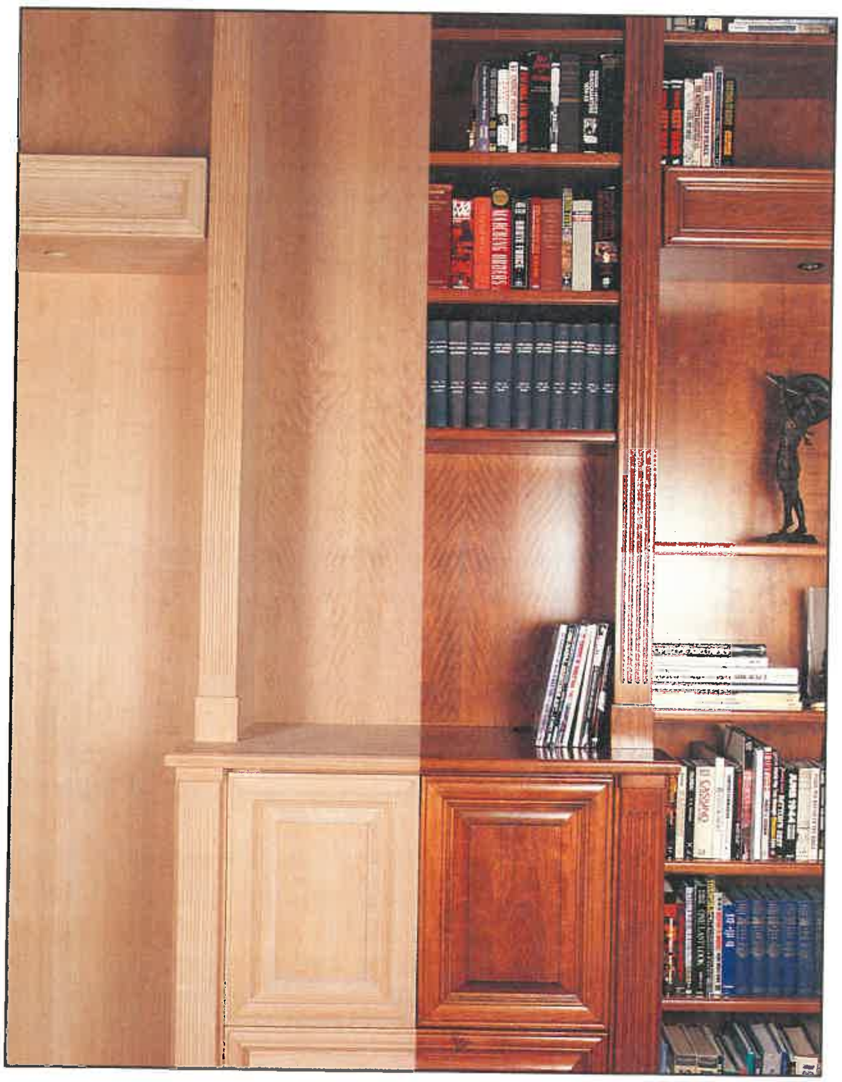
Modern Cabinetmaking

by
William D. Umstattd
Charles W. Davis



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The cover image courtesy of Jill and Gary Foss, Wainwright Construction, Gene Davis Photography, and Chuck Davis Cabinets.

Introduction

Modern Cabinetmaking explains and illustrates fine woodworking practices. It is written for anyone with an interest in the subject from a vocation or hobbyist viewpoint. This text covers the skills and techniques for the cabinetmaker, finish carpenter, and millworker.

Modern Cabinetmaking follows the logical order of the design and construction process. It begins with an overview of the text followed by a study of furniture styles and designs. Instruction on preparing sketches, drawings, and procedural plans follows to provide the reader with a solid working foundation.

Modern Cabinetmaking covers woodworking technology. It leads you through a discussion of materials and processes affecting the quality of your final product. You will learn the how, what, why, and when of selecting the appropriate materials whether they are fine hardwoods, softwoods, manufactured panel products, plastics, glass, or ceramics. Selection of hardware, abrasives, adhesives, and finishing supplies are also discussed in appropriate detail.

Modern Cabinetmaking also covers the procedures and techniques of fine cabinetmaking and furniture making. The use of hand and power tools and machines is thoroughly covered. As the text guides you through the processes, it shows how your decisions will affect the final product. Detailed information about finishing materials and processes is also included enabling you to finish products with lasting beauty.

Nearly everyone has an appreciation for fine cabinets and furniture. Whether your motivation for pursuing the study and practice of cabinetmaking is for personal or professional advancement, this text provides a great deal of background about woodworking. The information in ***Modern Cabinetmaking***, along with the experience and skills developed, will help you become successful in your cabinetmaking and woodworking pursuits.

Design Flexibility

Modern Cabinetmaking is designed to provide students, do-it-yourselfers, hobbyists, and aspiring cabinetmakers with practical information about cabinetmaking and woodworking. This text is written in clear, nontechnical language. Cabinetmakers at all levels will find it beneficial.

The text

Throughout the chapters of this text, different fonts (typefaces) are used to identify important term(s), identify figure references, or call out and emphasize the meaning or use of a word(s).

Important terms appear in ***bold-italic*** type. Many of these can be found in the *Important Terms* list at the beginning of the chapters. All of them are listed in the glossary at the back of this text. For example: ***lumber-core plywood*** has a solid wood center and thin veneer faces.

Figure references appear in **bold** type. This makes it easy to identify the text reference and corresponding illustration.

Words, terms, and references that are called out appear in *italic* type. For example: *lumber-core plywood* is used when cabinet edges are exposed. Refer to *Chapter 13, Manufactured Panel Products.*

Chapter components

At the beginning of each chapter is a list of *Objectives*. The objectives are topics covered and goals to be achieved in the chapter. Objectives are in the order they are presented in the chapter. Review the objectives before reading the chapter to get an understanding of the material to come. After completing the chapter, review the objectives once more as a review of the materials.

At the beginning of each chapter is an *Important Terms* list. Review the list before reading the chapter to get an understanding of the material to come. After completing a chapter, review and define each term. If you cannot do so, review the related section in the chapter.

A *Summary* is at the end of each chapter. It emphasizes the material covered in the chapter. Review the summary after completing a chapter. If something in a summary is not understood, go back and review that section.

Test Your Knowledge questions are presented at the end of each chapter. After completing a chapter, answer all of the questions on a separate sheet of paper. This is a great way to review the material covered in the chapter.

Special notices

There are a variety of notices throughout this text. These consist of safety sections, technical information or hints, cautions, and warnings.

Throughout ***Modern Cabinetmaking*** there are *Think Safety—Act Safely* sections printed in red. Safety is always of the utmost importance, whether you work at home, in industry, or at school. Always try to protect yourself and others against risk of accidents and injuries. Each section points out how you can avoid unsafe acts and hazardous conditions.

A *note* includes technical information and/or hints that are aimed at increasing knowledge about the systems, procedures, or applications dealing with cabinetmaking.

A *caution* identifies potential problems, such as temporary or permanent damage of equipment or tools. Proper operating procedures and safety measures must be followed. If a caution is not understood, always consult a supervisor or instructor.

A *warning* identifies potential problems that may result in personal injury if the proper operating procedures and safety measures are not followed. If a warning is not understood, always consult a supervisor or instructor.

Enhancing this Text

To aid in the learning process, a comprehensive workbook has been created. It contains a variety of related questions that are organized to correlate to the chapters in this text.

About the Authors

Dr. William D. Umstattd

Dr. William D. Umstattd is an Emeritus Associate Professor of Technology Education from The Ohio State University. He received his Bachelor of Science in Education degree with a major in Industrial Arts from Central Missouri State University, his Master of Arts degree with major emphasis in Education from the University of Northern Colorado, and his Doctor of Education degree in Industrial Education from Texas A&M University.

Dr. Umstattd has thirty-six years of experience in the field of education. He taught two years in elementary school, eight years in junior high schools, seven years in senior high schools, two years teaching instrument repair in an Army Ordnance School, and seventeen years at the university level teaching Technology Teacher Education. In addition to teaching, he has served as a manuscript reviewer and assistant editor for the Journal of Industrial Teacher Education. He also worked in industry as a technical writer preparing customer instructional manuals.

Dr. Umstattd has participated in a number of professional associations. He has done committee work for, served on the Board of Directors of, and received a Leadership Award from the International Technology Education Association. He has done committee work for and received an Honorary Life Membership to the Council on Technology Teacher Education. He served as Executive Director and received a Distinguished Service Award, a Laureate Award, and Life Membership from the Ohio Technology Education Association. He was a member of and received a Distinguishing Service Award and Laureate Citation from the Epsilon Pi Tau educational fraternity.

Mr. Charles W. Davis

Mr. Charles W. Davis taught courses in computer scheduling at the University of California Los Angeles. He taught computer user's classes at International Business Machines. He has written user's guides to software products and performed extensive reviews of numerous software publications. He has written a number of articles published in the *Fine Woodworking* and *Fine Homebuilding* magazines.

Mr. Charles W. Davis attended the University of Michigan's School of Architecture and received his undergraduate degree from Wayne State University, Detroit. He later attended San Diego State University's Graduate School.

Mr. Charles W. Davis' woodworking experience began in his early teens making small furniture items he saw in the wood shop at Romulus, Michigan High School. He and another high school friend manufactured unfinished bookcases for Sears, Roebuck & Co. during their senior year. In 1983, he opened Chuck Davis Cabinets in north Monterey County, California. He specializes in the design and fabrication of high-end custom wood and composite casework, including kitchen cabinets, bath vanities, entertainment centers, libraries, and bars.

About the Cover

The intention of the cover image is to visually represent the cabinetmaking process; from unfinished materials to the installed cabinetry. The library cabinetry on the cover was designed and built by Chuck Davis Cabinets. It was installed in the Pebble Beach, California residence of Jill and Gary Foss to house their extensive book collection. The general contractor for the residence was Wainwright Construction of Monterey, California.

The photographic images were produced by Gene Davis Photography of Newberg, Oregon. The unfinished portion was photographed in the shop of Chuck Davis Cabinets, while the finished portion was photographed in the Foss' residence. Gene Davis Photography also produced approximately 220 of the new images in this edition.

Acknowledgments

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Adjustable Clamp Co.
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American Woodmark Corp.
Amerock Corp.
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Architectural Woodwork Institute
Barrier Free Environments
Bassett Furniture Industries
Benjamin Moore & Co.
Black & Decker Corp.
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The Fine Tool Shop
The Fletcher-Terry Co.
The L. S. Starrett Co.
The Rawlplug Co.
The Stanley Works
The Woodworker's Store
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Tyler
Unfinished Furniture Store
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Wolcraft
Wood Handbook
Wood-Mode Cabinetry
Woodcraft
Woodtape, Inc.
Woodworker's Supply
Workrite

Table of Contents

Introduction to Cabinetmaking

1

Objectives

After studying this chapter, you will be able to:

- Identify the needs and wants for cabinets in everyday living.
- Discuss the importance of function and form for furniture and cabinetry.
- Explain the decision-making process for cabinetry production.
- Describe the processes of production and management technology.

Important Terms

combining
controlling
design decisions
form
forming
function
material decisions
organizing
planning
postprocessing
preprocessing
processing
production decisions
quality
separating

Throughout history, wood has been used to create many products. Even with the influx of plastics, wood continues to play an important role in our everyday lives. We store food, utensils, and personal belongings in or on wood cabinets. We sit on chairs and sleep on beds supported by wooden frames. We shop from store fixtures, work at desks, prepare food on counters, and pull books from shelves. All of these storage areas, work surfaces, and decorative products might be made of wood. See **Figure 1-1.**

Every product you see was once a need that an individual set out to meet. Ideas first put on paper, later became a design that had to be developed. Decisions were made. Problems, such as acquiring materials and operating tools or machines, were solved. Processes of cutting, shaping, assembling, and finishing were chosen to bring the design idea to reality.

This text covers the decision-making practices for producing fine cabinets and furniture. The

Figure 1-1. Left—Wooden cabinetry in the home is not only practical and functional, but beautiful as well. Right—Wood is used in the cabinetry and for the floor and other amenities, such as the vertical wine racks and the range hood spice shelf personalize a kitchen. (*KraftMaid Cabinetry, Inc.*)

topics focus on the many methods, materials, and machines that create these products. This chapter presents an overview of cabinetmaking and identifies the relationship of various steps, including design, materials, production, and management.

Design Decisions

Consider yourself a designer. Your responsibility is to help people meet their needs and wants for furniture and cabinets. See **Figure 1-2.** The product design you create might be original or influenced by an existing style.

Design decisions are conclusions made about the product design before work begins. *As-you-work* decisions about cabinetry needs, sizes, and shapes are very costly. Without a documented plan of attack, you will likely be wasting time and materials.

All design decisions are based on the two factors of *function* and *form*. Consider these topics as you begin to generate ideas for a product.

Function and form

Function describes the reason for having the cabinet or piece of furniture. Note the cabinets designed and manufactured for use in dentist's offices in **Figure 1-3.** A dentist must have many tools within reach of the patient in **Figure 1-4.** These cabinets provide storage of materials and support for lighting, equipment, and trays. The sink cabinet provides for cleanup and solid waste disposal through the hole in the countertop. This represents efficient planning and production. Another example of function is the attractive home library shown in **Figure 1-5.** Movable shelving makes this product flexible enough to display taller items. As a designer, you must see that every product meets the needs and wants of the user.

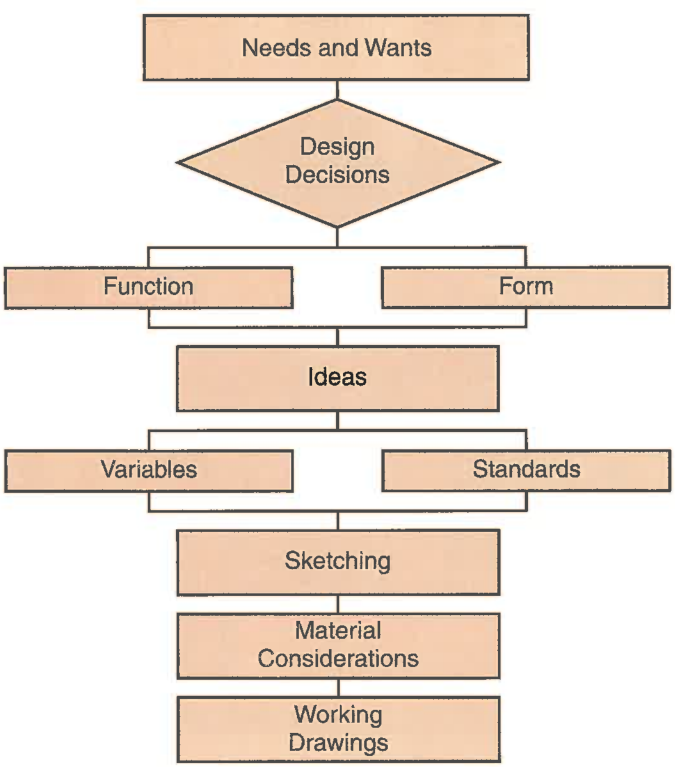


Figure 1-2. A series of decisions and considerations are made during the design stage.

Form is the appearance of the cabinet. What will the piece look like? Is there a particular style you want to copy, such as French Provincial, Early American, or Scandinavian? The appearance of the product must fit with the surrounding furniture.

Experienced designers say that *form follows function*. The cabinetry must first serve a purpose. If the product is not functional, even careful styling will not make it desirable.

Design ideas

Once the form and function of a product is considered, your ideas should be sketched. These quickly made pictures document your thoughts, and allow you to compare alternate designs. Production cabinet shops often create their designs with a computer-aided design (CAD) system. See **Figure 1-6.**

Design variables

Products vary in size depending on their intended use. A trophy case with 12" (305 mm) between shelves obviously will not hold a 14" (356 mm) trophy. You must take into account the size of objects to be stored. Furthermore, there are human factors to consider. For example, a child's chair will have different dimensions than an adult's chair. A table or counter designed for a person in a wheel chair must be a different height than standard cabinets and furniture.

Design standards

Many types of cabinetry are designed and produced based on standards. Kitchen cabinets are one example. There are standards for countertop height, distance between base and wall units, and unit sizes. Widths for factory produced units are established in modules of 3" (76 mm). This is further discussed in Chapter 49 of this text. When making a custom cabinet, set dimensions to meet customer needs.

Units of measure in most of the world are in the International (SI) Metric System. In this text, the

Figure 1-3. Cabinets for a dentist's office. A—When closed, this base cabinet has an attractive appearance, yet provides access to frequently used latex gloves. B—Upper cabinet provides access to paper cups and towels through opening in the bottom and latex gloves through the door. C—A variation provides glove access through the side. (*Adec*)

Figure 1-4. Careful arrangement of cabinets and furniture provides an attractive and efficient work facility for both the dentist and the assistant. (*Adec*)

Figure 1-5. Home library shelving displays the owner's collection of memorabilia. Low voltage lighting with dimmer switches add to their enjoyment. (*Chuck Davis Cabinets*)

metric units are in parenthesis. Most metric units have been rounded off to whole units, such as meters or millimeters. Only where more precise measuring is necessary, is the decimal point used. For example, you may encounter 1" (25 mm) or 3' (1 m).

Another measurement standard, the *32 mm system*, applies to case construction and hardware installation. Holes are drilled 32 mm apart at 37 mm from the edge of the cabinet front. *European* hardware mounting holes are also spaced this distance, making the hinge mounting plate, drawer slide, or fastener easier to install.

Additional concepts

Another design concept is ***ready-to-assemble (RTA)*** cabinets. The product is purchased unassembled in a neatly packaged compact carton. In this form, even a large furniture item can be moved through small doors and narrow stairways. The consumer then assembles the cabinet with special RTA fasteners. The assembled product often looks no different than preassembled-and-finished furniture. See **Figure 1-7.**

Ready-to-assemble cabinets and furniture came about after World War II when Europe was faced with a severe shortage of home furnishings. Furniture factories appeared nearly overnight to meet the demand for furniture. They began replacing solid wood with newly introduced panel products and plastic laminates. This decreased the cost per item and increased production quantities. However, since plywood, particleboard, and other panel products held nails and screws poorly, manufacturers set out to design new assembly methods. This led to the introduction of frameless construction methods and RTA fasteners, which are discussed in Chapter 16 of this text. RTA fasteners do not create a *permanent* joint. They connect and disconnect with ease. Yet, despite making assembly much easier, they hold with great strength, in both solid wood and composite materials. Initially, assemble-it-yourself cabinets were known as knockdown (KD) furniture and the fasteners were known as KD fittings. However, the name *ready-to-assemble* has gained wider use, because *knockdown* gives the impression of an unsturdy product.

Figure 1-6. Computer-aided design systems help cabinet designers determine size and layout of cabinetry. (*Alpine Structures*)

European manufacturers learned two important lessons about consumers with the introduction of RTA cabinet fasteners.

* Consumers who previously had difficulties moving large furniture enjoyed being able to disassemble furniture and reassemble it in a new location.
* Consumers did not mind buying furniture disassembled and assembling it themselves, provided that simple-to-follow instructions were included.

Material Decisions

There are many materials available for producing cabinets and fine furniture. These should be considered carefully throughout the design and production process. Materials you might consider

Figure 1-7. This ready-to-assemble computer console was assembled by a consumer. (*O'Sullivan Industries*)

include lumber, veneer, manufactured panel products, plastic laminates, plastic, ceramic, and glass. To assemble these materials, you will also choose among adhesives, mechanical fasteners, or joinery. A clear or opaque finish is applied, either before or after assembly. Hardware, such as hinges, pulls, and knobs, add the final touches to the product.

Lumber will be either softwood or hardwood. Softwood identifies lumber from cone-bearing trees that is typically used as a construction material. Hardwood describes lumber from leaf-bearing trees that is usually selected for making cabinets and furniture. Each specie has unique properties affecting appearance and workability.

Trees also are made into wood products such as plywood, particleboard, and veneer. ***Veneer*** is a sheet of thinly sliced hardwood or softwood used to cover poor quality lumber or manufactured panel products. Veneer is especially effective when inlaying or overlaying decorative designs.

Manufactured panel products certainly have a place in cabinetmaking today. Medium density fiberboard (MDF) and particleboard have become popular for kitchen cabinets, bath vanities, closets, and RTA products. These may be covered with enamel, plastic laminate, or veneer for appearance purposes. MDF is easily shaped into almost any pattern and is available in lengths up to 20′ (6 m). Because of this, MDF is widely used for finished interior molding.

Glass, plastic, and ceramic materials create durable surfaces. They are often applied to table or countertops and edges. Plastic laminates are extremely popular for durable, nonfading surfaces. Some have patterns that look exactly like wood grain.

Cane, a form of grass, is woven to provide patterns and texture. A cane seat can be more comfortable and lighter than solid wood. Cane also decorates cabinet door fronts and other surfaces.

Once cabinet components have been cut to size, they are assembled with adhesives or mechanical fasteners. You must select the proper type of adhesive, cement, glue, or mastic for bonding similar and dissimilar materials. If mechanical fasteners are used, you must also carefully choose the type. A wood screw holds well in solid wood, but poorly in particleboard. Select assembly materials based on the design and material of which the product is made.

At some point in the cabinetmaking process, you must smooth the components. Sanding is done before assembly to components that will be hard to reach after assembly. Exterior surfaces are typically smoothed after assembly.

Finishing materials are coatings that provide color and protection to the wood. Natural and synthetic products are available. Some finishes build up on the wood surface and others penetrate into the grain. Carefully select and apply the finish, because a poor finish can ruin hours or days of production time.

Production Decisions

Production decisions relate to making any product become a reality. They include choosing the tools, tooling and procedures necessary to build the product in the most efficient manner. See **Figure 1-8.** Design and ***material decisions*** greatly affect production decisions. A piece of furniture designed with many curves will likely be more difficult to produce than one with only straight surfaces. A cabinet that

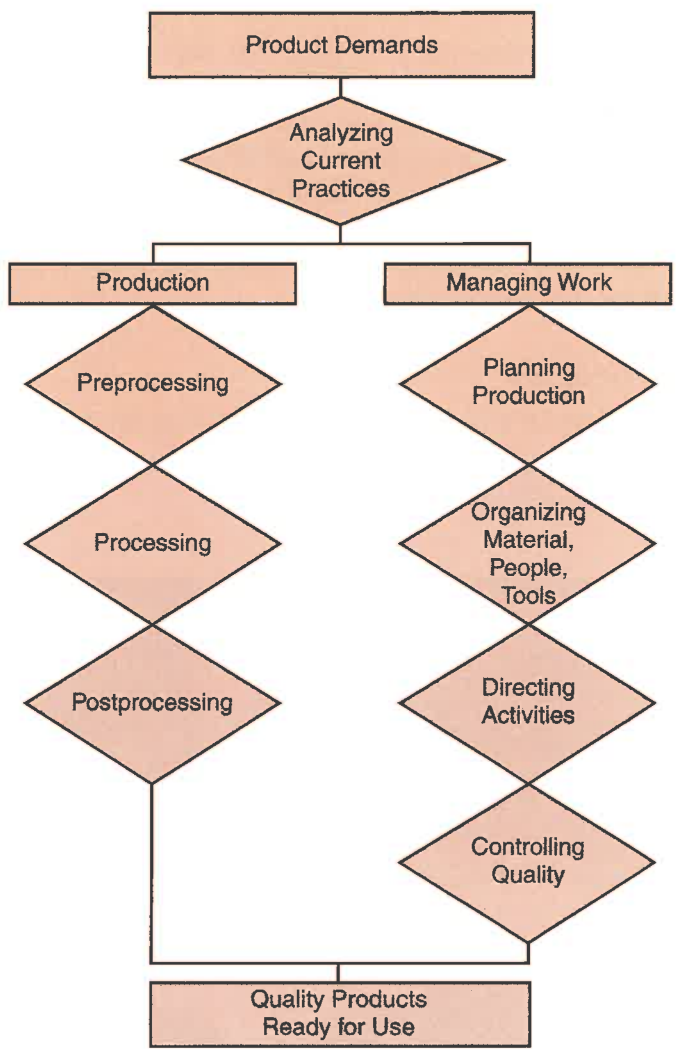


Figure 1-8. A series of factors are involved with producing a product.

includes stained glass doors is more difficult to create than one having solid wood doors. Make all decisions in an organized manner. It is important to plan each step.

Tools

There are many types of tools used in cabinetmaking. Most processing is done with stationary power tools, such as belt sanders, table saws, planers, and shapers. These reduce heavy and bulky materials, such as long lengths of lumber and plywood, into component sizes. See **Figure 1-9.** Portable power tools, such as orbital sanders, screw guns, and jig saws, are easy to handle and often more appropriate than stationary tools for small parts. Hand tools are generally used for minor operations, where set-up time for a stationary machine may be wasteful.

Tooling

Replaceable parts of *tools* that perform cutting operations, such as router bits, shaper cutters, drill bits, and planer blades are commonly called ***tooling***. Proper selection of these items is important to control costs and improve production and quality. Selection of the wrong tooling for the operation to be performed can adversely affect the safety of the machining operation.

Processes

Material processing for cabinetmaking fits into the three categories. These categories include separating, forming, and combining.

Figure 1-9. Reducing sheets of plywood to component sizes with a table saw. (*Delta International Machinery Corp.*)

Separating refers to cutting or removing material. Cutting stock on a table saw, sanding, or turning a spindle on a lathe are separating operations. Some machines are automated, or controlled by a computer. **Figure 1-10** shows a ***numerically controlled (NC)*** lathe. This means the movement of the lathe is controlled by the numerical data output from a computer.

Forming includes all operations where material is bent, or formed, into a shape using a mold or form. See **Figure 1-11.** No material is removed or added.

Combining includes bonding, mechanical fastening, and coating. See **Figure 1-12.** Each of these combining operations involves assembling or joining two materials.

Producing Cabinetry

Planning for production involves making efficient and effective decisions related to materials, tools, tooling, and processes. Today, most cabinetry

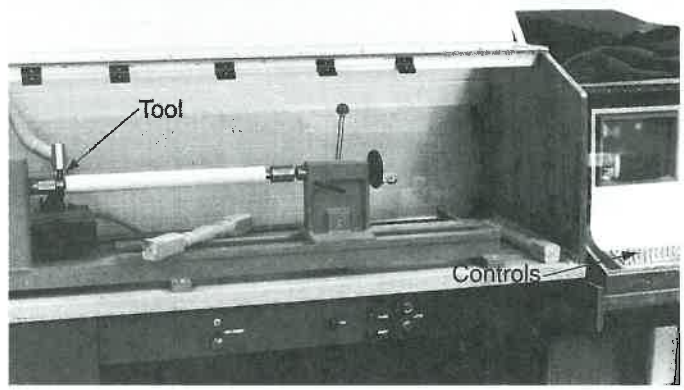


Figure 1-10. Numerically controlled machines reduce the amount of human labor needed to process a part.

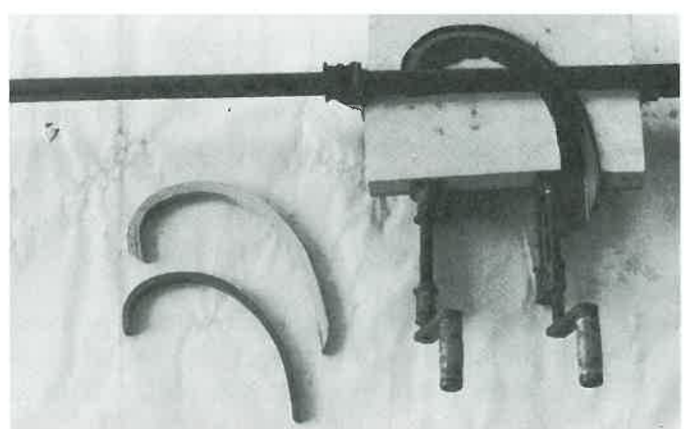


Figure 1-11. Forming wood with a mold and clamps.

is mass-produced by cabinetmaking industries using sophisticated machinery. You will make decisions based on simpler tools found in small- and medium-sized cabinet shops. First, selecting and setting up the equipment is done—this is ***preprocessing***. Then, sawing, shaping, sanding, assembling, and finishing is done—this is ***processing***. Finally, transporting and installing the finished product is done—this is ***postprocessing***.

Preprocessing

Preprocessing includes all activities before building a product. Designs are finished and mock-ups may be built. Mock-ups help you decide if the product will be functional and have a pleasing appearance. Materials are bought as standard stock items. This includes full lengths of lumber, sheets of plywood, boxes of screws, and containers of finish. They have to be received, stored, and marked as inventory. Storing materials in set locations helps you work more efficiently.

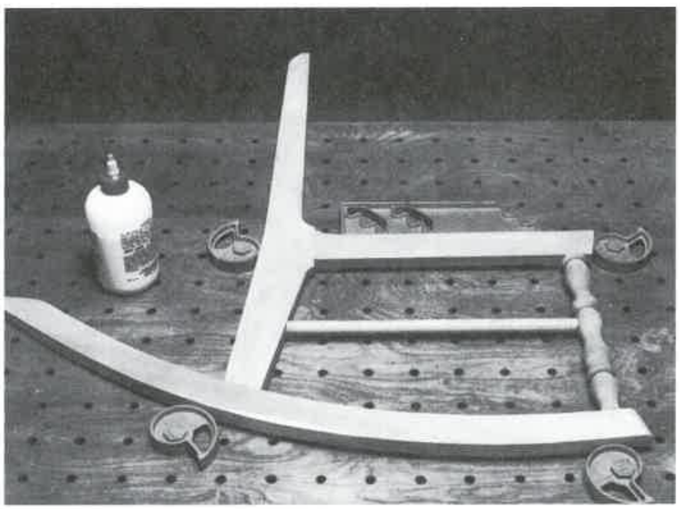


Figure 1-12. Assembling components with adhesive is one form of combining. (*Meyer-Vise*)

Processing

Processing includes all tasks from cutting standard stock to finishing the product. You need to cut components, such as cabinet doors, drawers, legs, bases, cases, shelves, and tops. Work progresses by cutting and shaping workpieces to size. Then, joints are made to hold the pieces in place. Holes may be drilled and bored for various mechanical fasteners. Then the components are sanded. A sampling of these processes is found in **Figure 1-13.**

Once cut to size and smoothed, parts are bonded together to give strength and structure to the product. Finally, a topcoating is applied by brushing, dipping, rolling, spraying, or wiping on the coating. This coating protects the product from moisture and wear.

Postprocessing

Postprocessing includes transporting, installing, and maintaining products. For example, desks you build in a home workshop might then be boxed and transported to an office. Installing refers to setting up the product, such as placing store fixtures or attaching cabinets to floors and walls. See **Figure 1-14.** Maintenance is necessary for cabinets and furniture. A product may be maintained by periodically applying a coat of wax. You may also repair scratches to restore the product's appearance.

A B C

Figure 1-13. Typical processes in cabinetmaking. A—Resawing. (*Delta International Machinery Corp.*) B—Drilling. C—Sanding. (*Delta International Machinery Corp.*)

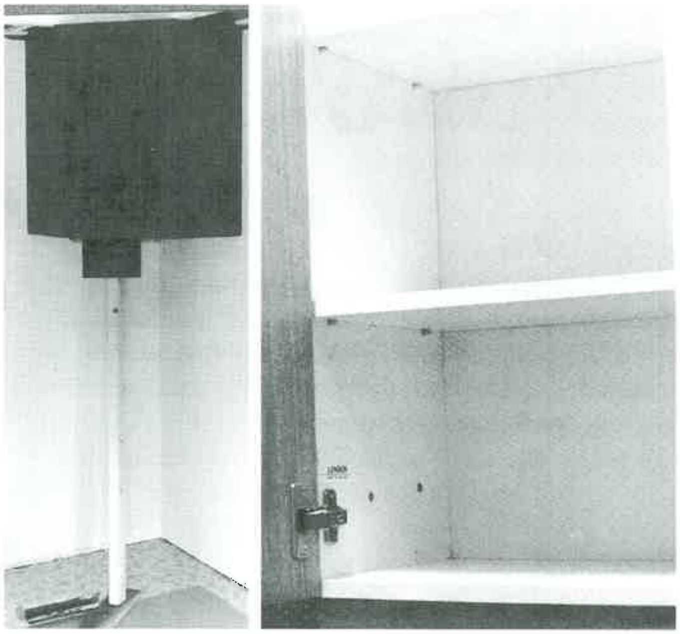


Figure 1-14. Installing cabinets is a postprocessing task you might do yourself.

Managing Work

Work has to be planned, organized, directed, and controlled to progress smoothly and safely. These activities are management responsibilities. An individual at home or school must make the same kinds of decisions as the well-paid business manager.

Planning

Planning involves establishing goals and deciding how they will be accomplished. Study alternative designs and processes to learn how others have solved similar problems. Experience with various functions, forms, materials, tools, tooling, and processes allows you to make sound management decisions.

Organizing for efficiency and safety

Organizing involves the four *rights*. Have the *right* information and the *right* material in the *right* place at the *right* time. Work must be scheduled efficiently to prevent wasting material and time. Progress may be slowed by undelivered equipment, machines that do not operate properly, adhesives or screws not on hand when needed.

Directing daily activities

Supervisors in industry see that planned and organized tasks are performed on schedule. When working alone, you should still have a schedule. Set guidelines are also valuable if people face an unpopular decision.

Controlling quality

Controlling involves comparing processed products to design and quality specifications. Suppose you cut all joints to size, but later find they do not fit. What should you have done? Trying a test joint could have prevented this problem.

Quality is ultimately measured by how well the product *meets the requirements and expectations* of the consumer. Quality may be specified by the designer or the person that uses it. Quality standards also have been established and documented. Two examples of these organizations are the ***Architectural Woodwork Institute*** and the ***Woodwork Institute of California***. Copies of their standards manuals are available to members and nonmembers. Many different aspects of quality are defined and presented in the manuals. The standards, or specification requirements, address lumber grades, plywood grades, interior woodwork and stairs, wood and manufactured panel casework, plastic covered casework, countertops, doors, finishing, and installation.

The documentation provides producers with a level playing field when bidding work. When applied to cabinetry and millwork, these standards usually are known as premium, custom, economy, and laboratory. When a designer specifies *custom*, and the product meets the *custom standards*, quality has been achieved.

Quality and productivity

Quality also involves productivity. When work falls short of the goals, corrective action must be taken. Reports and schedules are made to assist in monitoring work activities.

In industry, all management decisions should show concern for and involve employees. This helps build decision-making abilities and self-confidence. In every cabinetmaking shop, workers risk exposure to toxic substances, accidents, and injuries. People may be allergic to dust or finishing materials. Some solvents are toxic and flammable. Remember that hazardous conditions exist everywhere. Read labels and follow directions carefully when using machines and materials.

Summary

Cabinetmaking is both an art and a science. You can see the artistic and creative talents of the cabinetmaker in subtle curves, precise joints, suitable coloring, and flawless finish of a product. The cabinetmaking process begins with the designer's goal of meeting a need. Once the design is finished, fine woods and other materials are chosen to make the design become a completed product.

The science of cabinetmaking relates to production decisions. They involve the proper application of materials, tools, tooling, and processes in factories, schools, and homes. In this text, hand tool, portable power tool, and stationary power tool operations are explained.

Workpiece assembly and finishing control the final appearance of the product. Joinery determines how well workpieces will fit together. Abrasives help smooth surfaces. Finishing involves adding color and a protective topcoating. The quality of assembly and finishing can make the difference between a poor product and a well-crafted piece of furniture.

The following chapters trace cabinetmaking from selecting or creating designs to applying the final finish. Careful study of these topics will provide you the skills needed to *think and work safely* to design and create high quality cabinets and furniture.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Cabinetry should meet the _____ and _____ of those who use it.
2. Design for _____ first, then for _____.
3. Adapting cabinetry for children and adults involves _____.
   a. size charts
   b. human factors
   c. disabling injuries
   d. identifying needs
4. Production kitchen cabinet widths vary in _____ " modules.
5. *European* hardware is based on a(n) _____ mm screw hole diameter.
6. RTA stands for _____.
7. Major decisions about production relate to _____, _____, and _____.
8. Planning involves what two steps?
9. Organizing involves what four *rights*?
10. The _____ of a product is how well it *meets the requirements and expectations* of the consumer.

Fine quality is apparent in this oak dining room set. *(Thomasville)*

Cabinetry Styles

2

Objectives

After studying this chapter, you will be able to:

* Explain the progress of cabinetry styles from the 17th century to today.
* Describe the differences between traditional, provincial, and contemporary designs.
* List characteristics of the styles that belong to traditional, provincial, and contemporary designs.

Important Terms

American Colonial
American Modern
Chippendale
Duncan Phyfe
French Provincial
Georgian Colonial
Oriental Modern
Pennsylvania Dutch
Queen Anne
Scandinavian Modern
Shaker
Shaker Modern
Victorian
William and Mary
Windsor

Cabinets and fine furniture are often built to match a style. ***Style*** refers to the features of the cabinet that distinguish it from other pieces. Some of these features include the color, molding, and shape of the cabinet.

Many styles originated in 17th and 18th century Europe. Early styles were named after kings, queens, countries, or designers. Many people had pieces designed for them or did the designing themselves. The earlier styles have been *handed down* and modified over the years. However, the influence of European, Asian, and early American designers can still be seen.

Progression of Styles

Cabinetry is one way to express individual differences. Most early pieces were highly carved and very heavy. See **Figure 2-1.** By contrast, some had spindly legs and appeared that they would break if moved. See **Figure 2-2.** Both of these styles are typically identified as ***traditional cabinetry***.

As time passed, traditional designs were copied, technology advanced, and less carving was done. Ways were found to reduce the weight of some styles. Products were made to look stronger. More average people, or peasants, could then afford the cabinetry. These products were called ***provincial***, which meant for *people across the countryside*. See **Figure 2-3.**

The next transition in cabinetry saw curves replaced by straight line designs. This further reduced the cost of the product. The term ***contemporary*** was given to this style of cabinetry and furniture. See **Figure 2-4.**

Figure 2-1. This French Provincial style bombé door chest is an example of an early cabinetwork style. Modern hardware allows the doors to open back against the end panels. (*Thomasville*)

Figure 2-2. This chest on stand has cabriole legs. The piece is an example of a modern adaptation of the Chippendale style. (*Drexel Heritage Furnishings, Inc.*)

Figure 2-3. Provincial furniture had less carving than traditional pieces. (*Drexel Heritage Furnishings, Inc.*)

Early cabinetmaking

You have to admire the early manufacturers. Before the early 1800s, neither steam nor electricity was available. Pieces were produced with hand tools like shaper planes and shaped scrapers. Machines, like wood turning lathes and saws, relied on foot or hand power. Lathes and scroll saws had foot treadles. The cabinetmaker pressed the treadle with one foot that turned the workpiece or the saw blade. On other saws, an apprentice turned a handle to create the power while the master performed the operations.

In early America, handmade products were crude and plain. See **Figure 2-5.** As people moved westward, they loaded and unloaded their belongings. Many

Figure 2-4. Contemporary furniture uses straight lines with very little carving. These pieces are easier to produce with modern machinery. (*Drexel Heritage Furnishings, Inc.*)

Figure 2-5. Early American furniture was plain. Parts were held together by wood pins for easy disassembly. (*Ethan Allen*)

times, cabinets had to pass through small doorways. Furnishings were assembled with mechanical fasteners such as wedges, square pegs or round pins. These fasteners could be removed quickly to disassemble the furniture. To have carved, fragile furniture in this environment was not practical.

