apparatus shall be located in a draft-free area and in close proximity to permit rapid and smooth transfer of the test specimen from the heater to the forming block. (See Figure 3-14).
11. Lighting shall be from an overhead fluorescent light with bulb(s) positioned parallel to the line of sight, and providing 75 to 100 foot-candles (807 to 1076 lux).

NEMA Standard 1-30-1991

### 3.14.3 Test Specimens

1. Test specimens shall be 2 x 8 inches (50.8 x 203.2 mm) x thickness, cut from the right edge, center and left edge of the laminate. The edges of the specimens shall be sanded to remove minute cracks. Six specimens, three in the machine direction and three in the crossmachine direction, shall be tested.
2. Test specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.14.4 Calibration of Test Apparatus

1. Turn on the heating element 30 minutes prior to making any test. A voltmeter shall be used to check the applied voltage. The starting point voltage shall be 91 to 100 percent of line voltage, e.g., 100 to 110 volts.
2. Mark the sanded back of several calibration test strips with a single centered line parallel to the 8 inch dimension, using a 325°F (162.8°C) temperature indicator crayon.
3. Place a calibration strip on the heating apparatus at the center, decorative face down, centering the marked line over the heater element. Watch the temperature indicator crayon mark on the test specimen for signs of melting. When the mark initially melts, remove the specimen from the heating apparatus.

   Using the calibration strips, adjust the input voltage with the transformer so that the rate of temperature rise required to reach 325°F (162.8°C) will be 1 second per 0.001 inch (0.025 mm) of thickness. The total time variance shall be ± 2 seconds.
4. When three or more consecutive test strips reach the prescribed temperature/time curve (3), begin the test.

NEMA Standard 1-30-1991

For 0.045 inch (1.14 mm) thick laminate, the time to reach 325°F (162.8°C) = 45 ± 2 seconds.

Commercially available infrared thermometers may be used in place of the temperature indicator crayons. When using the infrared thermometer record the temperature for the initial melt during the calibration procedure. This temperature may be used as the set point. The calibration of the thermometers should be in accordance with the instrument manufacturer's instructions.

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### 3.14.5 Test Procedure

1. Measure the thickness of the test specimen with the machinist's micrometer and record it.
2. Using the temperature indicator crayon, mark the back of each test specimen with a single centered line parallel to the 8 inch dimension. Use the temperature indicator crayon having the temperature range recommended by the laminate manufacturer. In absence of a manufacturer's recommendation, use a 325°F (162.8°C) crayon.
3. Place the test specimen, decorative face down, on the center of the heating apparatus, centering the marked line over the heater element.
4. Watch the temperature indicator crayon mark on the test specimen for signs of melting. When the mark initially melts, remove the specimen from the heating apparatus. Immediately place it face down in the forming apparatus equipped with the proper radius forming block and form it.
5. The closing time of the forming die after its initial contact with the specimen shall not exceed 1 second. Allow the formed specimen to cool in the closed forming apparatus for at least 15 seconds. Remove and inspect the test specimen.
6. Record observations.

NEMA Standard 1-30-1991

If an infrared thermometer is used instead of the temperature indicator crayon, the thermometer probe should be placed above the specimen to ensure that its beam target area is narrower than the width of the specimen. The manufacturer's instructions should be followed. The test sample should be removed from the heating apparatus when the calibration set point is reached, and then proceed with forming.

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### 3.14.6 Test Report

Report that the specimens either "passed" or "failed."

1. "Passed" means that all of the test specimens formed to the prescribed minimum forming radius without cracking, blistering, crazing, or permanent discoloring.
2. "Failed" means that one or more of the test specimens did not form to the prescribed minimum forming radius or that it cracked, blistered, crazed, or permanently discolored.

NEMA Standard 11-14-1985

## 3.15 BLISTER RESISTANCE

### 3.15.1 Scope

This test measures the ability of postforming type high-pressure decorative laminate (HPDL) to resist blistering during postforming operations.

NEMA Standard 11-14-1985

### 3.15.2 Test Apparatus

The test apparatus shall include:

1. One two-element radiant electric heater, 120-volts, 1600 watts, or equivalent, mounted in a suitable metal-lined trough. See Figure 3-13.
2. A variable output transformer.
3. Temperature indicator crayons rated 325°F (162.8°C) or an infrared thermometer.
4. A timer.
5. A machinist's micrometer.
6. A wind screen such as shown in Figure 3-14.
7. Calibration strips of solid-color white laminate (General Purpose type) $2 \times 3 \times 0.045 \pm 0.002$ inch ($50.8 \times 20$).$2 \times 1.14 \pm 0.05$ mm) with the 8 inch (203.2 mm) dimension cut parallel with the machine direction of the laminate. The backs of the strips shall be sanded to obtain the specified thickness.
8. Lighting shall be from an overhead fluorescent light with bulb(s) positioned parallel to the line of sight, and providing 75 to 100 foot-candles (807 to 1076 lux).

NEMA Standard 1-30-1991

### 3.15.3 Test specimens

1. Test specimens shall be 4 x 8 inches (101.6 x 203.2 mm) x thickness cut from the right edge, center and left edge of the laminate. The 8 inch (203.2 mm) dimension shall be cut parallel with the machine direction of the laminate. Three test specimens shall be tested.
2. Test specimens shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.15.4 Calibration of Test Apparatus

1. Turn on the heating element 30 minutes prior to making any test. A voltmeter shall be used to check the applied voltage. The starting point voltage shall be 91 to 100 percent of the line voltage, e.g., 100 to 110 volts.
2. Mark the sanded back of several calibration test strips with a single centered line parallel to the 8 inch dimension, using a 325°F (162.8°C) temperature indicator crayon.
3. Place a calibration strip on the heating apparatus at the center, decorative face down, centering the marked line over the heater element. Watch the temperature indicator crayon mark on the test specimen for signs of melting. When the mark initially melts, remove the specimen from the heating apparatus.

   Using the calibration strips, adjust the input voltage with the transformer so that the rate of temperature rise required to reach 325°F (162.8°C) will be 1 second per 0.001 inch (0.025 mm) of thickness. The total time variance shall be 2 seconds.
4. When three or more consecutive test strips reach the prescribed temperature/time curve (3), begin the test.

NEMA Standard 1-30-1991

For 0.045 inch (1.14 mm) thick laminate, the time to reach 325°F (162.8°C) = 45 ± 2 seconds.

Commercially available infrared thermometers may be used in place of the temperature indicator crayons. When using an infrared thermometer, its probe should be placed above the specimen to ensure that its beam target area is narrower than the width of the specimen. Record the temperature for the initial melt during the calibration procedure. This temperature should be used as the set point. The calibration of the thermometer should be in accordance with the instrument manufacturer's instructions.

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1 Simultaneously start the timer and place the test specimen, decorative face down, on the center of the heating apparatus.
2. Stop the timer when blistering occurs and record the time. Blistering shall be detected by visual or audible means, whichever occurs first.

NEMA Standard 1-30-1991

### 3.15.6 Test Report

The blister resistance time in seconds shall be reported, based on the average values for three test specimens.

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## 3.16 DART IMPACT RESISTANCE

(Values under consideration.)

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### 3.16.1 Scope

This test measures the ability of high-pressure decorative laminate (HPDL) to resist fracture due to impact by a small diameter ball.

NEMA Standard 11-14-1985

### 3.16.2 Test Apparatus

The test apparatus shall include:

1. A free fall test apparatus of the type shown in Figure 3-16.
2. Impact darts weighing 50.0 ± 0.5 grams and 25.0 ± 0.5 grams respectively, consisting of a steel dart tipped with a 0.195 inch (5 mm) diameter ball having no damaged or flattened surface.
3. The tube and darts shall be lubricated with a dry lubricant to minimize friction.
4. A finely-divided powder of a color which contrasts with the specimen, such as chalk or graphite.
5. A cleaning solution of 50:50 volume mixture of VM&P naphtha and SD-3A ethyl alcohol.
6. Lighting shall be from an overhead fluorescent light with bulb(s) positioned parallel to the line of sight, and providing 75 to 100 foot-candles (807 to 1076 lux).
7. A clean, soft, white cloth.

