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Adhesives



—their growth, nature and uses in building construction

UNITED STATES GYPSUM

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CONTENTS

Chapter & Title	Page
1 ADHESIVES—BACKGROUND AND PRINCIPLES	3
Introduction	3
What is an Adhesive?	3
History of Adhesives	4
Recent Growth	5
Composition and Properties	5
Classifications	6
Principles of Bonding	8
Forces Affecting Bond Strength	8
Advantages	9
2 BUILDING ADHESIVES	12
Markets and Trends	12
Uses by Application	12
Regulatory and Testing Agencies	14
Classification Chart	15
3 U.S.G. ADHESIVES DEVELOPMENT	16
History of Growth	16
Technical Capability	16
Performance Testing	17
Manufacturing Facilities	18
Marketing Program	18
4 U.S.G. BUILDING ADHESIVES	19
Performance Properties	19
Applications	21
Products—Adhesives, Sealants	23
Test Results	26
Selector Chart	29
5 TOOLS AND EQUIPMENT	30
Hand Tools	30
Pumping Equipment	31
6 APPLICATION GUIDANCE	32
General Directions	32
Cartridge Preparation	32
GLOSSARY	34

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Chapter 1 ADHESIVES—BACKGROUND AND PRINCIPLES

Introduction

When early man discovered that blood caused his hair to stick together, the science of adhesion was born.

Most of the scientific development in adhesives, however, has been telescoped into the past twenty years. Adhesives have become so advanced that they were employed by aerospace scientists to hold together the space suits worn by the astronauts on the moon.

The science of adhesion and adhesives encompasses many disciplines and technologies—chemistry, metallurgy, physics, engineering—with the scope constantly broadening.

Concurrent with increased understanding of the nature and uses of adhesives, more and more industries are using them to replace less versatile products.

Although the growth of adhesives has been phenomenal, it has been especially so in the construction industry because they provide better and more versatile ways of bonding or fastening materials; contribute to lower manufacturing and installation costs; and improve the appearance and performance of materials.

This booklet covers three aspects of adhesives: (1) their growth and scope of usage, (2) the phenomenon of adhesion (bonding materials), and (3) construction adhesives—types, functions, current uses, and application techniques. The glossary (in rear) contains definitions of terms used in the science of adhesives to aid understanding of the technology employed.

The aim of this booklet is to provide a working knowledge for more effective use of adhesive products and processes as part of improving results in construction operations.

What is an Adhesive?

An *adhesive* is a specially formulated material used to bond two surfaces together. It contains a binder with other ingredients to help establish and control the bond characteristics.

The term *adherend* is generally used to refer to one body held to another body by an adhesive. The process of attaching one adherend to another with an adhesive is called *bonding*. The final construction of the two adherends and the adhesive is commonly called the joint assembly.

Less sophisticated materials such as rubber cement, glue, mucilage and library pastes are adhesives since they are bonding agents. However, caulks and sealants are not classified as adhesives. Their purpose is not to bond but to *fill a gap* (sometimes called a joint), to waterproof or weatherproof an opening.

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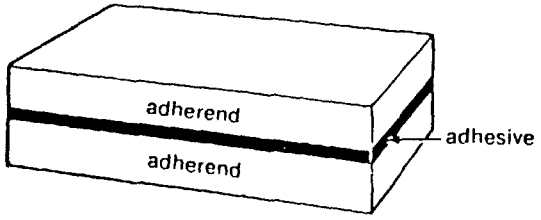

There is also a difference between a *binder* and an adhesive. The binder holds the other ingredients in the adhesive formulation together in proper ratio, and provides the primary bond to the substrates (adherends). A binder is usually made from polymers which are organic materials of high molecular weight that are either synthetic (neoprene rubber) or natural sap from rubber trees.

History of Adhesives

Although early man made use of the phenomenon of adhesion without really understanding it, he knew, from tribal warfare and from battling for survival, that hair matted to blood; or that insects became trapped in gum or soft pitch. He did not understand why, but he knew that two elements could be held together by certain sticky substances.

The earliest book of all, Genesis, records that bitumen, actually slime, was used as mortar by the builders of the Tower of Babel. History books refer to the bonding of papyrus by the ancient Egyptians with an adhesive made from plant gum. Veneered furniture and cases have been discovered recently in the tombs of the early Pharoahs. The adhesives used are believed to have either a starch or animal protein base. Similar types of adhesives are used today for sealing envelopes, coating postage stamps, and for veneering furniture.

The earliest known adhesives were simple organic glues, such as blood glues or fish glues, or glues made from gums or wheat paste. These came into general use during the Middle Ages, usually for attaching objects to wood surfaces.

Actually, very little happened in the way of developing a practical commercial adhesive until about 100 years ago, with the introduction of rubber cements.

Up until the late 1930's the only adhesives in common use were the same organic adhesives, such as animal, vegetable and casein glues, with casein glues being a by-product of ordinary milk.

World War II caused shortages in many natural and raw materials requiring industry to seek substitutes for materials vital to the war effort. Synthetic rubbers were developed for tires and gaskets, and the new technology also spurred breakthroughs in adhesive materials and applications.

Today, the use of adhesives has become so sophisticated it is commonplace for the wing structures of some airplanes to be held together by epoxy resin adhesives.

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Recent Growth

In industry, adhesives are used with a diversity of products such as paper, textiles, wood, rubber, plastics and metals and in varied industries such as aircraft, packaging, electrical and automotive.

Adhesives also serve many specialized applications. The dental profession uses them for restoring tooth structure, and physicians employ them in corrective surgical procedures. Photographers use bonding materials for processing film. Foundries apply binders for sand molding of metal castings. Specialized adhesives are also used for engine construction, insulation and finishing operations.

Today's automobile contains a minimum of 10 lbs. of adhesive; in the future, the entire car may be free from screws, welds or rivets. Shoe manufacturers are discarding nails and threads in favor of adhesive materials. The shipbuilding and toy industries utilize them—in some cases even for prime structural purposes.

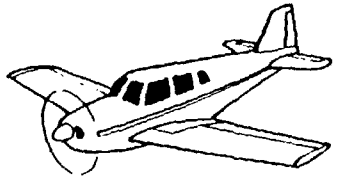
In construction, adhesives also have had extensive and varied applications for: roof construction and repair, plumbing, installation of subflooring, underlayments, finished flooring, floor covering, wall and ceiling tile, attachment of gypsum panels to wood or metal framing, bonding of laminates to various materials, adhering paneling, cabinetry, mouldings, trim and fixtures, and many other uses.

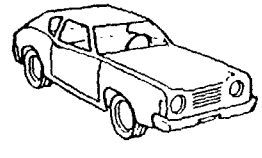
Composition and Properties

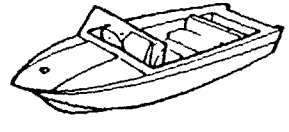
Most adhesives contain *five basic ingredients* which are combined in varying proportions depending on the function of the product:

Vehicle. The inactive liquid portion of the adhesive that provides the *fluidity* needed for mixing and applying the adhesive. The vehicle eventually evaporates, leaving the strong, dry adhesive which acts as the medium for attachment. There are two basic vehicles generally used—water and petroleum byproducts. These can be used independently or combined.

Binder. The substance that holds the other ingredients together and provides the primary bond to the substrates. The binder is usually made from polymers, natural or synthetic. The synthetics, such as neoprene, generally have superior characteristics.









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Fillers or extenders. The inert materials—dry powders of fine particle size—usually made of limestone (calcium carbonate), gypsum (calcium sulphate), sand (silica) or clay.

Viscosity control agents. The additives that make the material thick or thin. Viscosity is simply the *flowability* of the adhesive. A high (thick) viscosity is generally needed for a large bead or heavy application of adhesive. Low (thin) viscosities are essential when a thin film of adhesive is applied with a brush or roller to cover a wide area.

Preservative. This substance (such as formaldehyde) protects the adhesive from attack and spoilage by fungus or other microorganisms in the container and after application.

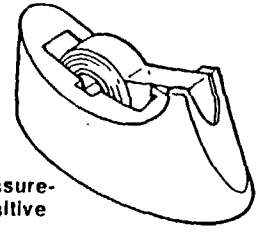
Manufacturers spend much research time and money to develop the proper combination of components or ingredients and the proper ratios of each. The composition of an effective adhesive is often fairly complex, particularly for some of the newer special-purpose products.

Classifications

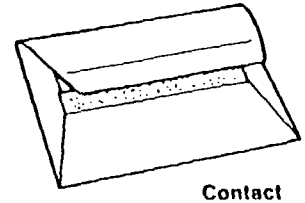
Adhesives may be classified in several ways; however, the method used here is by *application*. All adhesives fit into five broad groups—pressure-sensitive, contact, laminating, hot-melt and two-component types. These are basically in either liquid, paste or solid form.