Built-in closets and storage areas were unknown at this time. Clothing would hang on pegs on the walls or be placed inside movable cabinets.

Modern cabinetmaking

Today, people remain mobile. However, few pegs and pins are still used. Modern products include hinges, bolts, nuts, and screws. This hardware simplifies disassembly, reassembly, and provides space-saving features.

Powerful machines in operation today simplify the cabinetmaking process. Modern production practices involve jigs and fixtures to hold the work while the cabinetmaker performs the operation. In more automated facilities, the machine holds the work and performs the operation.

Because of mass production techniques, little free-hand surface carving is done today. Templates used with routers or shapers create the carved look. The same appearance can be achieved with molded or carved accessories.

Styles produced by today's manufacturers may follow various characteristics quite faithfully. However, the processes and materials have changed considerably over the years. Most styles are not intended to be *reproductions*, but many of today's products are derivatives of earlier styles. Many styles blend the finer features to two or more styles. Thomasville has a Shaker-style collection of bedroom and occasional furnishings called *Bridges*. This collection embodies design elements of both Shaker and Danish Modern design. As the name implies, the design bridges the gap between the traditional and contemporary styling. See **Figure 2-6.** Thomas Sheraton, Thomas Chippendale, and George Hepplewhite, whose names have been attached to styles, combined elements of the styles of others with their own.

Figure 2-6. This piece contains design elements of both Shaker and Danish Modern style. (*Thomasville*)

Traditional Styles

Names associated with cabinetry can be traced back hundreds of years. Some of the earliest periods date back to 16th century medieval Europe. The furniture of this era was made of oak that made it very sturdy and bulky. This style was imitated by the early American colonists.

During the 17th century, heavy oak furniture gave way to lighter, more elaborately carved walnut pieces. This furniture became known as traditional cabinetry. Each traditional style claims one or more unique features. Many of these features involve intricate carvings. These pieces would be too expensive to produce today in their original form. However, the influence of traditional styles still affects modern furniture.

William and Mary

Mary, Queen of England, and her husband, William, reigned in the latter 1600s and early 1700s. The ***William and Mary*** style introduced the gate leg table and the highboy. The ***gate leg table*** has legs that swing out (much like a fence gate) to support hinged table leaves. See **Figure 2-7.** The ***highboy*** is a drawered cabinet on legs. See **Figure 2-8.**

The legs on William and Mary cabinets, tables, and chairs were turned. Sections often looked like upside down cups. See **Figure 2-9.** Curved stretchers often times connected the legs for stability.

Other distinctive features were curved, decorative edges and arch-like sections. Veneering and marquetry (fitting veneer to form a picture or design) were also used.

Queen Anne

The new elegance in English furniture brought refinements in design and joinery in the 18th century. Cabinetmaking became a high art in both England and the American colonies. ***Queen Anne furniture,*** which is best known for the cabriole leg and carved surfaces, evolved during this time. See **Figure 2-10.** A ***cabriole leg*** is a curved leg that ends with an ornamental foot. Often times, cabriole legs ended with feet shaped as claws or paws.

Figure 2-7. Gate leg table. Legs swung out to support hinged table leaves. (*Thomasville*)

Figure 2-8. Highboy of the William and Mary style. (*Colonial Homes*)

Carvings that looked like scalloped shells were distinctive features. Queen Anne furniture also adapted the William and Mary arches. Some products had turned spindles attached. Chair splats (backs) generally were solid vertical components. Popular pieces of this style were highboys, lowboys, wardrobes, chairs, and desks. See **Figure 2-11.**

Chippendale

The ***Chippendale*** style evolved during the last half of the 18th century. Thomas Chippendale designed and built highly-carved mahogany and walnut furniture. Rarely was veneer used nor did he use inlays of any kind.

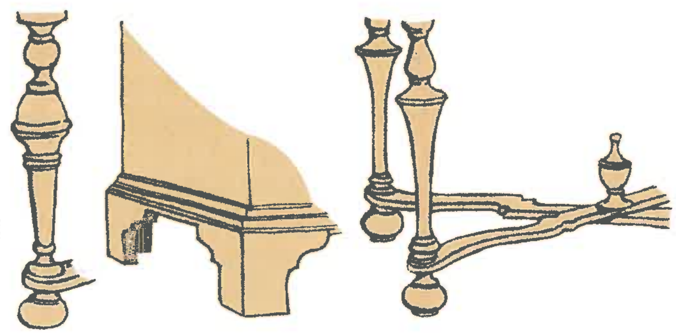


Figure 2-9. Left—Cabinet legs of William and Mary style were shaped like inverted cups. Right—A bracket foot. (*Colonial Homes*)

Figure 2-10. The cabriole leg was a principal feature of the Queen Anne and Chippendale styles. It was designed after the leg of an animal. The leg often ended in a carved foot. (*Otto Gerdau Co.*)

In 1754, Chippendale published the three volume "Gentlemen and Cabinetmakers Directory." The book brought him much fame in America and Europe, yet Chippendale was not an innovator. He borrowed characteristics from Chinese, French, and English designs.

Of his work, chairs were very distinctive. Cabriole shapes remained popular for front legs on chairs. However, the back legs were straight. Occasionally, all legs were straight. Chair backs were shaped in open loop sections or resembled the Queen Anne style. See **Figure 2-12.**

On tables and other pieces, Chippendale cut geometric shapes through the wood on the aprons (sides). This feature is called a ***lattice.*** See **Figure 2-13.** On other pieces, he only carved geometric shapes called ***fretwork.*** See **Figure 2-14.**

Chippendale was influenced by Chinese furniture, which is often made of bamboo. Notice the bamboo-like turnings on the diagonal stretchers in **Figure 2-13.** These products are referred to as ***Chinese Chippendale.***

Figure 2-11. Top—A highboy in the Queen Anne style had cabriole legs, arches, and intricate carvings. (*Thomasville*) Bottom—This lowboy features aspects of the William and Mary style. Curved stretchers connect the legs for stability. (*Drexel Heritage Furnishings, Inc.*)

Figure 2-12. Many Chippendale chair backs were shaped in open loop sections. (*Drexel Heritage Furnishings, Inc.*)

Figure 2-13. Chippendale features included lattice work (geometric shapes cut through wood) on table aprons (sides). Also note the diagonal bamboo stretchers between legs. (*Thomasville*)

Hepplewhite

George Hepplewhite was a designer and builder about the same time as Chippendale. ***Hepplewhite*** designed mahogany cabinet fronts, including curved doors and drawers. See **Figure 2-15.** His unique styling included spindly, square, straight legs or fluted round legs. Chair backs often looked like open shields or loops. Carved feathers, ferns, rosettes, and urns also were distinctive of his work. See **Figure 2-16.** Hepplewhite applied veneers extensively. This provided contrasting color and grain patterns.

Figure 2-14. This Chippendale table has fretwork on its legs. (*Drexel Heritage Furnishings, Inc.*)

Figure 2-15. This sideboard is a Hepplewhite adaptation. George Hepplewhite often made the fronts of his cabinets curved. Note the cornhusk inlays on the legs. (*Drexel Heritage Furnishings, Inc.*)

Sheraton

Thomas Sheraton was a designer with many skilled cabinetmakers working for him. ***Sheraton*** influenced furniture designs in the late 1700s and early 1800s. It is easy to see how his designs adapted other styles, such as the William and Mary's turned legs and arches, Queen Anne's carving, Chippendale's fretwork, and variations of Hepplewhite's open chair backs. Sheraton also introduced several products such as twin beds, drop leaf tables, rolltop desks, and kidney-shaped tables. See **Figure 2-17.** Sheraton used characteristics like Prince of Wales feathers along with carved drapery and flowers. His chair backs were filled with intricate carving and tracery.

Dual purpose cabinetry was another Sheraton contribution. Lowboys in dining rooms had door and drawer sections. Napkins, silverware, tablecloths, and other tableware were stored in the drawers. Dishes and stemmed glassware were placed behind the doors.

Sheraton also introduced the secretary. See **Figure 2-18.** The ***secretary*** was a bookcase with a hinged front door that opened downward forming a writing surface. Inside were compartments to organize small items.

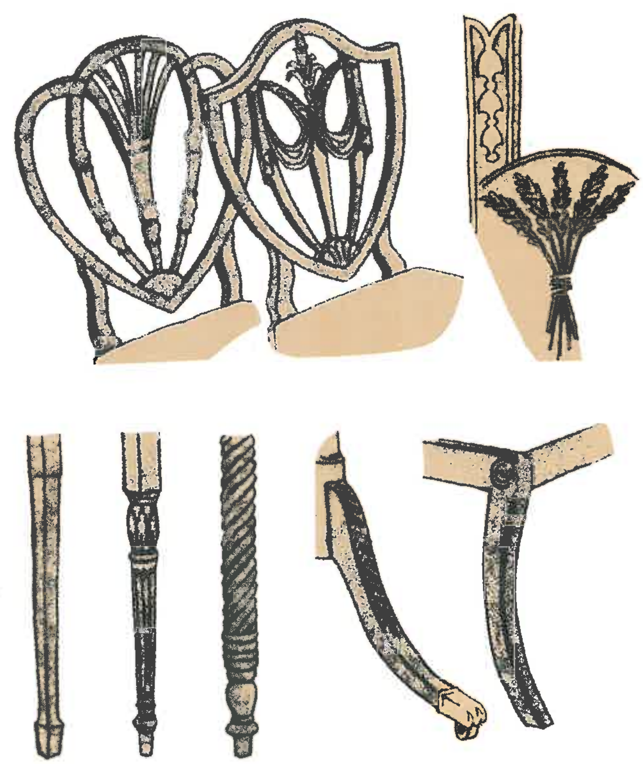
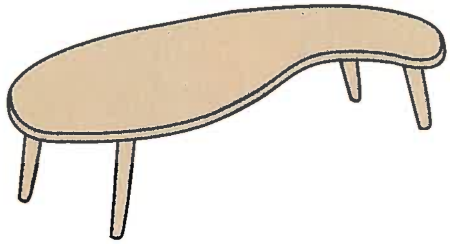


Figure 2-16. Hepplewhite features. Top—Chair backs looked like open shields or loops. Carvings of ferns and urns. Bottom—Legs took on many shapes including flutes and spirals. (*Colonial Homes*)



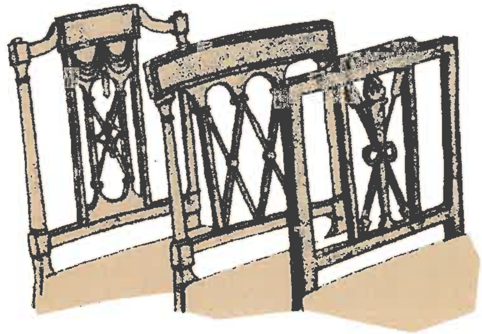


Figure 2-17. Top—Thomas Sheraton introduced the kidney-shaped table. Bottom—His chair backs were intricately carved and abounded in tracery. (*Colonial Homes*)

Provincial Styles

Provincial refers to simplified versions of European traditional styles. Typically, they were for average people. In early America, provincial style products were called ***Colonial***. The Colonial name was derived from furniture used in the colonies. However, many of these products took on traditional features. American colonists wished to remember styles from their European homeland. Other provincial styles are French Provincial, Pennsylvania Dutch, Shaker, Windsor, and Duncan Phyfe.

American Colonial

The ***American Colonial*** period lasted from 1620 to about 1790. Most of the products were very crude. Others were somewhat refined with European influences. Popular pieces included chests, benches, cupboards, gate leg tables, chairs, rockers, and cradles. See **Figure 2-19.** Ladder back chairs had a

Figure 2-18. A secretary has a fold down lid used as a desktop. This American Colonial style incorporated a hutch. On each side of the upper drawers are lopers, which are pull-out supports for the lid. (*Thomasville*)

Figure 2-19. Top—The end table has a simple design cut into the apron. Bottom—Frames and panels were used on the door of this washstand. (*Thomasville*)

Chippendale influence. See **Figure 2-20.** Turned spindle backs showed a likeness to the Sheraton style. Turned legs and curved edges illustrated provincial styling. Cane seats were woven for some added comfort.

French Provincial

French Provincial styles come from the middle 1600s to about 1900. Furniture was noted for having graceful curved edges. The cabriole leg was included in the design after it was introduced in the Queen Anne era. See **Figure 2-21.** Early pieces included bunk beds, stools, benches, and wardrobes. They were made by crafts-persons using fruitwood and walnut. The pieces were imitations of more elaborate traditional designs. In the 1800s, chairs, tables, desks, chests, and clocks were produced. See **Figure 2-22.**

Pennsylvania Dutch

Between 1680 and 1850, many people from Germany and Switzerland brought ideas from their homelands. Their furniture became known as the ***Pennsylvania Dutch*** style. Most products were straight-line and square-edge designs. Some curved edges were used, but most decorations were done freehand. Cabinets were often painted with animals,

Figure 2-20. American Colonial chairs had ladder backs with turned spindle back posts. (*Thomasville*)

Figure 2-21. French Provincial furniture had graceful curves. The round chair was a mark of this style. (*Thomasville*)

Figure 2-22. Top—Bedroom footstool in French Provincial style. Bottom—Notice the curves of the French Provincial table. (*Thomasville*)

fruits, people, and flowers. See **Figure 2-23.** Most products were cupboards, benches, tables, desks, and stacked chests called ***chests-on-chests***. See **Figure 2-24.**

Shaker

Shaker is a plain style produced from 1776 to the mid 1800s. The term Shaker refers to a religious group originating from the Quakers of England who immigrated to America. These pieces were extremely plain with very few decorations. Some Shaker products include chairs, tables (some with drop leaves), chests, and desks. See **Figure 2-25.**

The ingenuity of the Shaker designers became apparent in later products. Shaker designers introduced the swivel and tilt-back chairs.

Windsor

The Windsor Castle in England was the model for the ***Windsor*** style of chairs and rockers. The style involved bent wood arm rests, backs, and rockers. Turned legs, stretchers, rungs, and spindles were also used. See **Figure 2-26.**

The chairs were originally manufactured by ***wheelwrights***. These individuals were skilled at bending wood for wagon and carriage wheels. They also turned wagon wheel spokes.

Duncan Phyfe

The first American designer to adapt European and Asian styles was ***Duncan Phyfe*** (1790 to 1830). He loosely followed the Sheraton and Hepplewhite styles. However, Phyfe designs featured more fine carving. Phyfe also introduced the ***lyre-back chair,*** which was carved into the shape of a harp.

Another distinctive Duncan Phyfe contribution is the column pedestal. The ***pedestal***, with its curved legs, is used as the support for many modern tables. See **Figure 2-27.**

Contemporary Styles

Contemporary cabinetry has existed since about 1925. It is not an individual style with specific features. Rather, the term contemporary includes all the current furniture styles. Each style is a slight adaptation from another. Some pieces are simply copies of former styles with the word modern attached.

Modern styling is an influence rather than a style. It applies mostly straight lines to create

Figure 2-23. The Pennsylvania Dutch style. Cabinets were often painted with flowers or animals. (*Thomasville*)

Figure 2-24. Stacked chest such as these are called chest-on-chest. (*Thomasville*)

Figure 2-25. Shaker products were very plain. Left—Triangle table. Middle—China cabinet. (*Thomasville*) Right—Fold down desk. (*Craft Products*)

Figure 2-26. Windsor chairs were finely crafted by wheelwrights. Many turned wood spindles were used. (*Thomasville*)

Figure 2-27. Pedestals were used instead of four legs on Duncan Phyfe tables. Modern manufacturers have adapted this feature to their Chippendale style furniture. (*Drexel Heritage Furnishings, Inc.*)

geometric forms. This type of construction lends itself well to modern production techniques. Changes occur in modern styles as contemporary designers test new markets for their products.

The most common contemporary styles include Early American, American Modern, Oriental Modern, Scandinavian Modern, and Shaker Modern.

Early American

Early American furnishings combine colonial and plain styles. Curved edges, turnings, and bent woods are common features. See **Figure 2-28.** Many pieces have mechanical components like the Shaker swivel chair and tilt-back chair. On some pieces, pegs and pins are visible for appearance. They are usually permanent, unlike colonial furniture that has pegs to allow for disassembly.

American Modern

American Modern cabinetry usually means clean, undecorated products. Flat surfaces with straight or gracefully curved lines have eye appeal. Textures from cane or fabric provide accents. Legs are straight or slightly tapered, and they may be either round or square. See **Figure 2-29.** There are no carvings to collect dust. Pieces are free of easily broken small decorative parts. The design reflects an on-the-move family lifestyle. See **Figure 2-30.**

Figure 2-28. Early American style of furniture decorates many homes today. (*Thomasville*)

Figure 2-29. American Modern furniture has straight lines and is rarely carved or decorated. (*Thomasville*)

Oriental Modern

Oriental styles date back hundreds of years. Once they were highly carved and decorative. Today's ***Oriental Modern*** pieces combine straight lines and curved geometric shapes. Curved legs and wide feet are typical. See **Figure 2-31.** Stenciled or hand-painted copies of art remain on lacquered surfaces. Opaque lacquered surfaces are often seen on Oriental Modern pieces. See **Figure 2-32.**

Figure 2-30. American Modern designs reflect an active, mobile lifestyle. (*Drexel Heritage Furnishings, Inc.*)

Figure 2-31. Curved geometric shapes, such as the inward curved feet, are typical of Oriental Modern furniture. Note the inward feet. (*Thomasville*)

Figure 2-32. Often Oriental Modern pieces are finished with black or green lacquer. (*Thomasville*)

Scandinavian Modern

Styles from Swedish and Danish designers are recognized by their sculptured look. ***Scandinavian Modern*** furniture has gentle curves, especially on stretchers and tapered legs. See **Figure 2-33.**

Shaker Modern

Shaker Modern is an updated version of the original Shaker features. Various parts, legs in particular, remain slim and appear weak. Pin and peg ends may be visible. Most often these pin and peg ends are wood plugs over metal fasteners.

Coordinating Styles

Most of the discussion of style has focused on individual pieces of furniture. Often it is desirable that furniture within rooms be coordinated. Coordination of entire home interiors can be attractive. You can coordinate styles for the interior and exterior of the home.

Figure 2-33. Scandinavian Modern furniture is designed to have gentle curves and smooth texture. (*Dyrlund-Smith*)

Single rooms

Furniture within a single room should have the same style. This gives authenticity to the environment. ***Authenticity*** refers to how well the room matches the historic original room. For example, to make the atmosphere of a room feel colonial, all the furniture and decoration should be Colonial. Other rooms could have a different style. You might have a Queen Anne bedroom, a Sheraton dining room, and a Hepplewhite living room.

In contemporary design, there is no historic precedent to follow. Here, matching furniture creates harmony. Each piece of furniture fits well with the overall style of the room and furnishings.

Multiple rooms

Matching styles of multiple rooms increases the effect of authenticity. Harmony of the entire house is also achieved. Design characteristics of the furniture will apply to doors and door and window moldings. Wall and floor coverings are finished according to the overall style. Both built-in and freestanding cabinetry and furniture can be coordinated to achieve harmony. See **Figure 2-34.**

Changing and creating a style

The following examples describe how a room may be adapted to match a style. The room to be changed is a kitchen. First, begin with a basic floor plan and layout sketch of a room. See **Figure 2-35.** From this sketch, you can adapt the styles covered in this chapter to fit the room.

During the Hepplewhite, Sheraton, and Duncan Phyfe eras, raised panels were popular. These panel assemblies, along with combinations of furniture, illustrate the traditional style. See **Figure 2-36A.**

French Provincial was identified with graceful curved edges. These were placed on the doors and drawers of cabinets. Change the basic cabinet fronts and moldings to have a French Provincial kitchen. See **Figure 2-36B.**

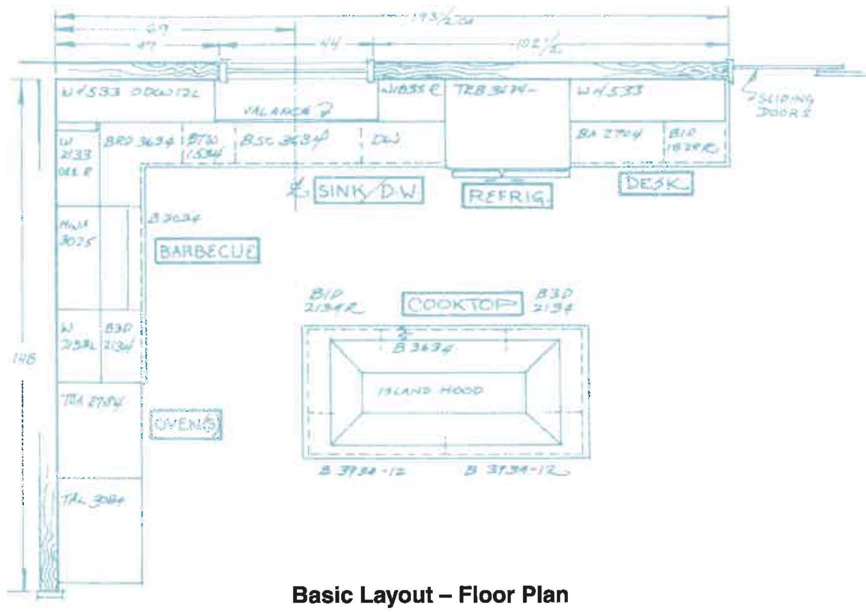
Colonial furniture was crude and bulky. To reduce weight, cabinetmakers would set thin panels inside thick frames to build doors. The colonial kitchen in **Figure 2-36C** uses plain, bulky cabinet fronts. Brick was commonly used in colonial times to build the fireplaces used in cooking. Today, it may be placed in the kitchen to surround cooking areas to impart an appearance of a colonial style.

Bedroom

Family Room

Dining Room

Figure 2-34. Coordination of furniture styles creates harmony of the interior of the home. (*Thomasville*)



Basic Layout – Floor Plan

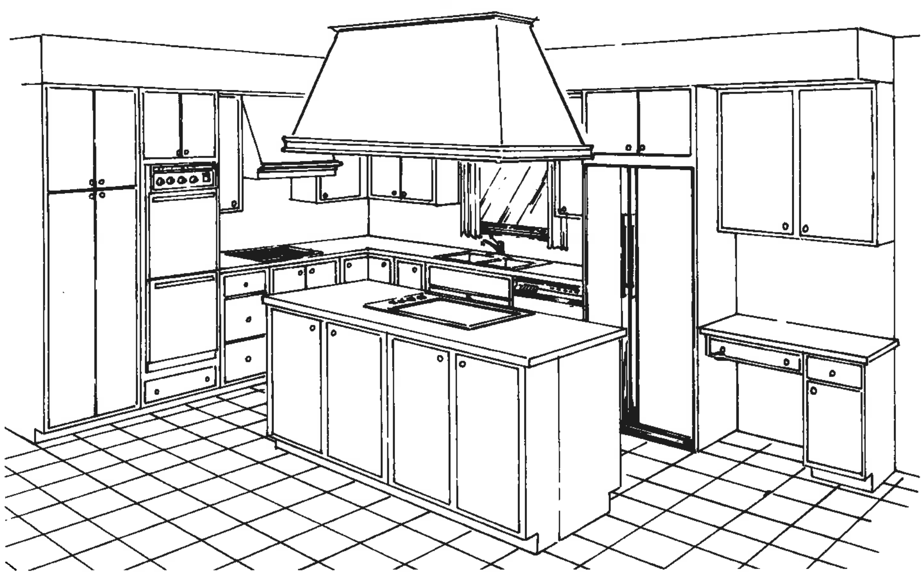


Figure 2-35. Sketches assist in determining how to change the style of a room. (*Wood-Mode*)

Shaker furniture is noted for smooth, undecorated, simplistic features. Cabinet doors had inset panels. Inset panels are shallower than the frame that surrounds them. The Shaker kitchen in **Figure 2-36D** is very simplistic. Even the rivets to hold overhead vent pieces together are shown.

Scandinavians used smooth surfaces with rounded corners. These are reflected in the Scandinavian kitchen. See **Figure 2-36E.**

Oriental furniture of Chippendale and Oriental Modern influence used geometric shapes. Chippendale carved lattices into the furniture. Oriental Modern furniture often uses straight-line designs. Many oriental designs include louvers. Louvers are frames of slanted rectangular slats of wood closely spaced in a frame. You cannot see through the louvers, but the slant allows openings for ventilation. The Oriental kitchen in **Figure 2-36F** uses repetition of louvers to form the cabinet front.

Coordinating interiors and exteriors

Many homes coordinate the interior style of furniture with the exterior of the house. To coordinate styles, you must look at homes of the period. You must also determine the furniture style of that period.

Home styles often are classified differently than furniture styles. Using the familiar kitchen layout, **Figure 2-37** gives some examples of interior/exterior coordination for Georgian Colonial, Victorian, English Tudor, Spanish, and Contemporary homes.

Georgian Colonial homes were usually rectangular, and windows were placed in perfect

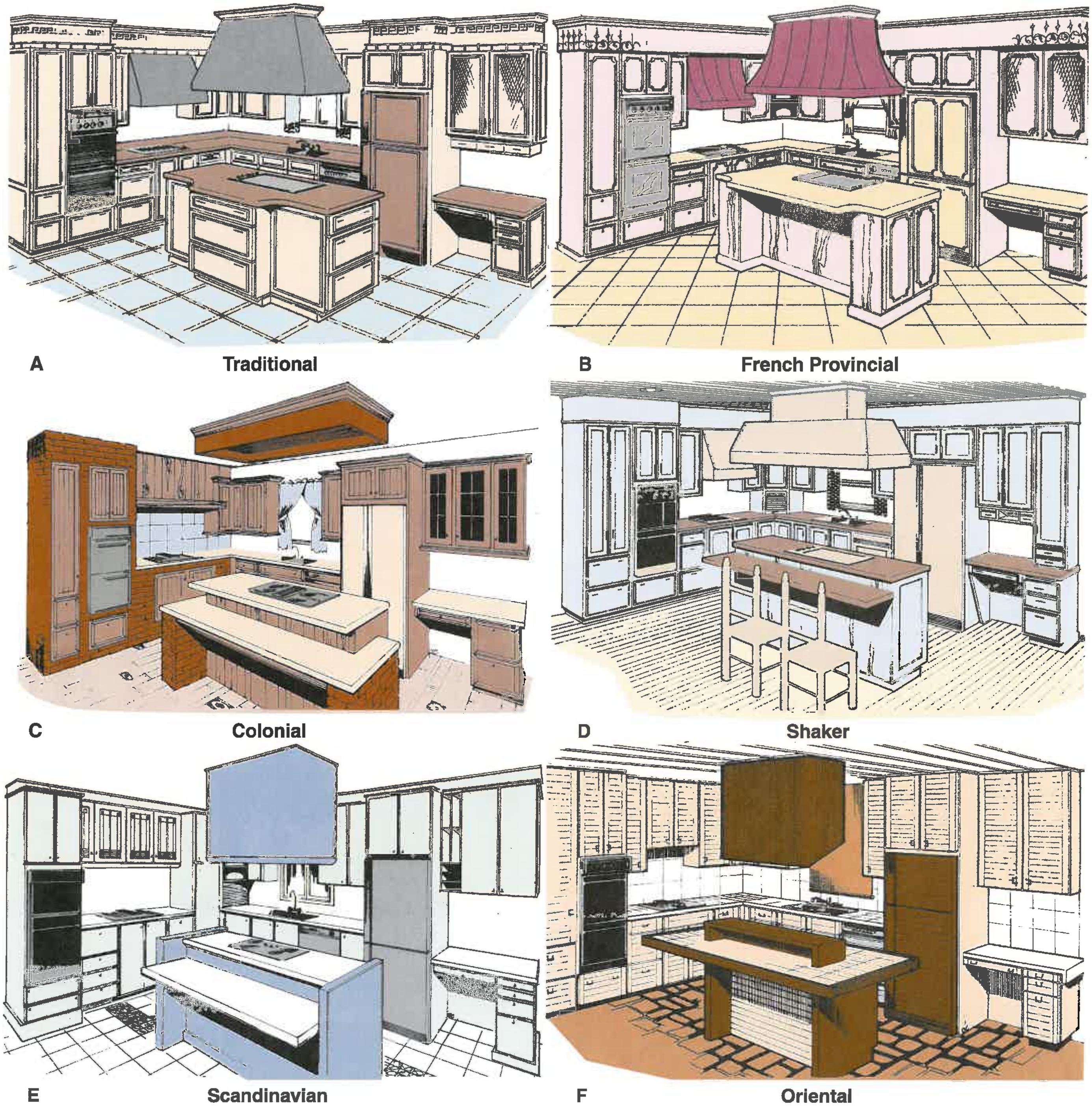
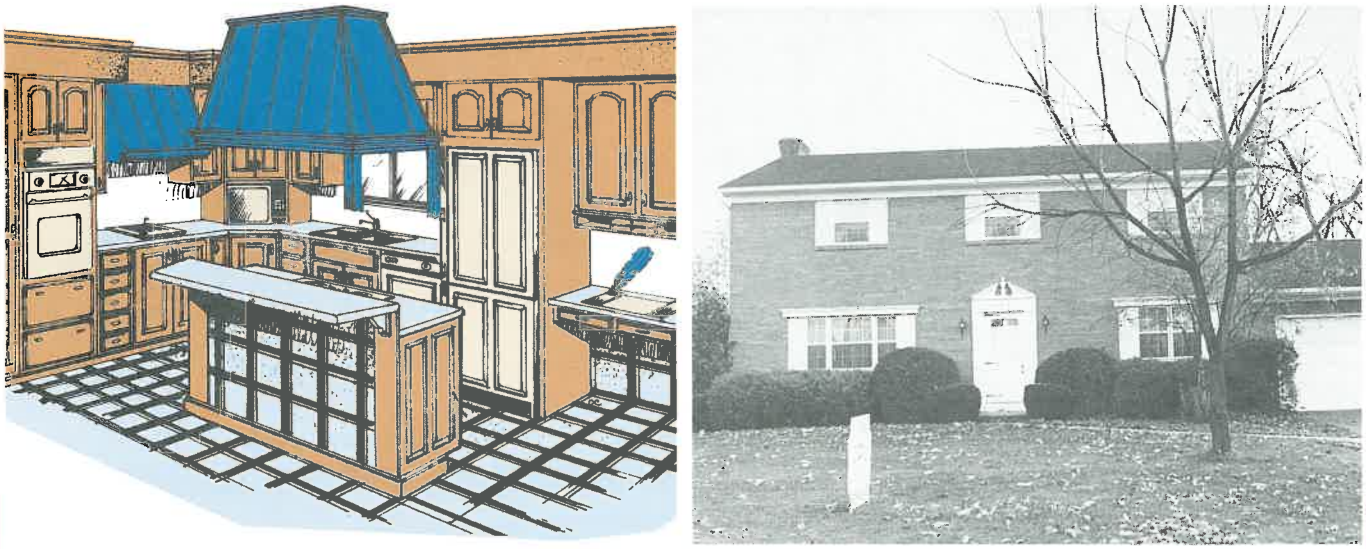


Figure 2-36. Many different styles can be created from the original room without much alteration. (*Wood-Mode*)

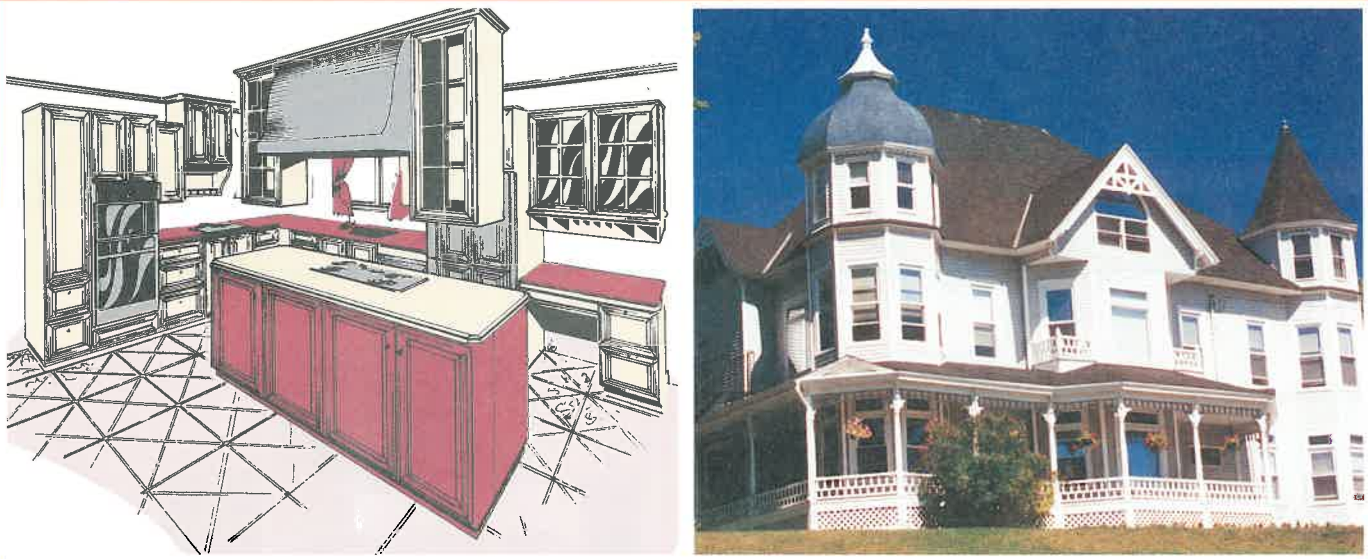
symmetry. Interior rooms were arranged to allow for the symmetrical exterior. The entrance was placed in the center of the front of the house. The front door had a small entrance portico with pilasters and a pediment above. The Georgian colonial kitchen is designed with symmetry. The doors are also designed with arches on the top of cabinet doors. See **Figure 2-37A.**

Victorian homes were large and heavily ornamented. Carvings and turnings were fastened to the underside of porch roofs. The homes were typically two story and irregular in shape. Designers paid little attention to harmony or pleasing proportions of the house. This Victorian kitchen is a toned down version of Victorian styling. Curved air vents cover the stove. Much of the ornamentation in modern Victorian rooms is left out. See **Figure 2-37B.**

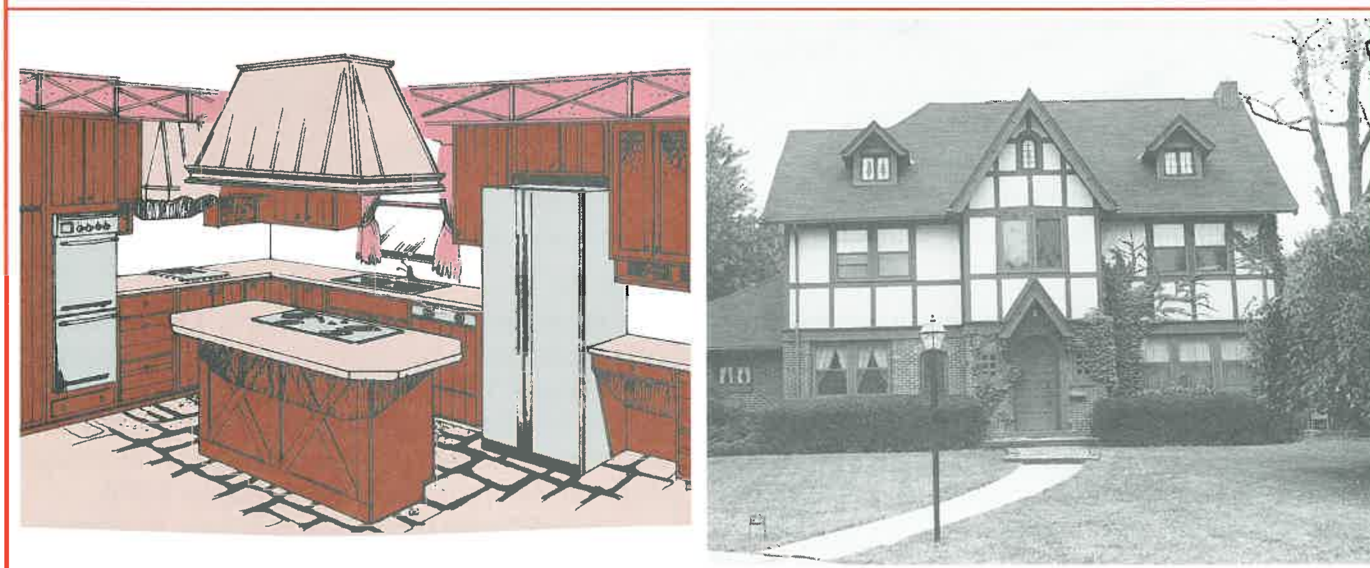
English Tudor homes are noted for their timber-like decorations. Solid thin boards surrounding wood panels are most often used. These characteristics are reflected in the cabinet fronts and soffits over the cabinetry. See **Figure 2-37C.**



A—Colonial



B—Victorian



C—English Tudor

Figure 2-37. Interiors and exteriors of homes may be coordinated. (*Wood-Mode, California Redwood Assoc.*)

Spanish homes are usually single story stucco brick homes with low pitch hip roofs. Architecturally, the houses are very simple. The floor plan usually is a U shape, with an open patio on the front side of the house. The entrance into the patio has multiple arches. The garage doors also have arched tops. The Spanish kitchen reflects this style. Brick is applied on the interior as it was on the exterior. Arches over certain food preparation areas are formed by bricks. Either real or imitation beams run across the ceiling to replicate earlier Spanish homes built of beams and clay. See **Figure 2-37D.**

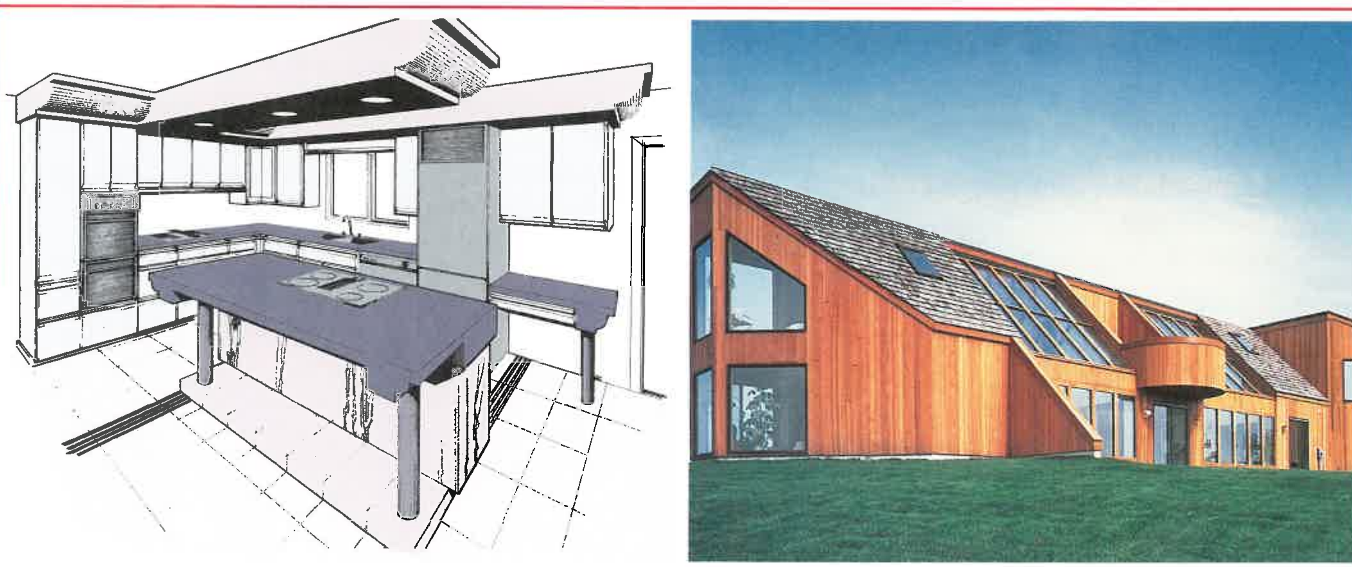
Contemporary homes include straight lines and simple geometric shapes. The home in **Figure 2-37E** is almost entirely made up of straight lines. An arc on one window is used to break monotony. The kitchen also follows the clean-cut, straight line design. Subtle geometric forms break the straight lines.