NEMA Standard 1-30-1991

### 3.16.3 Test Specimen

1. The test specimen shall be 8 × 8 inch (203 × 203 mm).
2. The test specimen shall be bonded to 3/4 inch (19 mm) 45 pound/ft$^3$ (720 kg/mm$^3$) nominal density, industrial grade particleboard with a contact adhesive in accordance with the adhesive manufacturer's instructions.
3. The bonded test specimen shall be conditioned for at least 48 hours prior to the test at a temperature of 73.4° ± 3.6°F (23° ± 2°C) and a relative humidity of 50 ± 5 percent.

NEMA Standard 1-30-1991

### 3.16.4 Test Procedure

1. Place the conditioned specimen face up on a rigid horizontal surface.
2. The 25 gram dart shall be used for testing high-pressure decorative laminates having nominal thickness of .032" or less. The 50 gram dart shall be used for testing all other high-pressure decorative laminate types.
3. Position the test apparatus, Figure 16, on the decorative face of the specimen so the edge of the round base contacts two edges of the square specimen across one 90° corner. The bottom of the circular base shall be flush against the face of the specimen.
4. Position the dart at a height of 5 inches (127 mm) as indicated by engraved numbers on the vertical tube and allow the dart to fall and impact against the face of the specimen. Catch the dart when it rebounds so that multiple impacts do not occur.
5. Move the test apparatus, Figure 3-16, to the right 5/8 inch (15.9 mm) keeping the edge of the circular base along the edge of the specimen.
6. Position the dart at a height of 6 inches (152 mm) and allow it to fall and impact against the face of the specimen. Again, catch the dart so that multiple impacts do not occur.
7. Again move the test apparatus to the right 5/8 inch (15.9 mm) as in step 5, and increase the height of the dart by 1 inch (25.4 mm) and allow it to fall and impact against the face of the specimen. Again, do not allow multiple impacts.
8. Repeat step 7 along 3 edges of the specimen as shown in Figure 3-17.
9. If the dart was dropped at every 5/8 inch (15.9 mm) increment following the 3 sides of the specimen as shown in Figure 3-17, there should be 26 impact points representing impact heights from 5 to 30 inches (127 to 762 mm). Such impact points should be in the shape of a square letter "U" on its side to the left.

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10. Using a 50:50 volume mixture VM&P naphtha and SD-3A ethyl alcohol and a clean, soft, white cloth, wipe each impact point, starting with the 5 inch (127 mm) drop height. Apply powder to the impact points, wipe off the excess, and observe for fracture which is damage at point of impact as defined by the presence of hairline cracks (frequently concentric) or flaking. Indentation without fracture shall be considered acceptable.
11. Preposition test apparatus so as to complete the open side of the "U" made by previous impact points. Make five drops from the drop height determined in step 10 which shall be the highest impact height at which no fracturing occurred. Repeat step 10 for the five points. If none of the impact points indicate fracture, the drop height shall be recorded as the impact resistance value.
12. If one or more impact points are fractured in step 11, the drop height shall be lowered by 1 inch (25.4 mm) and step 11 repeated.
13. Continue to repeat steps 11 and 12 until none of the five impact points indicates fracture, and record that drop height as the impact resistance value.

NEMA Standard 1-30-1991

### 3.16.5 Test Report

Impact resistance value in inches.

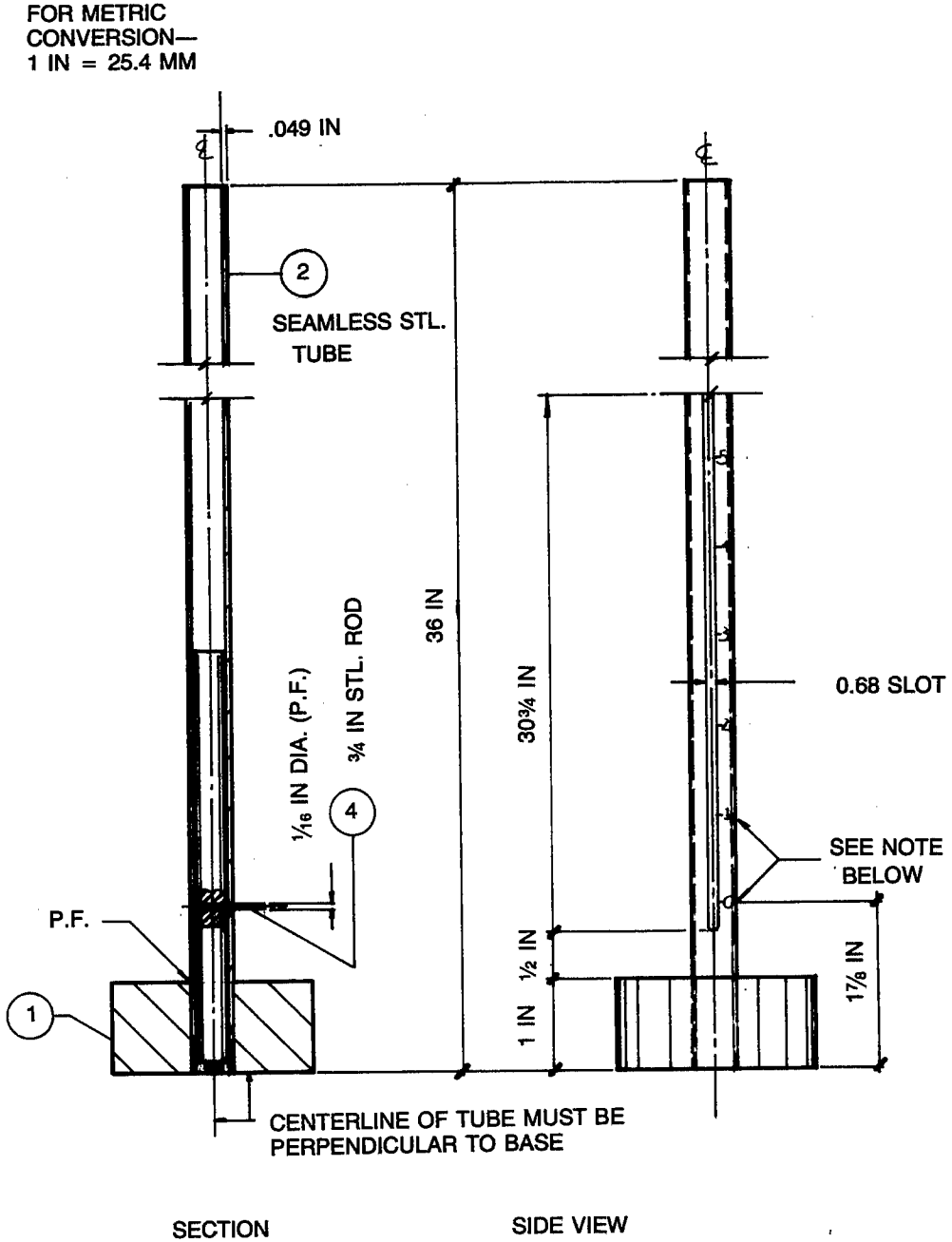
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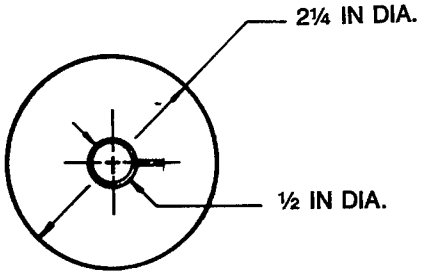
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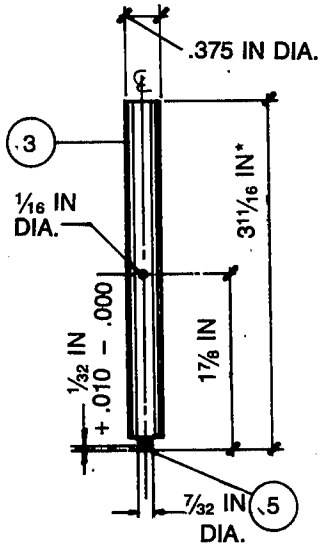