Pressure-sensitive. A solid adhesive dependent on external pressure applied to the product to obtain bond which is instant but usually only temporary. Pressure-sensitive adhesives have a tendency to *creep* (move or flow slightly) under load or pressure, and in construction applications should be used only to hold the substrate together until the permanent adhesive dries and secures the assembly. In panel installation, pressure-sensitive adhesives (such as DURABOND Vinyl Foam Tape) eliminate the need for external bracing or an excessive number of mechanical fasteners, which are difficult to conceal. Other examples of pressure-sensitive adhesive products are masking or cellophane tape and the types used for self-stick labels and floor tiles. These products are not required to carry a load.

Contact. A liquid material, which when dry, has good affinity for self-adherence and remains tack-free to the touch. The two adhesively applied surfaces stick to each other upon contact or impact. Contact adhesives generally provide permanent or instant bond. They are easily applied



Pressure-sensitive



Contact

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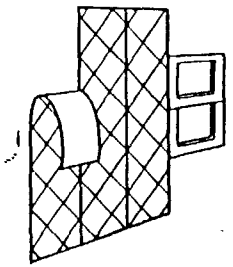
(usually in a liquid form), and their drying rate (elapsed time) can be controlled by proper selection of the vehicle. Examples of contact adhesives are DURABOND 600 or the types used for self-sticking envelopes or do-it-yourself shoe soles.

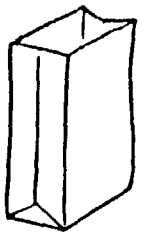
Laminating. A paste product used to bond two surfaces, requiring application to only one surface before joining. No predrying is required and the panels can be attached to existing wall surfaces or framing members immediately; however, some time is required for the assembly to achieve full strength. Laminating adhesives provide ease of assembly, the economy of fewer mechanical fasteners, application with a cartridge, notched trowel, brush or roller, and minimal cleanup when water-based. Examples of laminating adhesives are DURABOND 500 and white glue.

Hot-melt. Solid adhesives that require heat for proper bonding. The heat liquifies the adhesive, allowing it to be applied to the substrates. The bond is effected when the adhesive cools and solidifies. Hot-melt adhesives are generally 100% solids, without solvents that may release pollutants into the air, and the bond is temperature-dependent and not dependent on the evaporation rate of the vehicle. They offer fast assembly but have the disadvantage of bond loss when melt temperature is reached. Hot-melt adhesives are used in packaging, furniture assembly and for paper bag sealing.

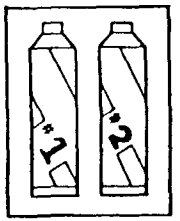
Two-component. This adhesive system is either liquid, paste or solid (usually made without solvent). The adhesive must be mixed with a hardening agent to effect the bond. After the adhesive and hardener are mixed, a chemical reaction between the two components produces the final bond. Two-component adhesives usually require no external heat, and provide high performance; the open time can be controlled by the type of hardener used. An example of this system is the epoxy adhesive kit sold in retail stores.



Laminating



Hot Melt



Two-component

These five groups can be simplified into two basic classifications—organic and inorganic:

Organic adhesives are of animal or vegetable origin such as animal hides, natural rubber or starch as well as organic man-made materials such as synthetic rubber and plastic. *Inorganic* adhesives are usually based on inert minerals such as silicates, clays and gypsum.

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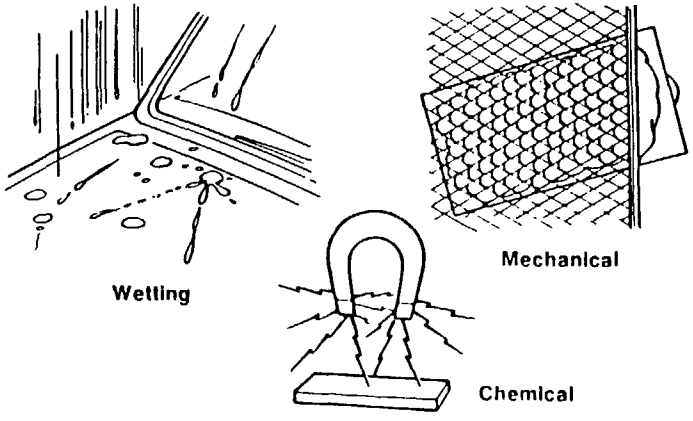
Principles of Bonding

The success or failure of any adhesive depends on its ability to adhere to the materials being bonded, and its own internal strength characteristics. Although the phenomenon of how one material adheres to another is still not well understood, what makes an adhesive *fail* to adhere is well known. Failure to adhere—or *bond*—means an adhesive system does not have the ability to bond adequately because of lack, or weakness, in one of the following characteristics:



Wetting. The adhesive's ability to wet (by water or other liquid) the adherend so that uniform surface contact is established. The dispersion of water on the hood of an unwaxed car is an example of good wetting; conversely, the beading of water on a waxed hood exemplifies poor wetting.

Mechanical. The facility by which a rough and irregular surface provides undercuts and a jagged condition conducive to locking—or keying—which induces mechanical meshing and a good bond. An example of good locking—or keying—is the way in which metal lath holds gypsum plaster.

Chemical. The ability of an adhesive to *want* to adhere, by an internal force, to another substance, just as the opposite poles of a magnet attract.

Forces Affecting Bond Strength

The inability of an adhesive to stick is failure in *bond strength*. The strength of the adhesive system is determined by two properties of the adhesive itself—adhesion and cohesion:

Adhesion is the property that bonds the surfaces of two substances together. The strength of this attachment is called adhesive strength.

Cohesion is the internal strength of the adhesive itself which can be stronger or weaker than the bond. This is called cohesive strength.

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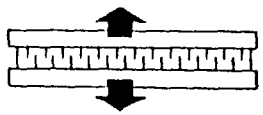
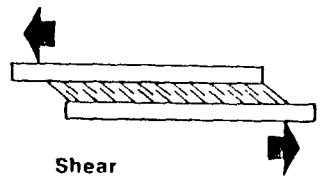
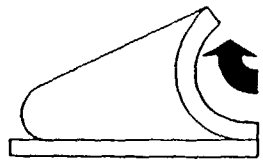


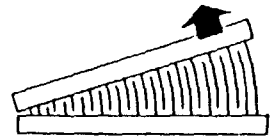
Tensile Strength



Shear



Peel Strength



Cleavage

The illustrations above show how an adhesive assembly can fail—or break—because of four forces that affect adhesive strength, cohesive strength or the adherend (the material to which the adhesive is being applied). The forces are:

Tensile Strength. The resistance of an adhesive to forces perpendicular to the bond line (a *pulling* action). Results are expressed in lbs./sq. in. at the time of rupture.

Shear. The force that causes different parts of an assembly to slip or slide, relative to each other, in a direction parallel to their plane of contact.

Peel Strength. The resistance to a load applied progressively to one *edge* of a flexible substrate. Normally the force is applied at an angle greater than 90° to the bond line.

Cleavage. The action or splitting at the adhesive line that results when a tensile or peeling force is applied to the bond line, at one edge of two rigid adherends being held together.

These forces are in turn affected by three human-related factors that are common causes of bond failure. The first is in the *improper choice* of the adhesive itself—using the wrong product for the job. The second is *improper preparation* of the surfaces, the result of lack of experience or carelessness. The third is *improper application* of the adhesive, resulting from lack of know-how or from the rush to finish the job.

Advantages

Adhesive bonding often fulfills the need for an easy and rapid joining of two adherends. In addition, it has other important advantages not found with mechanical fasteners such as nails, screws or rivets, or by means of soldering, welding or brazing:

1. More economical and more efficient attachment.
2. Concealed attachment not possible with most other fastening methods.
3. Reduction of mechanical fasteners (when desired).

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4. Smoother surfaces and contours obtained, such as in brake and clutch facings or aircraft assemblies, in which rivet heads or other projections affect performance.

5. More efficient and uniform transfer of stresses from one member to another than with mechanical fastenings, as in glued-wood roof trusses and helicopter rotor blades.

6. The design of better products by taking advantage of the best properties of each component. Examples are: light but strong sandwich panels, flush doors, metal-faced plywood, adhesive-bonded rubber mounts and combinations of wood, paper, metals, plastics, rubber and other materials.

7. Reduced corrosion of joints between dissimilar materials by decoupling of metal surfaces.

8. Better sealing in joints than with mechanical fastenings. Examples are bonding of extrusions to seal edges of sandwich panels; the fabrication of watertight wooden boats.

9. Reduced weight, as in aircraft assemblies, by the use of thinner gauges of metal reinforced around cutouts and along edges. Stiff, rigid, but lightweight panels with thin skins and honeycomb cores have been effective for this purpose.

10. Fewer problems with misaligned or uneven adherends such as twisted studs and offset framing members. Adhesive provides a pliable gap-filling bridge between panels and distorted framing and is readily compressed over protrusions.