Summary

For many early kings, queens, and designers, having a cabinetry style named after them was a form of recognition. These people dictated the various features of the piece. Some products were heavy and highly carved. Others appeared weak and top heavy. These styles are classified as traditional.

People of less prominence began to copy traditional products. They simplified some of the design features, which affected cost. These products were called provincial.

D—Spanish



E—Contemporary

Figure 2-37. continued)

Since the early 1900s, a contemporary styling trend has gained popularity. In some cases, this represents further simplification of former designs. Style has been altered due to advancing technology in production processes.

Contemporary cabinetry is a broad classification of designs. Earlier designs were modified with the term *modern*. Some have been created using other names. Simple straight and curved lines creating geometrical forms are used almost exclusively.

Design coordination often may be desired. Single rooms, multiple rooms, and home exteriors and interiors can be coordinated.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Three terms to classify cabinetry designs are _____, _____, and _____ .
2. A reason why contemporary designs have less carving than early traditional designs is _____.
3. Describe early cabinetmaking facilities and techniques.
4. Two products introduced by the William and Mary style were _____ and _____.
5. Arches are associated with _____ and _____ styles.
6. The Queen Anne style is best known for _____.
   a. bamboo stretchers
   b. cabriole legs
   c. fluted legs
   d. fretwork
7. Common Chippendale features were _____ and _____.
8. Chinese Chippendale used _____ between table legs.
9. The open shield chair back was associated with the _____ style.
   a. Hepplewhite
   b. Queen Anne
   c. Sheraton
   d. Windsor
10. What new pieces of furniture did Sheraton introduce?
11. _____ style first used the column pedestal to support tables.
    a. Duncan Phyfe
    b. Early American
    c. Pennsylvania Dutch
    d. Scandinavian Modern
12. A distinctive feature of French Provincial furniture was _____.
13. In early America, products were held together with _____, _____, or _____.
14. What features did American Colonial furniture borrow from other styles?
15. A common characteristic of Pennsylvania Dutch furniture was _____.
    a. cabriole legs
    b. carved decorations
    c. lattices
    d. painted decorations
16. _____ style cabinets were often painted with animals, fruits, people, and flowers.
17. The Pennsylvania Dutch stacked chests are commonly called _____.
18. Swivel and tilting chairs were created by the _____.
19. Windsor chairs were originally produced by _____.
20. _____ was the first American designer to adapt European and Asian styles.
21. Two Duncan Phyfe contributions are the _____ and _____.
22. _____ is not an individual style with specific features, but is an adaptation of all the current furniture styles.
23. How does the finish on most Oriental Modern furniture differ with other cabinet styles?
24. Contemporary cabinetry with graceful curves is _____.
25. Describe four home styles and features used on the interior of the home.

Components of Design

3

Objectives

After studying this chapter, you will be able to:

- Describe the difference between the function and form of a cabinet.
- Apply design elements and principles to create functional and attractive cabinets.
- Identify alternative designs with convenience and flexibility.

Important Terms

design	intensity
form	primary colors
formal balance	primary horizontal mass
function	primary vertical mass
golden mean	proportion
harmony	repetition
hue	value
informal balance	

Designing is the most creative practice in cabinetmaking technology. As the designer, your activities and decisions will affect the outcome of the product. Two factors that guide the development of the product during design are function and form.

Function

The ***function*** of cabinetry is to meet the needs of the user. A ***functional design*** serves a purpose. See **Figure 3-1.** The product may store clothes, recreational equipment, or dishes. It might house appliances or electronic devices, or be used to display trophies. Other functions could be supporting lamps, game boards, or worktables.

A functional ***design*** should be efficient and effective to meet the needs of the user. Your creative ability as a designer will determine how well the finished product meets these needs.

Form

Form refers to the style and appearance of the product. The form of the finished product should have a pleasing appearance. The product must be large enough and strong enough to serve its intended purpose. It should also fit in with the style of nearby furnishings. See **Figure 3-2.**

Levels of Design

Achieving a final design solution is challenging. The product must serve its purpose and be visually pleasing. As a designer, you are responsible to meet this challenge.

The three different ability levels among designers are copying, adapting, and creating. Beginners often copy a design from prepared drawings and specifications. As their knowledge and skill increases, they begin adapting. Designers at this level remember

t**Figure 3-1.** This functional design is used for storage, display, and as a writing desk. (*Thomasville*)

Figure 3-2. Furniture in a room should blend. (*Thomasville*)

design features they have seen and adapt them as they design products. Fully experienced designers should be able to create an original product. Regardless of your artistic ability, all levels of design use the same elements and principles.

Design elements

The four elements of design that you will apply are lines, shapes, textures, and colors. Individually, these elements describe specific details for a design. Combined, they form the overall visual appearance of the product.

Lines

Lines are the basic element in visual communication. Your eyes tend to follow the path of a line. See **Figure 3-3**. Straight lines lead your eyes in one direction, whether it be horizontal, vertical, or diagonal. Curved lines cause your vision to change direction.

Lines can accent a design. See **Figure 3-4**. Vertical lines accent a tall, narrow shape such as a

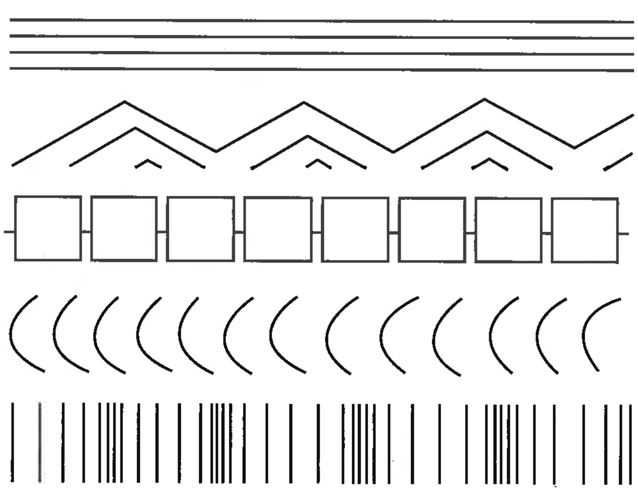


Figure 3-3. Lines will lead your eyes from one end to the other.

Figure 3-4. Top. Vertical lines enhance tall furniture like this curio cabinet. Bottom. Horizontal lines enhance wide furniture like this chest. (*Thomasville*)

curio cabinet. Horizontal lines dominate the design of a wide, low product such as a chest. Diagonal, or inclined, lines draw attention to a focal point.

Straight lines and square corners are the easiest to produce in cabinetry design. However, shaped curves and turnings are also simple to create. Lines and simple curves satisfy most needs for modern and contemporary products. Complex curves, such as those found in French provincial furniture, are harder to put into a modern design.

Shapes

Designs rely on lines to form shapes. ***Shapes*** represent masses or spaces and are described by the lines that enclose them. See **Figure 3-5**. A ***primary vertical mass*** is a shape that is narrower than it is high. A ***primary horizontal mass*** is a shape that is wider than it is high. See **Figure 3-6.**

Large primary masses should be divided into *major areas* and *minor areas* of different sizes. These areas may also be subdivided. A number of rules guide the designer in dividing spaces, both vertically or horizontally.

Vertical division

The rules of *vertical* division shown in **Figure 3-7** suggest the following:

- ***Rule 1.*** Two parts of unequal sizes (major and minor).
- ***Rule 2.*** Three parts of unequal areas.

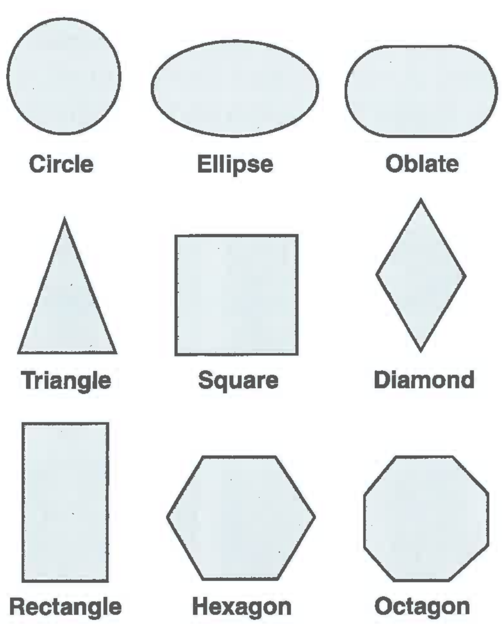


Figure 3-5. Single lines will enclose circular or elliptical shapes. Multiple lines enclose triangles, rectangles, and other polygons.

A

B

Figure 3-6. Top—A primary vertical mass is taller than it is wide. (*Thomasville*) Bottom—A primary horizontal mass is wider than it is tall. (*Sheraton*)

- *Rule 2a.* From bottom to top, the areas will be progressively smaller.
- *Rule 2b.* For other arrangements, the major area should be between the other two minor areas.

- *Rule 3.* More than three vertical divisions.
  - *Rule 3a.* First, separate them according to rules one and/or two.
  - *Rule 3b.* Then, subdivide these masses independently as needed.

Horizontal division

The rules of *horizontal* division shown in **Figure 3-8** suggest the following:

- *Rule 1.* Two equal areas.
- *Rule 2.* A major and a minor area but retain balance (informal).
- *Rule 3.* Three equal areas.

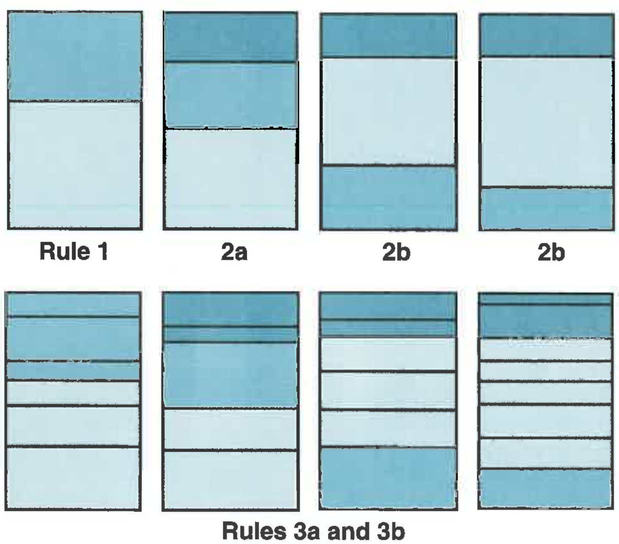


Figure 3-7. There are many ways to divide vertical masses.

- *Rule 4.* Three divisions with major and minor areas.
  - *Rule 4a.* One major area between two equal minor areas.
  - *Rule 4b.* One minor area between two equal major areas.
- *Rule 5.* More than three areas.
  - *Rule 5a.* Areas of equal size and importance.
  - *Rule 5b.* A large area with a number of smaller equal areas on each side.

These rules represent practices for dividing primary masses. The divisions may be accented with textures and colors.

Texture

Texture refers to the contour and feel of the surface of the product. You can specify woven cane (type of grass) to give a rough texture. Molding and trim is used to give texture to corners of cabinets. Texture can also refer to the quality of the surface finish. The texture could be rough or smooth; high, medium or low luster. Whatever material or method is used, it must blend with the style of the product.

Colors

There is an infinite number of colors in the color spectrum. However, all colors are produced from the three ***primary colors*** of red, yellow, and blue. When the primary colors are mixed in various combinations, three additional colors called secondary colors are created. The secondary colors include orange (red and yellow), green (yellow and blue), and violet (blue and red). When primary and secondary colors are mixed, six tertiary colors are created. A color wheel shows these combinations. See **Figure 3-9**. Colors on the opposite side of the color wheel are called complementary colors.

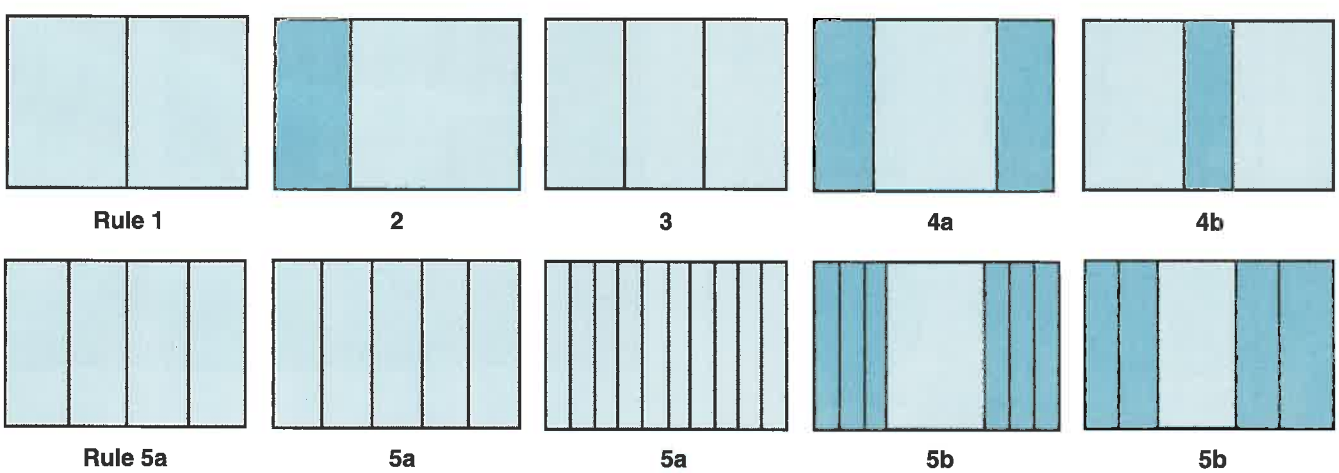


Figure 3-8. Horizontal masses should be divided according to these rules.

Figure 3-9. Mixing primary colors (red, blue, yellow) will produce secondary colors (violet, green, orange).

Color has three distinct properties of hue, value, and intensity. ***Hue*** refers to any color in its pure form. Each hue has value. ***Value*** refers to the lightness or darkness of the hue. A pure hue can be tinted to produce a lighter value to near white. A pure hue can also be shaded to produce a darker value to near black. See **Figure 3-10.**

The third property, ***intensity,*** refers to the brilliance of the color. Intensity also is called *chroma.* Any hue can be made less brilliant by mixing it with its complementary color. For example, small amounts of green added to red dulls the color. The more green added, the more gray the original red color will become. See **Figure 3-10.**

Color on cabinetry results from painted or stained surfaces. ***Paints*** contain color pigments that makes an opaque finish. Opaque finishes hide the grain and provide a protective topcoating. ***Stains*** color the wood and enhance the grain pattern. They contain dyes and sometimes pigments.

Hardware (hinges, pulls) of various colors can be installed on cabinets. Such items may be black,

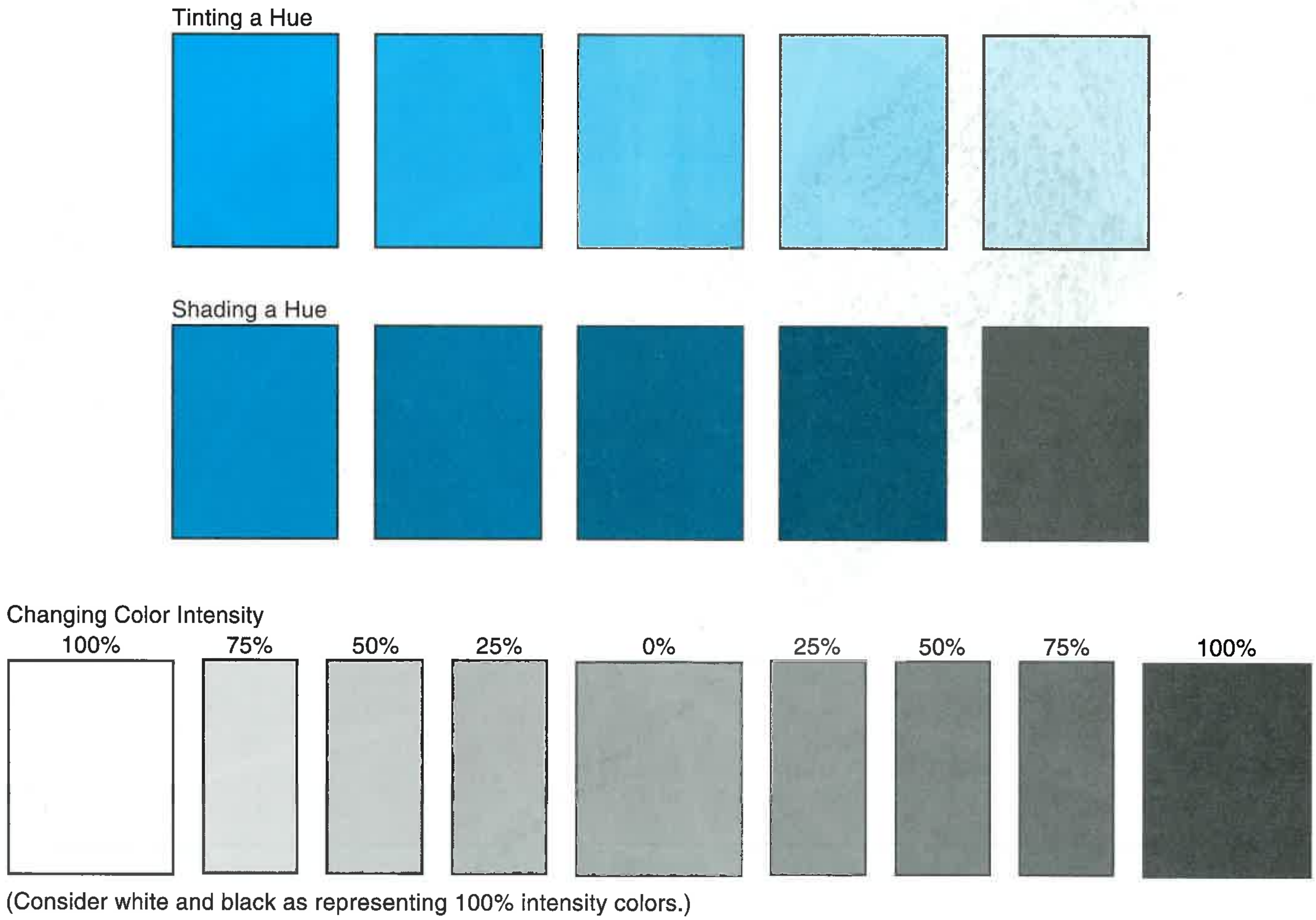


Figure 3-10. Tint, shade, and intensity change the appearance of a color.

white, gray, silver, brown, and gold. These are considered neutral colors and will accent any painted or stained surface. Other colors will need to be selected more carefully. Hardware should be the same or a complementary hue as the surface where it is attached.

Design principles

The ***principles of design*** describe how the design elements apply to cabinetry. These principles are harmony, repetition, balance, and proportion.

Harmony

Harmony is the pleasing relationship of all elements in a given product design. There should be harmony among the masses and the shapes. Create this harmonious feeling by following the rules dealing with shapes. *Harmony of textures* includes using compatible surface contours. *Harmony of colors* follows three basic rules:

- Less intense colors should be used on large areas.
- Bright colors are attractive in small areas.
- Complementary colors should be used. One hue may be the small intense accent of one color on a tinted or shaded color (such as solid red on green tint).

Repetition

Repetition means using an element or elements more than once to create a rhythm in the design and attract interest. See **Figure 3-11**. Straight lines, curved lines, spaces, textures, and colors are effective for this purpose. Experienced designers know when repetition is pleasing. On the other hand, you must recognize when repetition has been used excessively. Too many similar lines, masses, and other elements are boring.

Balance

Balance is the use of space and mass to give a feeling of stability or equality to a design. Balance may be either formal or informal.

Figure 3-11. The honey spice finish on this pine cabinetry gives the kitchen a golden glow. The finish allows the natural knots and distressing, characteristics of pine, to show. These design features add charm to the kitchen. (*KraftMaid Cabinetry, Inc.*)

Formal balance means equality on each side of a center line in the design. Center lines may run horizontally and/or vertically. One half of the product will be the mirror image of the other. For a square mass, balance means repeating a detail in any direction from the center. For a vertical rectangular mass, left and right halves are symmetrical. There may be a center of interest included on the surface. The center may include a decorative detail. It would be above or below the center. Placing a detail above the center is preferred. For a horizontal rectangular mass, the top and bottom halves are equal. Here the detail of interest is below the center line.

Informal balance is more difficult to describe. It is a feeling of balance in the design even though the design is not symmetrical. Usually, one side of the design is more solid than the other. However, to maintain balance, the open side is larger.

Proportion

Proportion is a relationship between the height and width or height and length of a product. Generally, a 2:3, 3:5, or 5:8 relationship is more pleasing than a square. The ancient Greeks arrived at a ratio of 1:1.618 that they called the ***golden mean*** or the ***perfect proportion.*** See **Figure 3-12.**

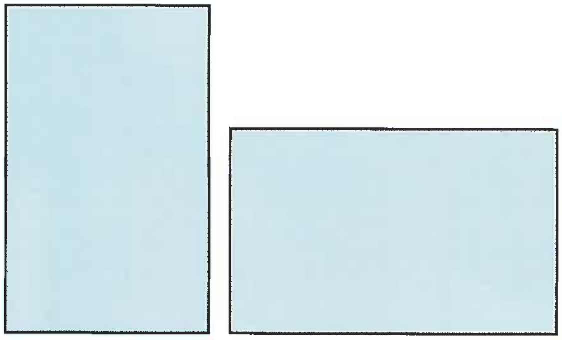


Figure 3-12. The Greek perfect proportion or *golden mean* was a 1 to 1.618 height to width (or height to length) ratio.

Proportion is a subtle relationship among elements and principles. The relationship may relate to the function and convenience of the product. When the function of the product requires greater ratios, major and minor masses should be created. For example, a gun cabinet requires extra height. See **Figure 3-13**. Separating the cabinet with texture, color, or additional features (such as curves and drawers) will make the height of the cabinet appear more in proportion with the width.

Figure 3-13. The use of small doors keeps this gun cabinet from appearing too tall. (*Emperor Clock, LLC*)

Design alternatives

Designing can be a challenge for even the most creative cabinetmaker. Making the function and form blend together is the most critical factor. The pace of people's lifestyles creates problems for a designer. People would like to find items quickly and be able to reach them easily. They dislike unloading a cabinet to get the pot or pan way in back. They would like to place rarely used items higher, lower, or farther from the center of activity.

People are relocating more often. This suggests that cabinetmakers should create light, sturdy cases that can pass through doorways or up and down stairs. Also, items of this nature are easily moved when rearranging room furniture.

During planning, you must consider the person who will use the product. Although design elements and principles are the first factors to be addressed, convenience and flexibility play a big role in designing a satisfying product.

Convenience

Convenience is the ease with which a person can use, move, or locate objects in a cabinet. Special cabinet hardware and careful design of cabinet space provides for convenience.

One way to achieve convenience is with hardware. Racks can be put on the inside of doors for condiments. Cups can be suspended from the bottom of a shelf with hooks. Pullout drawers or trays are especially helpful for storage of supplies. See **Figure 3-14**. Plan for these items during design and not after the cabinet has been built.

The selective use of space increases convenience. Deep drawers store sweaters better than handkerchiefs, socks, etc. Wide shelf spacing is best for blankets and sheets. Shelves for washcloths and hand towels may be narrower and closer together in a closet, because these items do not stack well.

Convenience can be increased in furniture as well as cabinets. For example, nested tables occupy the same space as a single table. See **Figure 3-15**. Folding chairs can be easily stored for occasional use.

Figure 3-14. This convenient utility room has racks, trays, baskets, and other useful storage areas. (*Wood-Mode*)

Figure 3-15. Nested tables take up less space than would a larger table. (*Thomasville*)

Convenience can be achieved by placing appliances, plumbing fixtures, tools, utensils, and work surfaces in proper relationship to each other. They are preferably placed in order of use by the worker. Convenience is more important in frequently used areas, such as in kitchens, offices, and commercial work areas. See **Figure 3-16**.

Increasing the use of room corners is a form of convenience. Some items, particularly if they are small, can be displayed or stored in triangular corner cabinets. Other corner cabinets, such as in the kitchen, may be designed with revolving shelves. These methods make good use of space that was formerly wasted.

Flexibility

Flexibility refers to how many uses your product will have. Adjustable shelving is flexible, because it can be made to store very large or very small items. More shelves can be added when needed. When designing for flexibility, convenience may increase or decrease. You may have to choose between them. Adjustable shelving is an example. More shelves, closely spaced, store items that are difficult to stack, such as canned and bottled goods. However, this plan may not work when you want a pullout shelf for an item. The hardware for it must be permanently mounted.

Figure 3-16. The organization in this photographer's framing salon keeps materials at hand in shallow, but large drawers. The cutting surface is inlaid in the countertop next to the mat cutter, with electric and compressed air outlets just below. Other nearby cabinet tops provide space for dry-mount press and paper cutter. The glass cutter is wall mounted. (*Chuck Davis Cabinets*).

Modular furniture is a different form of flexibility. See **Figure 3-17**. It helps meet the needs of people who are mobile. Pieces can be arranged and rearranged as desired.

A drop leaf extension table is another example of flexibility. It occupies little space when closed but can be opened to serve a large group for dinner. Flexibility and convenience must be considered as well as the elements and principles of design. A final design solution should include all of these fundamentals. Remember, the product built from your design has to be pleasing, both visually and functionally.

Design Applications

As a designer, you try very hard to meet the needs of people of all ages and physical conditions. Take pride in creating functional, tasteful cabinetry.

Your designs will frequently fit the architecture of a home. Consider a home style such as Colonial. Early American case goods, tables, and chairs may be found in various rooms. Built-in cabinets may use mounted hardware items of the same style. Home and furniture designs often are matched to give authenticity to the home. Pay close attention to the components of design when coordinating rooms or interiors and exteriors.

Traditional split level ranch homes and townhouses may be furnished differently. You could use traditional or modern furnishings. It might be formally or informally decorated. There may be decor combinations of Oriental, Spanish, or Mediterranean furniture and cabinets.

There are no hard and fast rules for cabinetry styles. The design of cabinetry and its match to the home is a matter of taste. A single style might be desired throughout. If contrasts are desired, you might incorporate different colors and styles. It is your job to plan for the wants and needs of the person who will use your product.

Summary

Efforts to design cabinetry are based on experience. Some designers copy. Others adapt. Still others create design solutions. Knowing how to adapt or create requires understanding the components of design.

Figure 3-17. Modular furniture has individual cabinets that can be rearranged as needed. (*Drexel-Heritage Furnishings, Inc.*)

The elements of design include lines, shapes, colors, and textures. They must be coordinated to produce pleasing products.

Principles of design guide the use of design elements. Principles include harmony, repetition, balance, and proportion. These help the elements blend. Masses and spaces may appear once or be repeated. Harmonious masses and spaces can be formally or informally balanced. You can proportion elements by using the golden mean ratio. It has been in use for many years.

An experienced designer will create alternative designs. Two factors to be considered for these designs are convenience and flexibility. Convenience refers to ease of locating, using, and moving objects. Flexibility refers to the product's ability to be rearranged for different purposes.

Cabinet and furniture designs should fit with their surroundings. Considerations may include how the design blends with the style of the home. Careful consideration of the components of design must be given when coordinating styles.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. The two primary concerns when designing cabinetry are _____ and _____.
2. Name the four elements of design.
3. Give an example of a primary vertical mass and an example of a primary horizontal mass.
4. List the primary colors.
5. Pure color is also called a _____.
6. Making a color lighter changes its _____, and adding a complementary color changes a color's _____.
7. List the four design principles.
8. How is harmony different from balance? How are they the same?
9. The relationship between height and width is called _____.
10. When you include design alternatives, be sure to consider _____ and _____.

Well designed and crafted cabinetwork gives an owner great satisfaction and years of service.

4

Design Decisions

Objectives

After studying this chapter, you will be able to:
- Identify needs and wants for a cabinet.
- Follow the steps of the decision-making process.
- Choose materials that will satisfy the design.
- Design cabinetry that is convenient and flexible.

Important Terms

brainstorming
cost analysis
decision-making process
functional analysis
mock-up
preliminary ideas
refined ideas
strength test
specifications
working drawings

The ***decision-making process*** guides your thoughts and actions through the many steps involved in creating a cabinet design. See **Figure 4-1.** It directs your activities during design.

The decision-making process allows for flexibility. You are not bound to one design idea. The design that is the most functional may not be the most attractive, and the design that is the most attractive may not be the most functional. A good design is a balance of all factors. The final decisions should meet the needs of the user.

Identifying Needs and Wants

Designing begins by identifying the needs and wants for a cabinet. A ***need*** refers to function. You might *need* a cabinet that will store food and spices. A ***want*** refers to added conveniences in the cabinet. You might *want* a cabinet on rollers, or one with racks on the doors. Another *want* may be the cabinet style.

Suppose you are planning to design a new kitchen layout. Every home needs a place for preparing and serving meals. Kitchen cabinets must be designed with the appliances in mind. Items include a range, refrigerator, sink, counter area, service area, and storage space. See **Figure 4-2.** Utilities for the appliances include gas, water, electricity, and drains. You might want a built-in microwave oven or dishwasher. Will they be purchased now? If so, the cabinet design will include the appliance. If not, will you allow space now and install them later?

You may also wish to design an entertainment center. Will the cabinet require room for both video and audio equipment?

Gathering Information

The next step in making design decisions is to gather information. For this discussion, the *need* is a home entertainment center. Information must be gathered that relates to function and form.

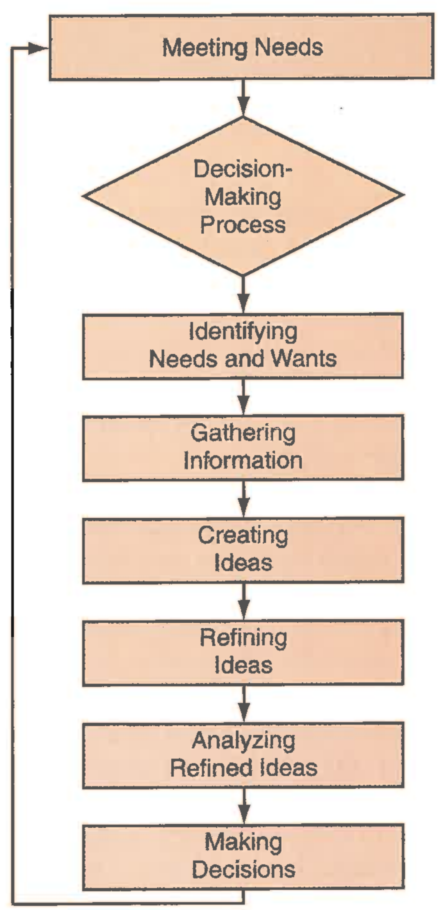


Figure 4-1. The decision-making process has a series of steps. The final decisions should meet the needs of the user.

Figure 4-2. Identify how the cabinet or furniture will be used. *(Aristokraft)*

Think of all situations where the product will be used. Every question listed on this page should be answered. More concerns may arise when creating preliminary ideas.

- What components (TV, stereo, VCR) will be stored in this cabinet?
- Will remote controls be used that require the passage of light?
- How large are the components?
- Where will this cabinet be used?
- How much space is available in the room where this entertainment center will be?
- Should the cabinetry be permanently attached or be movable? Remember, built-in cabinetry establishes a traffic pattern (people walking around the cabinet) that cannot be changed.
- Should the cabinet be modular? Modular pieces allow for flexibility in arrangements.
- What utilities (electricity, antenna, cable jack) are required for the components?
- Where are the utilities located?
- What cabinet style is desired?
- How much do you wish to spend?

One process for gathering information is brainstorming. When ***brainstorming***, you write down every idea or question that comes into your mind. It does not matter if the idea is practical. The object is to think of as many options as possible. You will sort through them later.

Creating Ideas

Once all information has been gathered, you start creating ideas. ***Preliminary ideas*** are made with that gathered information. This stage of design allows for much creativity. Use your knowledge of style, design elements, and design principles to develop ideas. Adapt the most practical and pleasing features to your design.

Begin by making sketches. Sketches show how space will be arranged. Do not worry about finer details such as dimensions or jointwork. Review all of the questions, answers, and information you have accumulated. Consider the function of the product and who will be using it. Also note how the person will use it (sitting, standing, etc.). Sketch all of your ideas as you think of them. Develop as many as possible and keep all of them until the final decision is made. The sketches can be cut out and moved around like pieces of a jigsaw puzzle. Use them to arrange a variety of designs.

Your sketches might be two- or three-dimensional. See **Figure 4-3**. Those with two dimensions show only length and height. Some designers find these inadequate. They prefer to see three dimensions. Three-dimensional drawings have an advantage over two-dimensional. The depth of the sides, as well as length and height, can be seen in one view.

Eventually you will run out of ideas. Be sure to keep all your ideas, because you will now begin refining them.

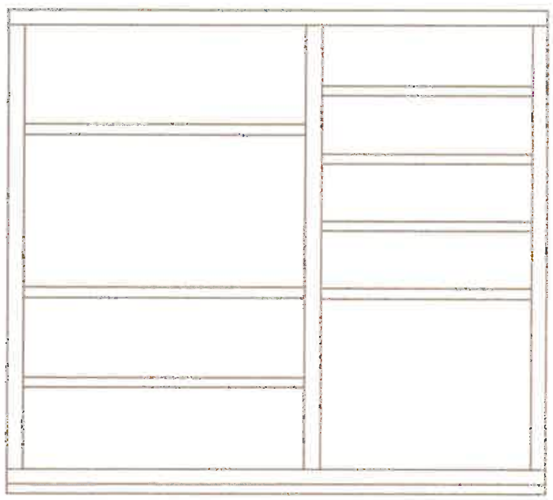


Figure 4-3. A—Two-dimensional sketches represent the height and width of a product. B—Three-dimensional sketches add depth to the design. They give a realistic view of the product. *(O'Sullivan)*

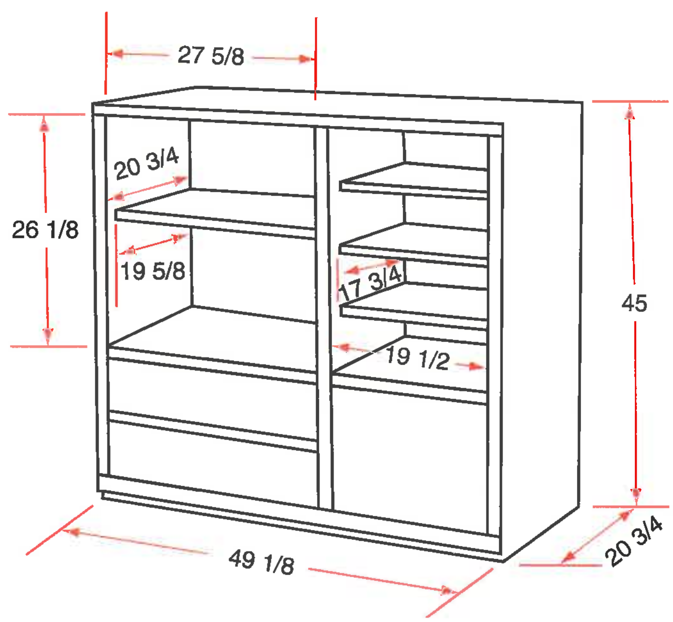
Refining Ideas

Refined ideas begin to include details. You may combine different features of your first ideas. Pick the best ideas from your sketches and put those together. The combined design should represent the proposed product very accurately. At this stage, you will also provide dimensions and decide on the material to be used.

Dimensions

At some point you must provide ***dimensions*** for the cabinet. Dimensions will be determined by the size of what will go in or on the cabinet. For an entertainment center, measure the components and size the cabinet accordingly. See **Figure 4-4**.

If you will be designing kitchen cabinets or furniture, there are standard dimensions you will follow. These include heights and widths for tables, chairs, and certain case goods. Standard dimensions



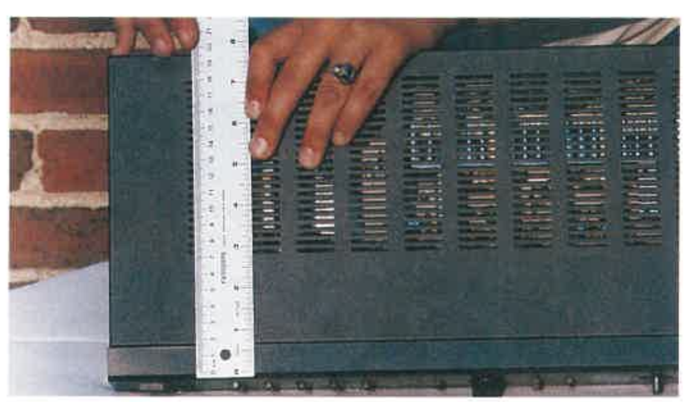


Figure 4-4. Dimensions are partially based on the intended function of the cabinet and the size of the items to be stored. *(O'Sullivan)*

are based on the average size of humans. These dimensions, and other considerations for humans, are discussed in the next chapter.

Add the dimensions to the refined sketches. Use a scale to draw the refined design. You can also make the sketch on graph paper. Let each square on the graph paper represent distance of the product. It might be one square equals ¼" (6 mm). The same square could represent 1′ (305 mm) for another product.

Materials

To determine the materials you need for the cabinet, you must first understand the different materials that can be used. The materials for cabinets are classified as follows:

- **Wood.** Hardwood and softwood lumber, veneer, cane, wood products (panels, molding).
- **Metals.** Steel, brass, aluminum, and copper edging and hardware.
- **Plastics.** Sheets, edging, laminated tops, hardware, etc.
- **Glass.** Sheet, pattern, mirror, stained.
- **Ceramic tile.** Different colors and shapes are available.
- **Adhesives.** Cements, glues, mastics.
- **Hardware.** Screws, nails, bolts, hinges, pulls.
- **Finishes.** Paint, enamel, stain, filler, oil, lacquer, shellac, varnish, urethane, etc.

This list above suggests decisions about materials. It does not include every material you might choose in building a cabinet. Later chapters will further examine materials used in cabinetmaking.

As the materials are identified, a parts list can be created. This list should contain all the materials that will be used to construct the cabinet. The material information and the dimensions are used later to create working drawings and parts specifications. See **Figure 4-5**. Working drawings and parts specifications are briefly discussed later in this chapter, and covered in detail in *Chapters 7* and *9*.

The materials you choose greatly affect the appearance of the product. Different woods produce different surface texture and color. Some are stronger than others. Some also cost more than others. You may decide to use manufactured panel products, such as plywood, instead of lumber.

Different woods have similar grain characteristics. You may wish to stain a cheaper wood to appear as a more expensive wood. Veneer can also be used to make a manufactured panel product look like lumber. There are many options that will achieve the desired outcome.

Other materials, such as metal, glass, and plastic, also affect the appearance. Hinges, pulls, and knobs made of these materials vary greatly in color, shape, and texture. Choose those that fit the style of the cabinet. When selecting hinges, you must also consider strength of the material. Use metal hinges if supporting heavy doors, such as those with leaded glass panels.