NOTE:
FOR METRIC
CONVERSION—
1 IN = 25.4 MM




TOP VIEW




PLUNGER DETAIL

| PARTS LIST | | |
|---|---|---|
| NO. | PART | QUALITY |
| 1 | POLYSET BASE | 1 |
| 2 | GUIDE TUBE | 1 |
| 3 | PLUNGER | 1 |
| 4 | HANDLE | 1 |
| 5 | BALL | 1 |

*3 11/16 IN LENGTH MAY VARY TO MAINTAIN 50 GMS. WT. OF PLUNGER

5 MM DIA. BALL FIT IN SOCKET AND SWAGE TO RETAIN

P.F. = PRESS FIT

NOTE:
SCRIBE LINES AND ENGRAVE NUMBERS "0" TO "30" AT 1 IN INCREMENTS BEGINNING 1⅞ IN FROM BASE

**Figure 3-16**
**DART IMPACT TESTER**

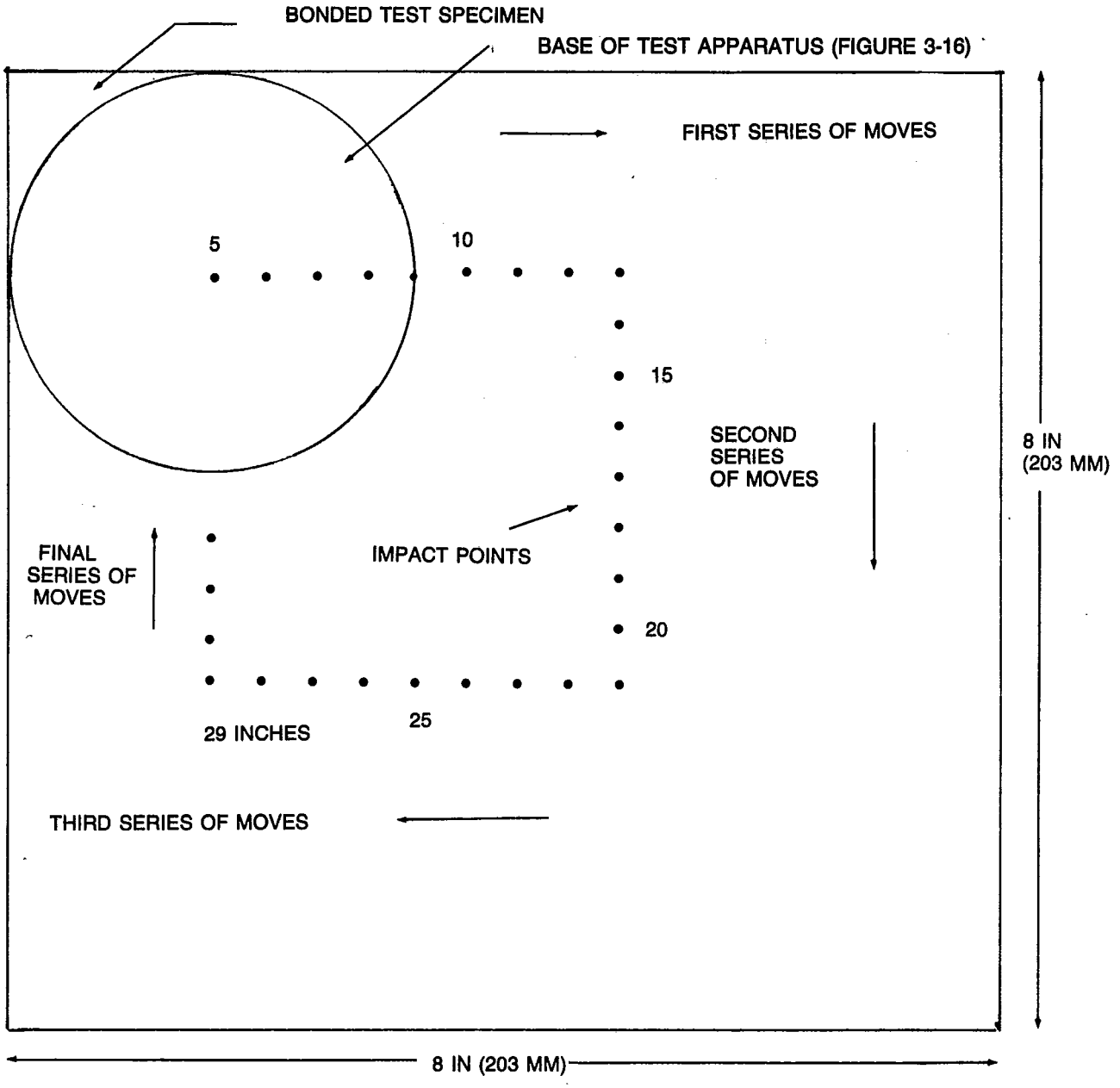



**Figure 3-17**
**PROCEDURE CLARIFICATION**
**FOR DART IMPACT RESISTANCE**

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# Section 4
# APPLICATION, FABRICATION, AND INSTALLATION

## 4.1 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 and gloss. 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 4 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 4 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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## 4.2 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 encompass such things as:

1. Proper adhesive spread
2. Proper cure time for thermosetting and polyvinyl acetate adhesives and proper drying, time for contact adhesives.
3. Use of proper bonding pressures
4. Use of proper fabrication techniques (see 4.6)
5. Proper conditioning of laminate substrate (see 4.4)

Like wood, a high-pressure decorative laminate has a grain direction, and its dimensional behavior is similar to that of wood (see Figure 4.1). When humidity varies, the width of a laminate undergoes greater dimensional change 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.

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## 4.3 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.

### 4.3.1 The Decorative High-Pressure Laminate

Laminates are of eight different types:

1. General-purpose,
2. Postforming,
3. Cabinet-liner,
4. Backer,
5. Specific-purpose,
6. High-wear,
7. Fire-rated, or
8. 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 designed for the specific fire-rated 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 recommendations 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 4-2 for an illustration of some of these types.

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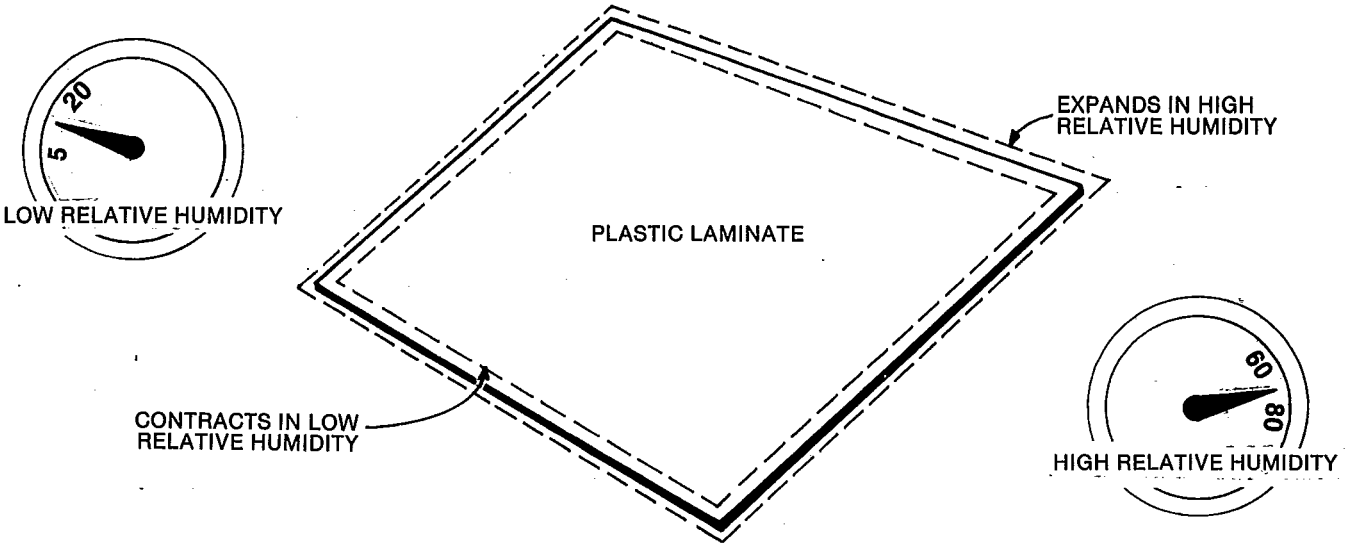