11. Greater strength of assemblies and systems, usually superior to those employing only mechanical fasteners. In the case of panels nailed to framing, tests have shown adhesive bond can provide as much as 100% greater resistance to tensile pull-off forces and more than 50% greater resistance to shear.

12. Resistance to racking or other live forces such as occur from shrinkage or expansion and contraction of substrates, due to the retained flexibility of the properly formulated adhesive.

13. Fewer fastener imperfections by reducing the number of mechanical fasteners required.

14. The property of the proper adhesive to eliminate bleeding of most surfaces, and prevent rusting or weakening of the bond line.

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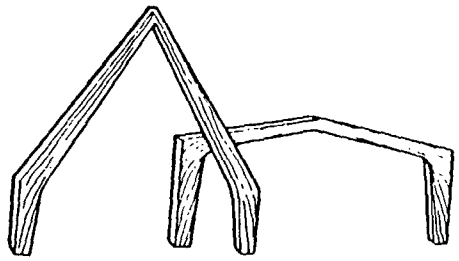
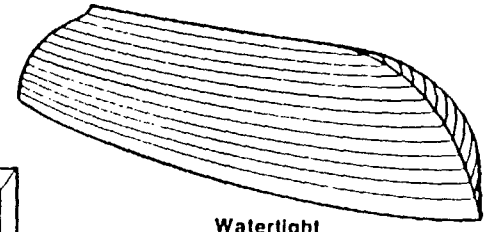
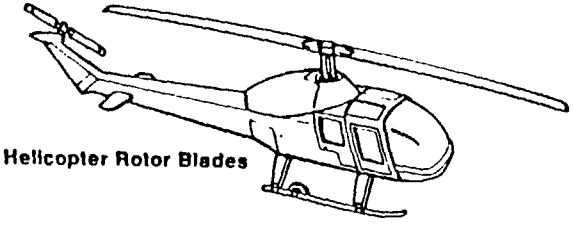


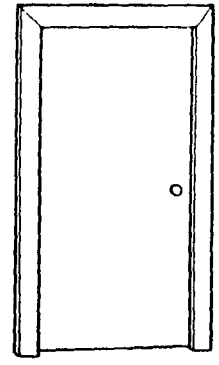
Glued-wood Roof Trusses



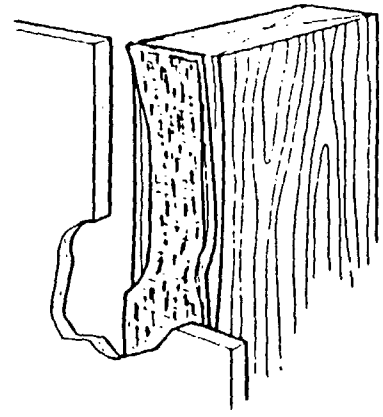
Watertight
Wooden Boats



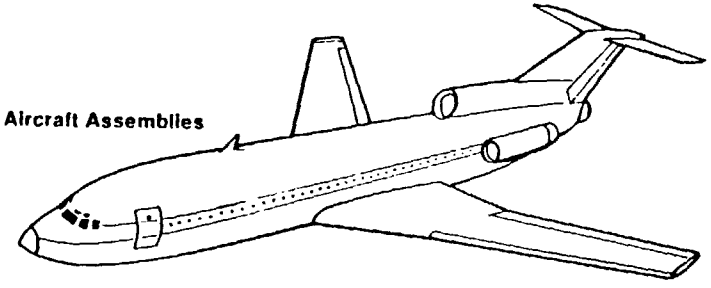
Helicopter Rotor Blades



Flush Doors



Gap-filling Bridge between
Panels and Distorted Framing



Aircraft Assemblies

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Chapter 2 BUILDING ADHESIVES

Markets and Trends

As one of America's growth industries, the adhesive business already exceeds $900 million in annual sales. Of this total, construction adhesives account for more than $180 million.

In 1963, industry sales were about $90 million and three years later, they had increased to $475 million. By 1971, the figure was $700 million. With the market showing more than *15% growth yearly*, sales volume is expected to reach $1-1/2 billion by the end of the 1970's.

In certain applications, such as flooring and wall tile, adhesives are accepted as much a part of the building process as are bricks, mortar or concrete. The versatility of epoxy resin adhesives in structural uses is now widely recognized. In the future, the major expansion of adhesive application will come from wider usage in all forms of building. The illustration (page 13) shows their prevalence in residential construction. The products include panel and stud adhesives, ceramic tile adhesives, resilient floor and carpet adhesives, floor joist adhesives, and specialty product adhesives.

Uses by Application

Eleven different types of adhesives are used in construction. Each is designed to do a specific job:

1. **Bonder.** Provides concrete-to-concrete or plaster-to-plaster bond when applying fresh concrete or plaster over existing dry surfaces.

2. **Framing.** Attaches panels (such as gypsum) to wood or metal framing.

3. **Insulation.** Adheres insulation materials such as rigid foam, mineral wool or glass fiber to surfaces to be insulated.

4. **Panel.** Bonds panels to wall or ceiling subtrates using a contact-type adhesive.

5. **Flooring.** Applies various flooring materials such as plywood, floor underlayment, floor tiles and carpeting.

6. **Ceramic Tile.** Joins ceramic or plastic wall tile to surfaces in bath and kitchen areas.

7. **Wallcovering.** Attaches vinyl film or wallpaper to surfaces or walls. Based on wheat paste, dextrin or organic polymers.

8. **High-Pressure Laminating.** Bonds plastic laminate sheet materials to counter tops or cabinet faces.

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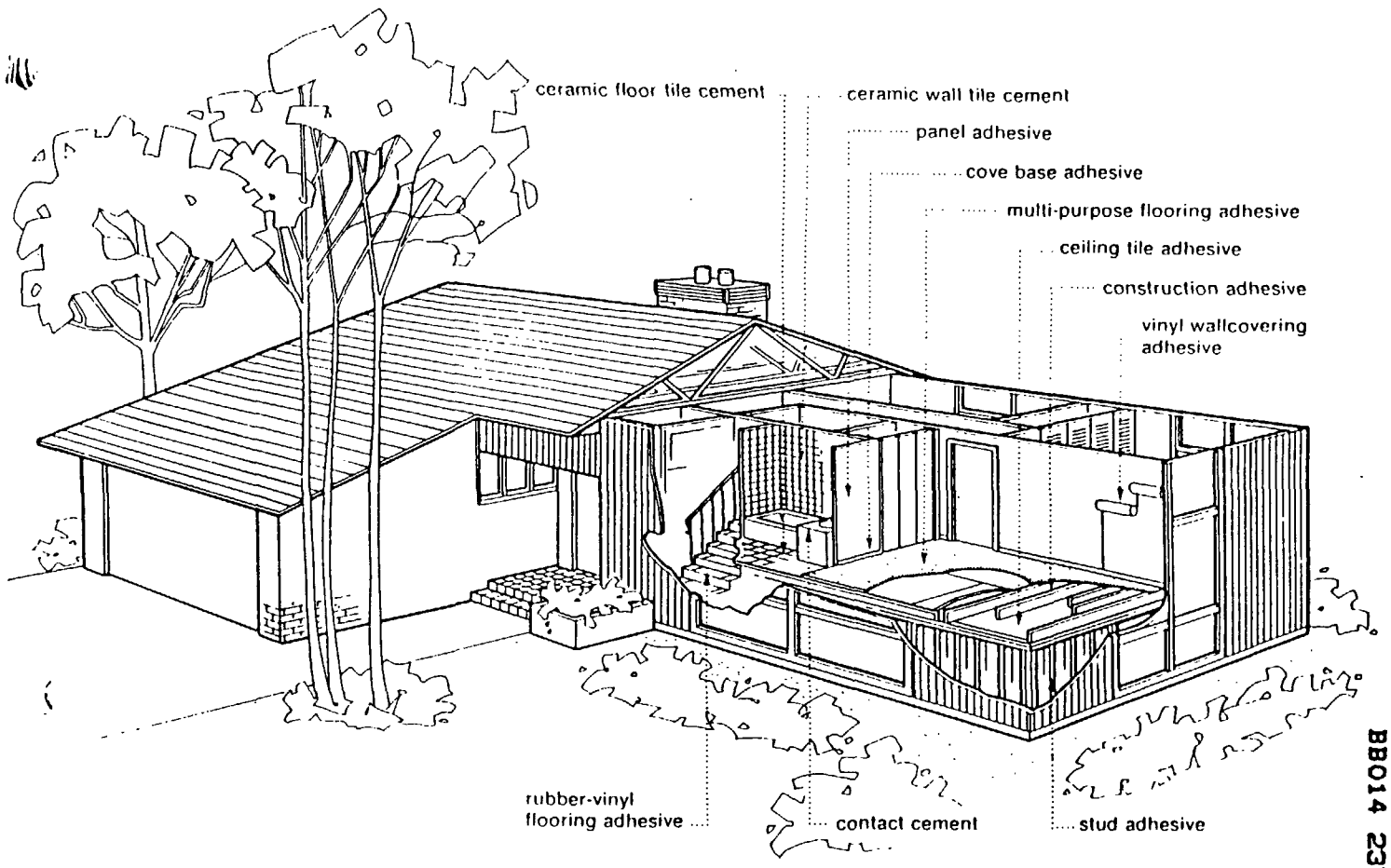
ceramic floor tile cement
ceramic wall tile cement
panel adhesive
cove base adhesive
multi-purpose flooring adhesive
ceiling tile adhesive
construction adhesive
vinyl wallcovering adhesive
rubber-vinyl flooring adhesive
contact cement
stud adhesive

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9. Trim and Moulding. Used to affix trim to the base in bathroom or kitchen areas. Generally mastic- or contact-type materials.