If you are working for a cabinet manufacturer, the materials may be specified. They are purchased in large quantities for mass production of products. In this case, you do not have the option of choosing materials. Company designers set the specifications.

Analyzing the Refined Ideas

After refining your ideas, you still may have more than one design idea. Check each design to see if it meets your needs and wants. Look at the cost, materials, and function of each of the products. Eventually, a final decision will have to be made. Changes can be made after you start building the cabinet, but this will be time consuming and wasteful of material and money. Three methods of analyzing your refined ideas are functional analysis, strength test, and cost analysis.

Functional analysis

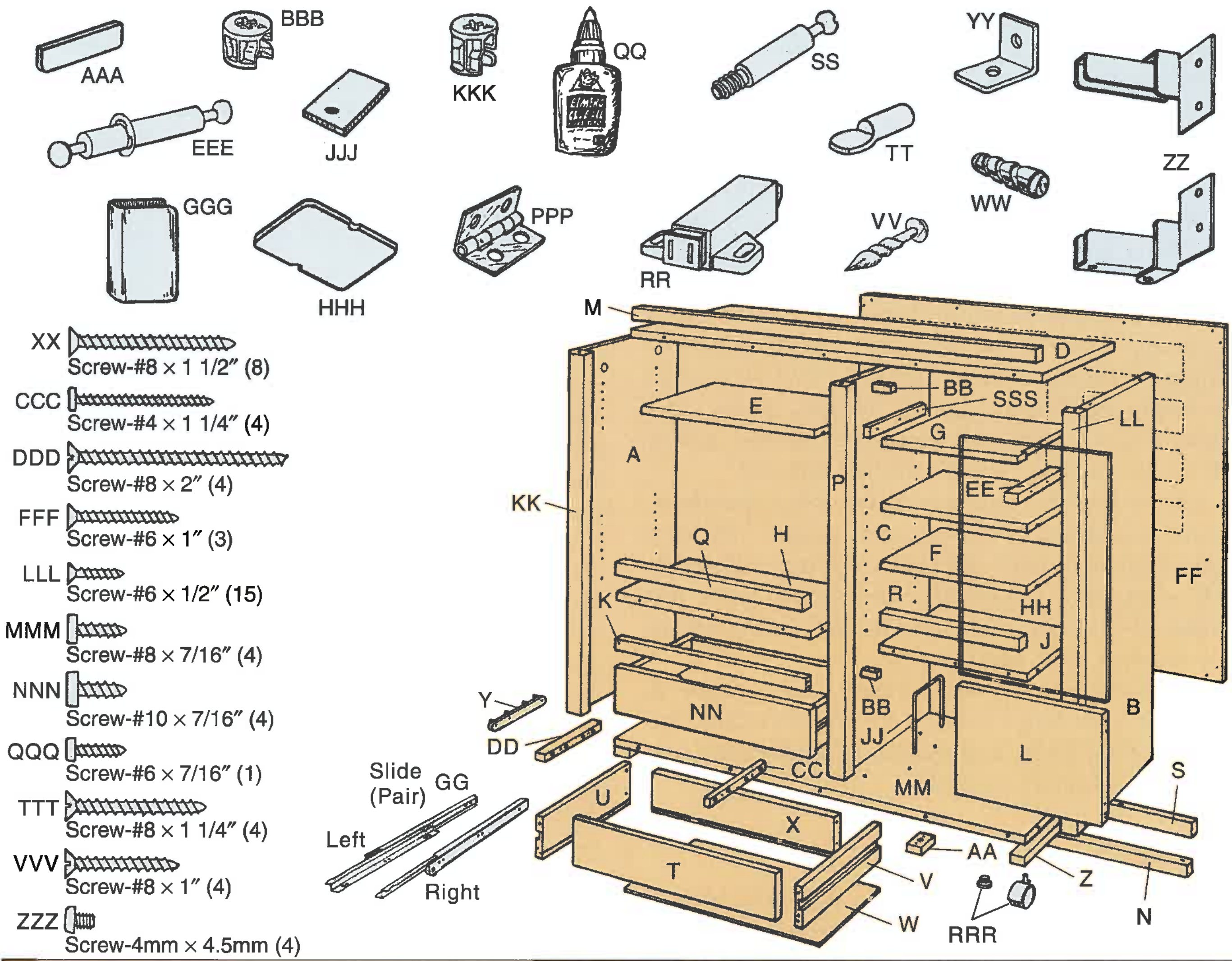
In ***functional analysis***, you check to see whether the product you have designed meets your needs. Refer back to the information gathering stage. Have you overlooked anything? Are estimated space and size requirements correct? Recheck your measurements. Will the doors and lids move freely? Will they close correctly? Will the cabinet hold the contents with ample room?

If you are unsure about any detail, construct a mock-up of the cabinet. A ***mock-up*** is a full size working model of your design. It is made of paper, cardboard, or Styrofoam. Also, if the components to be placed in the cabinet are heavy, construct a model of these components. This process will verify the design will work once it is built.

Strength test

You might perform a ***strength test*** on your design. Will the legs be strong enough? Will a shelf made of a specific material sag? Will the glue hold? Are screws needed for reinforcement?

The extent of the analysis will vary. If you copied a cabinet already in use, little or no testing is necessary. If your design is original, you may want to test the materials. Make sample glue joints and



Parts List								
Item	**Description**	**Qty.**	**Item**	**Description**	**Qty.**	**Item**	**Description**	**Qty.**
A	Left Upright	1	Y	Drawer Slides	4	YY	Angle Bracket	2
B	Right Upright	1	Z	Caster Block	2	ZZ	Hinge (Pair)	1
C	Center Upright	1	AA	Center Caster Block	1	AAA	Cover Plate	2
D	Top Shelf	1	BB	Magnet Block	2	BBB	Small Cam	13
E	Left Adjustable Shelf	1	CC	Right Drawer Spacer Rail	2	CCC	Screw	4
F	Right Adjustable Shelf	2	DD	Left Drawer Spacer Rail	2	DDD	Screw	4
G	Sliding Shelf	1	EE	Right Sliding Shelf Spacer Rail	1	EEE	Double Cam Bolt	2
H	Left Center Shelf	1	FF	Back Panel	1	FFF	Screw	3
J	Right Center Shelf	1	GG	Slide (Pair)	1	GGG	Strike Plate	1
K	Shadow Panel	1	HH	Glass Door	1	HHH	Cushion	1
L	Door	1	JJ	Record Divider	2	JJJ	Strike Plate	1
M	Top Rail	1	KK	Left Upright Rail	1	KKK	Large Cam	19
N	Bottom Rail	1	LL	Right Upright Rail	1	LLL	Screw	15
P	Center Rail (Upright)	1	MM	Bottom Shelf	1	MMM	Screw	4
Q	Left Center Shelf Rail	1	NN	Bottom Drawer Front	1	NNN	Screw	4
R	Right Center Shelf Rail	1	QQ	Glue	2	PPP	Hinge	2
S	Kick Panel	1	RR	Magnetic Catch	2	QQQ	Screw	1
T	Top Drawer Front	1	SS	Cam Bolt	28	RRR	Caster w/Insert	5
U	Left Drawer Side	2	TT	Shelf Pin	12	SSS	Left Sliding Shelf Spacer Rail	1
V	Right Drawer Side	2	VV	Screw Nail	24	TTT	Screw	4
W	Drawer Bottom	2	WW	Dowel	41	VVV	Screw	4
X	Drawer Back	2	XX	Screw	8	ZZZ	Screw	4

Figure 4-5. Design includes deciding dimensions and what materials will be used to construct the cabinet. From this information, working drawing and specifications can be created. *(O'Sullivan)*

test the strength. You might cut a piece of shelf material to length. Test the shelf with weight to see if it will resist bending.

Cost analysis

Cost analysis concerns money for equipment, materials, time, and space. Here again, many questions must be answered. Will additional tools and machines have to be purchased? Can you adapt available equipment safely? Is lumber available at a reasonable price? How does the cost of plywood compare with the cost of lumber? How expensive are hardware items such as hinges, pulls, and movable shelf supports? From the choices, which will be the most serviceable at the least cost?

Cost factors also influence ***make-or-buy decisions***. Should you make or buy drawer guides? Will you make permanent joints for shelves or buy adjustable shelf supports? Frequently, completed parts are purchased to speed cabinet production. Examples are legs, spindles, shelf supports, etc.

Space in the working area may be a concern. Is the work area large enough to accommodate the cabinetmaker, tools, and materials? Is the area free of health and safety hazards?

Making Decisions

Actually making decisions is the most important stage of the decision-making process. You reach this stage after identifying, creating, refining, and analyzing all the design factors. Accurately scaled sketches of various designs have been developed. Alternatives have been analyzed in terms of function, form, and cost. Remember, the finished product must satisfy the needs of the person who will be using it.

At this time, you have narrowed the alternatives to *one*. This final design satisfies the needs and wants of the user, it is functional, its form is attractive, it is structurally sound, and it blends with the style of its surroundings.

All of this design information must be recorded. This involves working drawings and specifications, which are covered in *Chapters 7* and *9*. ***Working drawings*** accurately communicate your design to the builder. One or more views are drawn to describe the shape of the product. Dimensions show length, width, and height. Notes are included to relate special information. This could include certain ways to process the material.

Specifications provide information on materials and tools. Information will cover materials as wood and wood products, plastic laminates, adhesives, hardware, and finishing materials. The list should include quantity, size, and quality descriptions. You might include the manufacturer's name and stock number for purchased items. A special tools and equipment list may be desirable. This list identifies items such as router bits, shaper cutters, and hole saws. These items may have to be ordered. Try to have tools, materials, and supplies in place before you begin working.

Summary

The decision-making process guides you when designing cabinetry. It is a logical way to make decisions when creating products. First, the needs and wants are identified. The problem might be that you need an entertainment center. Information is then gathered about the problem. Every question should be answered. Should the product be built-in or movable? Does it need doors to protect it from dust? Once all the questions are answered, designing can begin. The design should meet the needs of the user. It should also have a pleasing appearance.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. A(n) _____ refers to function, and a(n) _____ refers to added conveniences.
2. _____ is a method of producing questions during information gathering by writing down any and all ideas.
3. When creating preliminary ideas, _____ are used to draw the product.
4. When _____ ideas, details are first included.
   a. brainstorming
   b. refining
   c. analyzing
   d. None of the above.
5. _____ are determined by the size of the objects that will go in or on the cabinet.
6. A parts list can be created as the _____ for the cabinet are identified.
7. When analyzing your refined designs, what types of analysis should be used? Why?
8. The most important stage of the decision-making process is _____.
9. _____ accurately communicate the cabinet design to the builder.
10. Information about the materials and tools to be used for making the cabinet are provided by the _____.

Human Factors

5

Objectives

After studying this chapter, you will be able to:
- Describe the human factors that affect cabinet design.
- List standard dimensions for common cabinets and furniture.
- Identify safety factors that affect cabinet design.

Important Terms

architectural standards
armrests
human factors
line of sight
lounge chair
seat height
standard chair dimensions
standard dimensions
straight chair
table height

Cabinetry must fit the needs of the people who use it. They may be children, adults, the elderly, or disabled people. See **Figure 5-1**. Even though a product may be functional and attractive, it may not be the right size for every person. Body measurements and other distances should be known. Then, the product can be designed with the user in mind. These considerations are called ***human factors***. When you design cabinetry, you should consider:
- How far people can reach while sitting or standing.
- Safety.
- People's limits on stooping or bending.
- Space problems confronting the elderly and disabled.
- Line of sight problems.
- Physical body dimensions of the user.

When building customized cabinets and furniture, the dimensions can vary. Altering height, width, and depth helps *fit* products to people. Other times, you may not want to alter dimensions. Consider built-in cabinetry. If the design is altered too much, it may affect the resale value of the home.

Knowing the human factors involved helps designers adapt products to people. Furniture manufacturers establish sizes based on human factors. Many of these measurements have become standards for cabinetmaking.

Standard Dimensions

Standard dimensions are based on the average size child or adult. These dimensions are referred to as ***architectural standards,*** because they involve building design. These dimensions specify height, width, and length.

Height

Kitchen dimensions are given for the average size adult. Countertops are 36″ (914 mm) above the floor. Ranges for cooking are the same height. Countertops normally extend 25″ (635 mm) from the wall, and free-standing ranges extend 27½″ (699 mm). The space between the top of the base (lower) cabinet and the bottom of wall cabinets is usually 18″ (457 mm) and is seldom less than 16″ (406 mm). See **Figure 5-2**. Most countertop appliances, such as toasters and blenders, will conveniently fit in this space. Appliance manufacturers are very concerned with standards. People might not buy a blender that cannot fit on the countertop.

At times, these dimensions are inconvenient for those individuals who are not an average size adult. Children and shorter adults might need a stool to reach upper shelves of conventional cabinets. A convenient step might be designed into the base cabinet. Taller or shorter adults may want countertops and overhead cabinets adjusted.

A 30″ to 33″ (762 mm to 838 mm) cooktop and counter height is preferred for disabled people. However, the standard height may be used if a pullout work shelf is provided at the lower height.

Width and length

The width and length of large appliances, tables, *etc.* vary in size. Range and refrigerator widths vary from 24″ to 48″ (610 mm to 1219 mm). Tables are available in different widths, lengths, and shapes. Available space, comfort, and convenience will

Figure 5-1. Your designs will have to accommodate many different people. (*PhotoDisc, Inc.; Barrier Free Environments, Center for Universal Design*)

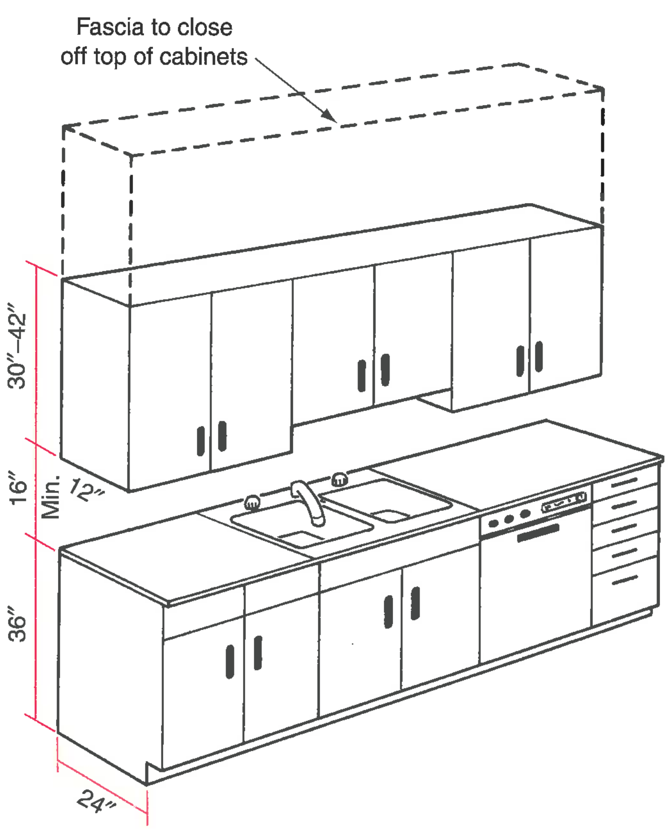


Figure 5-2. These are standard dimensions for kitchen cabinets.

influence choices in these cases. The cabinetmaker will apply standards to provide ample space for the user and manufacturer's specifications for built-in appliance dimensions.

Standing

Many activities require the user to stand while using a cabinet. See **Figure 5-3**. When standing, people perform three movements:

- Reach out in all directions.
- Bend at the waist.
- Stoop using knee and hip joints.

These body movements occur at counters, work surfaces, and machines. Usually, movements are restricted for people with canes, crutches, or walkers. These disabilities must be thought of when designing the product.

Counters

There are many kinds of built-in and movable cabinets that have counters. The counter is the top surface of the cabinet. Counter heights may be standard or adapted to human factors. An accepted average height of 36" (914 mm) is most

Standing		Average Male		Average Female		Age 10		Age 5		Elderly (Average Adult)	
		inches	mm	inches	mm	inches	mm	inches	mm	inches	mm
Height		69	1725	63.5	1590	50	1250	45	1125	64.5	1610
Eye level		64.5	1612	60	1500	46	1150	41	1025	60.5	1512
Easy reach	up	77	1925	71.5	1787	55	1375	49	1225	70	1750
	fwd.	21.5	537	20.5	512	16.5	412	15.5	387	20	500
	side	25.5	637	23.5	587	18.5	462	17	425	22.5	562
Shoulder width		18	450	16	400	11.5	287	10	250	16	400
Elbow height		42	1050	39	975	29.5	737	26.5	662	39	975
High counter		44	1100	40.5	1012	30.5	762	27	675	38.5	962
Low counter		38	950	34.5	862	26	650	23.5	587	32.5	812
Low reach		N/A		N/A		N/A		N/A		24	600
Kitchen aisle width		42	1050	42	1050	N/A		N/A		42	1050

Figure 5-3. These are average dimensions for people when standing.

often used for built-in units. Trash compactors and dishwashers are designed to fit into an opening that is 34½″ (876 mm) high. This distance is measured from the top of the finished floor to the top of the cabinet. The normal thickness of the countertop adds 1½″ (38 mm).

Low counters may be built for kitchens and other rooms. A 36″ (914 mm) standard counter height might be too high for an elderly person. This dimension could be lowered to 32″ (813 mm) at locations other than over an appliance that dictates otherwise.

Lavatories normally are 32″ (813 mm) high. For the elderly, this distance could be raised to 33″ (838 mm) to reduce bending.

High counters refer to built-in cabinets such as bars. These generally are 42″ (1067 mm) high. This height fits the person serving from behind the bar. People being served in front can stand comfortably. However, seats at a high counter must be above normal height.

Machines

Machine heights follow standards based on human factors. Some examples are 33″ (838 mm) jointers, 36″ (914 mm) table saws, sanders and shapers, 39″ (991 mm) radial arm saws, and 46″ (1168 mm) band saws.

Worktables

Worktables and workbenches vary from 32″ to 40″ (813 mm to 1016 mm). The type of work (woodworking, appliance repair) and the user's height may change this dimension.

Walking space

Space is needed for people to move between and around furniture. Even more space is needed for people with canes, crutches, or walkers. See **Figure 5-4**. For wheelchairs, a 5′ (1524 mm) minimum turning radius is required.

Sitting

When seated, people and chairs occupy space. They may be sitting around a table that also occupies space. People may be dining, working, or relaxing while seated. **Figure 5-5** indicates human factors for people when seated. Seat heights are measured from the floor to the top of the compressed seat cushion.

Chairs

Chairs should be designed for comfort and convenience. The two general classifications for chairs are straight and lounge. ***Straight chairs***

Disabled	Average Male inches	mm	Average Female inches	mm	Age 10 inches	mm	Age 5 inches	mm
Crutch space (max.)	33	825			28	700	21.5	537
Cane or one crutch (max.)	27.5	687	25	625	22	550	17	425
Doorway clearances (min.)	crutches 26.5	662	canes 22	550	walker 28	700		

Figure 5-4. People who walk with assistance need additional space.

Sitting		Average Male inches	mm	Average Female inches	mm	Age 10 inches	mm	Age 5 inches	mm	Elderly (Average Adult) inches	mm
Eye level		50.5	1262	45	1125	36	900	30.5	762	28	700
Easy reach (upward)		61	1525	56.5	1412	48.5	1212	45	1125	50	1250
Seat	height	17	425	16	400	16	400	13.5	337	16	400
	width (min.)	16	400	16	400	13.5	337	11.5	287	16	400
	length (max.)	18	450	17	425	12.5	312	10.5	262	16	400
Armrest height (above seat)		8.5	212	8	200	7	187	6	150	8	200
Table height		29	725	28	700	22	550	18	450	27.5	687
Leg room		18	450	16	400	16.5	412	13	325	21	525

Figure 5-5. These are average distances for people when sitting.

position the person upright for dining or working. ***Lounge chairs*** recline and are used for relaxing. Certain dimensions are helpful when designing chairs. These dimensions are seat height, seat depth, backrest angle and height, and armrest height.

Standard chair dimensions describe heights to accommodate average adult males and females. See **Figure 5-6**. Standard seat height is 17″ (432 mm). However, ***seat height*** (height at front edge of seat) for a shorter person may be reduced to 15″ (381 mm). If seat height is much below 15″ (381 mm), getting out of the seat may be difficult. For a taller person, the seat height can be increased to 18″ (457 mm). Seat depth may be varied. Also, note that the backrest angle and height are variable for lounge chairs. At angles greater than 30°, the head must be supported.

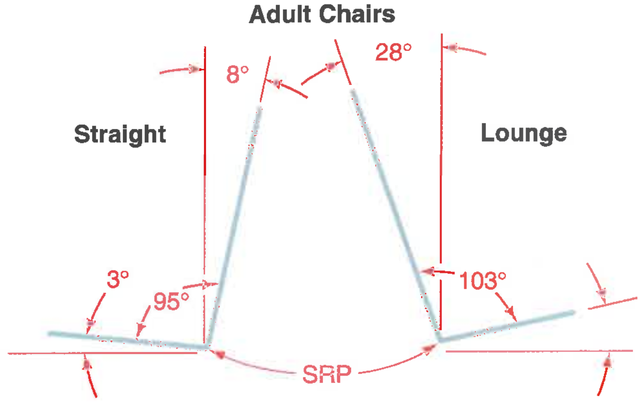
Many chairs have armrests. ***Armrests*** aid people when rising from a chair. They also support the arm while working or relaxing in a chair. Refer to **Figure 5-6** for suggested dimensions where armrests should be attached. Spacing varies from 19″ to 22″ (480 mm to 559 mm) between the armrests. Armrest lengths, from the seat back, are 12″ (305 mm) for arm and hand support. When working at a table, 8½″ (215 mm) is sufficient since part of the person's arm can rest on the worktable. For elbow support only, 6½″ (165 mm) is sufficient.

Seating at low and high counters applies similar standards. At a 36″ (914 mm) counter, use a 24″ (610 mm) chair or stool. Similarly, at a 42″ (1067 mm) counter use 36″ (914 mm) stools.

Tables and desks

There is a close relationship between chairs, tables, or desks. The heights must allow room for the person to move. They must also prevent the user from being pinched between the chair and desk. Maximum table heights and average chair heights appear in **Figure 5-5**. The difference between the table

0°–5°	Seat angle from horizontal	5°–25°
95°–98°	Seat to back-rest angle	95°–120°
5°–10°	Backrest angle from vertical	10°–45°
15″ (375 mm)	Backrest height from seat	21″–28″ (525–700 mm)
16″–17″ (400–425 mm)	Seat Reference Point (SRP)	11″–12″ (275–300 mm)



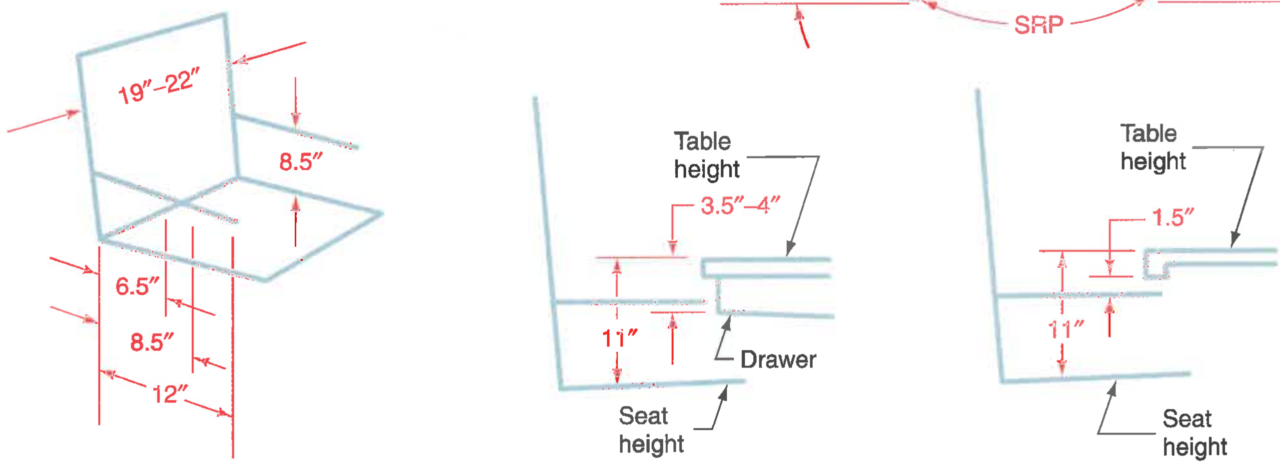


Figure 5-6. Straight chairs and lounge chairs use different standard dimensions.

and compressed chair should be 11″ (279 mm). This allows for the user's thighs to fit under the table. It also allows for drawer space under the table. Chairs could have armrests and the table might not have a drawer. In this case, there should be a 1½″ (38 mm) clearance.

Table heights vary with different purposes. Desks and dining tables are approximately the same height, 29″ to 30″ (737 mm to 762 mm). See **Figure 5-7**. Card tables and sewing cabinets are 28″ (711 mm) high. Surfaces for word processors and typewriters are 25″ to 26″ (635 mm to 660 mm). Computer consoles need work surfaces at various heights. The keyboard should be near word processors and typewriters table height, preferably adjustable in elevation and tilt angle. See **Figure 5-8**. The monitor should be placed at or below the normal sight line for a sitting person. The monitor can be placed lower for people who wear bifocal glasses. Disk drives and printers should be located at the side within reach.

End tables and night tables are 18″ to 24″ (457 mm to 610 mm) high. Heights for these tables may depend on the size of lamps used on them. Coffee tables vary from 11″ to 18″ (279 mm to 457 mm). Coffee tables can be raised for the elderly. Tables that are 24″ (610 mm) high reduce the amount an elderly person must bend.

Figure 5-7. Dining tables are approximately the same height as a desk.

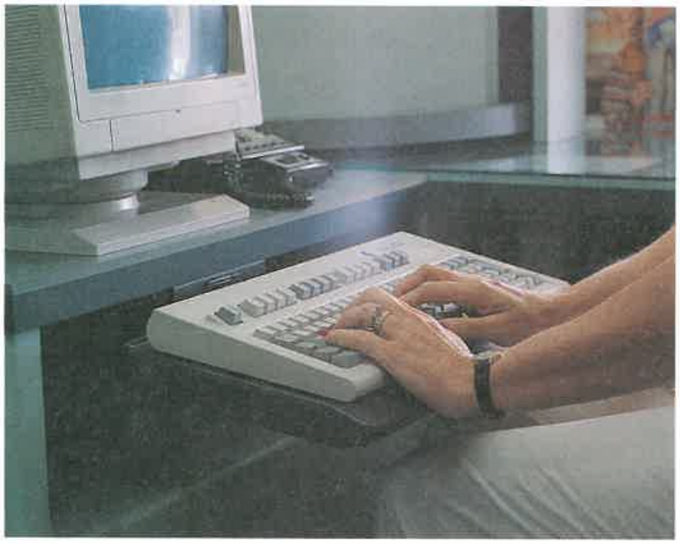


Figure 5-8. Fully articulated keyboard arm. Features include 6" (152 mm) height adjustment, 25° tilt, 360° arm rotation, and a hold-out lock. The keyboard tray has a sliding mouse tray that can be extended either to the left or right.

Wheelchairs

Wheelchairs present a special concern for designers. Space must be made available for mobility. Counters must be within reach of the person. The space requirements for wheelchairs are shown in **Figure 5-9.**

Reclining

Human factors for people who are reclining involve height and weight. These factors are most important in mattress manufacturing. If you build a bed, do so after determining mattress size specifications. See **Figure 5-10.**

Mattress sizes are standardized by manufacturers, but change from time to time as our lifestyle changes. However, custom-made mattresses are made in longer dimensions for tall people.

Beds often have headboards. They may be plain or may hold books, clocks, and radios. They might

Wheelchair		Average Male inches	Average Male mm	Average Female inches	Average Female mm	Age 10 inches	Age 10 mm	Age 5 inches	Age 5 mm
Eye level		48.5	1212	46.5	1162	42	1050	39	975
Easy reach	up	64.5	1612	59	1475	53.5	1337	46	1150
	fwd.	21.5	537	20	500	18	450	13.5	337
	side	20	500	17.5	437	14.5	362	10.5	262
	down	13	325	17.5	437	14.5	362	24.5	612
Table height		31	775	31	775	31	775	31	775
Leg room (chair arm to toe)		16.5	412	14.5	362	13.5	337	10	250
Seat	height	19.5	487	19.5	487	19.5	487	19.5	487
	width	18	450	18	450	16	400	12	300
	length	16	400	16	400	13	325	11	275
Clearances		Doorway		32	800	Passageway		36	900

Figure 5-9. People in wheelchairs require special space consideration. (*Barrier Free Environments*)

Mattress Sizes			
Crib	22¼ × 38¾	Twin	39 × 74, 80, 84
	25¼ × 50¾	Double	54 × 75, 80, 84
	31¼ × 56¾	Queen	60 × 80, 84
Single	30 × 75	King	72, 76 × 80, 84

Figure 5-10. There are several standard mattress sizes. (*Capistrano*)

support reading lamps. Locate shelves so the user can see and reach objects on the shelves. These same conveniences should be designed into night tables.

Line of Sight

Line of sight is the area that a person can see. It is the straight line between the eye and the object seen. It is an important factor in cabinet design. Any television or computer monitor should be placed where the viewer can see it without turning their head.

Standing and sitting

People may stand while tuning a stereo, reading a bulletin board, or looking at trophies. Eye movement is in a vertical arc. From eye level, the normal line of sight (head erect) is 10° downward. There is a convenient and maximum arc of eye movement. See **Figure 5-11**. This arc can be raised or lowered by moving the head.

Sitting restricts the line of sight. The normal line of sight downward is lessened to 15° below eye level. The primary display area would receive the most concentration. This range would be within 15° left, right, above, and below the line of sight. A larger secondary display area lies an added 15° in all directions. However, the outer range is uncomfortable. It is beyond the person's normal focus.

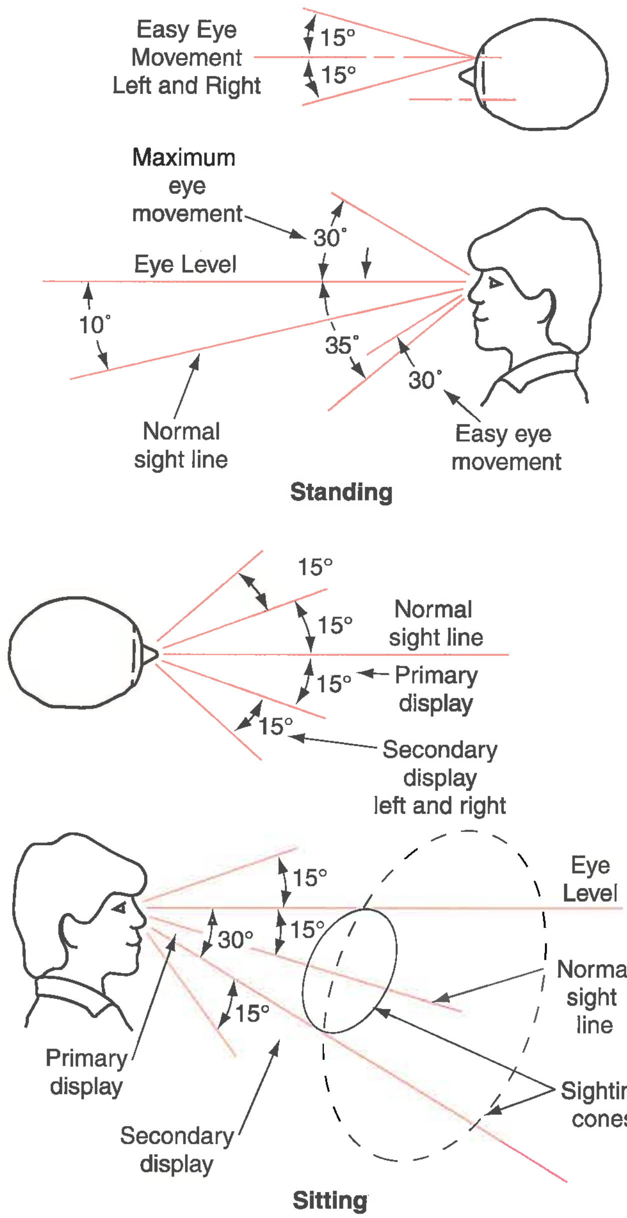


Figure 5-11. Eye level, sight lines, and displays all affect visibility.

Human Factors and Safety

More accidents and injuries occur in the home than anywhere else. There is an endless list of potential hazards. You could walk into something. You might be struck by an object. For a child, chances for possible accidents and injuries are increased.

Sharp edges and corners

Striking the corner or edge of a cabinet can be painful. It may cause temporary or permanent injury, especially at head and eye level. Wall cabinet corners, cabinet doors standing open, and pullout racks are very unsafe.

Other hazards include walking into desks, coffee tables, and other furniture. This represents a special problem for blind and vision-impaired individuals. People with normal vision can be injured in a dark room. Eliminate as many sharp edges as possible.

Furniture that is safe for adults may be hazardous for children. A child, at age two, is about 34" (864 mm) tall. This is half the height of an average adult. A child might strike a cabinet corner. This same corner causes no problems for adults.

As a designer, you must take into account these factors. Cabinets must be made as safe as possible for all who might encounter them.

Falling objects

Falling objects can cause cuts, bruises, or more serious injuries. Cups and cooking utensils are examples of potential problems if stored overhead. Adjustable shelves placed closely together help guard against excessive stacking. Designs for adjustable shelf supports provide for retaining the shelf during earthquakes. Certain latches keep the doors closed during earthquakes, but allow easy and ready access at other times. Retaining rails or ledges keep objects from sliding off a shelf.

Children's reach

Children are curious by nature. They seem to enjoy investigating things and are attracted by colorful, shiny objects. In addition, they cannot read nor can they realize where hazards exist. A child might pull a portable appliance from a counter or enter cabinets where toxic substances are kept. Make sure your design eliminates these hazards.

Design lockable compartments for poisonous materials. Locks are available that are totally invisible from the cabinet exterior, but open readily with a magnetic key. Design placement of electrical outlets that will reduce the necessity to have power cords that hang over the counter edge. Consider all situations that are hazardous for children.

Summary

Comfort, convenience, and safety often are overlooked by designers. Many times, cabinetry and furniture products do not serve their intended purpose. The problems are especially true for children, the elderly, and the disabled. Alter dimensions of cabinets to fit the user.

People stand at countertops, tables, machines, and similar surfaces. They may stand alone or with support, such as a crutch. People sit on chairs while relaxing or while working at a desk. Chairs and desks, or tables, should allow the user freedom to move.

Individuals in wheelchairs have special problems. Adapt counter heights for their reach. Space must also be allowed for wheelchair movement.

Standards exist for many of the dimensions discussed. Standard dimensions will meet the needs of a majority of people. Comply with them unless you are adapting for the elderly and disabled. If too many deviations are used for built-in cabinets, the resale value of the home may be affected.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Describe five of the human factors.
2. Standard dimensions are based on the _____.
   a. average size child or adult
   b. largest child or adult
   c. smallest child or adult
   d. None of the above.
3. Standard dimensions specify _____, _____, and _____.
4. The standard cabinet height is _____".
5. List the dimensions concerning chair size.
6. A person is positioned upright in a(n) _____ chair.
7. A person is in a reclined and relaxed position in a(n) _____ chair.
8. What dimensions control the size of a bed frame?
   a. height of a person
   b. mattress size
   c. size of the bedroom
   d. weight of a person
9. An important factor in cabinet design is _____, which is the area that a person can see.
10. When the head is erect, the normal line of sight is _____° downward.

Production Decisions

6

Objectives

After studying this chapter, you will be able to:

- Identify the need for a plan of procedure.
- List the steps in making production decisions.
- Describe alternative tools for completing cabinetmaking processes.

Important Terms

clamp time
curing time
dry run
fixture
jig
open time
OSHA
plan of procedure
planning
point-of-operation
production decisions
shelf life
stock
workpiece

Preparing to build cabinetry involves research and planning. Previous chapters dealt with design problems, or those *what to do* decisions. This chapter deals with the *how to do it* and *why to do it this way* decisions. See **Figure 6-1**. All are essential decision-making phases in the cabinetmaking process.

Production Decisions

Production decisions guide you in the *how to do it* and *why to do it this way* decisions. Production decisions relate very closely to design decisions. When designing, you develop your own working drawings. You might also choose to use someone else's drawings. The drawings specify the shapes, dimensions, and joinery for the product. They also list each part of the cabinet in a bill of materials. Once you have working drawings, you need to decide how to complete the product. This involves selecting tools, materials, and processes.

Making production decisions means solving problems. You confront problems and choices at each stage while completing your product. Decisions include how to do the following:

- Cutting
- Surfacing
- Forming
- Assembling
- Finishing

After making these decisions, you form a plan of procedure.

Planning Your Work

Planning is essential so you do not waste time and materials. Each step builds on previous tasks. For example, you cannot cut lumber to length accurately unless one end has been squared. Before you can square one end, you have to square the faces and edges. This is one example where planning your work beforehand can save time and reduce problems. Having a written plan of procedure prevents you from missing a crucial step. Some working drawings you buy may have a *plan of procedure* included. See **Figure 6-2**. However, you must develop a plan for your own working drawings.

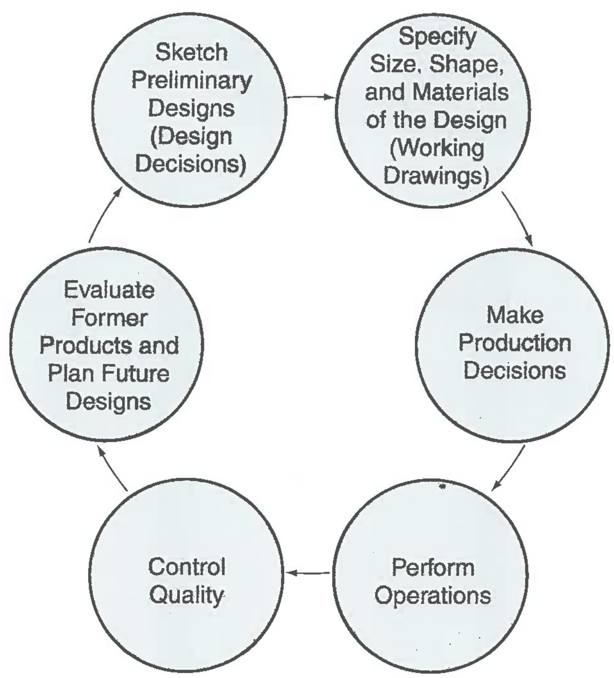
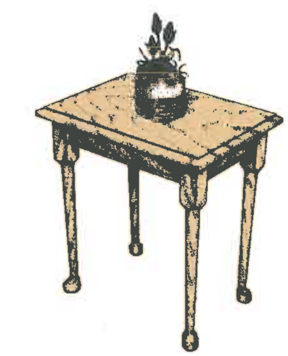


Figure 6-1. The cabinetmaking process is a series of phases. Production decisions are the link between working drawings and the operations needed to build a cabinet.