**Figure 4-1**
**HUMIDITY CHANGES**

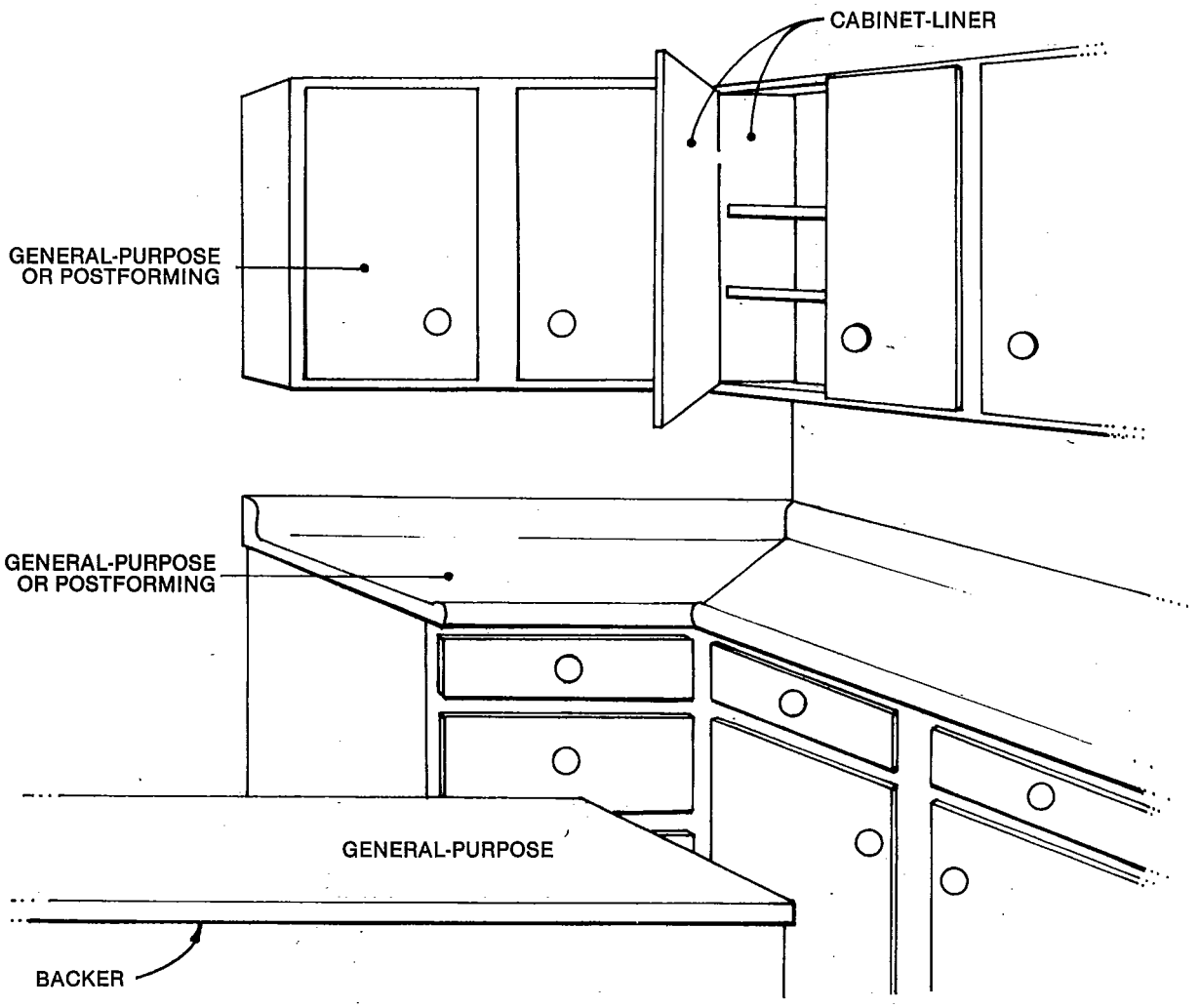



**Figure 4-2**
**TYPICAL TYPES OF LAMINATE USE**

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### 4.3.2 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 and upon the bonding facilities available. In all cases, the adhesive manufacturer's instructions for use should be followed closely. The following information for the individual types of adhesives is intended only as a supplement to the manufacturer's instructions.

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#### 4.3.2.1 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 185°F (85°C) for best results.
2. Resorcinol and phenol-resorcinol adhesives are recommended for use when moisture 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 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 gap-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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#### 4.3.2.2 POLYVINYL TYPES (WHITE GLUE)

Polyvinyl acetate (PVA) emulsion adhesives may be used for bonding laminates to wood substrates where resistance to moisture 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. There are catalyzed PVAs which are cured at high temperatures with improved performance.

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#### 4.3.2.3 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.

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.

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### 4.3.3 Factors Affecting Bonded Assemblies

Some factors affecting bonding are shown in Figure 4.3. Causes 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, and so forth. 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.

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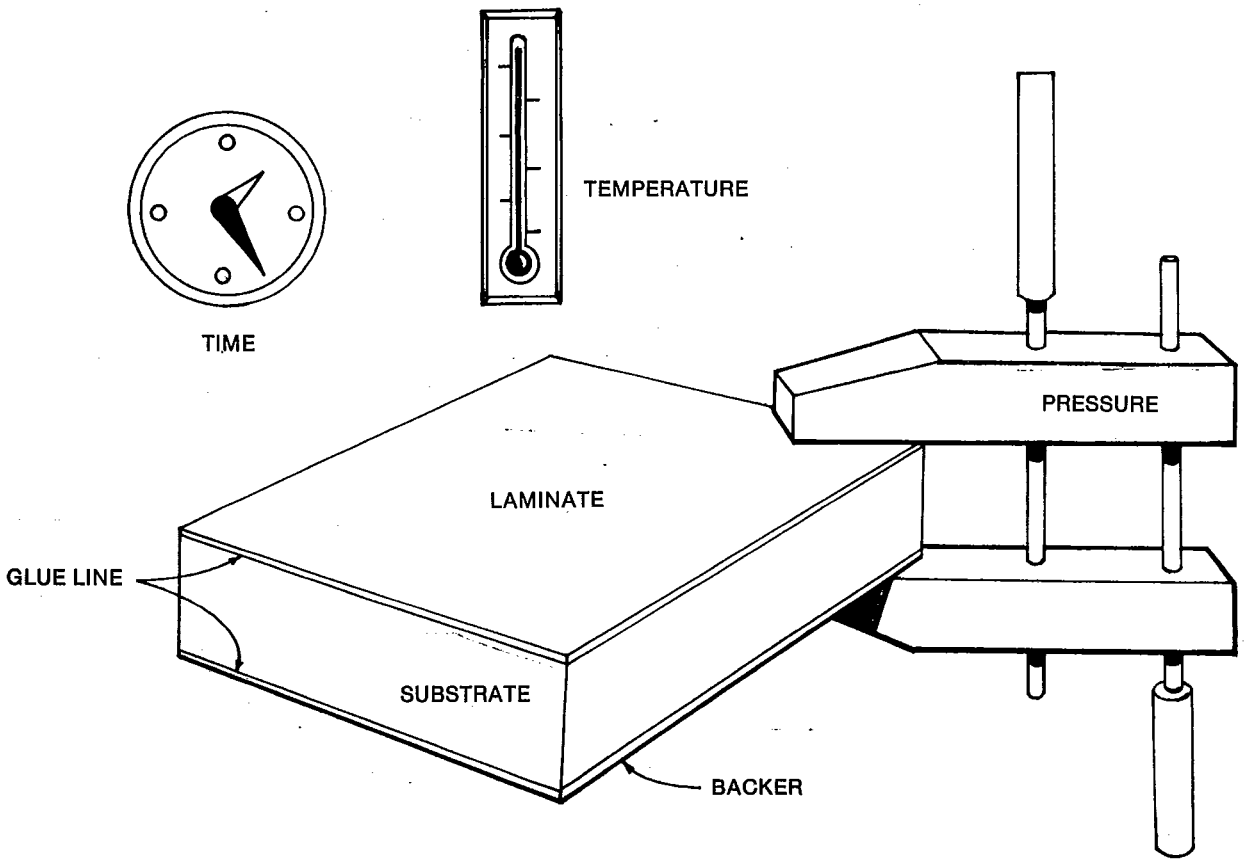