10. Ceiling Tile. Adheres ceiling tile to solid base where mechanical fasteners or grid systems are not used.

11. Utility or General Purpose. Attaches various materials and includes white glue, mucilage and bookbinding pastes, rubber cement and similar products.

The chart opposite shows how these 11 building adhesives fit into the five basic classifications described on page 6 and 7, and the three basic forms—liquid, paste or solid.

Regulatory and Testing Agencies

The chief code bodies, public agencies and trade associations involved with adhesives are:

NEMA - National Electrical Materials Assn.

ASTM - American Society for Testing Materials

APA - American Plywood Assn.

Federal Specifications Groups

NAHB - National Assn. of Home Builders

ICBO - International Congress of Building Officials

BOCA - Building Officials Conference of America

SBC - Southern Building Congress

HUD - Dept. of Housing & Urban Development (includes FHA—Federal Housing Administration)

NEMA has responsibilities for establishing standards concerning high-pressure laminates.

ASTM has established bonding standards for stud and drywall adhesives for the building industry as well as other adhesive standards for nonbuilding applications.

APA under AFG-01 has established a procedure for bonding plywood to floor joists using fewer mechanical fasteners and wider floor joist spacings.

Federal Specifications Groups are numerous and deal with all types of adhesives.

NAHB, ICBO, BOCA, SBC, HUD and **FHA** are primarily concerned with building materials and usually comply with the specifications and standards set by the four groups listed above.

The Ceramic Tile Assn. also sets certain standards for ceramic and plastic tile application in bathrooms and kitchens—two areas in which the use of adhesives is increasing.

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Classification of Building Adhesives

Type of Adhesive	Form	With Vehicle			Without Vehicle	
		Pressure-Sensitive	Contact	Laminating	Hot-Melt	Two-Component
Bonder	Liquid			X		
Framing	Paste, Solid	X		X		
Insulation	Liquid, Paste, Solid			X	X	X
Panel	Liquid, Paste		X	X		
Flooring						
Subfloor	Paste			X		
Underlayment	Paste			X		
Resilient	Paste			X		
Wood	Paste			X		
Carpet	Liquid, Paste, Solid	X	X	X		
Ceramic Tile	Paste			X		
Wallcovering	Liquid, Paste, Solid	X	X	X		
High-Pressure Laminating	Liquid, Paste, Solid		X	X	X	
Trim & Moulding	Paste			X		
Ceiling Tile	Liquid, Paste, Solid	X	X	X		
Utility or General Purpose	Liquid, Paste, Solid	X	X	X	X	X
All Other — Glass, etc.	Liquid, Paste, Solid			X	X	X

BB014 2375

Chapter 3 U.S.G. ADHESIVES DEVELOPMENT

History of Growth

In 1950, United States Gypsum Company introduced the first drywall stud mastic for attachment of gypsum panels to wood studs with the aid of mechanical fasteners. It was primarily a gap-filling material between the panels and the studs to provide a solid wall and minimize panel "rattle." Full mechanical fastening was still necessary.

In early 1962, U.S.G. marketed the first drywall stud adhesive designed to eliminate 60% of the mechanical fasteners needed for attaching panels to framing. Throughout the decade, the Company developed and experimented with formulations for internal use, primarily for lamination of facing materials such as vinyl films and aluminum foil to gypsum panels. Products also were perfected for laminating predecorated paper, mineral fiber board and wood fiber board.

DURABOND 200 Drywall Stud Adhesive, a solvent-based formulation, was introduced in 1969. Soon afterward came DURABOND 300, its counterpart in performance with the added safety of a water-based formulation. Both products provided up to 100% more tensile (pull-off) strength and 50% more shear strength than nail-attachment systems. They also reduced the need for ceiling and wall fasteners to a minimum.

At about the same time, U.S.G. released DURABOND 500, a mastic laminating adhesive, and DURABOND 600, a liquid contact adhesive.

In 1971, to further its sales growth in the expanding adhesives business, the Company enlarged production facilities at Gypsum, Ohio, Nashville, Tenn. and Toronto, Ont. In the same year, it acquired Chicago Mastic Company, Rosemont, Ill. Three years later, U.S.G. added the Permalastic Products Co., a division of Firestone Tire & Rubber Co. with two modern plants.

Because of the growing product line and its promising potential, U.S.G. in 1974 formed a separate Adhesives Division to direct further expansion and extend its service to the market.

Technical Capability

A unique, 250,000-sq. ft. Research Center in Des Plaines, Ill. houses the finest scientific equipment for development of U.S.G. adhesives for the building industry.

Every ingredient comprising a U.S.G. adhesive formula is carefully analyzed and precisely mixed. Sophisticated machines are used for performance evaluation and for making sure adhesives are uniform when applied.

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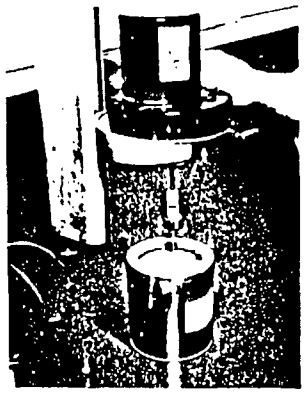
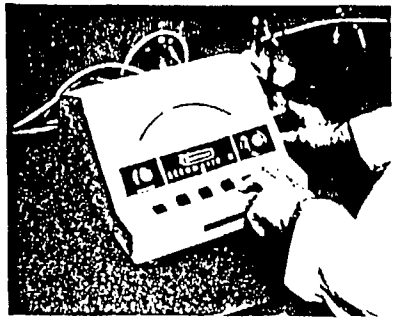


Viscometer



pH machine



Instron

Special equipment is used for measuring the pH factor which provides proper stability to adhesives.

A Viscometer is used for measuring viscosity (stiffness or fluidity) which is vitally important in making the adhesive bond properly.

An Instron machine checks the various tests for tensile, cleavage and shear strengths.

An environmental chamber enables technicians to test bond line or the adhesive in various temperatures from minus 200° to plus 600°F. to determine performance under various climatic conditions.

Constant-temperature rooms simulate temperature conditions wherever U.S.G. adhesives may be stored or applied. There are a "75-50" room, which maintains a constant climate of 75°F. and 50% relative humidity, and a comparable "90-90" room.

Performance Testing

Competitive testing is a never-ending job at the U.S.G Research Center. Tests for comparative shear strengths, bridging characteristics and aging are typical of the regular checks and analysis which adhesives undergo.

The rubber mill and paste mixer, for example, blend different rubber samples and compound them to discover the best kinds of rubber for adhesive formulas.

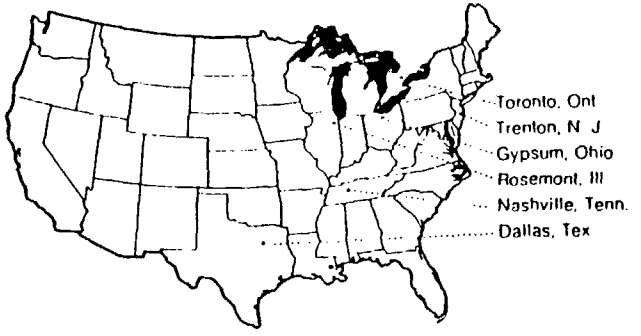
BB014 2377

In the Center's structural section, racking tests are performed on wall assemblies to determine shear strength. U.S.G. technicians have established that an adhesive-applied wall may be designed to be *three to five times stronger* than a wall using mechanical fasteners.

Manufacturing Facilities

U.S.G. adhesives are produced at six plants located in the United States and Canada, and warehoused at various points for prompt service.

Plant Locations



Marketing Program

U.S.G. adhesive products are marketed nationally through the Company's Gypsum, Consumer and Industrial Groups, the Adhesives Division, and in Canada through a subsidiary, Canadian Gypsum Company.

Through various product groups, U.S.G. sells adhesives to the construction, commercial, industrial and consumer markets. The Adhesives Division markets products for flooring and wallcovering, construction bonding and sealing, and for industrial applications such as automotive, insulation, metal and plastic fabricating, and packaging. The line includes adhesives for erecting and laminating gypsum board and prefinished paneling, and for uses with carpeting, vinyl floor tile, ceramic wall tile, ceiling tile, tileboard, mouldings and furniture assembly.