Plan of Procedure

1. Cut stock to 1/16″ over finished dimension.
2. Glue up 3/4″ workpieces to make a tabletop 18″ wide and 20″ long. NOTE: Alternate direction of growth rings for each successive board.
3. When the top has dried, smooth the surface with a scraper, then sandpaper.
4. Shape the edge with a rounding-over bit.
5. Cut 3 1/2″ long × 3/8″ wide × 7/8″ deep mortises in the legs with either a 3/8″ mortising chisel or a 3/8″ straight router bit.
6. Cut tenons on the front, back, and sides 3 1/2″ wide × 3/8″ thick × 3/4″ long. Cut them slightly oversize, then fit them in the mortises.
7. Shape the bottom edges of the front, sides, and back with a small bead.
8. Rough-shape the legs on a lathe. Leave 6″ at the top (with the mortises) square. Don't turn this portion at all.
9. Decide on an inside corner of the legs. Offset the foot of the legs 3/8″ in the direction of the inside corner.
10. Attach cleats to the inside of sides, front, and back with 1 1/4″-#8 wood screws. Position these 1/32″ away from the top edge of the sides, back, and front.
11. Assemble the sides, front, and back to the legs with glue. Clamp and let dry.
12. Assemble the leg assembly to the top from underneath with wood screws.
13. Sand the table with garnet paper. Be careful not to sand away the shaped edges.
14. Stain and finish as desired.

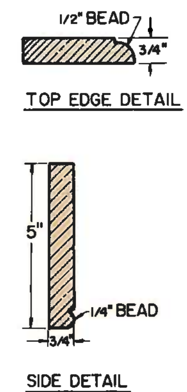


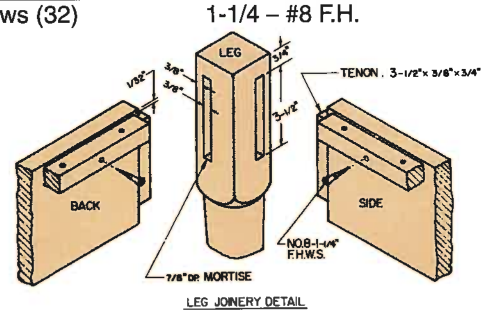
Bill of Materials (finished dimensions in inches)

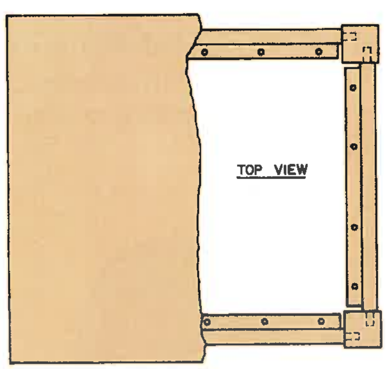
A	Top (1)	3/4 × 18 × 20
B	Legs (4)	2 × 2 × 25-1/4
C	Front/Back (2)	3/4 × 5 × 14-1/2
D	Sides (2)	3/4 × 5 × 16-1/2
E	Side Cleats (2)	3/4 × 3/4 × 14
F	Front/Back Cleats (2)	3/4 × 3/4 × 12

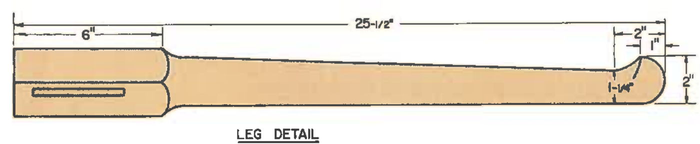
Hardware

Wood screws (32)	1-1/4 – #8 F.H.









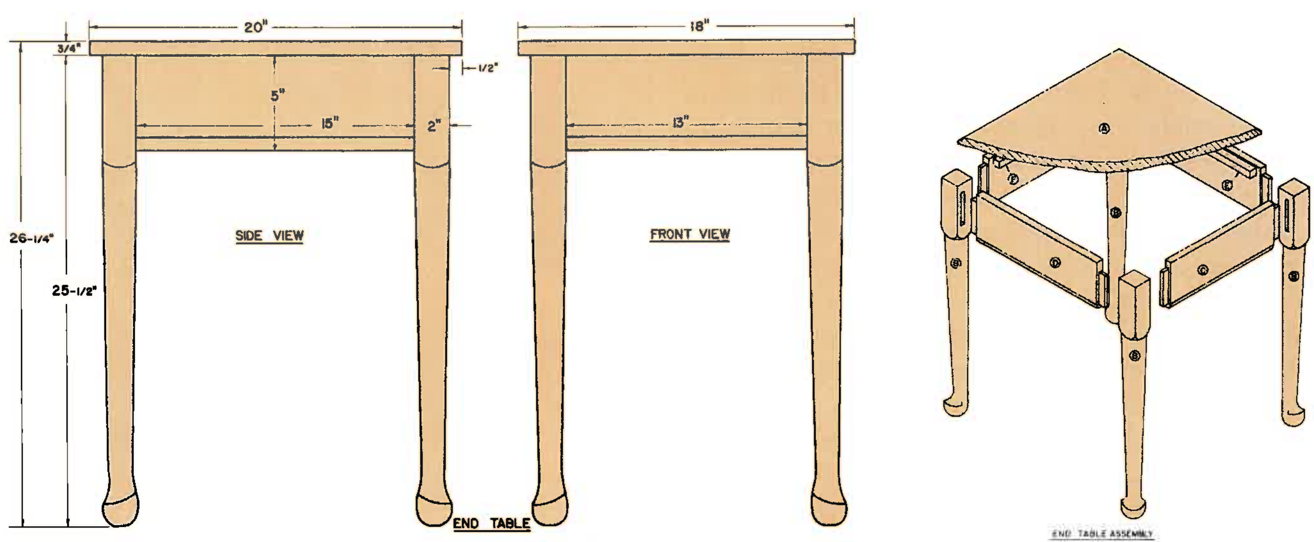


Figure 6-2. The plan of procedure for this end table is included in working drawings you buy. (*Shopsmith, Inc.*)

Plan of Procedure

The *what to do* steps in a ***plan of procedure*** usually remain the same for different products. However, you will alter them according to available equipment and your skills. Generally, the plan will follow these steps in production:

1. Identify appropriate tools.
2. Obtain materials and supplies.
3. Lay out and rough cut standard stock.
4. Square workpieces and components accurately to size.
5. Prepare joints.
6. Create holes and other openings.
7. Shape components.
8. Smooth components.
9. Assemble components.
10. Apply finish.
11. Install hardware.

You will notice the terms stock, workpiece, and component have been mentioned. They will be used throughout this text. ***Stock*** is the material in its unprocessed form—a full length board, a sheet of plywood, and so forth. ***Workpiece*** is rough cut stock being sized. A component, such as an assembled frame and panel door, is a workpiece when trimming ends and shaping profiles on the outer edge. ***Component*** is one or more workpieces being processed into a bill of materials item.

Identifying tools

The tools you have will determine how you process workpieces and components. Well-equipped cabinet shops have more equipment than the average home woodworker. See **Figure 6-3**. This affects production time, but not necessary the quality of the completed cabinet. The skills you have affect quality.

Figure 6-3. The type of tools you have affects production time, but not necessarily the quality of the completed cabinet. (*Stanley Tools*)

List the available tools and machines in your shop. There may be more than one that can perform the operations needed to build your product. Hand tools generally are versatile, but using them requires physical effort. Portable and stationary power tools do the same tasks, but quicker and with less effort.

When selecting tools, consider their hazards. Tools and machines differ as possible causes for accidents and injuries. Select the least risky, but most accurate, one available. Accidents usually occur at the ***point-of-operation*** (***PO***), which is where the cutter contacts the workpiece. Having the PO guarded will lessen your chance of being injured. See **Figure 6-4**. Using a pushing device can keep your hands and arms away from the cutter.

Identifying tooling

Selecting the proper blades, cutters, bits, and drills is an important decision. For example, suppose you are selecting a circular saw blade for a table saw. Rip and crosscut blades leave blade

Figure 6-4. Point-of-operation guards protect you from areas where the cutter contacts the workpiece. (*Ryobi*)

marks on the kerf sides. Carbide-tipped saw blades installed on a well-tuned table saw leave virtually no blade marks on the kerf sides. Only a light sanding may be required. For dense lumber or manufactured panels such as particleboard and fiberboard, you must use carbide-tipped blades. Thin kerf carbide-tipped saw blades require the least effort when cutting dense lumber. Modern cabinet shops buy only carbide tipped saw blades. Here again the tooling you select depends on the materials and their size. Any tool you select should be sharp. Dull tools will burn or tear the material.

Many product designs require that you form wood or plastic into curves. You probably will need force or pressure for this operation. Also, heat and/or moisture are used frequently to assist bending. Available equipment determines the forming process. Hydraulic presses work best. Mechanical clamps are a good source of pressure. Applying weight, such as a sandbag, is often adequate.

Using jigs and fixtures can increase the versatility of tools and equipment. A ***fixture*** simply holds the workpiece while the operator processes it. A vise is an example of a fixture. A ***jig*** holds the workpiece and guides the tool. A dovetail jig is an example. See **Figure 6-5**.

Obtaining materials and supplies

Have materials and supplies on hand before beginning production. Materials include any wood, metal, plastic, etc. that will become a part of the finished product. See **Figure 6-6**. Supplies include abrasives, adhesives, rags, or other consumable items that are not part of the finished product.

Figure 6-5. A dovetail jig both holds the workpiece and guides the router to make a dovetail joint. (*The Fine Tool Shops*)

Check the amount of materials and supplies you have in stock. Also note their condition. Wood stored in a moist environment may be watermarked or warped. Adhesives might not be effective if they have been stored too long. You may not have one grit size of sheet abrasive. Before ordering, compare materials in stock with the bill of materials.

There are many options when ordering material. For example, lumber is available rough or surfaced. Do you buy it rough and surface it yourself or do you buy it already smooth? You typically will pay extra if the seller surfaces the material. However, this may be worth the money if you do not own a power planer or jointer. See **Figure 6-7**.

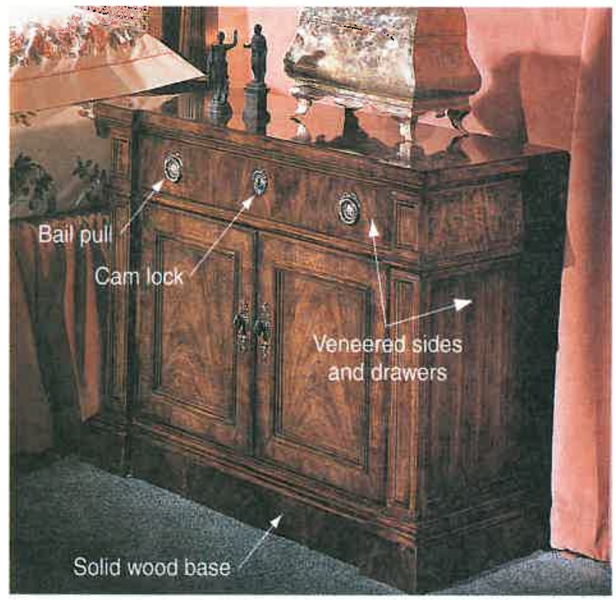


Figure 6-6. A number of different materials are visible on a completed cabinet. Those you do not see include fasteners and drawer slides. (*Thomasville*)

Figure 6-7. If you do not have a power planer, you might choose to buy boards already surfaced.

Another aspect of obtaining materials is *make-or-buy decisions*. The design may specify turned chair legs. Do you have a lathe and the time to *make* them? If not, you will have to *buy* legs ready-made. Cabinet doors in hundreds of styles may be bought for little more than the cost of the lumber to make your own. Large door manufacturers have great buying power and get the lowest prices. When you are buying wood to make a component or you are buying the component completed, delivery times must be considered.

Laying out and rough cutting stock

Stock is machine surfaced, measured, laid out, and rough cut larger than workpiece dimensions shown on the working drawings. The extra material allows you to square the workpiece to its finished dimension.

Machine surface all materials to be used in the project before layout. Then lay out each workpiece. To return to the planer at various stages of a project may result in workpieces of slightly different thicknesses. The setup may have been changed for any number of reasons. Also, most planers have a minimum workpiece length. Short lengths can get caught in the machine.

When laying out workpieces, be aware of grain direction (pattern of the wood) and wood defects (knots, splits, etc.). Grain direction may or may not be specified on the design. For example, drawer fronts might have horizontal or vertical grain. Usually, cabinet sides have vertical grain. Laying out and cutting a workpiece the wrong grain direction results in lost material and time. Wood defects can cause problems and should be avoided. Knots may fall out. Weather checks may cause splitting. Work around visible defects as much as possible. This is one reason to order extra materials. Of course, tight knots would not be removed from workpieces for a knotty pine project. Avoid any knots along the edge of the workpiece.

After layout, cut out the materials. You will likely use a stationary power saw for this operation. Make cuts from 1/32" to 1/16" (1 mm to 2 mm) oversize. If the workpiece is roughed out to the finished dimension, sanding it may make it undersize.

Squaring workpieces to size

Begin production by making workpieces from standard stock. If you buy rough lumber, this includes a series of surfacing and sawing steps. The following steps are done on stationary power equipment:

1. Surface one face on the jointer.
2. Smooth one edge with the jointer.
3. Surface the second face using the planer.
4. Rip the lumber to width on a table saw or radial arm saw. Have the jointed edge against the rip fence.

Note

You could make this 1/16" (2 mm) oversize. Then return to the jointer and smooth the ripped edge. This removes saw marks. If your planer has the capacity to pass the workpiece on edge, you can remove the saw marks and achieve accurate width and parallel edges. Do so on edges that will be visible or bonded together.

5. Square one end on a table or radial arm saw.
6. Crosscut the workpiece to length.

You may eliminate the first three steps if you buy lumber with four surfaced faces (S4S). However, check the lumber to ensure identical thickness of each piece to be used. Thickness may vary due to having been machined by the supplier at different times, or by different mills.

The order of steps for squaring workpieces with hand tools is no different. However, you will need more time and you may reduce the accuracy of squared stock. Use a framing square, hand plane of the proper size, and rip and crosscut saws. You may want to use a miter box to make accurate crosscuts.

Portable power tools will square workpieces. Portable power planes work well for edges and narrow-faced workpieces, usually those under 3" (76 mm) wide. See **Figure 6-8**. Portable circular and cutoff saws work well for ripping and crosscutting stock. Power miter saws will square ends.

Check machine setups frequently. Be sure angles of saw blades, fences, and other machine

Figure 6-8. A portable power planer works well for narrow faces and edges. (*Makita U.S.A., Inc.*)

parts are square (90° angle). Before squaring your workpieces, you might cut or surface a piece of scrap wood and inspect it. Do not assume that scales printed on the machines are accurate.

Preparing joints

Joinery is a very important part of the cabinetmaking process. A well made joint will make assembly easier and the finished product stronger and more attractive. There are more than 30 types of joints. Each can be made with various hand and power tools. For example, a groove can be made with a handsaw and chisel, hand router plane, table saw, radial arm saw, shaper, router, etc. Each varies in joint quality depending on the cabinetmaker's skill.

Consider the sequence of steps for making the joint. On some joints, one part should be made before another. For example, the mortise of a mortise and tenon joint should be made first. The tenon can then be cut to fit snugly. See **Figure 6-9.**

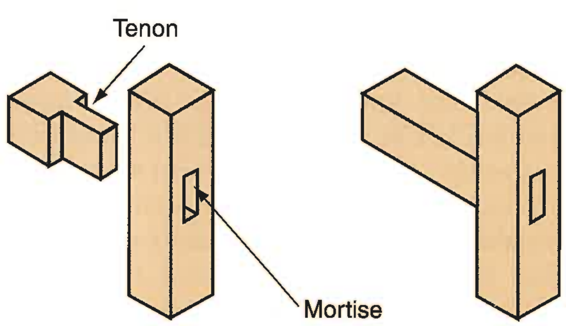


Figure 6-9. Cutting the mortise first allows you to cut and fit the tenon accurately.

For a dovetail joint, you can cut both pieces separately. However, with a dovetail jig, template, dovetail bit, and router, you cut matching workpieces with the same setup. This process is quicker and much more accurate. Yet, skill is needed to set the precise depth of cut for the dovetail router bit.

Creating holes and other openings

Holes, such as for installing hardware, are drilled after the stock is squared. This step generally precedes cutting curves and shaping edges because you need square corners and edges as reference points for locating holes. Also, you may need a straightedge to align a row of holes, such as the holes inside an adjustable shelf bookcase.

Holes may be made with portable, cordless, and stationary power drills or by hand tools. See **Figure 6-10**. Portable power drills and cordless drills are versatile. You can make holes almost anywhere and at any given angle. Stationary power drills, such as the drill press, are less versatile. However, you can set them more accurately for hole depths and angles. A line boring machine is used to accurately drill holes for 32 mm system cabinets. Use a brace and bit or a hand drill and twist drill bit for hand operations.

Large and irregularly shaped holes are made with a saw or router. By hand, use a compass, keyhole, or coping saw. With power tools, select a scroll saw, saber saw, or router. A scroll saw, also known as a jigsaw, is stationary. See **Figure 6-11.** A saber saw, also known as a bayonet saw, is portable. A router may be portable. With a portable router,

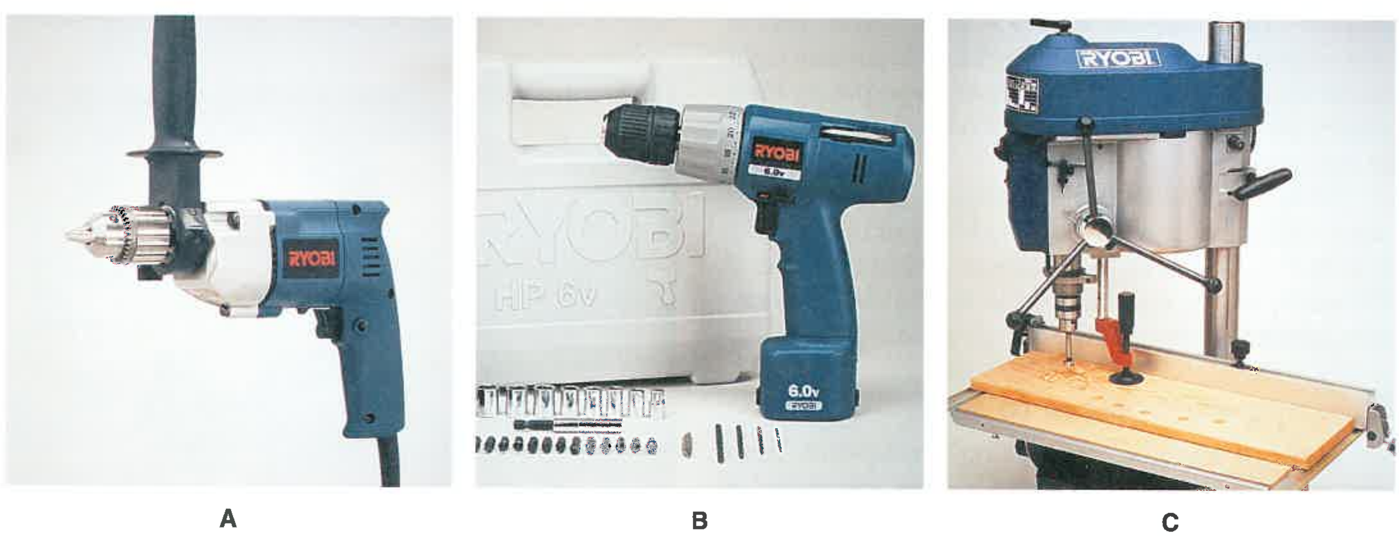


Figure 6-10. A—The versatility of a portable power drill makes it a needed tool in the shop. B—The cordless power drill makes it easy to work anywhere. C—The drill press is less versatile, but is more accurate than the portable and cordless power drills. (*Ryobi*)

you can cut your workpiece freehand or with a template as a guide. Sometimes you mount routers and saber saws upside down under an accessory table. Instead of holding the portable tool, you guide the workpiece over table.

Shaping components

Shaping means creating a curved face, edge, or end on a workpiece. The desired shape is shown on the working drawings. Shaping before making joints could result in poor joints because joinery generally requires square edges and ends. On the other hand, shaping could occur before making joints. For example, suppose you are making a frame and panel door. Shape the interior edges of the frame members, either cut miter joints or cope and pattern, assemble, and then shape the outside edges.

Shaping the face of the workpieces, like table legs, can be done with a saber saw, scroll saw, or band saw. Carving is a specialized means of shaping the face of a workpiece. Edge shaping is usually done with a router or shaper. See **Figure 6-12**. Choose the right router bit or shaper cutter to make the desired design.

Smoothing components

Smoothing a surface often is the most time-consuming part of the cabinetmaking process. You do this once you have cut and shaped each workpiece. The goal is to produce smooth surfaces. Hand planes, hand scrapers, and jointers take away saw kerf marks on straight edges. Spokeshaves and cabinet files do the same on curves. Hand and cabinet scrapers are used to smooth rough areas around knots on surfaces and edges. Then, an abrasive in sheet, belt, or disk form is used to finish the process.

There are many types of natural and synthetic abrasives. Some remain sharp and will clog less than others. For example, garnet lasts several times longer than flint abrasive. Synthetics, such as silicon carbide and aluminum oxide, are effective longer than garnet.

Abrasives come in many forms such as sheets, disks, belts, sleeves, sharpening stones, and grinding wheels. The fine or coarse texture of the abrasive is rated by grit size. The larger the grit size number, the finer the grains of abrasives.

Sanding machines decrease the amount of time spent preparing components for finish. Stationary belt and disk sanders are used to smooth component ends and edges. Portable belt and disk sanders are used to smooth surfaces. See **Figure 6-13**. Wide belt sanders and wide drum sanders smooth larger surfaces.

Abrasives leave scratches in the wood's surface. Coarse or medium abrasives remove machine and scraper marks. However, these abrasives leave visible scratches. Finer abrasives are used to remove these scratches. Always sand with the grain of the wood. This way, the abrasive marks blend in with the grain lines. Any cross-grain scratches will become apparent when finishing the product. Work until you achieve the surface quality you desire.

Figure 6-11. Large and irregularly shaped holes can be made with a scroll saw. (*Ryobi*)

Figure 6-12. Edge designs are created with a portable router and bit. (*Robert Bosch Power Tool Corp.*)

Using a series of abrasive grit sizes will smooth the wood in the least amount of time. First, you start with 80 or 100 grit abrasive, then use 150 grit. At this point you may *raise the grain* (expand the wood pores) with water by dampening the surface with a moist sponge. Expanding the grain lifts wood fibers that might raise later during finish. Not all wood species need to have the grain raised. Smooth the roughened surface with 180 to 220 grit paper.

Starting with a high-grit size abrasive wastes time. Not using the fine grit leaves too many noticeable scratches. These may be hard to see until the finish is applied. Then you will wish you had followed the recommended smoothing sequence.

Assembling components

Assembly usually occurs after all components have been cut to size and smoothed. However, occasionally you may make a component after assembling other parts. For example, suppose you are going to produce a desk. You would first complete the assembly of the desk body. Then you could measure, cut, and fit the drawers. After the finish is applied, you reinstall drawer slide hardware.

You can assemble the product with mechanical fasteners, hardware, and/or adhesives. For years, typical fasteners such as screws, nails, and staples have been used. You might consider newly developed fasteners for *ready-to-assemble* cabinetry. These permit quick disassembly and reassembly. You attach doors using hinges or sliding tracks. Some fasteners require that you create holes or mortise openings in the cabinet. Trim and moldings can be attached using air-powered nailers and staplers.

Adhesives include glues, cements, and mastics. If you plan to use adhesive, research various features that affect assembly time. You should find out the shelf life, open time, clamp time, curing time, and drying time. ***Shelf life*** of an adhesive is the time that passes between manufacture date and deterioration due to age and is usually expressed in years. ***Open time*** of an adhesive is the time between spreading and the time you must join the components. By that time, the assembly must be clamped. If this time is short, you must assemble your product quickly. ***Clamp time*** is the amount of time that the clamps must remain in place. ***Curing time*** is the time (usually hours) until the adhesive reaches its full strength.

You should assemble the product without adhesive first. This is called a ***dry run***. Clamp the assembly to see if all joints fit, dimensions are correct, and corners are square. You might select bar clamps, hand screws, spring clamps, band clamps, or any number of clamp types. See **Figure 6-14**. Determine which

Figure 6-13. Smoothing a surface with a portable belt sander. (*Robert Bosch Power Tool Corp.*)

Figure 6-14. These double bar clamps consist of two radiused hardwood bars and are fully adjustable to varying lengths of stock. They provide clamping on a full range of widths and simultaneously apply pressure from sides, top, and bottom when pieces are glued edge-to-edge. (*Shopsmith*)

clamping procedure ensures that corners are square. Prevent clamps from marring the wood surface with pads or backing blocks (pieces of smooth soft wood). Preset the opening of the clamps, especially if the adhesive will set quickly. Lay them aside in a precise order. That way you know which to position first, second, etc., after the glue has been spread.

If an adhesive is not specified in the working drawings, consider the intended use of the cabinet. If it will be outside, select a waterproof adhesive.

Applying Finish

Finishing affects the quality of any product, no matter how well it was designed and constructed. There are many decisions to make before applying finish to the product. Included are material selection, application procedure, health considerations, and environmental decisions.

Material selection

There are a number of finishing materials on the market. Each one has a different effect on the appearance of the product. Stain will change the color of the wood. Bleach will lighten the wood, yet retain the same color tone. Filler will fill in the open pores of the wood, making the surface smoother.

Most people think of finishing materials as the topcoating, the final layer of finish. There are natural and synthetic topcoatings. Many natural materials, such as linseed oil, varnish, and shellac are being replaced by synthetic finishes. The synthetic materials, such as polyurethane, synthetic lacquer, and other resin-base materials are easier to use and more durable.

Finishing products will either build up on or penetrate the wood surface. Built-up finishes form a film on the surface of the wood. The film resists scratches, dents, and some liquids. However, if damage occurs it is more difficult to repair. Often, you must remove the coating material and refinish the product.

Penetrating finishes are absorbed into the surface. They include oil-resin finishes, linseed oil, and tung oil. They are best for products exposed to minimum handling because the finish provides little protection from damage. However, penetrating finishes allow you to feel the wood texture. Also, they can be easily repaired by simply wiping additional finish on the wood.

Application procedure

The procedure for applying a built-up finish includes preparing the product surface, bleaching, wash coating, staining, sealing, and topcoating. For a penetrating finish, you need only prepare the surface, then apply the finish.

Before applying any finishing material, inspect the surfaces. Remove any dried adhesive with a sharp chisel, hand scraper, or cabinet scraper. Dried glue does not accept stain. Raise dents by placing a wet rag and a warm iron over the dent. If the wood has been chipped away, make repairs with wood putty, colored shellac sticks, or similar materials. Leave tiny defects if you will be using filler on an open grain wood. This material will fill and hide them.

Sand the product lightly where glue was removed or where marks and dents were repaired. Then remove dust from the surface with a fine bristle brush, vacuum cleaner, or clean, dry rag. Now the surface should be ready for finish.

There are several methods of applying liquid coating materials. These methods are brushing, dipping, rolling, spraying, and wiping. Available equipment usually determines which method you select. Brushing is common for stains, sealers, and almost all built-up topcoatings. Dipping is a quick way to coat small components. Rolling covers large surfaces quickly. Spraying is often used because it gives a quality finish while, at the same time, allowing you to cover large areas quickly. See **Figure 6-15**. Wiping is done by hand with a lintless cloth pad. Bleaches, stains, and penetrating finishes are often applied by this method.

Figure 6-15. Spraying is an efficient method of applying finishing materials. (*ITW DeVilbiss*)

Health considerations

Concern for personal health should be given throughout the cabinetmaking process. Gloves should be worn when working with irritating substances or hot materials. A respirator should be worn when finishing or creating dust. Always wear safety eyewear when working with toxic materials or operating machines.

For example, the finishing process presents some special concerns. Are the vapors toxic? Are they flammable? When working with finishing materials, wear a respirator, rubber gloves, and protective clothing. Finishing should be done in a ventilated finishing room that is free from heat and open flames.

The environment in which you work should be safe. In addition to being well ventilated, the work environment must have a dust collection system, approved fire extinguishers, and a temperature and humidity control system. Temperature and humidity affect the setting and curing time of adhesives and finishes. Leftover materials must be disposed of or stored in containers meeting ***Occupational Safety and Health Administration*** (***OSHA***) standards. See **Figure 6-16.** Containers that contain flammable materials should be stored in a safety cabinet.

Environmental decisions

Several finishing conditions relate to the environment. The area should be well ventilated to remove fumes and dust. Dust can settle on the wet surface and cause roughness. Try to control the temperature where the work is to be done. Some materials have a minimum and maximum temperature range, such as 65°F to 75°F(18°C to 24°C). This information is found on the container label. Also have adequate lighting so you can tell whether the finish covers evenly or has dry spots, sags, or runs. A bare incandescent bulb at a low angle of reflection will help detect these defects.

Installing hardware

The last step in the cabinetmaking procedure is installing hardware. Much of the hardware should have been fitted before finishing. This way screw holes will have been drilled during assembly. Marking on and drilling through a finish can crack or peel it. If drilling holes and aligning hardware is necessary, apply masking tape first. Then mark hole centers on the tape. Next, drill through the tape along with the wood. If a hinge or lock must be mortised, lay that out on tape also. If sawing is required, tape helps prevent chipping the wood fibers.

Working Your Plan

Working to complete a high-quality cabinet is your goal. Following the set plan of procedure is the means to achieving your goal. Remember, safety, health, and efficiency are major concerns while processing materials.

Summary

This chapter has summarized the topics you will discover in the remainder of the text, especially those that concern procedures for making production decisions. It serves to acquaint you to the problems of production and considerations made during the cabinetmaking process.

A B

Figure 6-16. A—Finish saturated waste materials should be disposed in a proper waste container. B—Toxic and flammable finishing materials should be stored in a safety container and placed in a safety cabinet. (Justrite Manufacturing Co.)

The plan of procedure is your guide for making production decisions. A well thought out and documented plan will save you hours of frustration and wasted materials. It will also challenge you to find new uses for available tools.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. _____ is essential so you do not waste time and material.
2. The five decisions that are made for the plan of procedure are _____.
3. The *what to do* steps are listed in the _____.
4. Rough cut stock being sized is _____.
   a. a workpiece
   b. stock
   c. a component
   d. None of the above.
5. In cabinetmaking, PO means _____.
   a. plane off
   b. point-of-operation
   c. put into operation
   d. portable-tools-only
6. The most common indication of a dull tool is _____.
   a. burn marks
   b. planer marks
   c. rough knots
   d. saw tooth marks
7. Virtually no blade marks on the kerf sides is a characteristic of _____ saw blades installed on a well-tuned table saw.
   a. rip
   b. crosscut
   c. hollow ground
   d. carbide-tipped
8. When rough cutting stock to make cabinet parts, you should _____.
   a. cut the workpieces the exact dimension of the finish part
   b. first surface the lumber
   c. cut the workpieces oversize
   d. cut the workpieces undersize
9. Why should you use a medium abrasive before a fine abrasive?
10. Explain how a built-up finish is different from a penetrating finish.

Provide brief answers to the next five questions based on your understanding of this chapter.

11. Generally, why would you not finish the individual parts of a cabinet before assembling them?
12. Why is it, in most cases, desirable to use stationary power tools rather than portable power tools?
13. What factors should you consider when deciding whether to make or buy a certain part of the cabinet?
14. In what case would you cut, assemble, and smooth components, but not apply a finish?
15. What factors affect the time you must spend to develop a plan of procedure?

Fine quality is apparent in these teak cabinets. *(Dyrlund-Smith)*

7

Using Working Drawings

Objectives

After studying this chapter, you will be able to:

- Describe the types of working drawings used by cabinetmakers.
- List the parts of a working drawing.
- Identify the importance of specifications.

Important Terms

alphabet of lines
architectural drawings
blueprint
component details
detail drawings
development drawing
elevations
exploded view
floor plan
multiview drawing
pictorial view
section drawing
shop drawings
title block
whiteprint
working drawings

Working drawings guide you when designing and building a product. See **Figure 7-1**. A set of ***working drawings*** contains both drawings (which illustrate the product) and specifications (which list the materials and supplies). Working drawings should be prepared for every product.

A complete set of working drawings has all the necessary information to produce the cabinet. This will include views of the product showing style and features. These views will detail the size and jointwork required for different parts of the cabinet. Working drawings also include dimensions, materials, supplies, and a plan of procedure.

Working drawings record decisions made during the design process. They also standardize the building of a certain cabinet. For example, two cabinets produced from the same set of drawings should be identical. This occurs if the builders have equal amounts of cabinetmaking skill.

Commercial drawings of cabinet products can be purchased. These would only be used if the drawings meet your design needs. Using purchased drawings will eliminate the time-consuming design process. They are pretested for function, strength, and appearance. You can modify these drawings if they do not exactly fit your design needs. However, be careful not to alter parts that are essential for the strength of the product.

Types of Drawings

Cabinetmakers work from prints or original drawings. The prints are copies called whiteprints or blueprints. ***Whiteprints*** are white with blue lines to show the drawings. Whiteprints are often called ***blue line prints***. ***Blueprints*** use a blue background with white lines for the drawing.

There are two types of drawings the cabinetmaker commonly uses. They are architectural drawings and shop drawings.

Architectural drawings

Architectural drawings are used by contractors to construct the home. They are also used by interior designers to plan for furnishings. The cabinetmaker needs floor plans, elevations, material specifications, and work schedules shown on the architectural drawings. These drawings will determine the size and style of cabinets to be built.

Floor plans

Floor plans explain where built-in cabinetry is to be located. In a kitchen, placement of the sink, cooking unit, refrigerator, and other major appliances are given. Utilities, such as electricity, gas, and plumbing for major appliances, are shown as symbols. See **Figure 7-2**.

Elevations

Elevations are used to represent vertical views of built-in cabinetry. They show the view you would see when positioned in front of the cabinet. See **Figure 7-3**. Elevations are used primarily for kitchens. They may be used for bathrooms, utility rooms, recreational rooms, or any other room with built-in cabinetry.

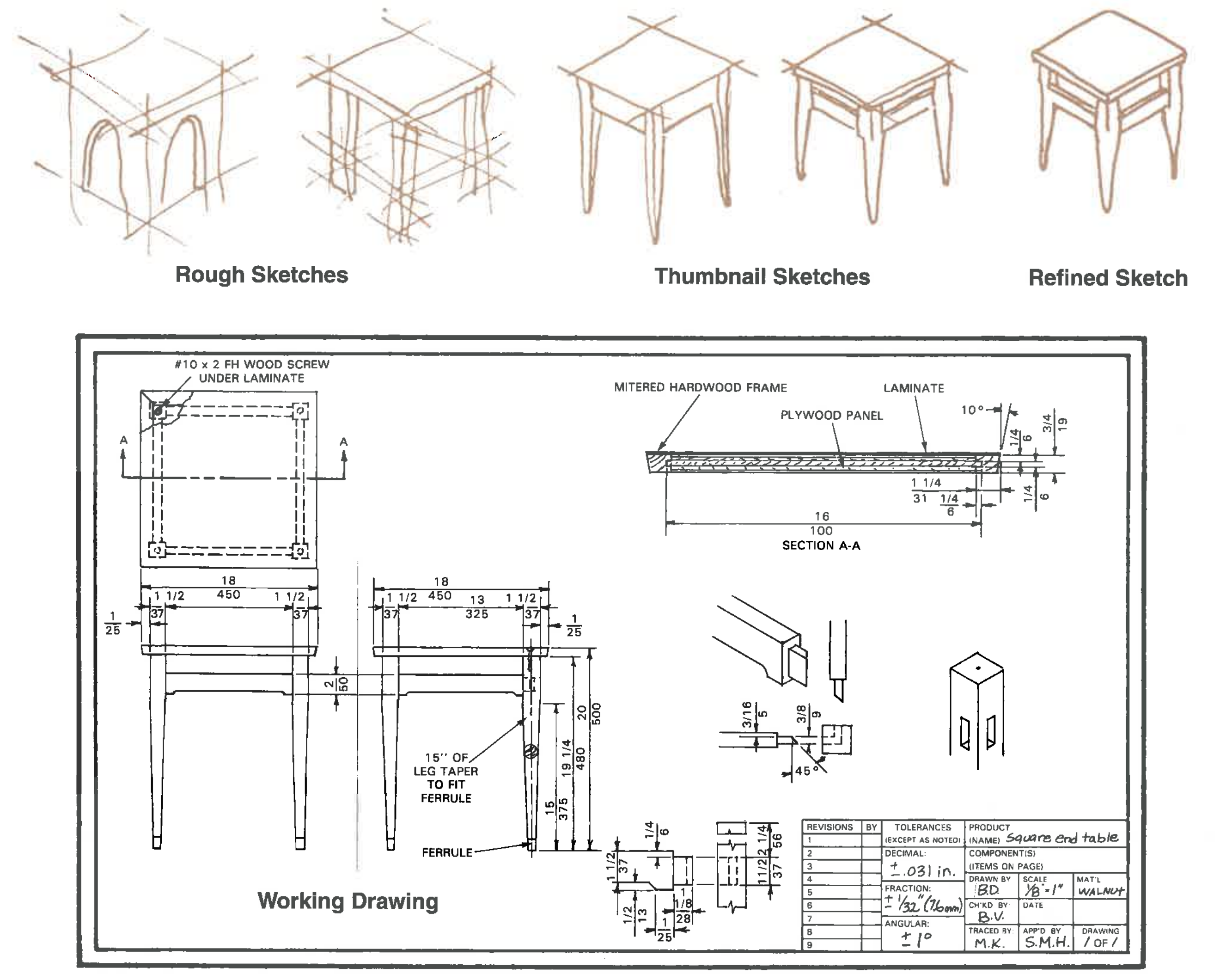


Figure 7-1. Working drawings made to accurately show size and features of the product. The product is then built using specifications of the drawing.