**Figure 4-3**
**FACTORS AFFECTING BONDED ASSEMBLIES**

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4. Bonding of surfaces under 70°F (21.1°C) - Unless otherwise indicated by the manufacturer, the temperature of the gluing area and all materials should be 70°F (21.1°C) 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 70°F (21.1°C) 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.
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 longhanded 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 x 8 feet (609.6 x 2438.4 mm). If larger panels are required, these should be shop-fabricated.

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### 4.3.4 The Substrate

Good quality particleboards, medium- and high-density fiberboards, and plywood 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 Figures 4.4 and 4.6. It should be noted that certain properties of the assembly are influenced by the density of the substrate. Plaster board, gypsum board, plaster, concrete, and similar materials are not recommended because their internal bond strength is not sufficient for this service.

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## 4.4 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 the new ones.

The following general information about conditioning should be noted:

1. Most problems which arise after fabrication and installation are due to differentials in expansion or contraction between the laminate and substrate (see Figure 4.4). 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 75°F (23.9°C) and at a relative humidity of 45 to 55 percent. Provision should be made for the circulation of air around the components.
2. Warp in the laminate 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

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they cannot be fed properly through glue spreading or bonding equipment.

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## 4.5 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.

### 4.5.1 Sawing

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

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### 4.5.2 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-20 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 1/4 to 1/2 inch (6.35 to 12.7 mm) wide. For straight cutting, the blade should be 1 to 1-3/4 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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### 4.5.3 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 4-5 and meeting the conditions of Table 4-1 have been found to be satisfactory.

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### 4.5.4 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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### 4.5.5 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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### 4.5.6 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 1/32 inch (2.38 mm) back from the cutting edge for a 1 inch (25.4 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.

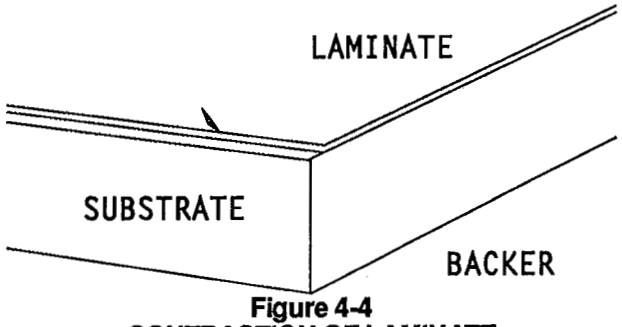



**Figure 4-4**
**CONTRACTION OF LAMINATE**

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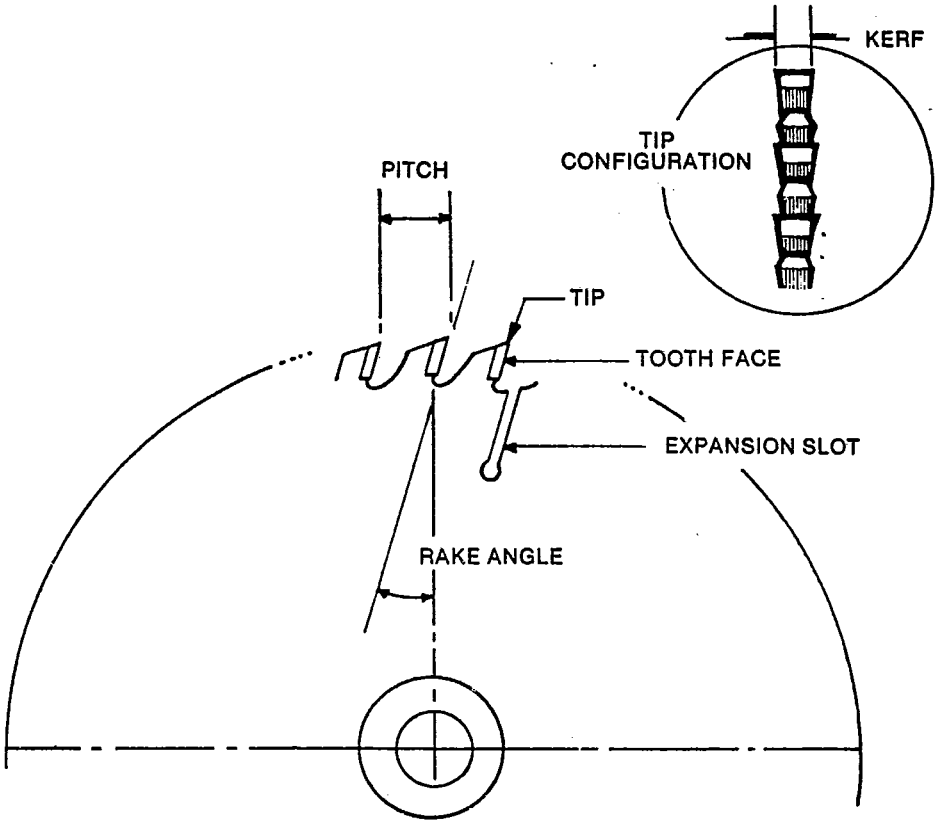



**Figure 4-5**
**SAW BLADES**

**Table 4-1**
**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 m) | 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 | 0.0684 to 0.110 in. (1.74 to 2.79 mm) | 0.094 to 0.135 in. (2.39 to 3.43 mm) |

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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 (0.5 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 hole saw or flycutter. For very large holes, a router and template should be used.

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## 4.6 GENERAL RULES FOR FABRICATION AND INSTALLATION

### 4.6.1 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, or
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 70° to 75°F (21.1° to 24°C) and a relative humidity of 45 to 55 percent (see Figure 4-6) 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 4.3.2).
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.

   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 4-7).

   Polyvinyl acetate, urea, resorcinol, and similar adhesives generally require approximately 40 pounds per square inch (275.8 kPa). Proper pressing should produce a tiny bead 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.

   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 receptacles, ranges, sinks, grills, windows, chopping blocks, "L" shaped counter tops, and so forth) all inside corners should be smoothly rounded using a minimum corner radius of 1/8 inch (3.175 mm) A router is an ideal tool for making cutouts (see Figure 4-8).
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.