A new retail line of DURABOND products, introduced in 1974, is distributed through home centers, building supply and paint stores. It encompasses surface preparation items, caulking compounds and adhesives designed and packaged for home use by do-it-yourself customers.

Because of their established reputation with professional contractors and the completeness of the new retail line, U.S.G. adhesives and the DURABOND label are becoming one of the fastest-growing product groups in the building field. They are recognized by tradesmen and consumer alike as exceptional in performance and value.

United States Gypsum has a unique advantage over most adhesive producers in the ability to formulate adhesives as one of the components it supplies to make up complete building systems. Thus the product is precisely tailored to its application.

BB014 2378

Chapter 4 U.S.G. BUILDING ADHESIVES

Performance Properties

DURABOND Drywall Adhesives are formulated for specific systems and applications and provide a complete line of field-tested products for wall and ceiling construction. They consist of DURABOND 200, 300, 500 and 600 Adhesives, Panel and Multi-Purpose Adhesives, and DURABOND Vinyl Foam Tape. Each offers the user the advantage of dealing with a single manufacturer who supplies all the components of the finished wall or ceiling—gypsum panels, drywall screws and adhesives, other metal accessories, joint treatment and paint—all made by United States Gypsum to *work together*.

An adhesive is only as good as the properties provided in its formulation. In the case of DURABOND Adhesives, these properties have been proven superior in field experience as well as in the laboratory.

First, good bonding requires a product that gives high performance in the properties described below as they affect the specific application for which the adhesive is intended.

Bridging. The property that allows the adhesive to bridge the gap between two irregular substrates such as warped plywood or a twisted stud. Important because true or parallel substrates frequently cannot be obtained.

Aging. The ability of the adhesive to retain its bonding characteristics despite the effects of age-inducing oxygen from the air. The performance of the adhesive assembly is dependent on this property. Because asphalt tends to embrittle an adhesive, products containing this material have poor aging property.

Open time. The usable time available for making an adhesive assembly. Open time and strength properties are dependent upon each other, so it is important that open time is adequate for the job.

Nonskinning time. The time in which the surface of the adhesive forms a skin. If the skin hardens too quickly, the adhesive will not wet the substrate properly to effect strong surface attachment.

Consistency or Viscosity. The ability of a material to flow. A stud adhesive should have a buttery viscosity for cartridge gun application; a laminating adhesive requires low viscosity (more fluidity) for roller or brush.

Legging. The capacity to form legs to bridge the gaps between surfaces to be bonded. Legging speeds drying and is important primarily in contact-type panel adhesive.

Wetting. The ability of an adhesive to wet (or distribute itself over) the surface which it is bonding. An essential

BB014 2379

property in that it maximizes the points of contact between the adhesive and the adherends (substrates).

Adhesion. The strength to bond the surfaces of two substrates together. This property largely determines the bonding power of the adhesive.

Cohesion. The internal strength of the adhesive to hold itself together; can be stronger or weaker than the bond. Cohesive strength is another important factor in determining the strength of an adhesive system.

Controlled absorption. Constitutes the adhesive's ability to penetrate or strike into the substrate. Important in providing mechanical, chemical or surface attachment.

Nonstaining. This quality permits the substrate to be satisfactorily painted when some adhesive remains on the surface. Asphaltic products, in general, stain or bleed through the painted surface.

Shelf life. The period of usability of an adhesive after being stored in an unopened container. One year is generally considered good.

Color. Provides identification of the product being used and is important when the adhesive is painted after drying.

Mildew resistance. The capacity to combat mildew and bacteria attack which can severely limit long-term bonding characteristics of the adhesive and the bond line.

Moisture resistance. The quality that provides permanence by resisting humidity and protecting the performance of the installation or application.

Flame resistance. Ability to resist fire and eliminate the hazards of open flame during use. After drying, most adhesives will burn when subjected to direct flame; however, water-based adhesives offer the advantage of nonflammability in the wet stage.

Cleanup. Facility of the adhesive to be cleaned off quickly and easily, while providing strong resistance to removal after drying. Water-based or latex adhesives generally clean up faster than solvent products that require the use of mineral spirits or similar chemicals.

Freeze-thaw resistance. Ability to withstand freeze-thaw conditions in storage, use, or after application. Several cycles of freeze-thaw should be inherent in all quality adhesives; however, withstanding effects of three cycles in the unopened container is considered good.

Plasticizer resistance. The ability of an adhesive to resist the migration of the plasticizer from plastics which attack the bonding properties of the adhesive system.

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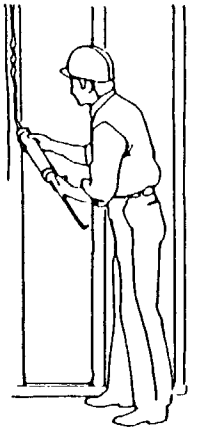
Applications

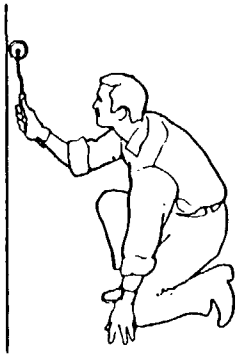
Gypsum Panels to Metal Framing—DURABOND 200 Adhesive is recommended because the solvent in the formula cleans any oil from the metal studs and provides excellent bond to metallic surfaces. The working properties are also less susceptible to change during cold weather.

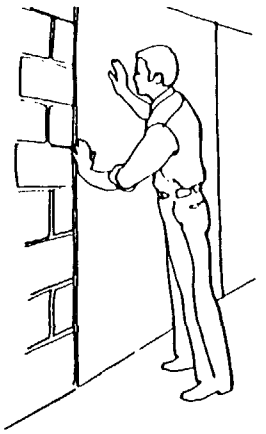
Gypsum Panels to Wood Framing—DURABOND 300 Adhesive is recommended because of the affinity of this water-based material with cellulosic wood products. DURABOND 200 is the secondary recommendation for this application.

Gypsum Panel to Gypsum Panel—DURABOND 500 and 600 provide equal performance characteristics for this application. Selection depends on method and speed of attachment desired. DURABOND 500 is applied with a notched trowel or Ames applicator tool and allows for panel adjustment. Because it is applied as a thick bond line, it permits bridging and leveling of the finished surface. DURABOND 600 is applied with a paint roller or brush and gives instant attachment without the panel adjustment feature.

Gypsum Panels to Above-Grade Masonry—DURABOND 500 is designed for concrete-type surfaces. It bridges the irregularities of these rough surfaces and is highly water-resistant after drying. The use of gypsum panels with an adhesive is not recommended below grade.







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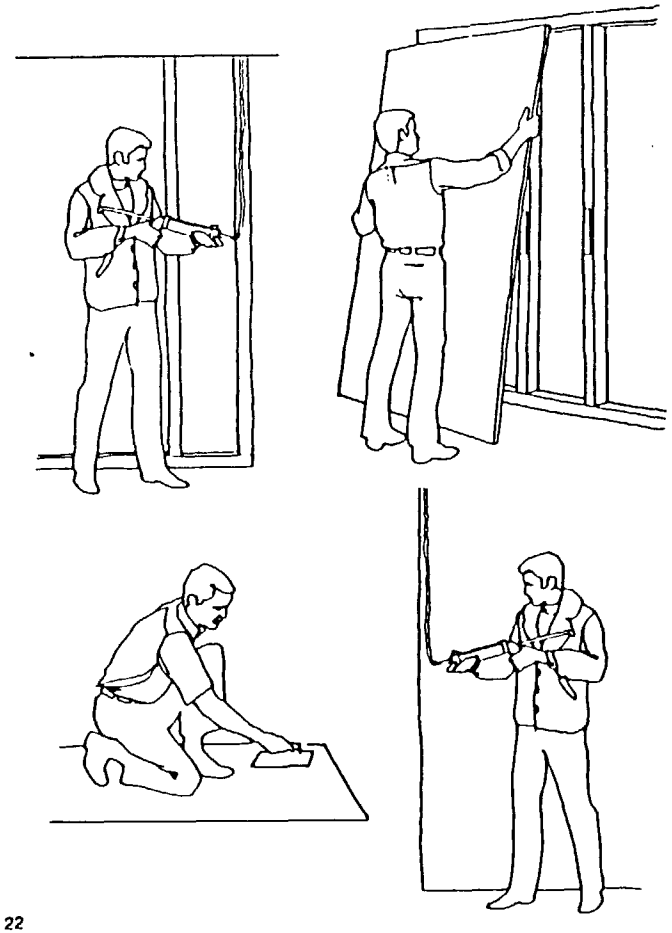
Wood Panels to Gypsum Panels, Wood and Metal Framing—DURABOND Panel Adhesive is designed to give fast bond in these applications and permits attachment of even slightly warped panels. Secondary recommendation is the use of DURABOND Vinyl Foam Tape with either DURABOND 200 or DURABOND 300.