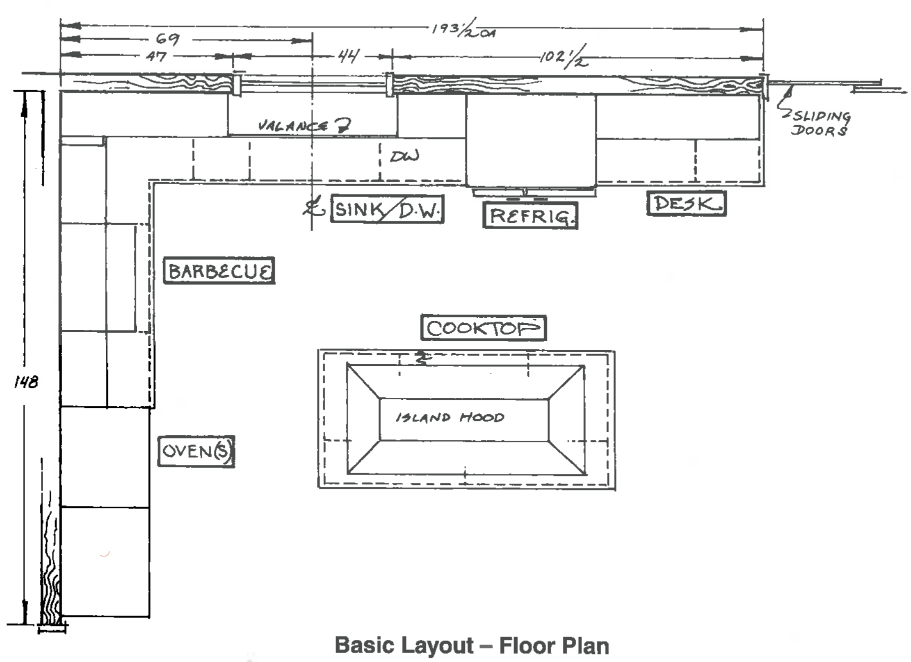


Figure 7-2. A floor plan shows layout of utilities, cabinets, and major appliances. (*Wood-Mode*)

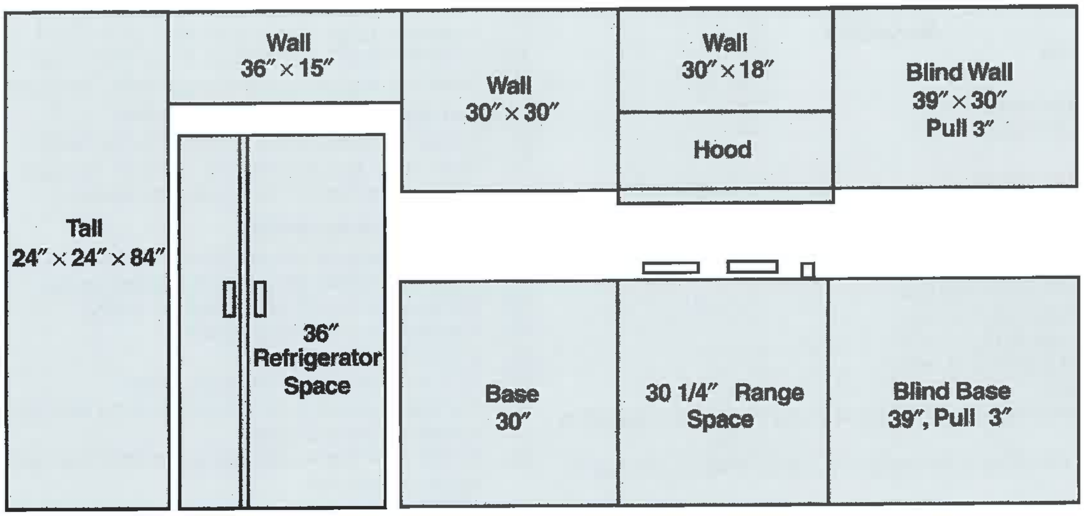


Figure 7-3. An elevation shows a *real life* view of the structure when finished. (*American Woodmark Corp.*)

Material specifications

Material specifications list the types of lumber, molding, or paneling to use. They will also identify styles of hinges, pulls, catches, and other hardware. Finishing materials, such as stain, varnish, and countertop laminate, also would be prescribed.

Work schedule

The suggested ***work schedule*** tells the cabinetmaker when to install built-in cabinetry. This is essential for new construction due to the many persons working at the same time. Plumbers and electricians may need to install utilities before the cabinets are installed. The work schedule may also call for wall finishes to be applied before installing cabinets.

Shop drawings

Shop drawings are to be submitted to the contractor, architect or designer, or owner for approval prior to fabrication and are used by cabinetmakers to build a product. They are different from architectural drawings in that they only show the product. They do not show the surrounding furnishings. Shop drawings usually accompany architectural drawings for built-in cabinetry. The architectural drawing shows the proper dimensions and placement of the cabinets. The shop drawings detail how the cabinet is to be built.

Shop drawings include one or more views of the product, material specifications, and a plan of procedure. The views show details of sizes and jointwork necessary to produce the product. Individual parts and their dimensions are also shown. A three-dimensional view called a ***pictorial view*** is frequently included to represent the assembled product. See **Figure 7-4.**

The material specifications on shop drawings are similar to those used in architectural drawings. However, the material specifications in shop drawings cover specific pieces and hardware used to build the product. Individual manufacturers for parts are sometimes noted.

The plan of procedure for shop drawings is different from the work schedule for architectural drawings. The shop plan lists, in order, the separate operations to construct the cabinet. Each part and the machine used to produce it is given. **Figure 7-5** shows a set of shop drawings including views, bill of materials, supplies, and plan of procedure.

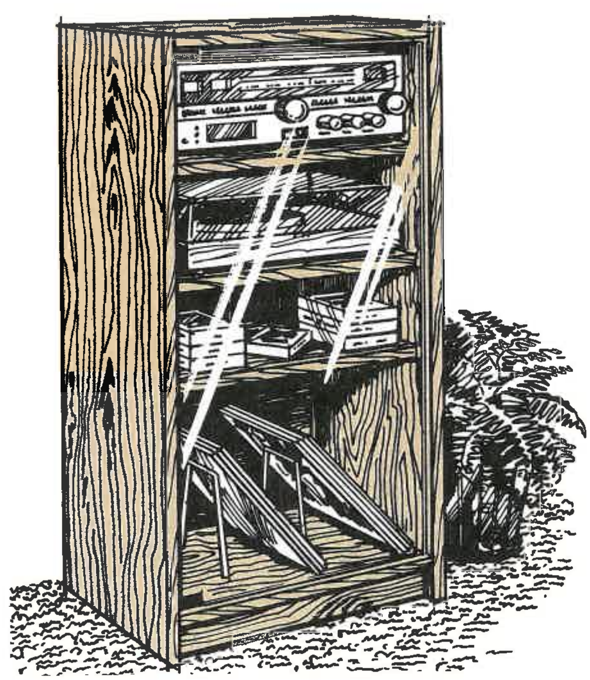


Figure 7-4. A pictorial view of the cabinet is often included in shop drawings. (*Sauder*)

Supplies

Assorted abrasives
Adhesive
Filler (for countersunk nail holes)
Stain (if desired for natural finish)
Sealer*
Top coating* (clear or opaque)
*If opaque paint is used, eliminate stain and sealer and apply primer and paint.

Plan of Procedure

Cabinet body subassembly

1. Square all components to size.
2. Saw 45° corners on A and G.
3. Make dado cuts in B, C, and D.
4. Make rabbet cuts in C, D, and J.
5. Bevel C and D.
6. Drill 1/4″ dowel holes 9/16″ deep in E and F. (Two are needed in each joint.)
7. Angle drill 1/4″ holes 9/16″ deep in D and E. (Five are needed for each joint.)
8. Make a dry run assembly (no adhesive) of B, C, D, E, F, and G. Use 10 V dowels between D and E. Use 4 U dowels between E and F.
9. Check for squareness.
10. Disassemble and smooth surface, edge, and end grain except where glue will be applied.
11. Glue B, C, D, E, F, and G with appropriate dowels. Drive nails through B and C into the edges of both G shelves.
12. Remove excess adhesive from the cabinet body subassembly before it begins to set.
13. Cut, shape, fit, and install moldings L and M with glue and brads.

Knickknack shelf subassembly

14. Saw H, K, and J to shape.
15. Smooth the grain on the irregular edges and surfaces of H, J, and K.
16. Glue, nail, and remove excess adhesive on H, J, and K knickknack shelf subassembly.
17. Align knickknack shelf in the corner under the A bottom.
18. Drill 1/4″ dowel holes through A and 1 3/8″ into H and J.
19. Glue, nail, and remove excess adhesive from subassembly.

Cabinet top and bottom installation

20. Shape the visible edges of both A components.
21. Glue, nail, countersink, and remove excesive adhesive from joints where the A components are installed.

Panel door subassembly

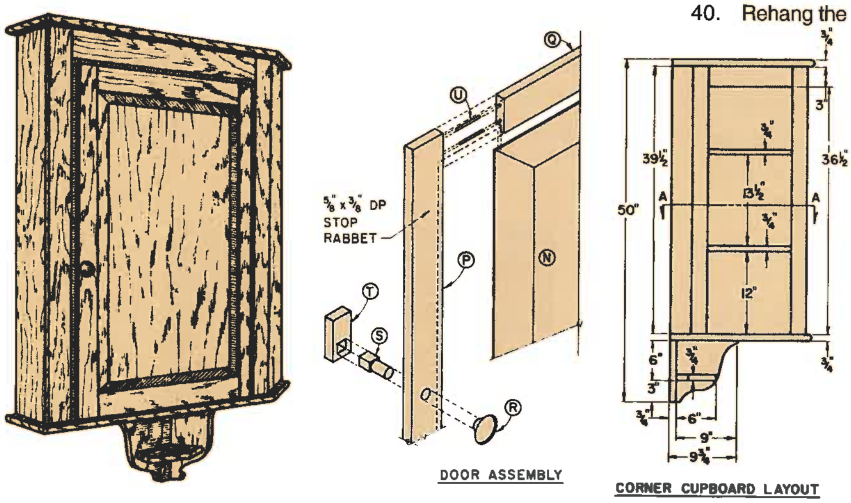
22. Make rabbet joints on both Q components.
23. Make blind rabbet joints on both P components.
24. Drill U dowel holes 1 1/16″ deep in P and Q.
25. Assemble door without adhesive.
26. Inspect for squareness.
27. Glue door frame subassembly together.
28. Remove any excess for the corners of the blind rabbets as needed to allow for the door panel.
29. Fit the door frame subassembly in the door opening with 1/16″ space on each side.
30. Install the door on its hinges.
31. Position the latch mechanism.
32. Remove the hinges and latch.
33. Make 8° bevels on edges and ends of N.
34. Abrade and fit panel into door frame subassembly with 1/32″ space on the sides and ends. This allows for expansion and contraction.
35. Remove the panel.
36. Inspect all surfaces of subassemblies and remove blemishes.

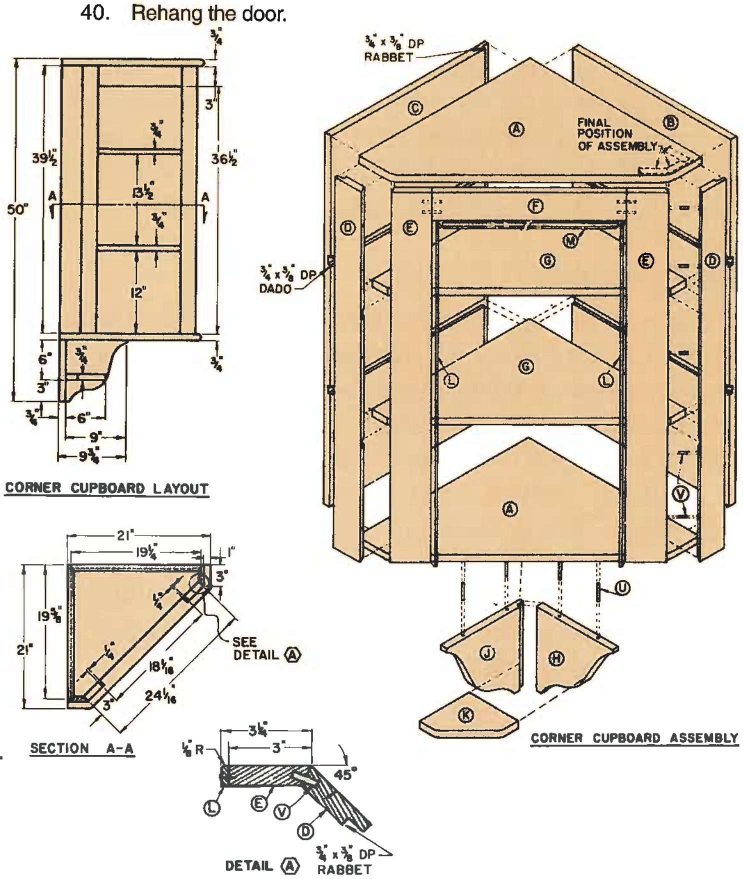
Disassemble and finish

37. Apply the desired finish to all subassemblies and the latch if it is wood.

Final assembly

38. Install the door panel with two wood screws and washers on the panel ends near the corners. (Mechanical fasteners allow for panel expansion and contraction due to humidity.)
39. Reinstall the latch.
40. Rehang the door.





Bill of Materials (finished dimensions in inches)

A Top and bottom (2)	3/4 × 21 × 21	P Door stiles (2)	3/4 × 2 1/2 × 36-1/2
B Back	3/4 × 19-1/4 × 39-1/2	Q Door rails (2)	3/4 × 2 1/2 × 12-3/8
C Back	3/4 × 19-5/8 × 39-1/2	R Latch handle	2 (dia.) × 1-1/2
D Sides (2)	3/4 × 3 × 39-1/2	S Latch pin	3/4 × 3/4 × 2-1/4
E Front frame (2)	3/4 × 3 × 39-1/2	T Latch catch	3/4 × 1-3/4 × 3
F Frame top rail	3/4 × 3 × 18-1/16	U Joinery dowels (16)	1/4 (dia.) × 2
G Shelves (2)	3/4 × 19-1/4 × 19-1/4	V Joinery dowels (10)	1/4 (dia.) × 1
H Knickknack shelf	3/4 × 9-3/8 × 9	**Hardware**	
J Knickknack shelf	3/4 × 9-3/4 × 9	1oz.	#18 × 1″ brads
K Knickknack shelf	3/4 × 6 × 6	1/2 lb.	4d finish nails
L Opening molding (2)	1/4 × 3/4 × 36-1/2	4	1/2 × #4 RH wood screw
M Opening molding	1/8″ (ID) washers	4	1/8″ (ID) washers
N Door panel	3/4 × 32-1/2 × 13-3/8	1 pair	hinges

Figure 7-5. Most shop drawings include a plan of procedure to assist the cabinetmaker during construction. (*Shopsmith*)

Reading Shop Drawings

There is a logical order to follow when reading shop drawings. First, note the information in the title block. Second, look at the views (pictorial, mult view, section, and details). Third, check the list of materials. Fourth and finally, review the plan of procedure.

Title block

The ***title block*** is a rectangular space on each page of the set of drawings. See **Figure 7-6**. It provides information on the product such as:

- Product, or project name (building name for architectural drawings).
- Scale of the drawing.
- A page or drawing number along with the total number of sheets.
- Revisions of the original drawings.

The title block is essential in shop drawings. It specifies the name of the drawings and number of sheets as well as other identifying information. These items are used to determine which project the drawings are for, who drew them, and the scale of the drawings. The scale indicated on the title block can be used if a critical dimensional is missing. A rule can be used to measure the part. For example, there is a missing critical dimension on the drawing in Figure 7-1. The drawing has a scale of 1/8″ = 1″, which means every inch on the drawing equals 8″. The ruler shows an actual 2″ measurement. Thus, the missing critical dimension is 16″.

Pictorial views

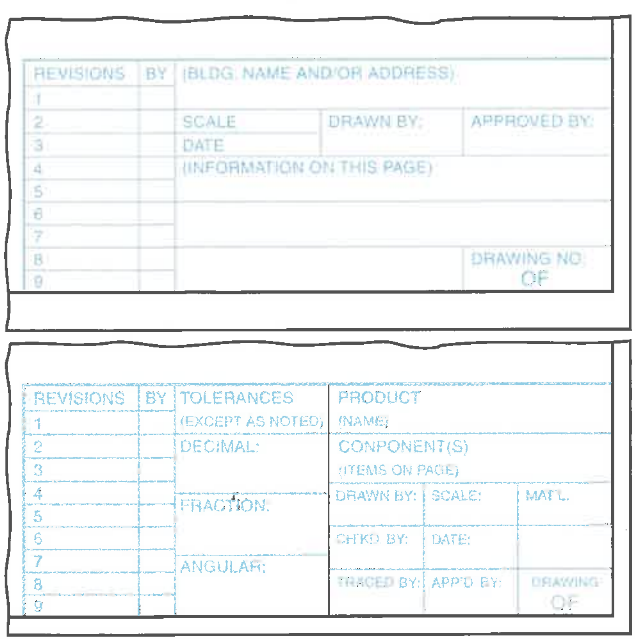
A ***pictorial view*** may be either a photograph or a line drawing. It represents a picture of the final product. More than one surface is usually shown. Dimensions are added if no other views are included in the set of shop drawings. If dimensions are included, they are overall dimensions of the product. See **Figure 7-7**.

Exploded and assembly views

Pictorial views may be exploded views and assembly views. ***Exploded views*** show the product disassembled. See **Figure 7-8**. ***Assembly views*** have dotted lines that show how the product is to be assembled. Refer to the *Door Assembly* and the *Corner Cupboard Assembly* in Figure 7-5.

Parts balloons

Parts balloons are often included on pictorial drawings. A ***parts balloon*** is a circle that may or may not have an arrow attached. Refer to Figures 7-5 and 7-8. The balloon is either printed near or over the specific part of the product or the arrow points to a specific part. Inside the balloon, there is a symbol (letter and/or number) that corresponds to a separate list of parts. Using the pictorial drawing with parts balloons, you can see where a part fits in the overall product.



Shop Drawing

Figure 7-6. The title block identifies the product, designer, and important information about the drawings.

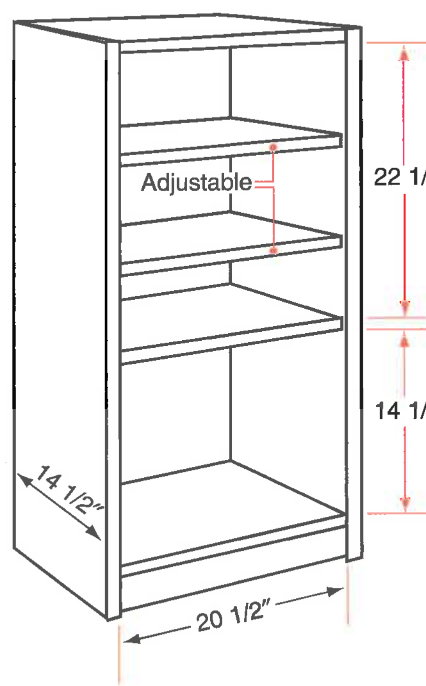


Figure 7-7. Dimensions may be included on the pictorial view. (*Sauder*)

Multiview drawing

Multiview drawings use two or more views to describe the product. It provides most of the information necessary to plan and build the cabinet. Multiview drawings include two-view and three-view drawings.

Two-view drawing

Two-view drawings are used for cylindrical objects, such as those turned on a lathe. Examples are lamp stems, chair spindles, and round table legs. On these objects, a top view of the object would be the same as a front view. Therefore, only a side or end view and a front view are shown.

Three-view drawing

Three-view drawings typically show the front, side, and top views. See **Figure 7-8**. These drawings are the most common shop drawing. Lines that can be seen are called *visible lines* and are drawn solid. Lines that cannot be seen (joints, inside shelves) are called *hidden lines* and are shown by a series of dashes. With so many lines representing the product, detail drawings are often included. They reduce congestion or confusion in a multiview drawing.

Detail drawings

Detail drawings are individual components or joints that are drawn separately. They are used as

List of Materials
(nominal dimensions * in inches)

A	Top and seats (9 pcs.)	2 × 6 × 72
B	Seat supports (2)	2 × 6 × 60
C	Legs (4)	2 × 6 × 36
D	Braces (2)	2 × 3 × 30
E	Center seat supports (2)	2 × 3 × 11½
F	Tabletop supports (2)	2 × 4 × 29½
G	Center top support	2 × 4 × 29½
	#12 × 2½" Flathead wood screws (60)	
	5⁄16" × 3½" Carriage bolts (16)	

* Standard lumberyard dimensions

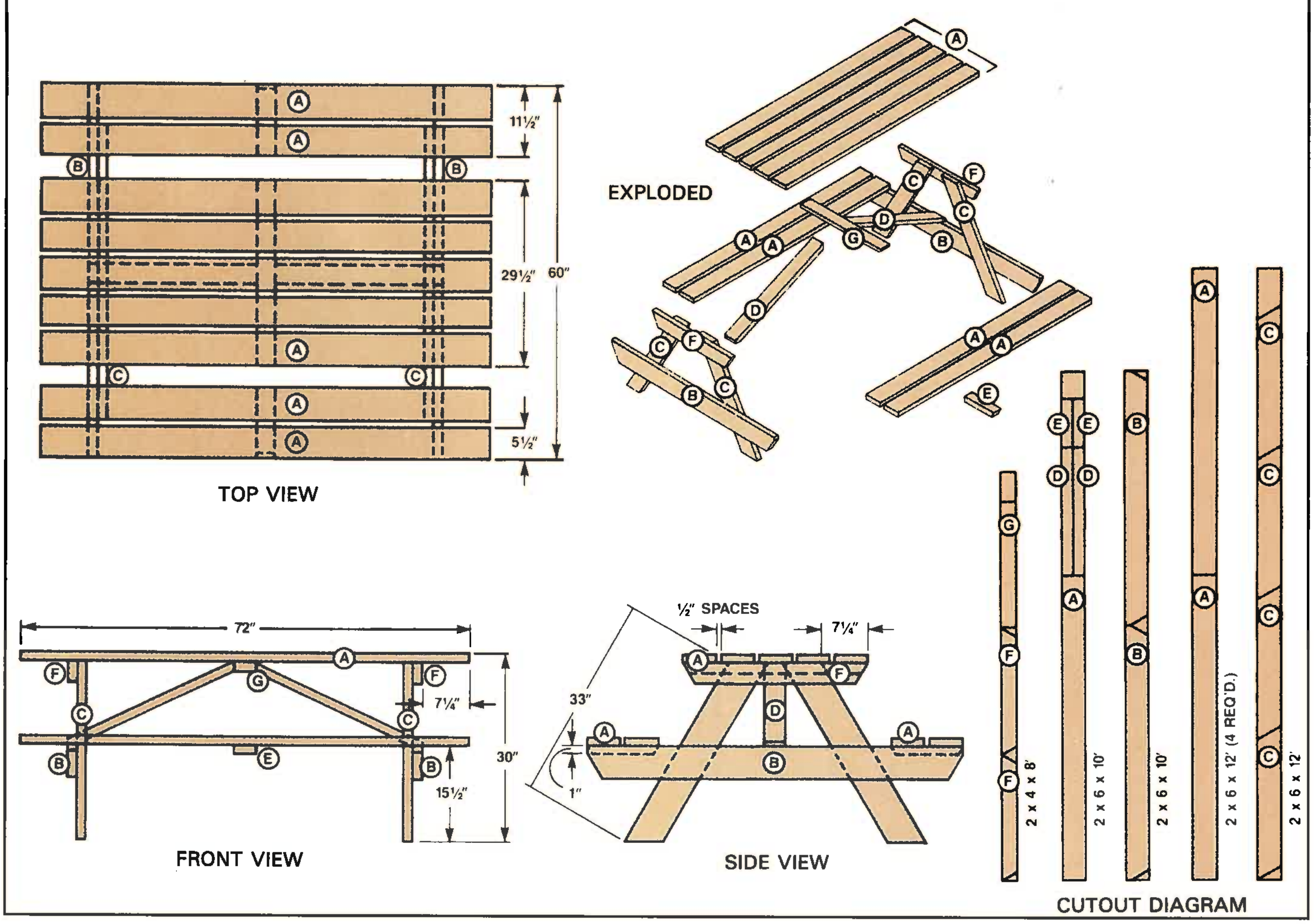


Figure 7-8. A three-view drawing is the most important part of shop drawings. Exploded views and cutout diagrams assist the cabinetmaker. Parts balloons help relate component parts in each view. (*Shopsmith*)

helping drawings. Notes are included to describe special features or procedures.

Detail drawings are separate from the main drawing. They may be on a separate page. The detail drawing is referred to on the main drawing using letters or a note such as: SEE DETAIL 3 ON SHEET 2. This note will help you locate how the detail drawing fits with the main drawing. Refer to Figure 7-5.

Section drawings

Section drawings allow you to see an object as if material was cut away. The removed section may be part of a joint to let you see how the joint was constructed. Section views are also used to show the material of a cabinet part. Diagonal lines are placed in section views to represent material that was cut. See **Figure 7-9.**

Development drawing

Development drawings, also called stretch-outs, show the layout of the product as if it were unfolded or flattened. They are used for products that are formed. They assure that enough material is used to achieve the correct product size when the pieces are formed.

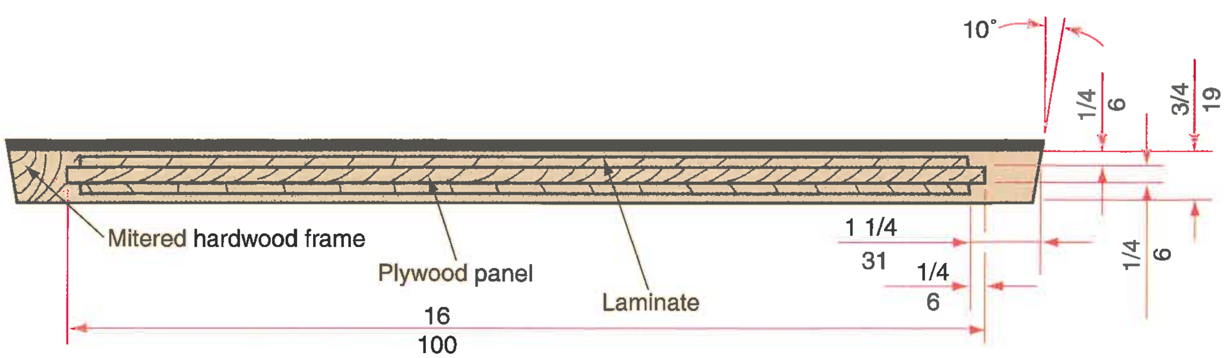
The Language of Drawing

The purpose of any language is to communicate. Verbal and written languages communicate ideas. A *drawing language* communicates lines, shapes, texture, and color. It would be impossible to describe a piece of furniture using only words and sentences. Therefore, drawings must communicate how a product is to be built. Drawing languages include an additional alphabet other than letters and numbers. It is the alphabet of lines.

Alphabet of lines

The *alphabet of lines* is the universal language of drafting. Each line communicates by its form and thickness. See **Figure 7-10.**

* ***Visible lines.*** Form the outline of the object they enclose. They may form circles, triangles, rectangles, or other shapes.
* ***Hidden lines.*** Illustrate an edge or corner that is not visible in a given view.
* ***Center lines.*** Tell you that an object is symmetrical (mirror image). Its left half (or top) is the same as its right half (or bottom).
* ***Extension lines.*** Mark the edges or corners of the product that must be dimensioned.
* ***Dimension lines.*** Describe distances between extension lines.
* ***Leader lines.*** Have one arrowhead. They direct attention to the drawing. Notes usually have a leader line to point to the object they discuss.
* ***Radius lines.*** Show dimensions of arcs and circles. An arrow points from the dimension to the edge of the arc or circle. Another arrow extends from the center to the edge.
* ***Cross section lines.*** Indicate material in a section view.
* ***Phantom lines.*** Show alignment or alternate position details.
* ***Cutting plane lines.*** Reveal a cutaway section. Arrowheads show which way the reader will see the cutaway surface (section view).
* ***Break lines.*** Limit a partial view of a broken section. For short breaks, a thick freehand line is used. For long breaks, long ruled dashes joined by freehand *zig-zags* are used.
* ***Border lines.*** Enclose the entire drawing for a finished appearance. They also separate individual drawings.



Section A-A

Figure 7-9. A section view is a cutaway view. It shows the materials of which the part is made.

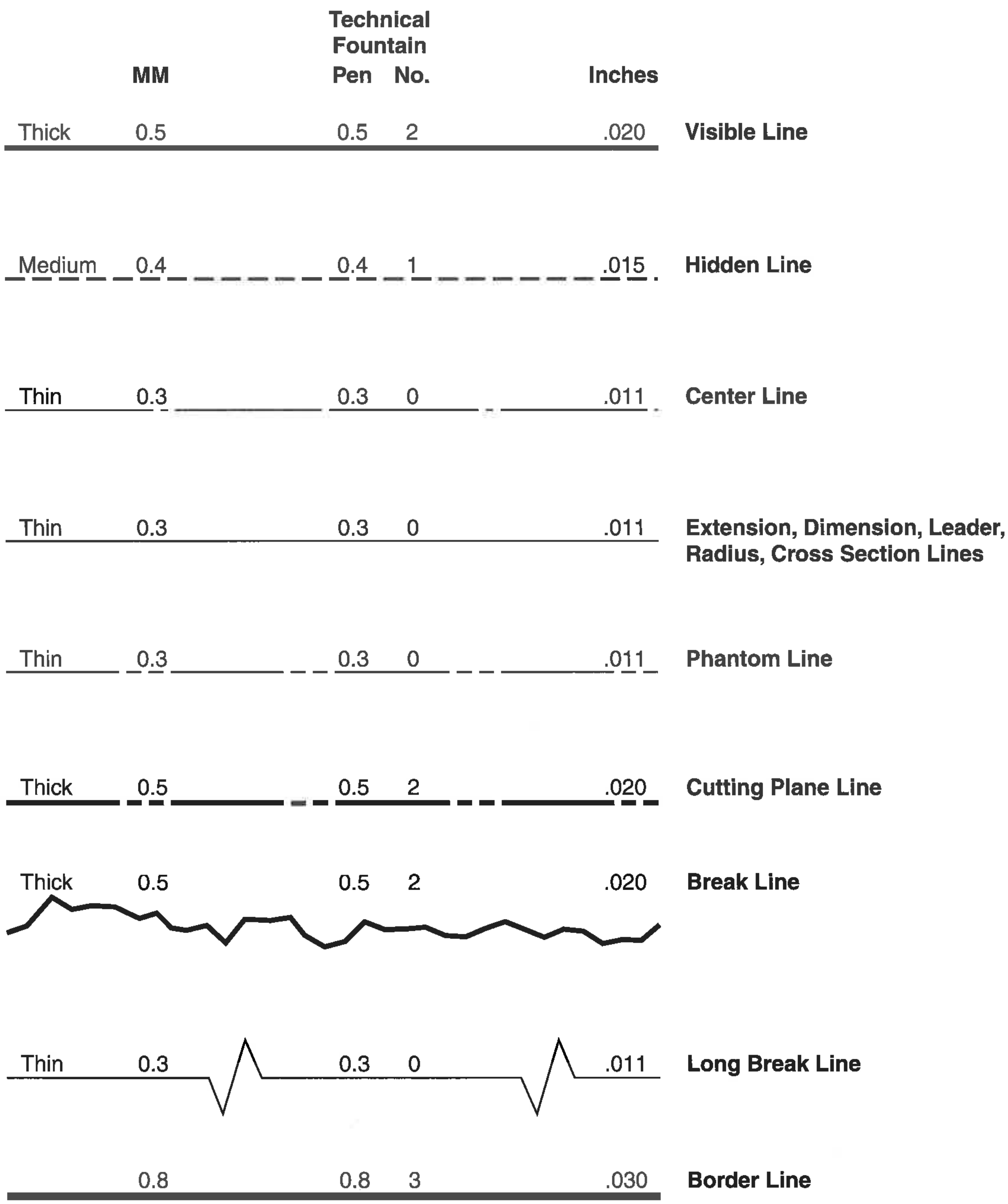


Figure 7-10. Line styles are used to represent different aspects of the drawing.

Alphabet of letters and numbers

Letters and numbers, like lines, are symbols of communication. Use them when instructions can be given better with words than with pictures. You can abbreviate frequently used terms when entire words or phrases would clutter the drawing. See **Figure 7-11.**

Numbers are used primarily to indicate dimensions. Critical dimensions will include a tolerance distance. On some shop drawings a global tolerance is given in the title block. This tolerance refers to all dimensions in the drawing. Individual tolerances are given as: 3½″ ± 1/64″ (88.4 mm ± 0.4 mm). Therefore, the dimension can range from 3 31/64″ to 3 33/64″ (88.5 to 89.3 mm). Tolerances are widely used for mass production of cabinets. The tolerance assures quality control in the product. For custom, or limited production, cabinetry tolerances are not necessary.

The alphabet of lines and alphabet of letters and numbers are essential when reading working drawings. In addition, you must be able to read specifications. This must be done before starting to work on a product.

Abbreviations			
Architectural Drawings			
CLG	–ceiling	MIN	–minimum
FLR	–flooring	MAX	–maximum
BC, OC	–between or on center	LG	–length
CAB	–cabinet	HGT	–height
CLO	–closet	DW	–dishwasher
CL, C	–center line	REFR	–refrigerator
CTR	–counter	VAN	–vanity
Shop Drawings			
CL, C	–center line	CTR	–counter
R	–radius	FIN	–finish
DIA	–diameter	LAM	–laminate
ASSY	–assembly	MAX	–maximum
AVG	–average	MIN	–minimum
DIM	–dimension	NO, #	–number
DWG	–drawing	RD	–round
ID	–inside diameter	W/	–with
OD	–outside diameter	WO/	–without

Figure 7-11. Abbreviations reduce the text required in a drawing.

Reading Specifications

Specifications list the materials for producing the product. ***Architectural drawing specifications*** are general and include the kind of wood, stain, color, etc. **Shop drawings** include precise material specifications. The individual manufacturer of the product is often noted. Some items found in specifications include the following:

- Solid lumber (kind, size, quality)
- Wood products (plywood, hardboard)
- Specialty woods (veneers, inlays, overlays)
- Hardware (hinges, catches, pulls)
- Specialty fasteners (waterproof adhesives, specific ready-to-assemble connectors, stainless steel screws)
- Finishing materials (abrasives, stain type and manufacturer, top coat)
- Other components (dowel rods, glass, ceramics, plastic)

Supplies include all items needed to build the cabinet. They should be acquired before work begins. The supplies a cabinetmaker should acquire include abrasives, cleaning materials, masking tape, packaging materials, and special tools. Having to find or buy supplies after work begins can result in wasted material and time.

Plan of Procedure

The ***plan of procedure*** generally is included in shop drawings. It provides a sequence of steps to build a product. Refer to Figure 7-6. Some operations do not have to follow a sequence. Other operations can be accomplished only after a previous operation is complete.

Summary

Working drawings guide you when designing and completing the product. A cabinetmaker must be able to interpret the information found on working drawings.

The two categories of working drawings are architectural and shop drawings. Architectural drawings include floor plans, elevations, specifications, and work schedule. Shop drawings contain pictorial drawings, orthographic drawings, details, specifications, and a plan of procedure.

Working drawings communicate a product with the alphabet of lines, letters, and numbers. The alphabet of lines is the universal language for illustrating a product. Letter or number abbreviations specify different materials needed to build a product.

Working drawings include both drawings and specifications. Specifications list materials. Architectural specifications are more general. Shop specifications give a precise list of material and supply types, quantities, and often their manufacturer.

A plan of procedure guides the cabinetmaker in building the product. It lists the machines and operations used to shape the various parts.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Prints of working drawings can be _____.
   a. blue
   b. white
   c. yellow
   d. Either a or b.
2. The two types of drawings used by the cabinetmaker to produce built-in cabinets are _____ and _____.
3. Material specifications for architectural drawings contain what information?
4. How is a work schedule for architectural construction different from the plan of procedure used in shop drawings?
5. What information is found in a shop drawing?
6. The title block of a working drawing contains _____.
   a. alphabet of lines
   b. name of the designer
   c. parts balloons
   d. material specifications

7. Why is a two-view drawing made for cylindrical parts rather than a three-view drawing?
8. On a separate sheet of paper, sketch the following lines:
   a. Visible line
   b. Center line
   c. Hidden line
   d. Extension line
9. The minimum size of a part with a dimension of 4 ¼" ± 1/8 would be _____".
   a. 4 3/8
   b. 4 1/8
   c. 4 15/64
   d. 4 15/32
10. Shop specifications list _____, _____, and _____.

Making Sketches and Mock-ups

Objectives

After studying this chapter, you will be able to:

- Identify the types of sketches used to design cabinetry.
- Describe how mock-ups are used to analyze a design.
- Apply the techniques of sketching to draw isometric, cabinet, and perspective sketches.

Important Terms

appearance mock-up	pictorial view
cabinet drawing sketch	refined sketch
hard mock-up	rough sketch
isometric sketch	sketch
perspective sketch	thumbnail sketch

Sketches and mock-ups are useful aids when designing, laying out, and producing cabinetry. The old saying that a picture is worth a thousand words is very appropriate to sketching. A quickly made sketch conveys information that would be difficult to describe otherwise. A ***sketch*** records your ideas and makes communications easier.

Sketching is part of the design process. Sketches are made to record ideas for a product. Later, they are relied upon for preparing *working drawings*. During production, sketches are also made. They may show changes in the original design. Some might refer to machine or equipment setups.

Mock-ups are three-dimensional replicas of your design made of convenient inexpensive materials. They could be paper, cardboard, or scrap wood. They are used for analysis of your design before the product is built. The mock-up may be a full scale replica or a scaled-down version of the product.

Types of Sketches

Sketches may be either rough, thumbnail, or refined sketches. The kind you choose depends on the desired accuracy of the sketch. ***Rough sketches*** provide simple outlines and very little detail. ***Thumbnail sketches*** represent the product with more accuracy. ***Refined sketches*** add specific details, such as dimensions and materials. See **Figure 8-1**.

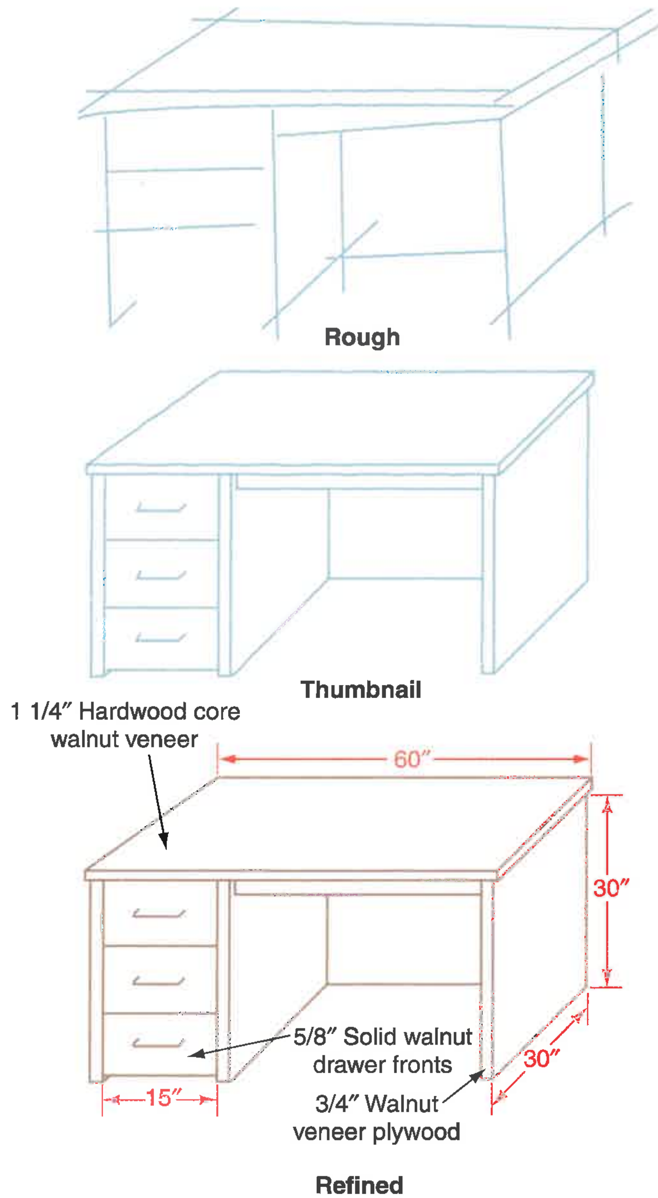


Figure 8-1. Top—Rough sketches only show outlines of a design. They have very little detail. Middle—Thumbnail sketches add details to accurately show the product. Bottom—Refined sketches include most information to be put on a working drawing.

Sketching

Sketching communicates ideas with a drawing. Some sketches show several surfaces of an object. Most are drawn in three dimensions. Suppose you are planning to build a small table. First, get a picture of it in your mind. Then, draw the front, top, and side views. These three views come together to show what the product will look like when it is finished. Three-dimensional sketches are called pictorial sketches.