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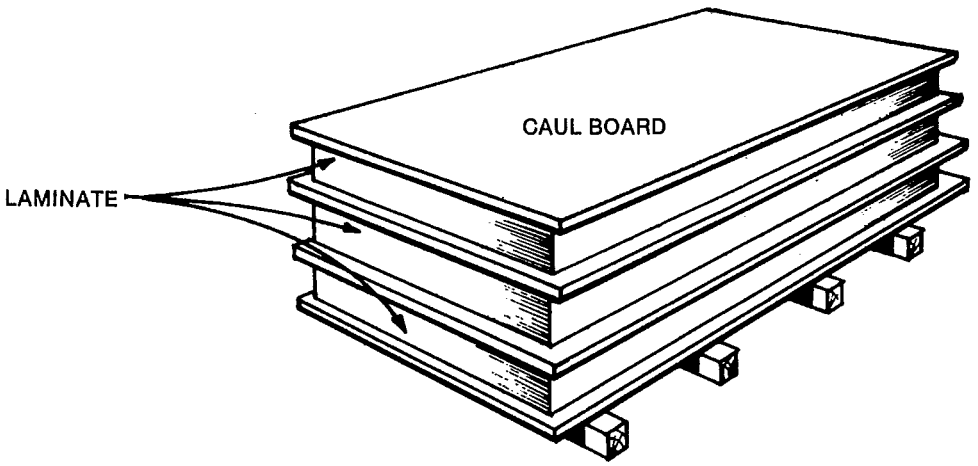




**Figure 4-6**
**CONDITIONING OF LAMINATE**

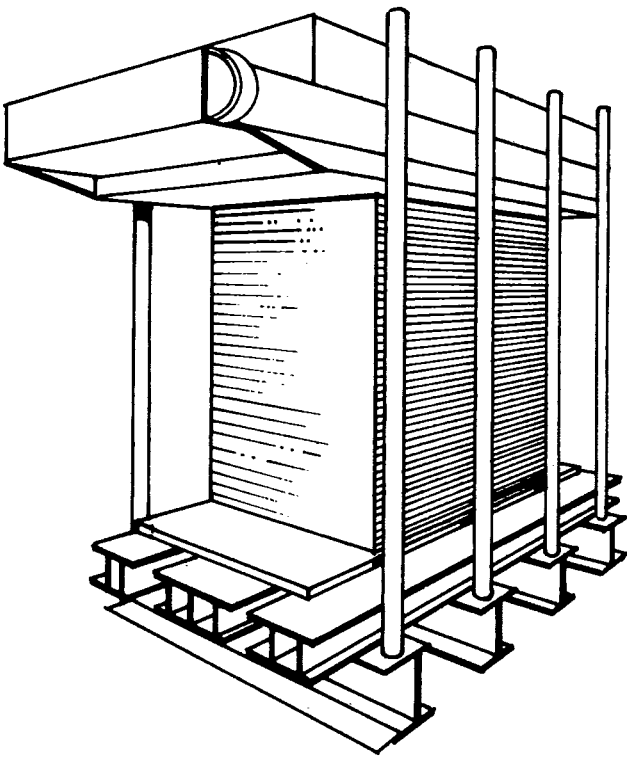


**Figure 4-7**
**PRESSURE CLAMPS**

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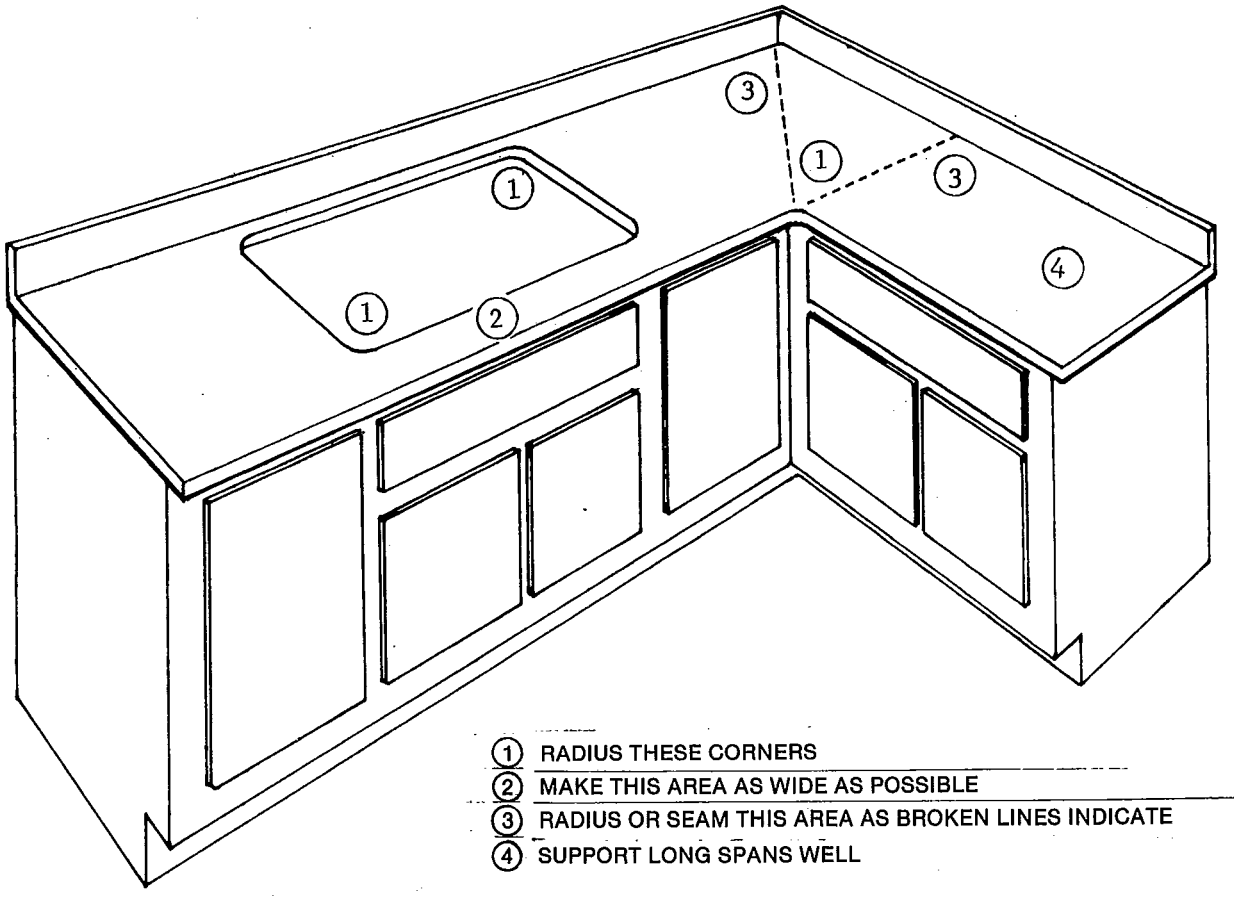



**Figure 4-8**
**LAMINATE CUTOUTS**

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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. Backsplash seam areas on countertops which are exposed to spilled water or other fluids should be waterproofed to ensure a tight seal. Rabbet-and-groove construction with a water-proofing adhesive or a receiving-type molding with caulking compound should provide satisfactory protection
10. When laminate is bonded to a substrate, precaution should be taken to prevent warping of the assembly. 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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### 4.6.2 Installation on the Job (See 4.4)

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 particleboard or plywood 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 4.6 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 with a roll 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 4-9). 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 4.5 and 4.6.

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## 4.7 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 materially, 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 4-10). Postformed cabinet doors (see Figure 4-11) generally need a backer or decorative laminate to minimize warpage. However, the materials 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 backsplash 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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## 4.8 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 may dull tools more rapidly than wood, it may be necessary to sharpen tools frequently as dull tools 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 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.