Hardboard Paneling to Gypsum Panels, Wood and Metal Framing—DURABOND Panel Adhesive is recommended. DURABOND 200 Adhesive with DURABOND Vinyl Foam Tape can be used successfully as an alternate; DURABOND 300 is not recommended because of the moisture sensitivity of hardboard paneling.

Plywood Subfloors, Wood and Metal Joists—DURABOND Multi-Purpose Adhesive is recommended. This product increases floor stiffening and reduces floor squeaks. When only squeak reduction is needed (and added stiffening is not), DURABOND 200 or 300 Adhesive is recommended.

DURBOND Multi-Purpose Adhesive may be substituted for any of the DURABOND Adhesives recommended in the applications above. Where instant bond is sought, DURABOND Vinyl Foam Tape should be used regardless of the DURABOND Adhesive selected.



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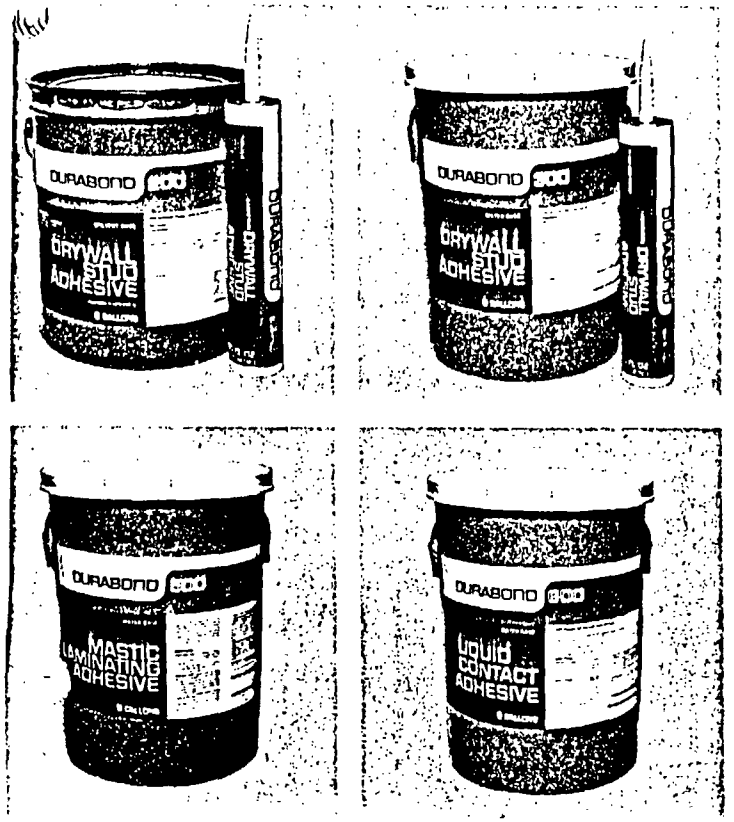

Products—Adhesives

DURABOND 200 Drywall Stud Adhesive

A solvent-base stud adhesive for gypsum panel application to wood or metal framing. Solvent base provides more controlled vehicle evaporation in damp or cold weather; makes DURABOND 200 preferred with metal framing, as solvent etches through residual oil on framing for a superior bond. Adhesive requires minimum fasteners in field of ceiling panels. Contains no asphalt and has good aging properties. Cleans up with any petroleum solvent. Exceeds ASTM standards (see chart on page 27).

DURABOND 300 Drywall Stud Adhesive

A water-base stud adhesive for gypsum panel application to wood framing in interior walls and ceilings. May be used with various types of SHEETROCK Gypsum Panels, TEXTONE Vinyl-Faced Panels and other U.S.G products (see Selector Chart, page 29). Water base avoids flammability hazards of solvent-based adhesives. Adhesive is pumpable and is generally applied from a cartridge gun. Requires minimum fasteners in field of ceiling panels. Cleans up easily with water. Since rate of drying is dependent on humidity conditions, DURABOND 200 is the preferred choice in humid climates. DURABOND 300 exceeds ASTM standards (see chart, page 27), and is the only water-base adhesive that complies with ASTM Standard C557-73.

BB014 2383

DURABOND 500 Mastic Laminating Adhesive

A water-base laminating adhesive for attaching one gypsum panel to another, or to monolithic concrete and concrete block, wood fiber sound-deadening board, and most other existing wall surfaces. After DURABOND 500 is applied to base surface, the face panel is placed and the lamination is completed with mechanical fasteners. Field fasteners are not required, however, when panels are prebowed, or where DURABOND Vinyl Foam Tape is used. DURABOND 500 allows panel adjustment after erection; provides excellent bond after impacting. Cleans up with water. No specifications (ASTM or Federal) have been established for this product.

DURABOND 600 Liquid Contact Adhesive

A water-base contact adhesive for lamination of SHEETROCK Gypsum Panels in double-layer systems. Low viscosity permits application with short-nap paint roller or brush. After adhesive application, the two surfaces to be bonded are allowed to dry. After adhesive turns to dark blue color, panels are combined and impacted to effect bond. Only ceilings—not walls—require permanent fasteners in addition to adhesive. Product has good freeze-thaw resistance and high heat-aging properties. Cleans up easily with water. No specifications (ASTM or Federal) have been established.

DURABOND Panel Adhesive

A solvent-base contact adhesive for bonding wood and gypsum panels to wood studs or existing walls. High legging property allows solvent to evaporate for quick drying. Adhesive is applied to studs, panel is then brought into contact with adhesive, tacked at the ceiling and withdrawn from studs. Within 10-15 min., panel is impacted for bond. Cleans up with petroleum solvent. No specifications (ASTM or Federal) have been established.

DURABOND Multi-Purpose Adhesive

A water-resistant, rubber-base adhesive for applying plywood or wood subflooring; plywood, hardboard or gypsum wall panels and plywood roof sheathing. Bonds to most construction surfaces—wood, concrete, concrete block, masonry, ceramic tile, galvanized steel and aluminum. May be used for exterior applications even when temperatures are below freezing. Its exceptional strength and tight bond improve floor stiffness and reduce the number of nails required. Bridges minor framing irregularities; eliminates sag on vertical surfaces; resists insects and vermin. This elastomeric adhesive remains flexible with age to help quiet squeaky floors. Cleans up with any petroleum solvent. Conforms to procedures given in HUD-FHA "Use of Materials" Bulletin UM-60, ASTM, and APA (AFG-01) standards (see charts, pages 27 and 28).

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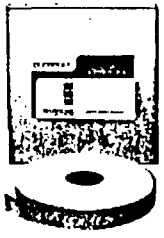

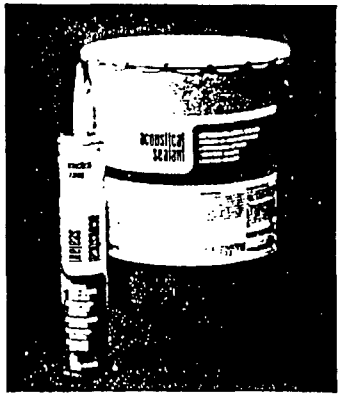

DURABOND Vinyl Foam Tape

Made of high-strength vinyl foam, double-faced with pressure-sensitive adhesive for contact bond. Designed for *temporary* attachment of gypsum panels to interior substrates and framing members until permanent DURABOND Adhesive attains ultimate strength. Eliminates need for temporary screw or nail fastening and temporary bracing. Scrapes off with putty knife. No specifications (ASTM or Federal) have been established.

Products—Sealants

SHEETROCK W/R Sealant (1)

A water-resistant product for sealing the cut edges of special SHEETROCK W/R Gypsum Panels for use in bathrooms, kitchens or other high-moisture rooms. Easily brushed on cut edge of surfaces over which ceramic or other wall tile is to be applied.

USG Acoustical Sealant (1)

A highly elastic, water-base sealant for reducing sound transmission in partition and ceiling systems to achieve specific STC values. Provides excellent adherence to most surfaces including metal, ceramic and masonry; seals spaces at perimeters of partitions and surface penetrations such as cutouts at electrical boxes and telephone installations.

(1) A sealant and not an adhesive for bonding substrates. Designed to adhere to most surfaces but not to carry loads

BB014 2385

This sealant provides the necessary mass to block sound penetration and is capable of filling relatively large gaps which many foamed tapes cannot.

USG Acoustical Sealant exhibits low shrinkage because of high solids content, and good freeze-thaw resistance. It is nonstaining, and is easily pumpable or applied from cartridge in beads. Rapid cleanup with water.

Test Results

DURABOND Adhesives have been tested against industry standards to determine their effectiveness in meeting or surpassing such requirements. In every case, these products complied with and exceeded the standards, as detailed in the two charts on page 27 and 28.