Pictorial sketches

Pictorial sketches are three-dimensional sketches that are best suited for cabinetry and furniture. How the product is drawn depends on your eye level. A product that sits on the floor would likely show the top, front, and side views. A product that hangs from the ceiling would be drawn as if you were viewing it from below. Here, you would include front, side, and bottom views. Pictorial views may be isometric, cabinet, or perspective sketches. See **Figure 8-2**.

Isometric

An *isometric sketch* represents a product as seen from a corner. Vertical lines of the product are vertical on the sketch. Horizontal lines of the product are shown in true length at 30° from horizontal in the drawing.

Cabinet

Cabinet drawing sketches represent the product as if it were viewed from the front. The front view will be a true shape. To add depth, lines representing the side of the object are drawn half length at a 45° angle.

Perspective

Perspective sketches represent a true view of an object. They are hard to sketch and are rarely used in cabinetmaking. The farther objects are away from you, the smaller they appear to be. On paper, this is accomplished with vanishing lines. Increased depth will be smaller in size.

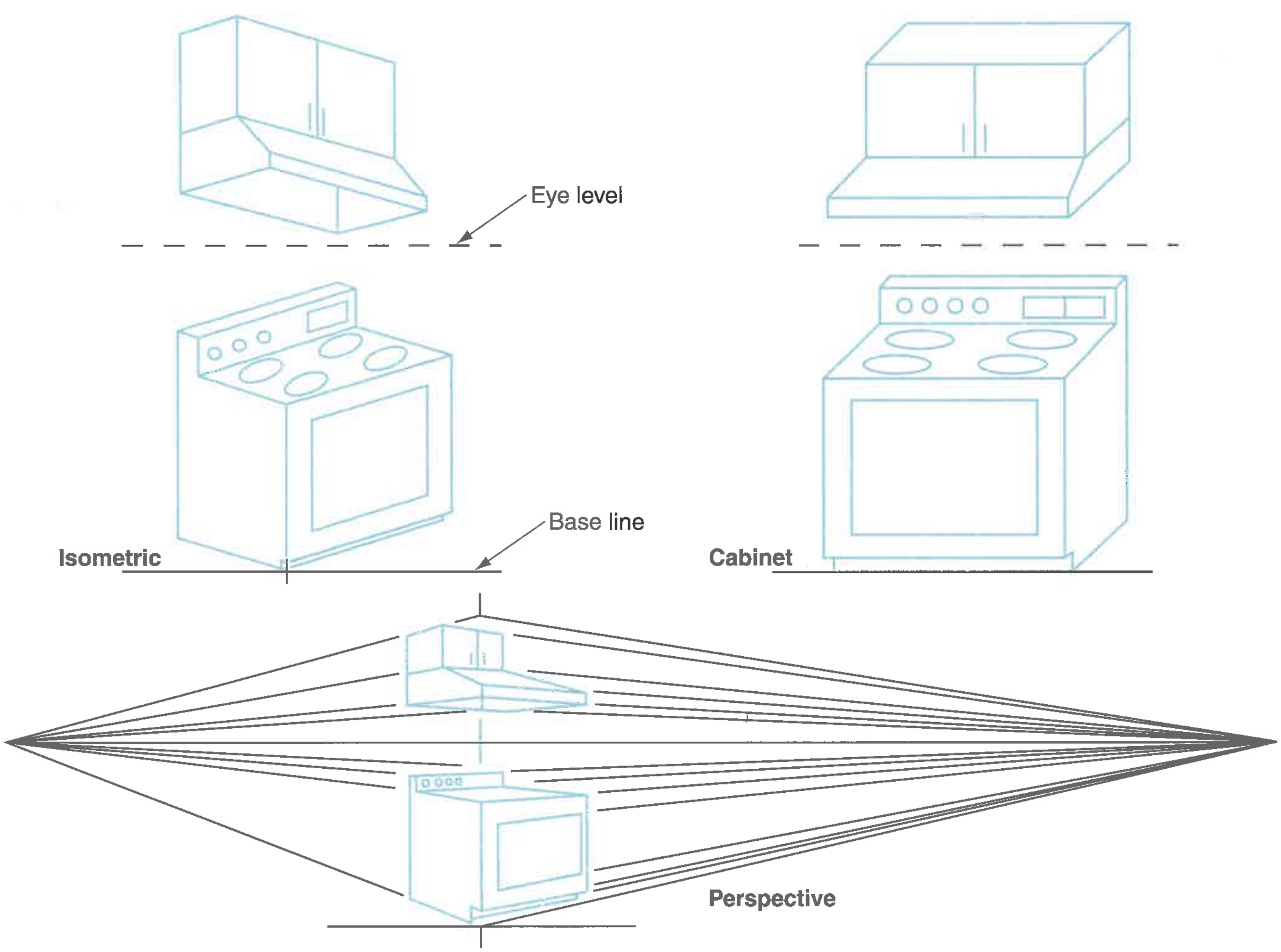


Figure 8-2. Three different types of pictorial sketches. Notice how the isometric and cabinet sketches distort the object.

Techniques of Sketching

There are four skills for successful sketching. The first is to grip the pencil with the fingers as though you were writing. The second is to keep your wrist flexible. The third is to maintain free arm movement. The fourth skill is coordination of the grip, wrist, and arm to create straight and curved lines.

All lines are drawn lightly at first. Then darken those lines that best enclose the object.

Straight lines

As you have seen in the previous figures, horizontal, vertical, and diagonal lines are used in most sketches. Sketching should illustrate an object as you would see it. With nine straight lines, the surfaces of a cube can be enclosed. See **Figure 8-3**.

Graph paper, or isometric grid paper, is helpful when first learning to sketch. Follow the printed lines of the paper to keep your lines parallel. See **Figure 8-4**. Practice will help you to develop coordination of your fingers, wrist, and arm.

For the beginner, horizontal lines are the easiest to control. Each line of the object can be drawn horizontally by turning the paper as the angles of lines change. As you gain experience, vertical and angled lines can be drawn without moving the paper.

With experience, you can use unlined paper. First, mark the end points of the lines. Then, add short line segments between the two points, guiding the pencil between starting and stopping points. Reposition your hand for each segment until the desired length is reached.

Cabinet sketches

When creating a cabinet drawing, sketch the horizontal line of the base. See **Figure 8-5**. Then, cross the horizontal line with light vertical lines indicating the sides and important front features of the cabinet. Next, complete the front, darkening the lines that enclose parts of the cabinet. You can then draw lines to indicate depth. Remember, depth lines are half length at a 30° to 60° angle.

Isometric sketches

To sketch an **isometric** drawing, sketch a horizontal line. See **Figure 8-6**. Next, cross the horizontal line with a light vertical line. From the intersection of these two lines, draw lines at a 30° angle from horizontal. The intersection of these five lines forms the lower front corner of your design. From here, other lines can be added to complete the drawing.

Curved lines

Curved lines are more difficult to sketch than straight lines. A good method is to lightly sketch different points that the curve will pass through. Then sketch light, curved lines to connect these points. Make sure the transition from point to point is smooth. It should not look like a *connect-the-dots* puzzle.

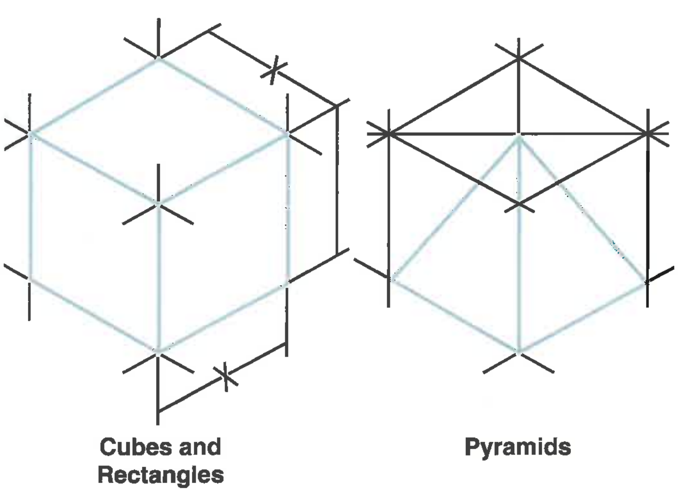


Figure 8-3. Straight line sketches are easiest to create.

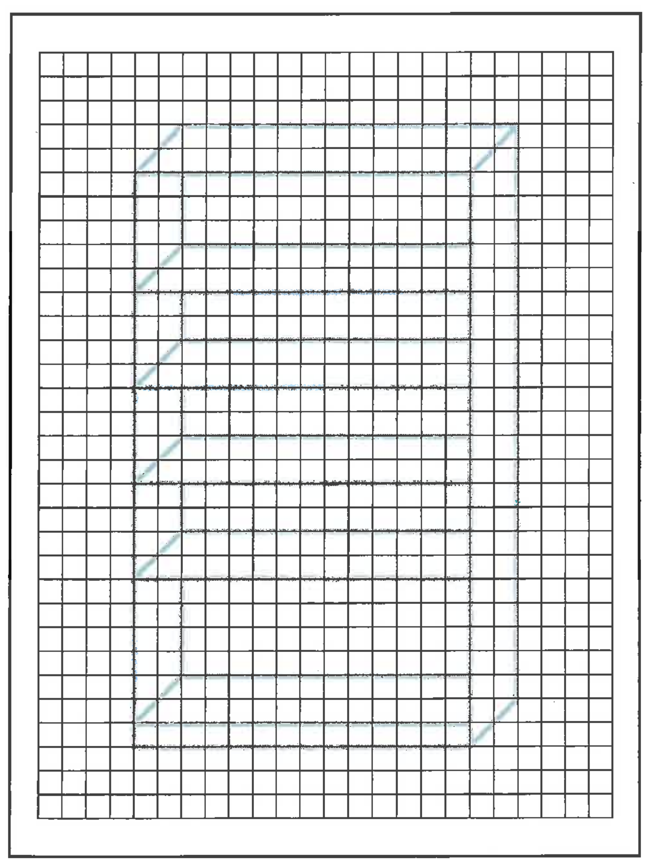


Figure 8-4. Grid paper is used to help keep sketched lines straight.

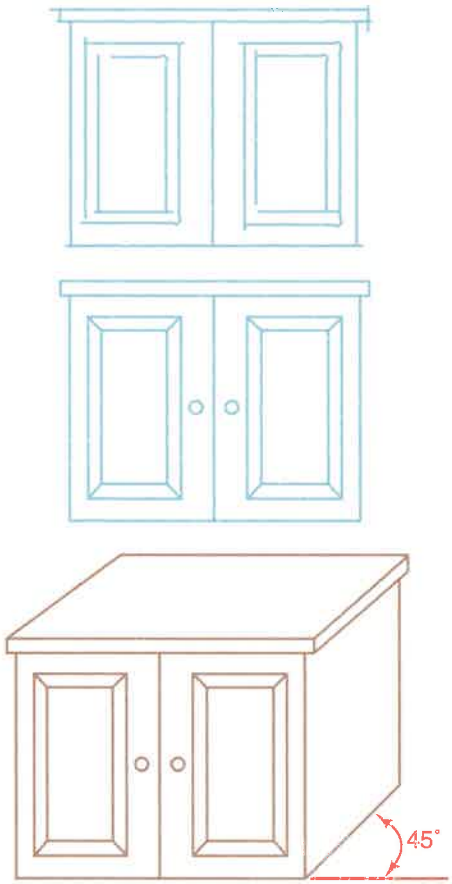


Figure 8-5. The steps in sketching a cabinet drawing. Top—Light outlines. Middle—Darken lines that accurately outline the object. Bottom—Lines are added to show depth.

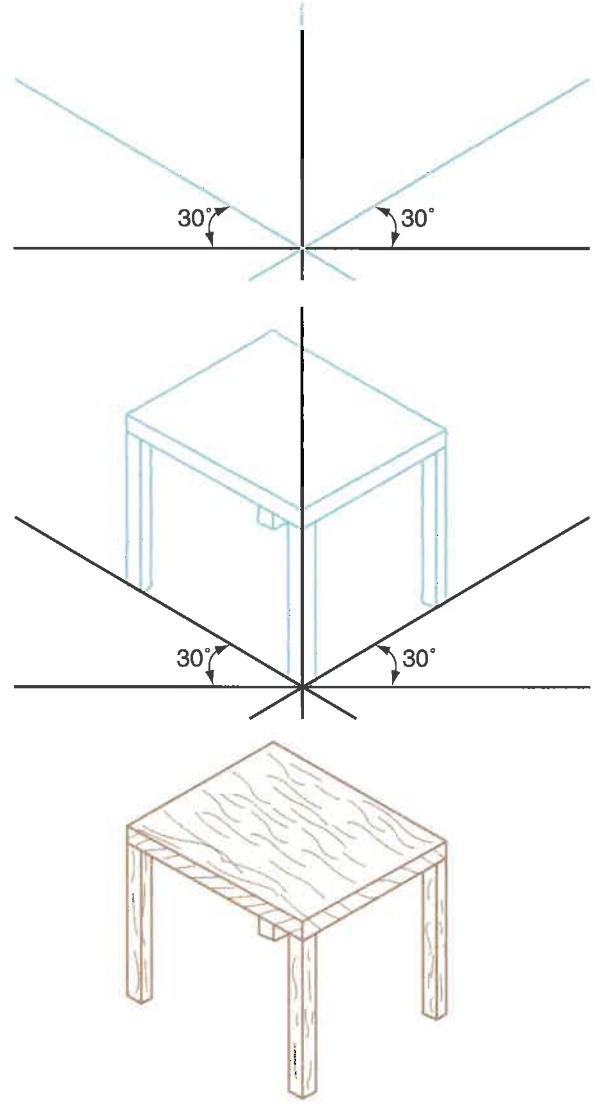


Figure 8-6. The steps in sketching an isometric drawing. Top—One vertical and two 30° lines make up the front corner of the object. Middle—All horizontal lines of the product are drawn at 30° on an isometric sketch while vertical lines remain vertical. Bottom—The final drawing with unnecessary lines erased.

Circles and ellipses

Circles appear on views that are seen by looking straight at the front, top, or side of an object. An **ellipse** appears to be an egg shape. It is used to represent circles viewed at an angle.

Circles

The easiest way to create a circle is to use a template. For instance, draw around a coin of the approximate diameter. You can also sketch a circle within a square. First, draw a square the size of the diameter of the circle. Then, draw diagonals between corners of the square. Mark the radius measurement from the intersection of the diagonals toward each corner. Then, draw a circle using the radius marks and the sides of the square. See **Figure 8-7**.

Ellipses

Ellipses can be used to represent circles viewed at an angle. They may be found on all sides of isometric or perspective sketches. On cabinet drawing sketches, ellipses are used on the top and side views.

To sketch an ellipse, draw an isometric square the size of the diameter of the circle. See **Figure 8-8**. The isometric square will appear as a diamond shape. Then, locate the center of the circle and draw isometric center lines. Now draw arcs between the center lines to complete the ellipse.

Perspectives

Perspective sketches are more difficult to prepare. Only vertical lines are parallel to each other. Horizontal lines are aimed at a vanishing point. Equally spaced vertical distances get closer as they approach the vanishing points. See **Figure 8-9**.

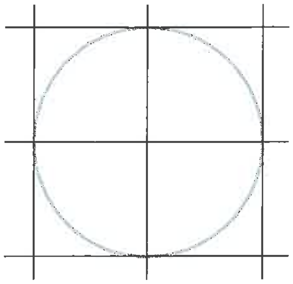


Figure 8-7. Circles are best sketched within a square.

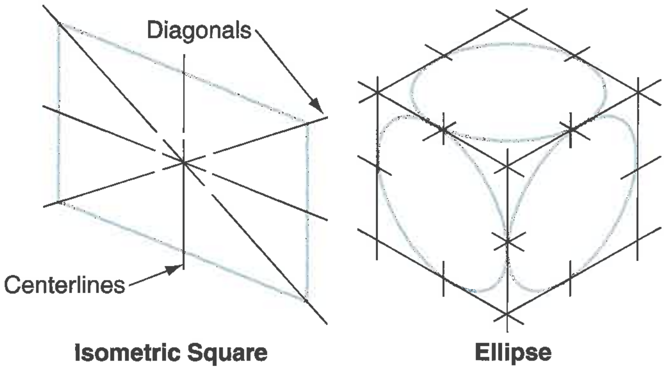


Figure 8-8. Ellipses are drawn in an isometric square that resembles a diamond.

The size of objects in perspective sketches can only be estimated. First, identify two vanishing points on each side of the object. Draw a vertical line at the intersection of two lines. All horizontal lines lead to these vanishing points. The horizontal lines are drawn less than actual size. The only vertical part of the drawing with true length is the vertical line at the intersection. The height of each part of the object is measured on this vertical line.

Dimension lines

Dimensioning on sketches is relatively simple. Be sure that extension lines are made in the intended direction. Keep dimension lines parallel to the edge being measured. Adding overall width, length, and height dimensions to a sketch may be very useful.

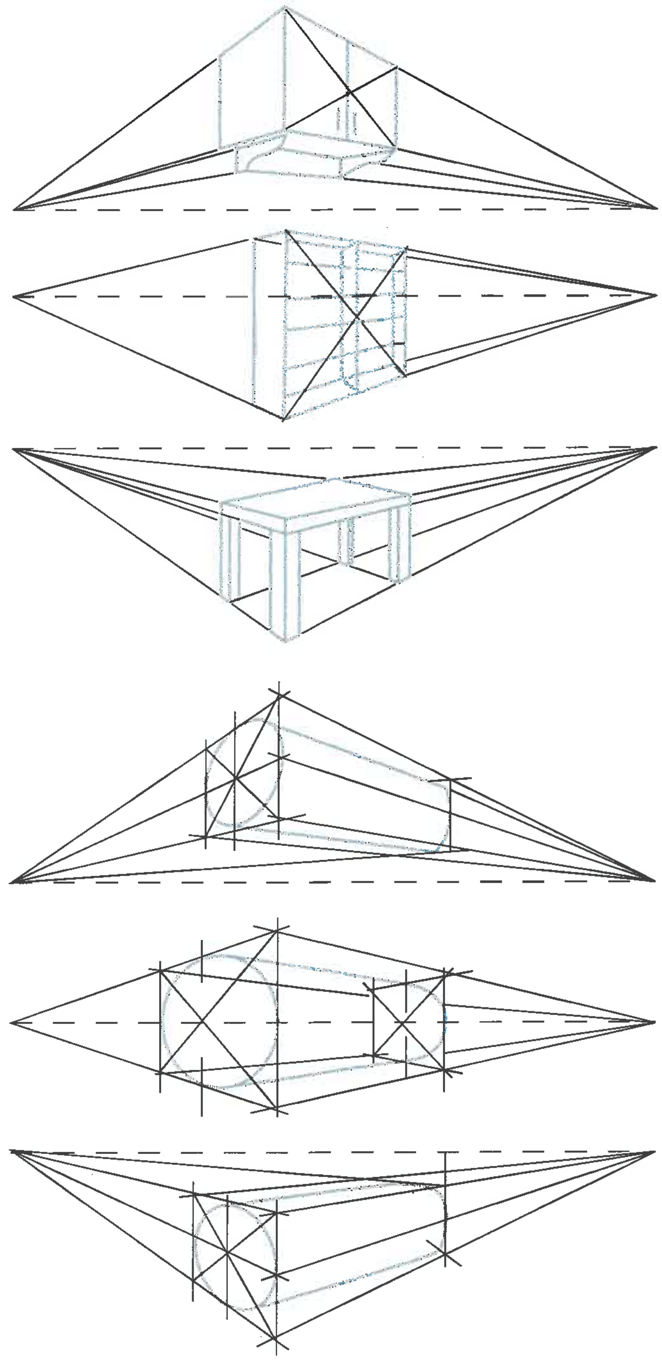


Figure 8-9. Perspective sketches are the most difficult to draw; yet, they most accurately show the product.

Developing Mock-ups

A ***mock-up*** is used to represent a product without wasting expensive wood or other materials. Decisions based on a working drawing may not be adequate. Mock-ups help solve design and building problems. With a mock-up, the product can be seen in three-dimensional form. It is built of paper, cardboard, foam board, and glue or tape. The two kinds of mock-ups are appearance mock-ups and hard mock-ups.

Appearance mock-up

An ***appearance mock-up*** looks like the final product, but is not functional. For example, a cardboard box may be covered with wood grain contact paper to make it resemble a silverware chest. Handles and knobs could be attached to make it more realistic. This three-dimensional representation of the product lets you see its final appearance. To analyze function, a hard mock-up is made.

Hard mock-up

Hard mock-ups are working models of the product, and may be fully or partially functional. For example, the cardboard lid and drawer of the silverware chest previously mentioned would move. The silverware could be placed inside to see if it fits. You could also determine the final arrangement of pieces. This is a fully functional hard mock-up.

Hard mock-ups are also used to adapt products to people. For example, a mock-up might be built to test the use of a product with a person in a wheelchair. Can the person reach objects in or on the cabinet? Do the doors open easily? These are human factors. A hard mock-up may not have dividers in the drawers for silverware. However, the major parts of the product are functional to test reach, space, and comfort. Mock-ups are often used in the automotive and aerospace industries to test human factors. See **Figure 8-10.**

Figure 8-10. Using a hard mock-up of a kitchen designed for homes where it may be necessary for small children to assist their parents.

Summary

The value of sketches and mock-ups is to present a design solution. Sketches and mock-ups can save time in communications. They allow you to record and communicate ideas quickly and clearly.

A sketch might illustrate a product to be built. It could describe a jig or fixture for production. A mock-up may represent the basic shape of a product. It might illustrate how a product looks or how it works. Any or all these practices can prevent wasted time and materials.

Sketches generally illustrate three views of an object. Most people visualize an object in this manner. Isometric and cabinet sketches are quite common. Perspectives are not used as much, because they take longer to prepare. Sketching is simple to master. You must first learn to create simple lines and circles. Practice will make you proficient at sketching these and more complex geometric forms.

Mock-up building is more involved. You must measure, cut, and assemble components made of inexpensive material. Appearance mock-ups look like the final product, but are not functional. Hard mock-ups may not be finished like the final product, but they are scaled, functional models used to analyze how the product will work.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. The purpose for making sketches and mock-ups is to save _____ and _____.
2. Sketches are used during _____.
   a. production
   b. design
   c. Both a and b.
   d. Neither a nor b.
3. What makes rough, thumbnail, and refined sketches different? When would you use each of them?
4. Why are most sketches made in three dimensions (pictorial views) instead of being drawn as a three-view drawing?
5. Name the three types of pictorial sketches.
6. Isometric views are drawn with _____.
   a. all three views with true shape and size
   b. no views with true shape and size
   c. one view with true shape and size
   d. two views with true shape and size
7. Cabinet drawings have _____.
   a. all three views with true shape and size
   b. no views with true shape and size
   c. one view true shape and size
   d. two views with true shape and size
8. What type of pictorial view uses vanishing points?
9. What is the method for sketching a line? A circle? An ellipse?
10. Name the two types of mock-ups. What is the difference between them?

Producing Working Drawings

9

Objectives

After studying this chapter, you will be able to:

- Identify the effects computers have on producing working drawings and cabinetmaking in general.
- Identify the equipment and supplies used to produce working drawings.
- Explain the activities leading to a finished drawing.
- Describe how to generate a bill of materials.

Important Terms

bill of materials	Gothic lettering
compass	mechanical lead holder
computer-aided design	parallel bar
divider	personal computer
drafting board	scale
drafting machine	T-square
flexible curve	technical pen
French curve	

Creating an original design challenges even the most experienced cabinetmaker. Begin by making decisions about the features you wish in the product. Then decide the best way to produce the product. Next, make sketches that show this information. From these sketches prepare the working drawings. Working drawings contain the graphics, measurements, and notes needed to build the product.

Working drawings for cabinets, case goods, chairs, and tables is part of drafting technology. Activities include laying out geometric forms, transferring designs, and providing details. The equipment and supplies to construct the working drawings varies. You might be using a computer and computer software or you may be drawing by hand.

Computer use in Cabinetmaking

Computers are being adapted to cabinetmakers. The use of computers has eliminated much of the drudgery of manual drafting. See **Figure 9-1.** ***Computer-aided design*** (*CAD*) software will produce the simplest cabinet drawings and floor plans, as well as the more complex perspectives and three-dimensional drawings. Manual drafting techniques and equipment are discussed later in this chapter.

Besides being a tool for the production of drawings, computers and computer software help integrate the entire process of cabinetmaking. From design to delivery and beyond, the computer is involved. Computers provide the ability to perform many functions such as sketching and refining ideas, designing complete rooms, performing automated drawings, reproducing and updating designs, parts lists and bill-of-material information, material optimization, estimating and job costing, part and product labeling, part machining, machinery linking, and appliance guide.

Sketching and refining ideas

Computers are used as a tool to create cabinet ideas. As more designers use computers, the brainstorming, sketching, and refining of design

Figure 9-1. Computer-aided design (CAD) systems are being used more and more in the cabinetmaking industry. *(Altium)*

processes are computerized. Software programs take sketches through the design steps to a finished working drawing.

Portability provided by laptop computers enables you to take a computer to the job site. This flexibility enables you to perform a variety of job-site duties, such as recording dimensions or cabinet design with the customer.

Room design

Room interiors are designed to fit any shape or style of room desired. Perspectives, elevations, and floor plans should be created. Color detailed three-dimension presentation drawings should be produced.

Many software programs allow you to completely design a room. You can include all furniture, fixtures, countertops, cornices, light rails, and cabinets in place. You have the ability to insert special cabinets from component parts that you have designed. These perspective drawings can be viewed from a number of view points. See **Figure 9-2.** Moving the view point makes it seem like you are moving through the room.

Perspective drawings create very realistic elevations. See **Figure 9-3.** Lighting, shading, textures, and materials can be added to the elevations to make them look like a color photograph.

With advanced software programs, you can imagine yourself moving through the design you create. By connecting a number of room designs, an animated tour can be created. It is like walking through a house.

Automated drafting

Automated drafting makes plan revisions fast, accurate, and easy. Elevation, cross section, floor plan, and three-dimensional drawings can be created. Some software includes predrawn woodworking items, such as walls, doors, windows, casework, molding profiles, joint constructions, and countertop details.

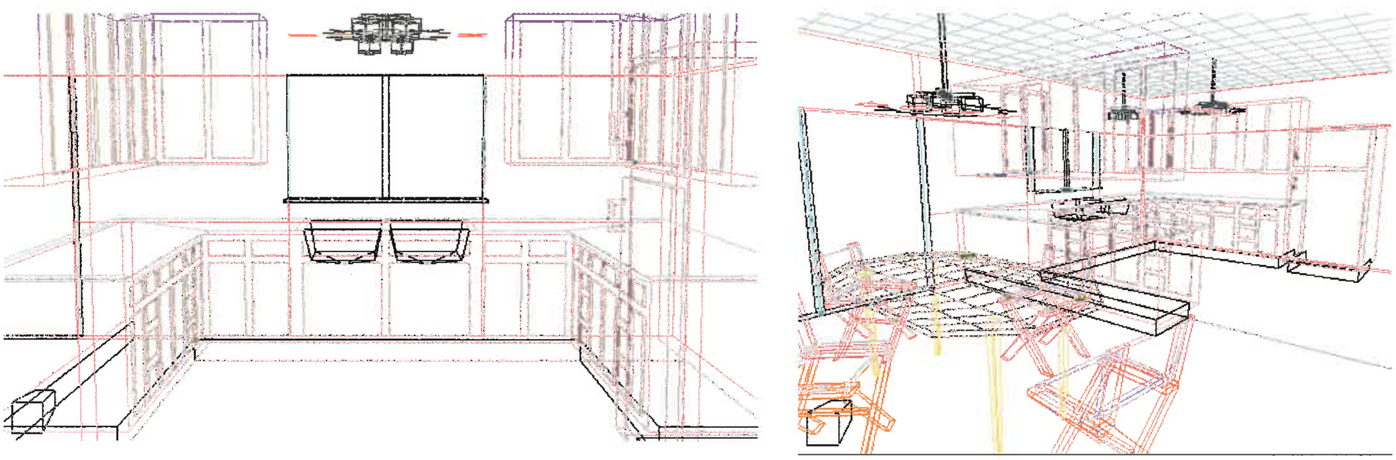


Figure 9-2. Computer-generated perspective drawings and three-dimensional room elevations. Left—The one-point perspective view shows a kitchen and cabinetry elevation. Right—The two-point perspective view shows a kitchen and dining area. *(Autodesk, Inc.)*

Figure 9-3. Left—The drawing made to look as if it were real. Middle—Color and shading can be added to give more definition to the drawing. Right—Added lighting, textures, and colors give a photographic-quality representation of the drawing. *(Autodesk, Inc.)*

Copying and updating designs

Because computer-generated designs are easy to manipulate, you can use computers to copy and update old designs. Time-consuming manual drafting techniques are being replaced almost instantaneously by computers.

Changing a whiteprint or blueprint meant making a new drawing. Now with computers, an additional copy is simply plotted. Old pencil drawings can now be scanned (captured electronically) and stored on a computer or computer disk. This allows a cabinetmaker to capture, reproduce, update, and save handmade drawings.

Parts lists and bill-of-material information

After a design is completed and material specifications are known, the computer compiles and stores the information. Now a customized parts list and complete bill-of-materials is available instantaneously.

Material optimization

Once the cabinet design is complete, computers help determine the most efficient way to use materials. See **Figure 9-4.** For example, you can get a printout of the best way to cut rectangular parts from sheets of cabinet material. Cutting layouts and reports on anticipated yields and costs can be printed out. This information can be used to create price quotations as well as estimating machinery usage times.

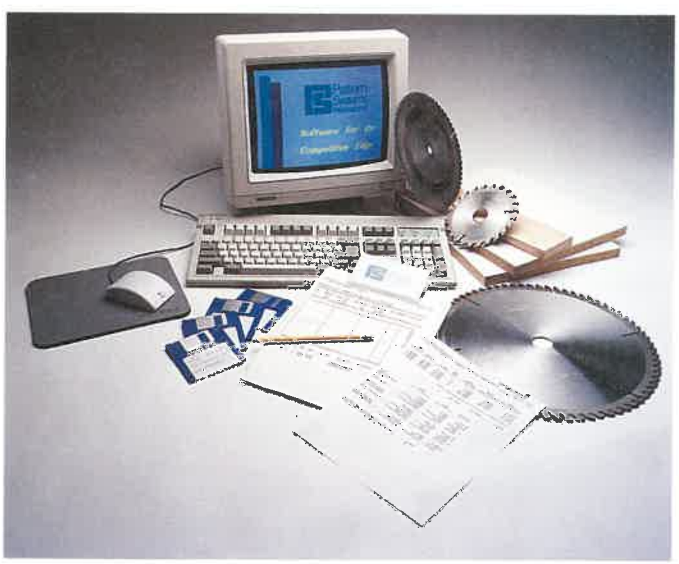


Figure 9-4. Saw blades and panel cut drawings are symbolic of the items produced and controlled by the computer. (*Pattern Systems International*)

Estimating and job costing

Computers can automatically produce estimates, quotations, contracts, and change orders from the room design. The estimates take into account material waste for each cabinet part, hardware, accessories, labor, taxes, overhead, and profit. The cabinet price is figured using your method of pricing, whether by the lineal foot, square foot, labor table, per box, or actual material and labor cost.

Part and product labeling

Printed labels help keep track of parts, subassemblies, and completed products. Parts labels can be printed in the sequence of the cutting list. The computer operator specifies the size, quantity, and content of the labels. Labels may be produced with product bar codes, which make inventory automation possible. This information can be adjusted as the need arises.

Machinery linking

The computer stores the geometry of machining locations on both custom and standard sized parts. Interfaces to CNC machining center software is usually a feature of the computer system.

Software will automatically download cutting patterns to computerized saws and drilling patterns to universal machining centers. This eliminates errors by bypassing the manual keying of instructions by the operator at the machine console. Productivity increases are a direct result of this download capability.

Appliance guide

Computer software is now available to provide the cabinetmaker with information regarding thousands of appliances. These products feature appliance dimensions, up-to-date rough-in dimensions, electrical requirements, and installation information. Door panel specifications are included.

Computer presentations and sales aids

A cabinetmaker may use the computer to create presentations of the designs they can build. A retail cabinet dealer may sell the cabinets of many different manufacturers. Large volume cabinetmakers will use the computer to create a database that is distributed to their kitchen cabinet dealers.

The cabinet designer takes the measurements of the room and draws the walls. The designer selects cabinets, one at a time, from a manufacturer's supplied menu for computer placement on the plan. Then appliances are picked and put in place, followed by supporting cabinets. Other cabinets are then picked as needed.

Detailed floor plans, elevations, and near photograph quality perspective drawings are produced for review by the designer and the customer. Accessories, such as bread boxes, pull-out wire baskets, and valances are added. When all revisions are worked out, final floor plans, elevations, and price lists are produced. When accepted by the customer, the order is sent to the manufacturer by facsimile. The design and order may be sent as a file by e-mail.

Manual Drafting

Many cabinetmakers still use manual drafting techniques and equipment. Several pieces of equipment are needed for manual drafting. They include straightedges, drawing boards, pencils, pens, compasses, dividers, scales, templates, and irregular curves.

Straightedges

Straightedges are used to draw straight lines. The simplest and most common straightedges are T-squares and triangles. Although the T-square and triangle are suitable for most drawings, parallel bars and drafting machines are more accurate drafting straightedges.

T-squares

T-squares are placed with the head against the end of the drafting board. The blade is then horizontal. A right-handed drafter places the head against the left side of the board. A left-handed drafter places the head against the right side of the board. Then it does not interfere with arm movement.

Triangles

A ***triangle*** placed on the blade of the T-square allows for drawing lines other than horizontal; vertical; right and left at 30°, 45°, and 60°. Triangles are specified by their three angles. The two most common triangles are the 30°-60°-90° and the 45°-45°-90°. An adjustable triangle is used to obtain other angles.

Parallel bar

A ***parallel bar*** is much like a T-square. However, it is constantly held horizontal by a series of cables or tracks under the edge of the board. See **Figure 9-5**. The bar moves up and down the board while remaining horizontal. A triangle is used in conjunction with a parallel bar to draw vertical and angled lines.

Drafting machine

The ***drafting machine*** combines the functions of a T-square, triangle, scale, and protractor into one tool. One end of the arm is clamped to the table. The other end contains two rules at right angles that are attached to a mechanism to index angles. See **Figure 9-6**. Even when moving the drafting machine, the rules remain at the same angle. The angle is changed by rotating the base plate mechanism.

Drawing boards

A ***drafting board*** provides a flat rectangular surface for drawing. Modern drawing boards are made of hard plastic or other engineered wood materials. They resist warping which can occur in wood boards.

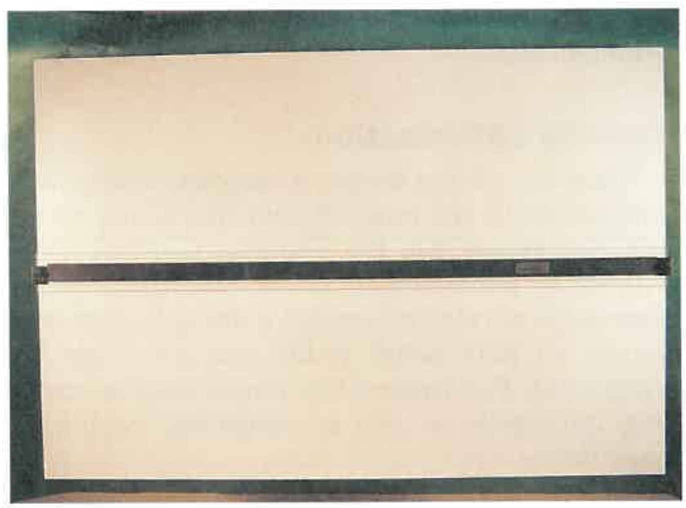


Figure 9-5. Parallel bars make horizontal lines.

Figure 9-6. Drafting machines combine the functions of a T-square, triangle, and scale. This machine is mounted to a table that may be tilted to a comfortable angle.

A sheet of vinyl often is placed on the surface of the board to reduce damage from pencil, compass, and divider points. The surface remains smooth, even if punctured. The vinyl material expands to close the hole.

Lead holders and pencils

Mechanical lead holders are the most popular drawing tool. There are two types of lead holders. One holder uses thick leads that must be sharpened; the other uses thin leads. See **Figure 9-7**. Different size leads are not interchangeable between these two types of holders.

Figure 9-7. Lead holders. Top—Thin leads maintain a fine line. Bottom—Thick leads must be sharpened

The *lead* is actually a combination of clay and graphite. The lead comes in varying degrees of hardness, depending on the clay content. This variation provides for easy alteration of line weight. Hardness classifications are designated by various combinations of numbers and letters. The classifications range from 8B (very soft) to B and H (medium hard) to 1 OH (very hard). In between B and H are HB and F hardness classifications. The harder the lead, the lighter the line. A pencil with 4H lead is relatively hard and used to make light construction, extension, and dimension lines. A 2H lead has medium hardness and is used for object lines. An H pencil is softer and used for dark border lines. The F lead (even softer) is used for lettering. When drawing, always use the same hand pressure. Change the line weight by changing lead.

A set of pencils is an alternative to mechanical lead holders. See **Figure 9-8**. They also come with varying degrees of graphite hardness.

Figure 9-8. Pencils are still being used by some drafters.

Technical pens

Technical pens perform much like lead holders. Each pen tip produces a different line thickness. Because inked drawings cannot be modified easily, place vellum paper over the pencil drawing and trace the underlying drawing. If you plan to ink a drawing to produce better whiteprints or blueprints, make sure the original pencil drawing is complete.

Compasses and dividers

Compasses are used for making circles and arcs. Like the mechanical lead holders, different leads are used for thin, medium, and thick lines. The compass includes a lead holder on one side and a point on the other side. An adjusting wheel alters the radius of the compass. See **Figure 9-9**. The lead is rotated around the point to produce circles and arcs. For use in inking, compasses have ink holders instead of lead.

Dividers are used to transfer distances without marking the paper. They look somewhat like compasses, however, instead of a steel point and a lead point, there are two steel points. The distance between divider points is maintained by a thumb-screw lock.

Scales

Scales allow you to control the amount of space covered by pictorial, multiview, and detail drawings. For example, a scale may indicate that ¼″ = 1′-0″.

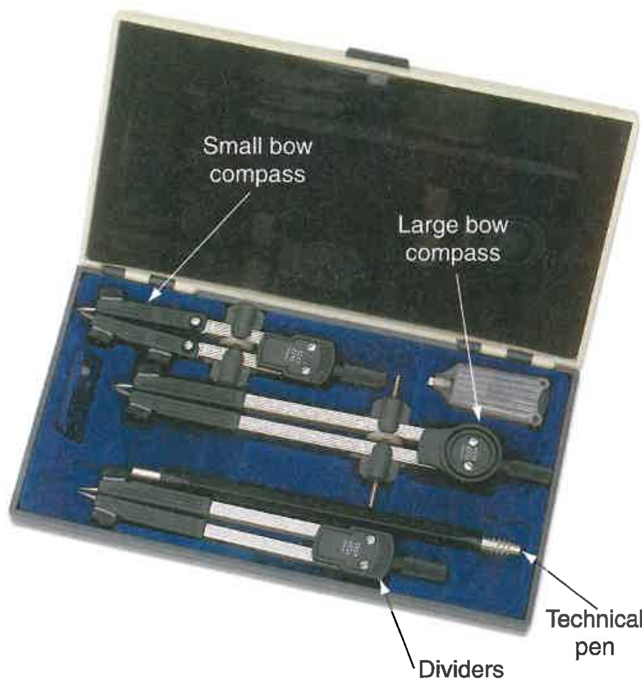


Figure 9-9. A drafting set contains equipment for laying out lines, circles, and distances. (*Hearlihy & Co.*)

Therefore, a 40′ wide house would measure 10″ on the drawing. There are three scales used by cabinetmakers: architect's scale, engineer's scale, and metric scale. See **Figure 9-10**.