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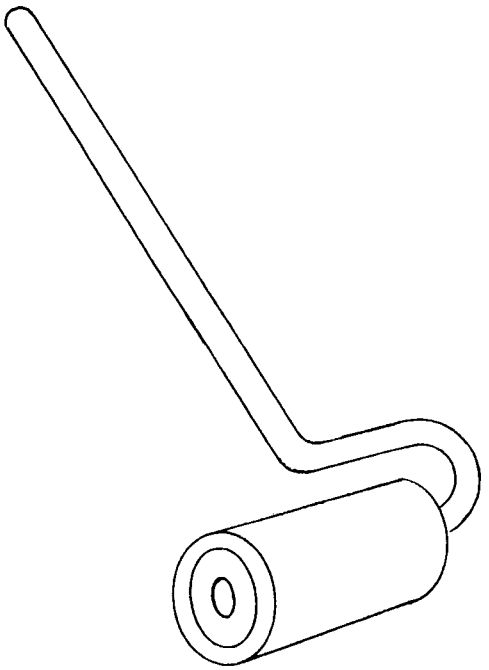


**Figure 4-9**
**"J" ROLLER**

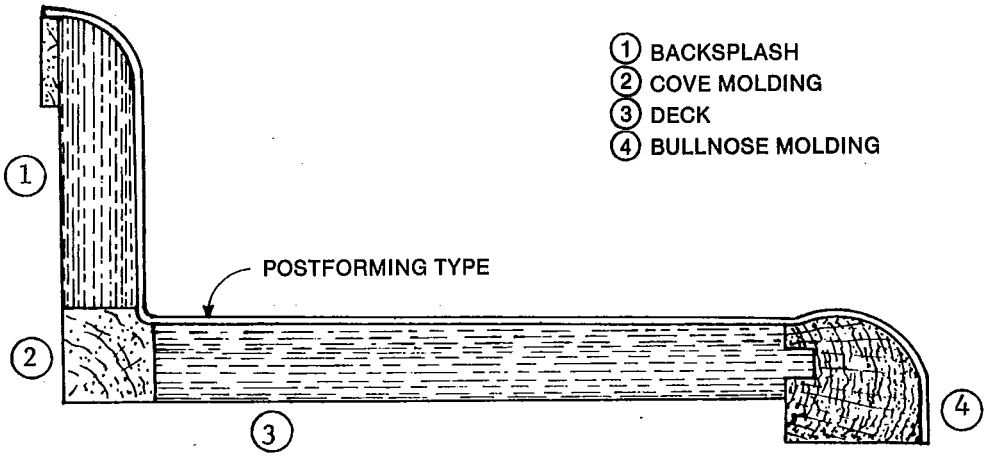



**Figure 4-10**
**TYPICAL POSTFORMED TOP**

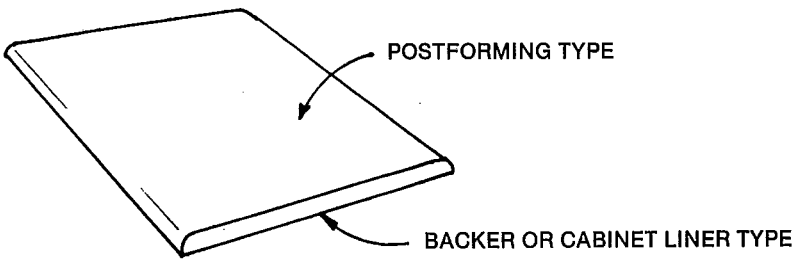



**Figure 4-11**
**CABINET DOOR**

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3. Seal exposed core edges with metal moldings, by self-banding with laminate, or by waterproofing compounds, and so forth, where they are exposed to water or continually high humidity. This is particularly applicable to joints in work tops, counters, bars, sink tops, baths, shower areas, and so forth.
4. Avoid making cutouts in bonded assemblies where the entire core is cut away, thus leaving the laminate unsupported. Cutouts may be made, but some portion of the core material should remain as a support. In sawing angle cuts, such as in "L" shaped counters, care should be exercised so that the laminate is not undercut. All inside corners should be rounded to prevent corner cracking.
5. Avoid making miter joints at 45° angles for outside corners of wall paneling, applied edges of tops, and so forth. 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 1/8 inch (3.175 mm) or larger in the corners is recommended to minimize corner cracking. The largest practical radius should be used.

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## 4.9 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 4-12) 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 to 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.
2. Opening of joints or seams (see Figure 4-13) may be caused by improper conditioning and bonding. Allowance should be made for some movement of the laminate.
3. Separation of the laminate from the substrate (see Figure 4-14) 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 adhe-

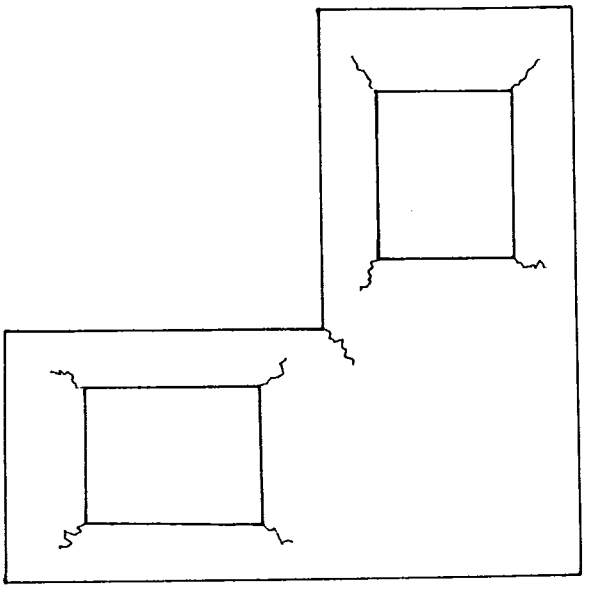


**Figure 4-12**
**CRACKING OF LAMINATE**

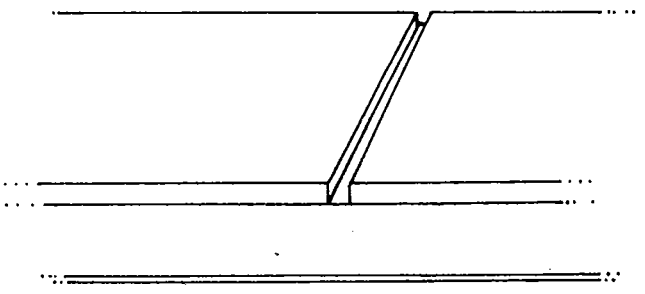


**Figure 4-13**
**OPENING OF JOINTS OR SEAMS**

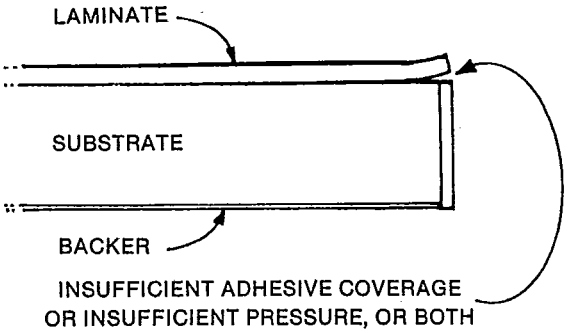



**Figure 4-14**
**SEPARATION OF THE LAMINATE FROM THE SUBSTRATE**

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sives in 4-3.3. 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.

4. Blistering or bubbling of the laminate surface away from the substrate (see Figure 4-15) can be caused by starved glue line, improper conditioning, and inadequate pressure or drying. When contact adhesive 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.

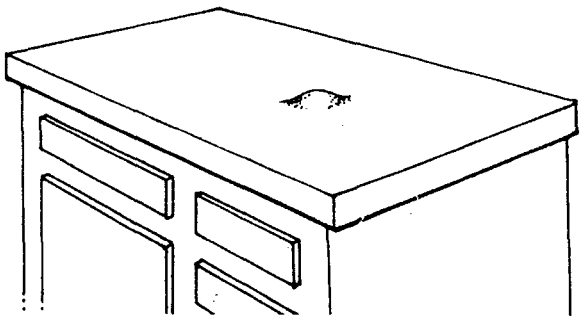


**Figure 4-15**
**LAMINATE BLISTERING OR BUBBLING**

5. The forming of a blister or bubble over a small area, often accompanied by a darkening of the laminate (see Figure 4-16) 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 150°F (65.6°C).