American Society for Testing Materials (ASTM)—C557-73

Performance Standards for Stud and Drywall Adhesives

ASTM Test	ASTM Requirement	DURABOND 200 Adhesive	DURABOND 300 Adhesive	DURABOND Multi-Purpose Adhesive
Shear Strength (psi—after 24 hrs.)	10	40	54	64
Shear Strength (psi—14 days)	40	74	81	64
Tensile Strength (psi—24 hrs.)	15	34	36	43
Tensile Strength (psi—14 days)	25	149	297	150
Open Time (minutes)	30	90	60	60
Bridging (minimum)	1/4" gap	exceeds 1/4" gap	exceeds 1/4" gap	exceeds 1/4" gap
Aging	500 hrs. at 158°F.	exceeds 500 hrs.	exceeds 500 hrs.	exceeds 500 hrs.
Freeze-Thaw Stability (psi)	10 at 3 cycles 0°F. to 73.4°F.	31	55	61

BB014 2387

American Plywood Association (APA)—AFG-01

Performance Standards for Gluing Plywood to Wood Floor Joists

APA Test	APA Requirement	DURABOND Multi-Purpose Adhesive
Ease of Application	workable 0°F. to 100°F.	easily workable
Shear Strength (wet lumber—lbs)	225	294
Shear Strength (frozen lumber—lbs.)	150	163
Shear Strength (dry lumber—lbs.)	225	804
Shear Strength (1/16" thick glue line—lbs.)	150	218
Aging (in oxygen bomb)	500 hrs. min.	exceeds 500 hrs.

APPLIED SURFACE
SHEETROCK Gypsum Panels
SHEETROCK W/R Gypsum Panels
Foil-Back SHEETROCK Gypsum Panels
IMPERIAL Gypsum Base
TEXTONE Vinyl-Faced Panels
USG Triple-Sealed Gypsum Sheathing
Plywood Underlayment
Hardboard
Wood Paneling
Wood Furring
Steel Floor and Ceiling Runners, Furring Channels
Rigid PVC Mouldings
Wood Fiber, Mineral Fiber Board

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DURABOND Adhesives Selector Chart

BASE SURFACE[4]								
SHEETROCK Gypsum Panels	**Foil-Back SHEETROCK Gypsum Panels**	**IMPERIAL Gypsum Base**	**Wood Studs, Joists and Furring**	**Plywood and Particle Board**	**Steel Studs, Joists and Furring**	**Unit Masonry** (brick, concrete block), **Concrete**	**Wood Fiber, Mineral Fiber Board**	**Painted Surfaces** (clean smooth, sound)
500, 600, M-P[1]	500, 600, M-P	N/R[2]	300, 200, M-P	500, M-P	200, M-P	500, M-P	500, M-P	500, M-P
N/R	N/R	N/R	300, 200, M-P	N/R	200, M-P	500, M-P	N/R	500
N/R	N/R	N/R	200, M-P	N/R	200, M-P	N/R	N/R	N/R
500, 600, M-P	500, 600, M-P	500, 600, M-P	300, 200, M-P	N/R	200, M-P	500, M-P	500, M-P	500, M-P
500, 600	N/R	N/R	300, 200, Panel[3]	500	200	500	500	500, Panel
N/R	N/R	N/R	300, 200, M-P	N/R	N/R	N/R	N/R	N/R
N/R	N/R	N/R	M-P, 200, 300	N/R	M-P, 200	M-P, 500	N/R	N/R
Panel, 200, M-P	Panel, 200, M-P	N/R	Panel, 200, M-P	Panel, M-P	Panel, 200, M-P	Panel, M-P	M-P, Panel	Panel, M-P
Panel, 200, 300, M-P	Panel, 200, 300, M-P	N/R	Panel, 200, 300, M-P	Panel, M-P	Panel, 200, M-P	Panel, M-P	M-P, Panel	Panel, M-P
M-P	M-P	N/R	N/R	N/R	N/R	M-P	M-P	M-P
N/R	N/R	N/R	N/R	M-P	N/R	M-P	N/R	M-P
Panel	Panel	N/R	N/R	Panel	N/R	Panel	N/R	Panel
N/R	N/R	N/R	M-P, 200	N/R	M-P, 200	M-P	N/R	N/R

(1) M-P—DURABOND Multi-Purpose Adhesive (2) N/R—Not a regular or recommended application (3) Panel—DURABOND Panel Adhesive (4) Adhesive listed first is preferred usage

BB014 2389

Chapter 5 TOOLS AND EQUIPMENT

Selecting the correct tools and equipment for specific applications is critical to adhesive performance, job efficiency and man-hour savings. Tools specially designed for these uses are described here.

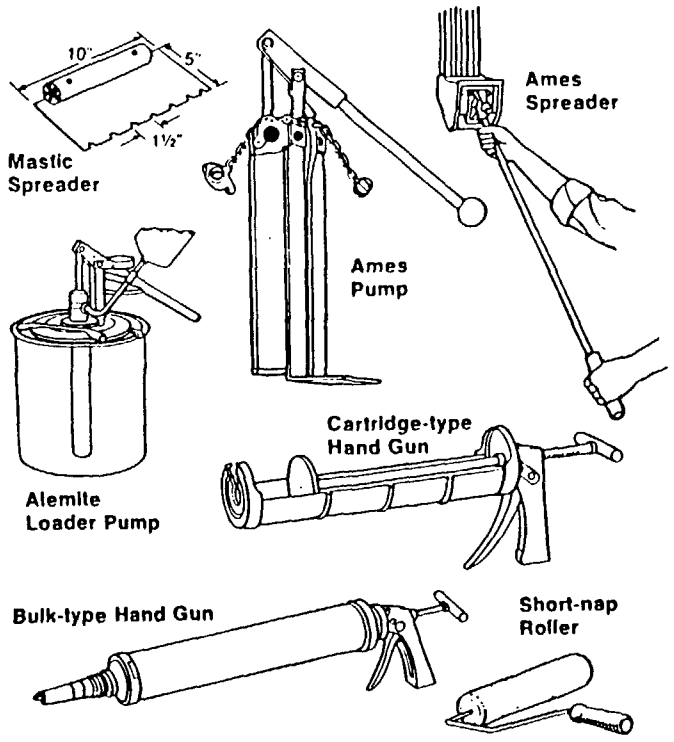
Hand Tools

Trowel or Mastic Spreader—Stainless or galvanized sheet steel makes the best spreader. Other materials may provide poor spreading action because adhesives tend to accumulate and dry in the notches. Spreaders should have the approximate stiffness of a plaster trowel and be kept clean at all times. They are used to apply adhesives over large areas and to base-layer panels in strip-laminated partition construction.

Ames Spreader—Choice of 7, 10, 12-in. widths Designed to accurately and uniformly apply *water-based* adhesive in vertical strips to base-layer panel or to face panel. Special orifices may be obtained to produce different-sized beads.

Ames Pump—Provides speedy filling of Ames Spreader from 5-gal. pail. Adhesive (water-based only) is strained by a screen in the pump.

Cartridge-Type Hand Gun—Used with 30-oz. cartridges for narrow surfaces such as stud faces. Bead size is deter-



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mined by cut of nozzle. Aids uniform application of adhesive. Applicator capacity: 1/10 gal., 1 qt.

Bulk-Type Hand Gun—Has trigger mechanism, withstands rough usage and offers minimum resistance to large bulk load of adhesive. Applicator has 1-qt. capacity; may be filled using Alemite Loader Pump.

Note: Bulk guns and pumping equipment are often used to minimize pilferage of cartridges.

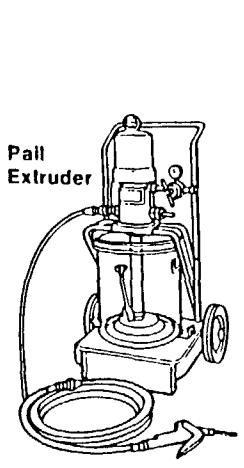
Alemite Loader Pump, Model 7537—Clamps on 5-gal. container of DURABOND Adhesive to mechanically load bulk-type adhesive hand guns. Eliminates waste of hand and paddle loading methods.

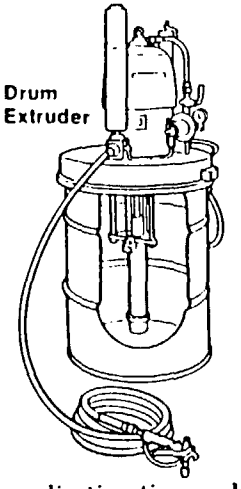
Short-Nap, Carpet-Type Roller—Used to cover large areas such as contact surfaces of gypsum base- and face-layer panels.

Pumping Equipment

Because of their high-volume output, pumping machines provide greater efficiency and production in the transfer, flow and spray of adhesives. Conventional fastening methods are being supplemented or replaced by power equipment in many building operations such as flooring, partitions and ceilings.

Large pumping equipment permits purchasing in bulk and high-volume application to cut job costs; contributes to job economy by reducing waste, application time and pilferage of cartridges.