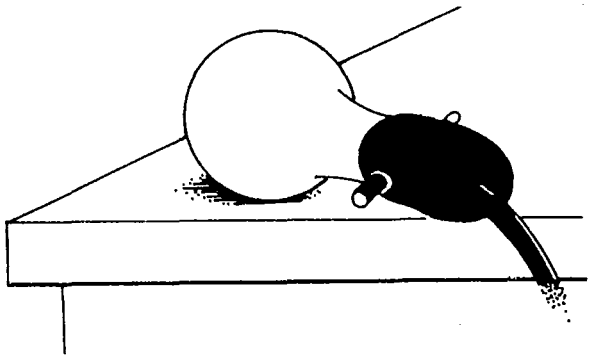


**Figure 4-16**
**EXPOSURE TO HEAT SOURCE**

6. Cracking of the laminate in the center of the sheet (see Figure 4-17) 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.

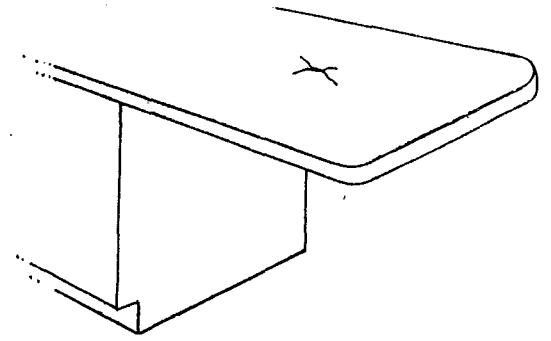


**Figure 4-17**
**LAMINATE CRACKING**

7. Warping of the assembly (see Figure 4-18) may be generally caused by unbalanced construction or unbalanced glue lines. Proper HPDL backer sheets should be chosen and aligned so that their grain direction is parallel to that of the face 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.

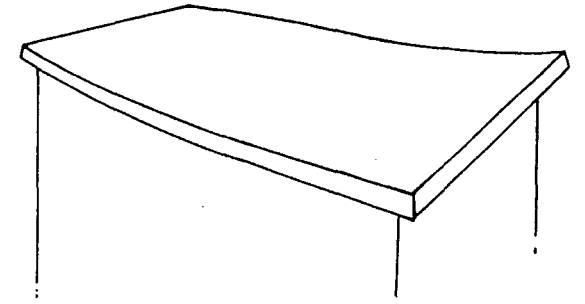


**Figure 4-18**
**LAMINATE WARPING**

## 4.10 Care and Maintenance of Laminate Surface

High-pressure decorative laminate (HPDL) surfaces are highly resistant to wear, scratching, boiling water, food

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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, soft, white 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. 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 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.
8. Avoid commercial cleaning products containing harsh chemicals that cause etching of the surface of the laminate.

   Products intended for cleaning sinks, ovens, stoves, tiles, bricks, toilet bowls, stainless steel, and ceramics that contain the following chemicals: hydrogen peroxide, hydrochloric acid, sulfuric acid, nitric acid, phosphoric acid, lye, sodium bisulfate, potassium permanganate, or other materials known to be strongly acidic or alkaline in nature should not be permitted to contact the laminate surface. 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. If the nature of the agent is unknown, the chemical manufacturer should be consulted.

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# APPENDIX A
## (Authorized Engineering Information 1-30-1991)
## CLEANSER SUITABILITY

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

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 1/4 to 1/2 inch (6.35 to 12.7 mm) spot cleaner 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.

For the rubbing evaluation, a straight line washability and abrasion machine, a cellulose sponge 3 x 4 x 1-3/4 inches (76.2 x 101.6 x 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, and so forth, should be used at full strength. 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.

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# APPENDIX B
## (Authorized Engineering Information 11-14-1985)
## PREPARATION OF SOILING AGENT

This Appendix describes the ingredients and procedures that should be followed in the preparation of the soiling agent specified in 3.12.

The following ingredients and quantities comprise the mixture for preparation of the soiling agent:

| | |
|---|---|
| Potting Soil | 1050 grams |
| Silica Gel | 450 grams |
| NaCl | 150 grams |
| Gelatin | 112.5 grams |
| Palmitic acid | 90 grams |
| Stearic acid | 45 grams |

These ingredients should be mixed by hand with a rigid spatula 1/8 × 1 × 16 inches (3.2 × 25.4 × 406.4 mm) in a suitable container until well blended. If necessary, the potting soil should be sifted through a sieve 1/8 inch (3.2 mm) mesh to remove large solid particles such as roots and bark, prior to measuring the quantity shown above.

The mixture, as prepared, should be ground in a ball mill for 12 to 24 hours or until the consistency of fine powder is achieved. The type of ball mill (rotary vs. shaker, steel ball vs. glass marble, large vs. small container) and the time of grinding should not alter the final consistency of the soiling agent.

Grinding should be sufficient to form a fairly fine-grained powder. Additional grinding could result in a further reduction in particle size which could cause increased difficulties in handling the product. For instance, it could become too easily suspended in the air and could be blown away; and it could result in increased difficulties in mixing with the other components.

The ground mixture should be transferred to a 2 gallon mixing container. The balls used for grinding should be removed. A fairly effective method of removing the grinding balls is to sift the ground mixture through a 1/8 to 1/4 inch (3.2 to 6.4 mm) mesh sieve.

The following components should be added to the mixture:

| | |
|---|---|
| Portland cement | 450 grams |
| Plaster of paris (china clay) | 450 grams |
| Carbon black | 45 grams |
| Red iron oxide | 7.5 grams |

The components and the mixture described above should be mixed until well distributed.

If the portland cement does not have a fine texture, it may require grinding.

The finely powdered dry components used in the mixture could easily be suspended in air. Therefore, care should be taken when transferring the mixture to minimize loss of material, and to minimize contamination of personnel and laboratory equipment. It is recommended that the transfer and mixing operations be conducted in a fume hood or other such enclosure having adequate ventilation.

The following components and their quantities as listed below should be measured into a suitable container:

| | |
|---|---|
| Oleic acid | 45 grams |
| Lanolin | 30 grams |
| n-octadecane | 30 grams |
| 1-octadecene | 30 grams |
| lauryl alcohol | 15 grams |

The mixture should be mixed and warmed on a hot water or steam bath until it liquifies in order to facilitate transfer and mixing.

The liquified mixture should be added to the dry mixture and mixed well.

The resulting mixture should then be weighed.

The weight of the mixture, under perfect mixing conditions, should be 3000 grams. However, small amounts of the components can be lost in transfer between containers due to suspension of fine particulate in the air and retention on the container(s) and grinding apparatus.

Tap water, equivalent in weight to 57 percent of the weight of the mixture should be measured. The water should be added to the mixture and should be stirred until uniform in consistency.

The resulting mixture comprises the soiling agent and it should then be stored in a wide mouth container. Plastic is recommended for the container as the mixture may expand after mixing which could cause fracturing of a glass container if used. The mixture also tends to "thicken" over time. The container should be kept tightly closed to avoid loss of moisture from the complete soiling agent.

The mixing of all the components could be done prior to their grinding in the ball mill and transferring to a suitable container(s). This change in procedure does not alter the consistency of the final product, nor does it alter the total time required to produce the soiling agent. However, combining all the dry components before grinding could increase the difficulty of transferring the dry mixture after grinding; could increase the amount of material lost during transfer; and could increase the contamination of the working area. It could also result in the need of a larger container(s) than previously described for ball milling.

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# NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced 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 their particular needs. 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.

*(Standardization Policies and Procedures, p. 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.

*(Standardization Policies and Procedures, p. 2)*

## 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.

*(Standardization Policies and Procedures, p. 8)*

## Categories of Standards

National Electrical Manufacturers Association Standards are of three classes:

1. NEMA Standard, which relates to a product, process or procedure 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.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

*(Standardization Policies and Procedures, pp 7 & 16)*

## 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, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

*(Standardization Policies and Procedures, pp. 7 & 16)*

## 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, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon. *(Standardization Policies and Procedures, pp 7 & 16)*

## 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.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

July 17, 1990

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