Most machine dispensing systems are available with a selection of pumps, flow valves, nozzles and accessories. Equipment manufacturers offer a wide choice of components to provide the exact system for the job.

Pail Extruder—For high-volume extrusion of adhesives from pails. Air power depends on viscosity (low, medium or high) of the material. Offered in portable or mobile units with pump, air regulators and gauge, pail ram, adapter and hose.

Drum Extruder—Comparable to pail extruder; used for high-ratio extrusion of adhesive from bulk containers.

BB014 2391

Chapter 6 APPLICATION GUIDANCE

General Directions

The following recommendations will help explain the proper use of adhesives and the conditions which may affect the quality of the finished job.

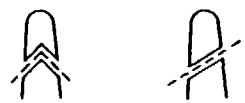
1. Select the proper adhesive for a specific job.
2. Make sure that all substrates are clean, sound and free from oil, dirt or contamination.
3. Exercise care regarding open flames when using flammable solvent adhesives in poorly ventilated areas.
4. Prevent freezing of adhesives whenever possible.
5. Apply adhesives at temperatures between 50° and 110°F. except as directed by the manufacturer. Low temperatures may cause water-base products to ice the surface and result in poor bond. Extremely high temperatures may cause solvent-base products to evaporate rapidly, shortening open time and damaging bond characteristics.
6. Close containers whenever adhesive is not in use. Evaporation (or escape) of vehicle can affect adhesive's wetting and application properties.
7. Do not exceed open time specified by manufacturer. Disregard of directions may cause poor bonding.
8. Follow manufacturer's recommendation on proper amounts of adhesive to be applied. Too small or too large a bead will lead to performance problems or waste.
9. Apply adhesive with proper tools (as recommended by the manufacturer).

Cartridge Preparation

Cut the cartridge tip in two different ways: For walls, make a chevron or "V" cut in order to produce a round, uniform bead on the stud. The cut edge of the nozzle then rides along the stud easily.

For ceilings, use a single, angled slash across the nozzle. In this way, there is a wipe-on effect on the ceiling joist to minimize dripping.

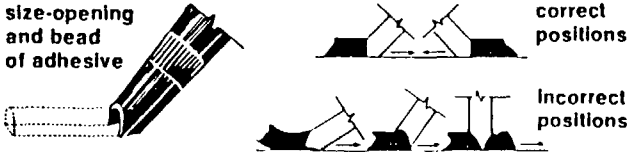
With a 3/8-in. bead, approximately three gal. of adhesive will prepare framing for 1,000 sq. ft. of gypsum panels.

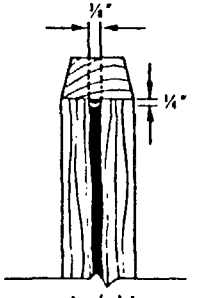


for walls for ceilings

BB014 2392

Proper nozzle opening and gun position (see sketches) are required to obtain the right size and shape of bead for satisfactory results. Initial height of bead over framing should be 3/8 in. and of sufficient volume to provide 1/16-in. thickness of adhesive over the entire support.







BB014 2393

GLOSSARY

Adherend—Any object which is held or fastened to another object by an adhesive. Sometimes called a substrate, especially when concealed behind another surface, such as the base layer in double-wall construction.

Adhesion—The property that bonds surfaces of two substances together.

Adhesive—A substance capable of holding two or more materials together by surface attachment.

Adhesive Failure—The failure of the adhesive itself when the bond fails internally or separates from the surface.

Applicator—A tool such as cartridge gun, brush, or roller for applying the adhesive to the surface to be bonded.

Binder—A substance holding the other ingredients together. It is usually made from polymers, natural or synthetic. The synthetics, such as neoprene, generally have superior characteristics.

Bond—Uniting or adhering surfaces of materials by the use of an adhesive.

Bond Line—The line where the adhesive comes in contact with the substrate surfaces.

Bond Strength—The unit load, measured in lbs./sq. in., required to break an adhesive assembly—with failure in or near the plane of the bond. Failure can occur by tension, peel, cleavage or shear.

Bridging—The property in an adhesive that allows it to fill or bridge the space between two surfaces or substrates. It fills the gap between surfaces, thus maintaining a bond.

Cleavage—The action of splitting at the adhesive line, resulting when a tensile or peeling force is applied to the bond line, at one edge of two adherends.

Cohesion—The internal strength of the adhesive itself, which can be stronger or weaker than the bond.

Creep—The tendency of the adhesive to flow or move under certain load or stress conditions.

Dry Strength—The strength of an adhesive after drying or setting.

Laminate—A product made by bonding two or more materials, or layers of materials, together. To laminate is simply to unite layers of materials together with an adhesive.

Nonskinning Time—The period required for surface of the adhesive to form a skin.

BB014 2394

Open Time—The period in which an adhesive—after it has been applied to a surface—effectively adheres to another surface, or substance. Usable time for making an adhesive assembly.

Peel Strength—The resistance to a load applied progressively to one *edge* of a flexible substrate. Normally the force is applied at an angle greater than 90° to the bond line.

Racking—A wall or plank twisting within its own plane, the top moving sideways, in a scissors effect, with the bottom still firm.

Shear—The force that causes different parts of an assembly to slip or slide, relative to each other, in a direction parallel to their plane of contact.

Skinning—The formation of a tough surface, or skin, over the adhesive after it is applied to an adherend or substrate. With too thick a skin, the adhesive won't transfer well from one surface to another—won't bond well.

Solvent—The liquid substance used as the vehicle in an adhesive mix. Can be composed of water or organic solvents. A solvent, such as kerosene or gasoline, also can be used to cut grease or for adhesive cleanup.

Tack—Property of an adhesive that enables it to form a bond of measurable strength immediately after it has been brought into contact with an adherend or substrate.

Tensile Strength—The resistance of an adhesive to forces perpendicular to the bond line (a *pulling* action). Results are expressed in lbs./sq. in. at the time of rupture.

Viscosity—The fluidity or flowability of a material—the internal resistance of an adhesive to flow when that resistance is directly proportional to the applied force. Viscosities can be high, medium or low. An example of a material with a low viscosity is water. An example of a material with a high viscosity is axle grease.

Wet Strength—The strength of an adhesive during the drying period.

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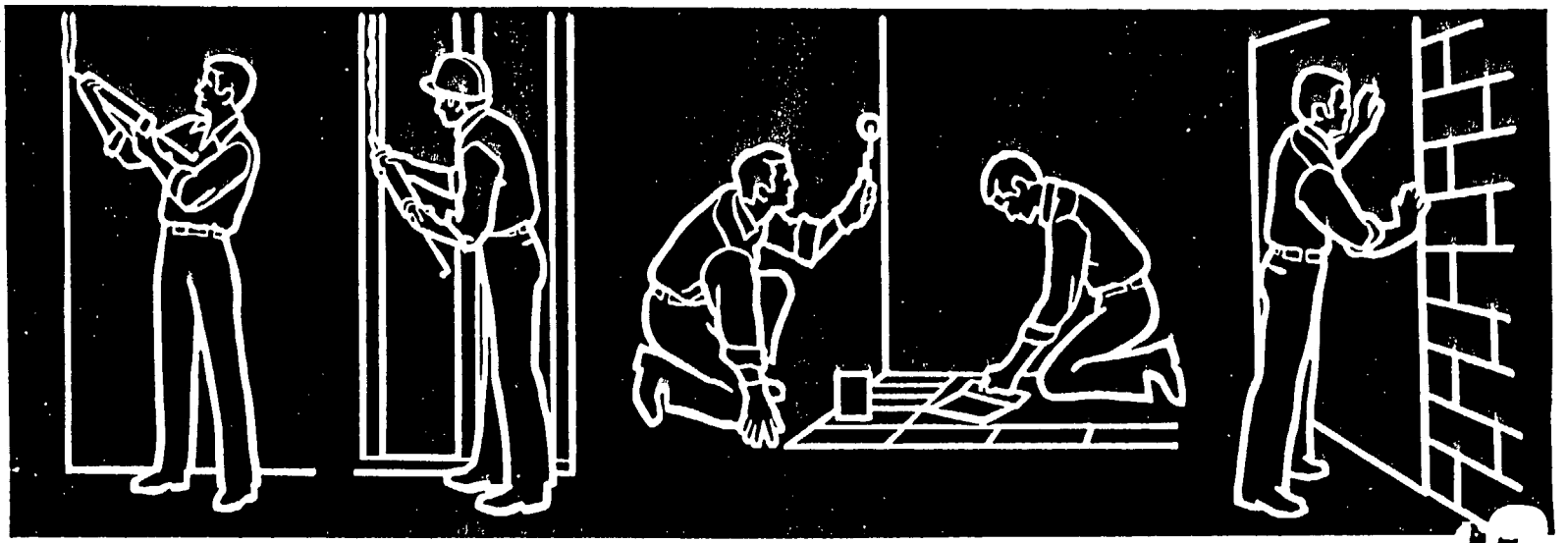

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