An ***architect's scale*** permits various scale factors, including 3/32″, 1/8″, ¼″, 3/8″, ½″, ¾″, 1 ½″, and 3″ equal to 1′. The scale is triangular in cross section; each of the scale factors is found on one of the six sides.

An ***engineer's scale*** is divided differently. Inches are divided into decimal parts. A 10 scale divides an inch into 10 units. A 50 scale divides an inch into 50 units. When measuring, the 10 scale could equal 10′, 100′, or 1000′. Engineers' scales are triangular in cross section, but may be flat with a beveled drawing edge.

Metric scales are divided into ratios such as 1:20. This means the drawing is one-twentieth the size of the actual object. Thus, one meter divided by 20 equals 5 centimeters, and the scale is 5 cm = 1 m. Other ratios are 1:10, 1:25, 1:50, 1:100, 1:150 and 1:200 parts of a meter. Metric scales can also be triangular or flat.

Templates

Templates help draw common shapes. There are hundreds of different kinds of templates. Most are made of transparent plastic. Architects use certain templates to trace symbols (plumbing, electrical) on floor plans. Cabinetmakers would use templates for constructing geometric shapes such as circles, isometric ellipses, lettering, or other specific purposes. See **Figure 9-11.**

To use a template, find the desired shape on the template and align it on the drawing. Then trace around the inside of the opening to transfer the symbol to your drawing.

Irregular curves

Irregular curves are made using templates or flexible curves. See **Figure 9-12**. **French curves** are clear plastic templates for drawing curves. They create arcs where the center of the arc is unknown or not important. These templates help to create smooth, flowing lines. There are many sizes and styles of irregular curves and you will likely need several.

Flexible curves are made out of pliable lead in a plastic casing. They are useful for creating long curves. Just bend it to the proper form and it remains in that position while drawing the curve.

Drafting materials

The drafting material may be paper, vellum, or polyester (plastic) film. Quality is based on strength, surface stability, erasability, and resistance to brittleness, caused by aging.

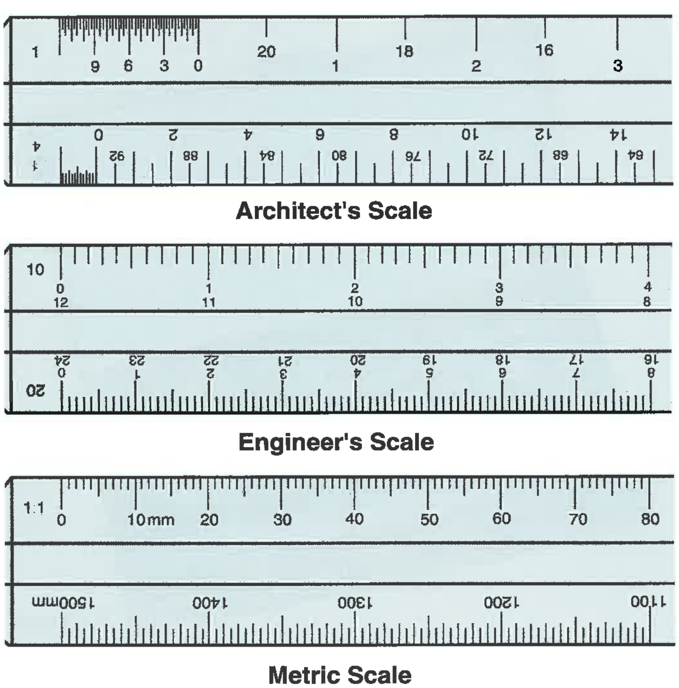


Figure 9-10. Different scales are used by architects and mechanical engineers.

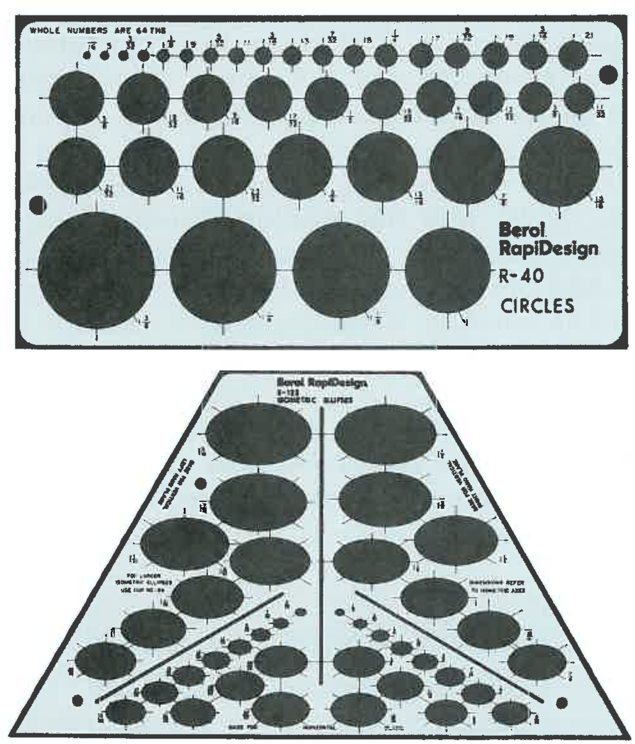


Figure 9-11. These templates reduce the time it takes to draw circles and ellipses. (*Hearlihy & Co.*)

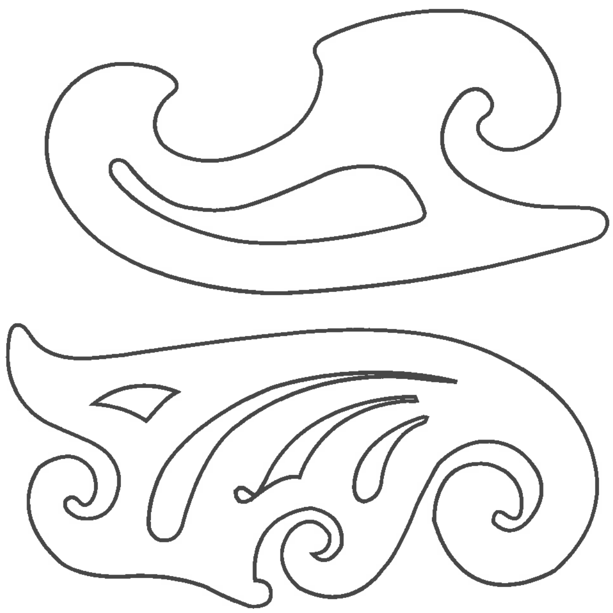


Figure 9-12. Top—A French curve can be used to draw any irregular curve. Bottom—A flexible curve will bend to trace long curves.

Paper

Drafting paper is opaque (nontransparent) with the qualities noted previously. It is three to four times as thick as a sheet of typing paper of the same size. It may be white or tinted light green, blue, or cream color. Tinting reduces eye strain.

Paper can be purchased in rolls or by the sheet. Sheet sizes are 9″ × 12″ (A size), 12″ × 18″ (B size), 18″ × 24″ (C size), 24″ × 36″ (D size), 36″ × 48″ (E size).

Vellum

Vellum is a translucent (almost clear) paper. Vellum is often used as a tracing paper. A sheet of vellum is placed over a drawing and traced on to produce a master copy for prints. Sheets are available in various sizes with preprinted borders and title blocks. Title blocks may be located in the lower-right corner, full height on the right border, or full width along the bottom border. For a visual aid, some vellum sheets are available with faint blue grid lines.

Polyester film

Polyester (plastic) film probably is the highest quality material for drawing and copying. You mark on it with pencils or pens. Marks can be erased several times without marring the material. The result is an excellent master for making prints.

Supplies

An almost endless list of supplies is available to the drafter. Some items for general use are as follows:

- A roll of drafting tape to secure paper or film to the board or vinyl board cover.
- A special pencil sharpener for wood pencils. It removes only the wood from around the lead.
- A pencil pointer to form the tip of the lead. A sheet of sandpaper can be used also.
- A soft rubber eraser to remove unnecessary lines.
- An art gum eraser to remove smudges.
- An erasing shield.
- A protractor for measuring angles.
- A cleaning pad.
- A dusting brush.

Other items used in inking are:

- A container of the recommended ink.
- A supply of ink-erasing fluid for film.
- A sharp knife or single-edge razor blade to scrape away dried ink errors on paper.
- A bottle of recommended pen cleaning fluid.

These materials, equipment, and supplies help you become a more productive drafter.

Equipment maintenance

There are two major areas of concern for maintaining drafting equipment. One is keeping pencil and compass points sharp. The other is keeping equipment clean.

Sharpen drafting pencils with a drafting pencil sharpener. It removes only the wood casing and does not shape a point. Point drafting pencils with an abrasive pad or a mechanical pointer. Mechanical pointers create cone shaped points. This shape can be placed on a pencil by rotating the pencil while rubbing the lead on an abrasive pad. Some drafters prefer a wedge shaped point. Sharpen a compass lead by rubbing it with an abrasive pad on the outside edge of the lead. Remove any loose graphite from a pencil or compass after pointing it. Wipe the lead with a dry cloth or press the point into a scrap piece of foam plastic. This removes graphite dust.

Avoid denting or nicking straightedges. They are ruined once this happens. To prevent warping or bending, T-squares should be stored upside down and flat.

Wash plastic and vinyl tools with detergent and warm water. Wipe metal tools with a cloth before storing to remove finger prints that might etch the metal.

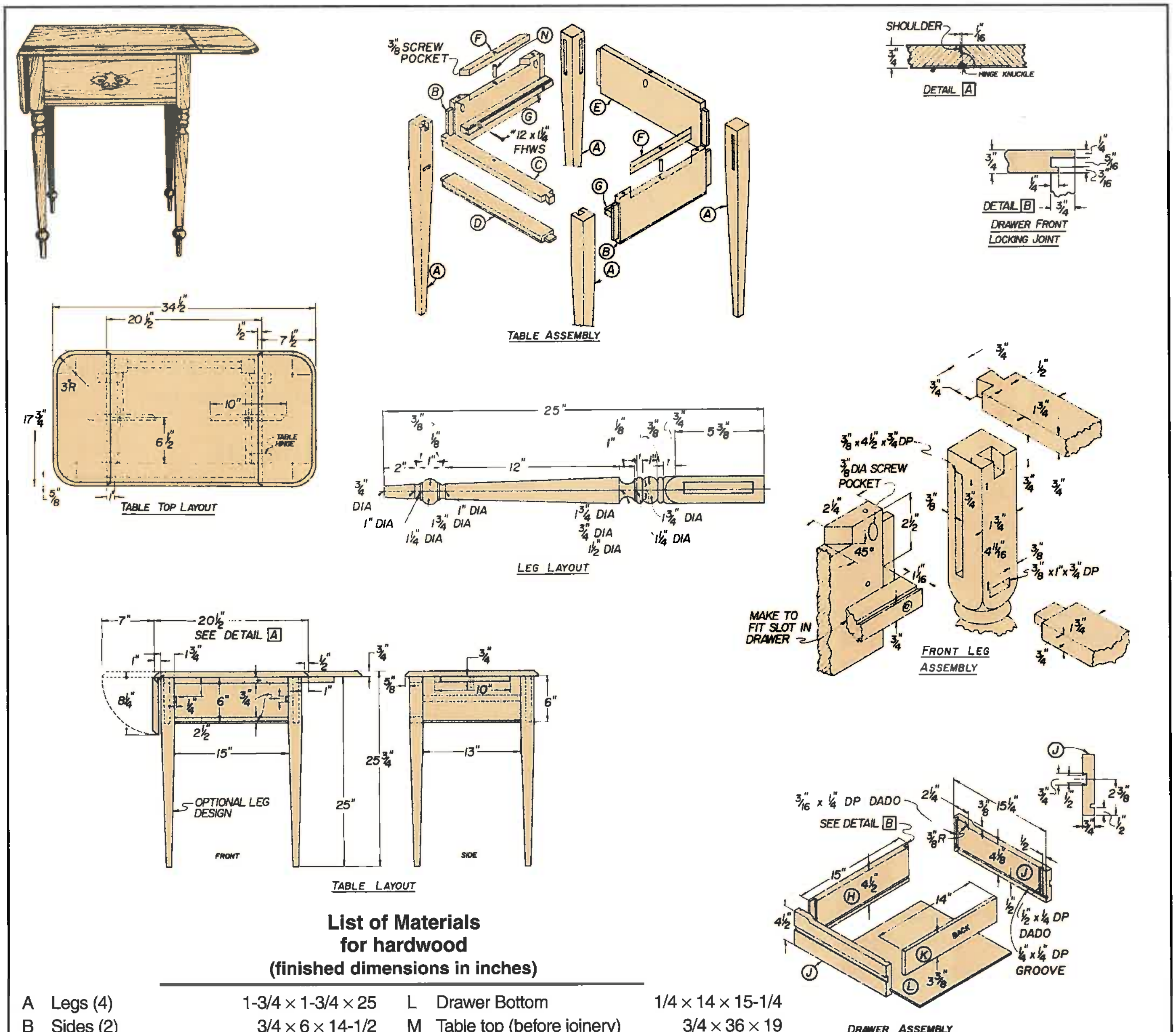
Remove dried ink from plastic tools with a diluted ammonia solution (window cleaner). Remove dried ink from drawing pens and plated metal tools with pen cleaning solution. Empty the liquid ink and clean the points if you will not use them for several days.

Producing Shop Drawings

Shop drawings can be created several different ways. No method is right or wrong, but the drawing must contain the essential parts of a title block, a multiview drawing, details, and notes. If needed, a pictorial assembly or exploded view can be added. See **Figure 9-13**.

Preparing the title block

A *title block* is necessary to identify your drawing. It contains the product name, drawing checker, scale of the drawing, sheet number of the drawing (if more than one), general tolerances, and material specifications. Sample title blocks were shown in *Chapter 7*.



List of Materials for hardwood (finished dimensions in inches)

A	Legs (4)	1-3/4 × 1-3/4 × 25	L	Drawer Bottom	1/4 × 14 × 15-1/4
B	Sides (2)	3/4 × 6 × 14-1/2	M	Table top (before joinery)	3/4 × 36 × 19
C	Front Top Rail	3/4 × 1-3/4 × 16-1/2	N	Dowels (2)	3/8 dia. × 1-1/2
D	Front Bottom Rail	3/4 × 1-3/4 × 16-1/2			
E	Back	3/4 × 6 × 16-1/2			
F	Drop-Leaf Supports (2)	3/4 × 3/4 × 10		**Hardware**	
G	Drawer Guides (2)	3/4 × 1-1/16 × 13	4	#12 × 1-1/4″ Flathead wood screws	
H	Drawer Front	3/4 × 4-1/2 × 15	6	#12 × 1″ Roundhead wood screws	
J	Drawer Sides (2)	3/4 × 4-1/2 × 15-1/4	4	1-1/4″ Table hinges	
K	Drawer Back	1/2 × 3-3/8 × 14		(2 pr. Stanley #46-3300)	

REVISIONS	BY	TOLERANCES (EXCEPT AS NOTED)	PRODUCT (NAME)		
1		DECIMAL:	COMPONENT(S) (ITEMS ON PAGE)		
2			DRAWN BY:	SCALE:	MAT'L.
3		FRACTION:	CH'KD. BY:	DATE:	
4					
5		ANGULAR:	TRACED BY:	APP'D. BY:	DRAWING
6					
7					
8					
9					

Figure 9-13. A complete set of working drawings contains a title block; multiview, detail, pictorial, and assembly drawings; bill of materials, and plan of procedure. (*Shopsmith*)

Plan of Procedure

Legs (A)
1. Square to size.
2. Cut mortises in all legs (six of one size and two of another).
3. Saw and chisel single dovetails on front legs.

Drop-Leaf Supports (F)
1. Square to size.
2. Bevel the ends.

Sides (B) and back (E)
1. Square to size.
2. Drill screw pockets.
3. Saw recesses for drop leaf supports (F).
4. Prepare tenons on all ends of (B) and (E).
5. Drill for dowels (N) in parts (B).

Front top rail (C) and bottom rail (D)
1. Square to size.
2. Saw tenons on (C).
3. Prepare dovetails on (F).

Assembly of components (A), (B), (C), (D), and (E)
1. Smooth all surfaces that will receive finish.
2. Glue dowels (N) in sides (B).
3. Assemble and clamp (A), (B), (C), (D), and (E) without adhesive.
4. Inspect for squareness.
5. Disassemble components and lay clamps aside.
6. Coat every surface to be bonded with adhesive.
7. Reassemble, reclamp, and square the assembly.

Decide to make or buy drawer glides (G)
1. If you buy:
   a. Install them on sides (B).
   b. Change dimensions for the width of the drawer as needed.

Drawer
1. Square drawer front (H), sides (J), back (K), and bottom (L) to
2. size.
3. Saw locking rabbet joints on (H).
4. Saw dadoes in (J) to fit the rabbets on (H).
5. Saw dadoes in (J) of (K).
6. Saw grooves in (J) for (L).
7. Assemble the drawer without adhesive.
8. Inspect for squareness.
9. Disassemble the drawer.
   If you make drawer glides:
   a. Rout the dovetail groove in (J).
   b. Square drawer guides (G).
   c. Rout the edges of (G) to fit the groove in (J).
10. d. Drill screw holes in (G).
11. Smooth all drawer components as necessary.
12. Coat joints (except the groove for [L]) with adhesive.
13. Reassemble with clamps and check for squareness.
14. Allow adhesive to cure and remove clamps.
    Install the drawer with screws in (G).

Top (M)
1. Square glued workpieces to size.
2. Saw the radii on the four corners.
3. Smooth any rough saw marks.
4. Shape or rout all edges and corners with decorative router bit.
5. Make cuts to separate the drop leaves.
6. Shape or rout the table joint with matched cutters or bits.
7. Smooth all surfaces as necessary.
8. Install the table hinges with 1/16 in. between the leaves and top.
9. Install the drop-leaf supports (F).
10. Attach (M) to the table assembly with screws in the screw pockets in (B) and (E).

Finish as desired.

*(**Figure 9-13.** Continued)*

Creating multiview drawings

A ***multiview drawing*** is the most accurate description of design features. When creating views, refer to the alphabet of lines to determine characteristics and weight for different line types. A typical procedure for completing a multiview drawing is as follows:

1. Decide what views describe the product totally.
2. Select an appropriate scale so that the drawing will fit on your paper.
3. Establish view placement.
   a. The front view should be the face of the product with the most features. This view is located at the lower left portion of the drawing.
   b. A top view is directly above front view.
   c. A right side view is placed to the right of the front view.
   d. Include other views as needed. If a left side view is required, the front view is placed in the center of the paper. Left and right side views are placed on the appropriate sides.
4. Leave adequate spacing between and around the views for dimensions and notes. A space of 2" (51 mm) is recommended.
5. Enclose necessary views with light construction lines using a straightedge. Be sure to use the proper scale.
6. Measure necessary distances to lay out joints and other details. Geometric forms, such as lines, rectangles, circles, and arcs describe your design.
7. Transfer all visible and hidden edge or surface lines from one view to another.
8. Add extension, dimension, and leader lines as explained below.
9. Erase any unnecessary lines. Use an erasing shield to prevent removal of dimension or object lines.
10. Add notes where needed to explain part of the design. These should be 1/8" (3 mm) high.
11. Develop detail drawings for portions of the multiview drawing that are unclear. Details are usually enlarged to provide a precise view of intricate parts of the product.

Dimensioning

Dimensioning includes both linear and radial distances using extension, dimension, leader, and radius dimension lines. See **Figure 9-14**.

Linear dimensioning

Linear dimensions note measurement of a straight surface. It could be horizontal, vertical, or inclined.

Extension lines mark the edges to be measured. Extension lines start 1/16″ (2 mm) from the object and extend 1/8″ (3 mm) beyond the farthest dimension line.

Dimension lines show the distance being measured. The lines should start at least 3/8″ (10 mm) away from visible edge lines. Short distances are dimensioned nearest the view. Additional dimension lines are ¼″ (6 mm) apart. Dimension lines for the overall sizes of objects are placed farthest from the views. Put an arrow where a dimension line meets an extension line.

You must add numbers to show distance. Measurements are given in one of two ways. Customary dimensioning requires that you leave a break in the dimension line. The number is placed in the space. It may be in fractions, decimal, or metric units. Dual dimensioning requires no break in the dimension line. The decimal is placed above the line and the metric is placed below.

Leader lines

Leader lines direct the readers' attention to some point. A common practice is to point from a note to where it is applied.

Radial dimensioning

Radius dimensions note measurements for circles and arcs. They include a line that extends from the center to the edge of the circle or arc. They terminate with an arrow. A leader line extends from a point outside the arc or circle to the edge. The dimension figure is placed at the outer end of the leader line. The leader line can also be placed to point at the center of the circle if it would interfere with other dimensions.

Lettering

Lettering on shop drawings is Gothic style. Only uppercase letters are used. When using a lettering guide, align it with the straightedge. See **Figure 9-15.** For freehand lettering, draw two guidelines 1/8″ (3 mm) apart. Letter and numbers are formed within these guidelines. Stacked fractions, like those in Figure 9-13, extend slightly above and below the guidelines. Fractions, like those in Figure 9-14, are set side-by-side with a slash and stay within the guidelines.

Figure 9-16 shows how letters and numbers are drawn. The letters and numbers with similar strokes are grouped together. If you are using tracing paper, draw guide lines on a separate sheet of paper and slide it under the tracing paper.

Letter templates or transfer letters are also used for lettering drawings. See **Figure 9-17.** These items decrease time of lettering and increase the lettering consistency.

Developing details

Details serve many purposes. You can enlarge and illustrate contours, joints, assemblies, etc. As explained in *Chapter 7*, details usually are separated from the multiview drawings. They may be pictorial assembly or exploded views, section views, or simply enlarged isometric views. Details are referenced using notes such as SEE DETAIL 1, SHEET 2.

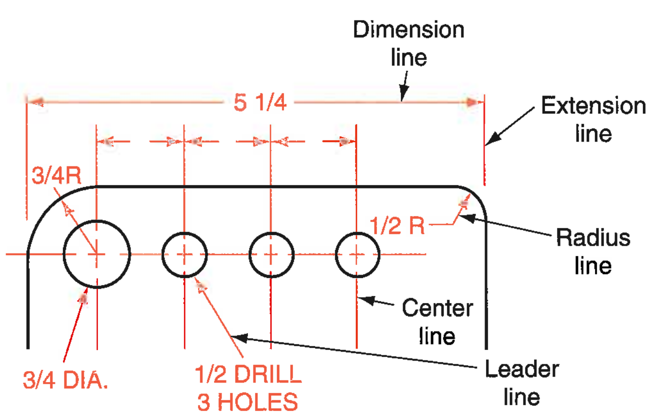


Figure 9-14. Method of dimensioning lines and circles is different. Leader lines point out important information.

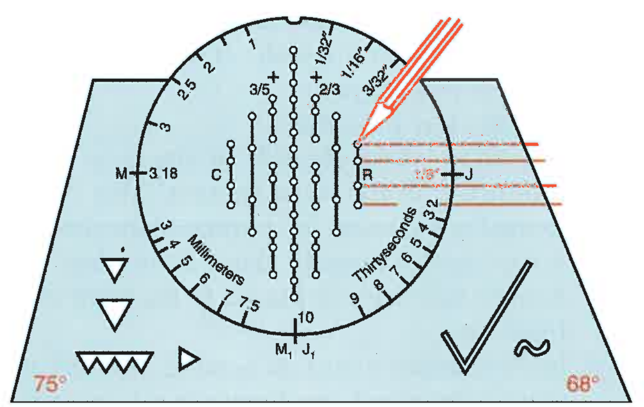
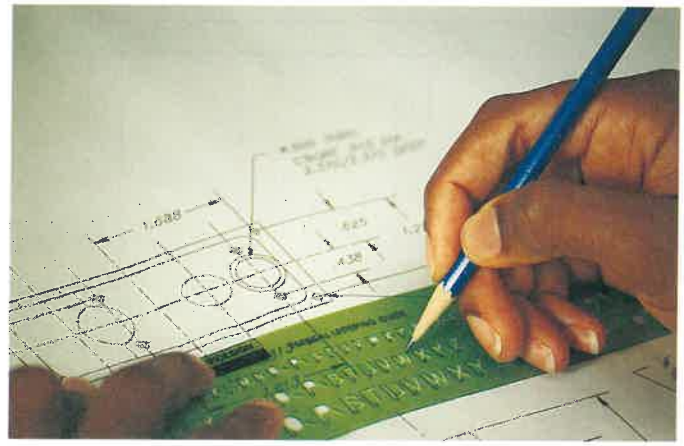
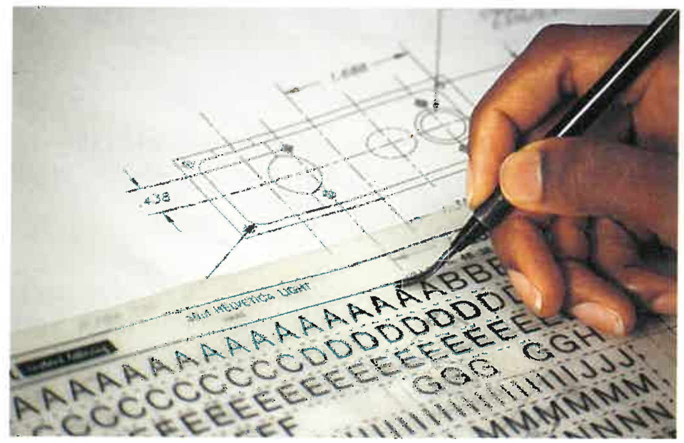


Figure 9-15. This template is used to create lettering guidelines.

Figure 9-16. Suggested pen stokes for uppercase letters and numbers.



A



B

Figure 9-17. Lettering. A—Templates are use to create consistent letters. B—Transfer letters are also used to create consistent letters.

Saving time with details

Notice on **Figure 9-18** the balcony rail spindles are not fully drawn except the first one. This procedure saves time during drafting and does not hinder production of the rail. Commonly used parts can be drawn once with contours as a detail drawing. Block in the space on the multiview and pictorial drawings where the part is located.

Creating a bill of material

On shop drawings, all components must be identified. Parts can be named or given numbers. These parts are listed in a ***bill of materials*** (***BOM***) during or after the drawing is finished. A BOM assists you in ordering materials. Refer to Figure 9-13. It also provides a record in case a replacement part is necessary. The bill of materials contains the following:

- Name and/or part number of all parts visible in the multiview, detail, or pictorial drawings.
- Quantity.
- Manufacturer of the part, including code or identification numbers.
- Dimensions of the part.
- Additional notes or comments.

Listing standard stock

Standard stock refers to quantities of materials and supplies as you buy them. For example, your bill of materials specifies a top, two sides, and five shelves for a bookcase to be made out of 1″ × 10″ (25 mm × 254 mm) lumber. This lumber dealer sells in even lengths from 8′ to 16′ (2.44 m to 4.88 m). Determine the length of board and the number you need.

Hardware is sold in standard stock quantities, such as each, pair, dozen, hundred, or pound. For example, drawer pulls and catches may be obtained individually or in boxes containing 10, 12, or 25 pulls. Hinges are sold in pairs and in boxes or cases of larger quantities. Nails are usually sold by the pound.

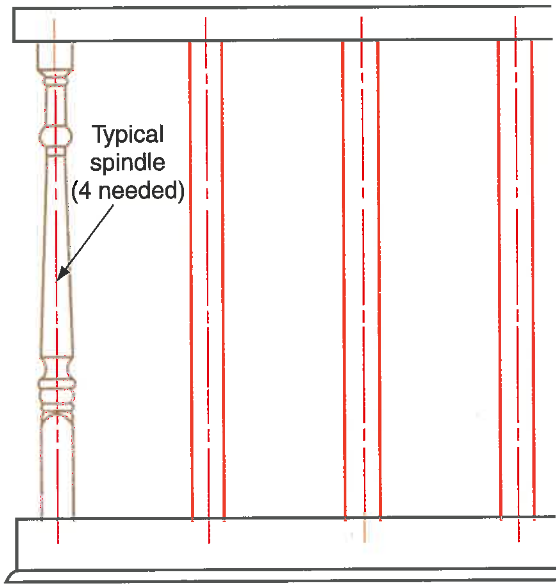


Figure 9-18. When drawing details of repeated objects, such as a balcony rail, draw one object completely. Block in the others.

Screws may be obtained individually, in display packages of variable quantities, in boxes of 100, 1000, 5000, and up to 30,000 of some of the smaller sizes. Larger quantities generally reduce the unit cost. However, the extra quantity may become a storage problem.

Standard container sizes exist for adhesives and finishing materials. These are found in pints, quarts, and gallons; or grams and liters.

Summary

Cabinetmakers who design as well as build products have to prepare working drawings. Computers and computer software are being utilized for cabinet design applications. In addition to design, computers are being used for performing automated drafting, reproducing and updating designs, parts lists and bill-of-material information, material optimization, estimating and job costing, part and product labeling, part machining, machinery linking, and appliance guide.

Use the appropriate supplies to produce accurate work. Equipment includes a straightedge, drawing board, triangle, lead holder, paper, compass, scale, and templates.

Working drawings contain information essential in describing the product. Title blocks identify the product, scale, drafter, and other details. Multiview drawings show the layout of all parts of the design. Dimensions give measurements of each part. Detail drawings further explain intricate features of the design.

The bill of materials lists the materials needed to produce the product. This table includes part name or number, quantity, dimensions, manufacturer, and other important characteristics of the material. Many commonly used items may be stocked in quantity in the shop. Other components may be purchased.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. The use of _____ has eliminated much of the drudgery of manual drafting and cabinet and room design.
2. In cabinetmaking, computers provide the ability to perform the task of _____.
   a. sketching and refining ideas
   b. compiling parts lists and bill-of-material information
   c. estimating and job costing
   d. All of the above.
3. Pencils are composed of wood surrounding writing material made of _____.
   a. charcoal
   b. graphite
   c. hardened clay and graphite
   d. lead
4. Dividers have _____ steel points and compasses have ____.
5. Templates are commonly used to _____.
   a. determine the scale of the drawing.
   b. draw the title block.
   c. measure critical distances.
   d. draw symbols, letters, and numbers on the drawing.
6. Clean plastic tools with _____.
   a. an ammonia solution
   b. pen cleaning solution
   c. detergent and water
   d. isopropyl alcohol
7. A(n) _____ is used to remove dried ink from plastic tools.
   a. ammonia solution
   b. dry cloth
   c. pen cleaning solution
   d. isopropyl alcohol
8. Explain the procedure for creating a multiview drawing.
9. On a separate sheet of paper, sketch the placement of views for a multiview drawing.
10. List the information typically included on a bill of materials.

Wood Characteristics

10

Objectives

After studying this chapter, you will be able to:
- Describe the common growth pattern of all trees.
- Explain the difference between hardwood and softwood cell structure.
- Determine the moisture content and specific gravity of a particular wood.
- Describe the properties of wood.

Important Terms

average moisture content
cambium
earlywood
equilibrium moisture content (EMC)
hardwood
heartwood
latewood
lignin
oven-dry weight
phloem
sapwood
softwood
tracheids
wet weight
xylem

Cabinetmakers who produce high-quality cabinetry understand wood characteristics. They are very careful about selecting, storing, handling, and processing wood to retain its desirable qualities. These qualities include natural beauty, strength, durability, elasticity, and easy maintenance.

Because of its varying color and pattern, wood has natural beauty. Cabinetmakers enhance this beauty through the shaping and finishing of wood products.

The structural qualities of wood make it a desirable building product. Pound for pound, some wood species are as strong as steel. Most will last for centuries with regular maintenance. If a wood product is marred, it can be resurfaced and refinished to restore the original beauty.

Wood is an elastic material. It will *bounce back* to its original shape after being dented or bent. This property is applied in the construction industry where wood beams are used as floor joists.

Tree Parts

A tree is nature's largest self-supporting plant. It obtains water and food through a complex system of roots, branches, and leaves.

A tree is held upright and nourished by either a tap root or fibrous root system. See **Figure 10-1**. A tap root is one long tapered vertical root with small hairs. It extends deep into the ground. The fibrous root system consists of many roots and root hairs spread out close to the ground surface. Both systems absorb water and minerals. These are carried by the trunk to the crown where they are processed into food.

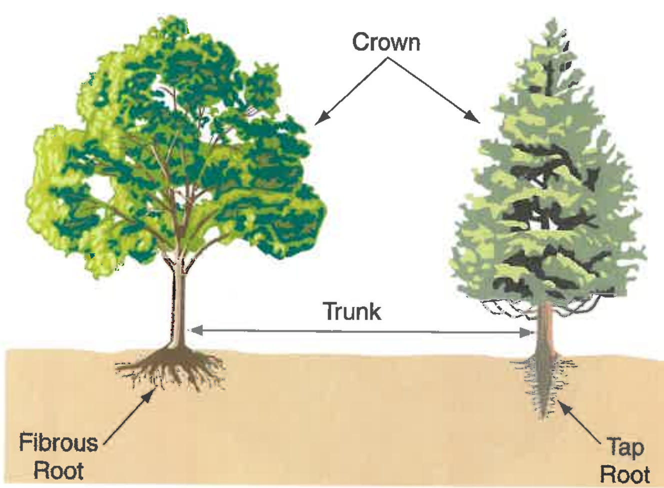


Figure 10-1. Tree growth occurs in the roots, trunk, and crown. Each part serves a different purpose for the tree.

The trunk extends up from the ground and supports the crown. The trunk transports the water and minerals to the crown through an internal pipeline of cells. The crown converts nutrients to food. This conversion is done by ***photosynthesis***, which is the formation of carbohydrates (food) in the green tissues of plants exposed to light. The food is then carried to the various parts of the tree for nourishment and growth.

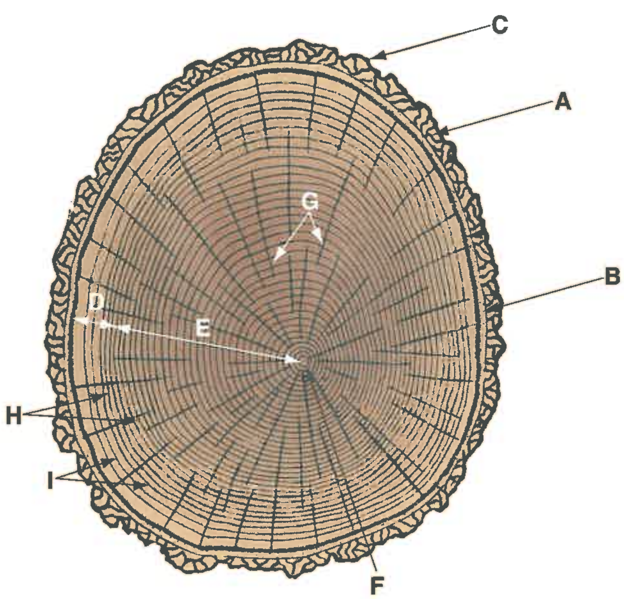
Tree growth depends on the addition of millions of cells annually. Their development extends the lengths of the branches and the roots. It also increases the diameter of the roots, trunk, and limbs during each growing season. Thus, a tree not only grows upward, but also downward and outward.

Growth Characteristics

A cross-section of a log reveals the layers of a tree. See **Figure 10-2**. These layer include bark, cambium, earlywood, latewood, annual rings, sapwood, heartwood, pith, and wood rays.

Bark

Bark is the outer layer of dead wood that protects the tree from weather, insects, and disease. Its texture and thickness range from smooth and thin to rough, corky, and thick, depending on the tree species.



A Phloem or inner bark (Outside layer of cambium)
B Xylem (Inside layer of cambium)
C Bark
D Sapwood
E Heartwood
F Pith
G Rays
H Earlywood layers
I Latewood layers

Figure 10-2. This cross-section of a tree shows the different layers associated with tree growth and function. (*Forest Products Laboratory*)

Cambium

Cambium is the layer of cell production just beneath the bark. The ***phloem*** is the outer part of the cambium that generates new cells for the bark. It is often called the inner bark. Besides creating new bark, phloem carries food from the leaves to feed the branches, trunk, and roots. The ***xylem*** is the two-cell thick, inner layer of the cambium that creates new cells for tree growth. Cells developed by the xylem become sapwood, which carries water and nutrients to the leaves.

Earlywood and latewood

The cambium produces new cells at different rates, depending on the time of year. ***Earlywood,*** also called *springwood,* is where the cells develop quickly, are larger, lighter colored, and have thinner walls. This occurs in the spring when there is plenty of moisture.

Latewood, also called *summerwood,* is where the cells are smaller, darker colored, and have thicker walls. This occurs when cells continue to be added during the summer when available moisture decreases.

Annual rings

Annual rings are the light and dark colored rings formed by the earlywood and latewood growth. The age of the tree can be estimated by counting the rings. A light ring and a dark ring is considered to be one growing season. More than one ring is possible in a given year. The tree might be affected by drought or insects during the growing season. This would cause temporary slow growth. When moisture is available and growth resumes, earlywood is again created.

When the sawmill produces lumber, logs are cut through the annual rings. This forms a light and dark pattern called the grain. When cabinetmakers work with wood, the grain pattern is very important because it affects both strength and appearance.

Sapwood and heartwood

Each new annual ring becomes part of the sapwood. ***Sapwood*** is a thick section of young cells beneath the cambium. These cells carry water and nutrients to the leaves. As new growth occurs, older sapwood becomes inactive. It turns dark in color due to chemical change and concentrated gums, resins, tannins, and minerals. This dark colored, inactive section of the tree is called ***heartwood***.

Pith

The *pith* is a thin, round, spongy core at the center of the tree. The pith is where the young tree began to grow. Nearly all branches grow from the pith.

Wood rays

Wood rays carry water and nutrients outward from the center of the tree. Rays are several cells high, several cells wide, and extend horizontally to the outer part of the tree.

Tree Identification

Trees are classified as either deciduous or coniferous. ***Deciduous trees*** are broad-leaved trees that usually drop their leaves in the fall. Oaks, ashes, birches, and maples are examples of deciduous trees. Wood from deciduous trees is called ***hardwood.***

Coniferous trees have needles or very small scale-like leaves that remain green throughout the year. They are commonly referred to as evergreens. The word conifer means *cone bearing,* which is another identifying characteristic of evergreens. Pines, spruces, and firs are examples of coniferous trees. Wood from conifers is called ***softwood.***

Wood Classification

The terms *hardwood* and *softwood* classify trees according to their characteristics. It does not mean that all deciduous trees are harder than conifers, nor that all conifers are softer than deciduous trees. They are named because the cell structure of hardwood and softwood trees have noticeable differences.

Wood cell structure

There are about three million cells per cubic inch (16 cm^3) of wood. Enlarged sections of a softwood (white pine) and a hardwood (American tulip) show the difference in cell structure. In examining cell structure, there are three viewing angles noted. See **Figure 10-3.**

- ***Cross-sectional face.*** Seen when you cut across the annual rings. An example is the top of a stump.
- ***Radial face.*** Seen when the tree is cut through the center. This cut is nearly perpendicular to the growth rings.
- ***Tangential face.*** Seen by slicing an edge off the section of trunk. The surface of the cut is tangent to the annual rings. On a larger section of log the annual rings appear as arrows. Each corresponds to a new layer or growth.

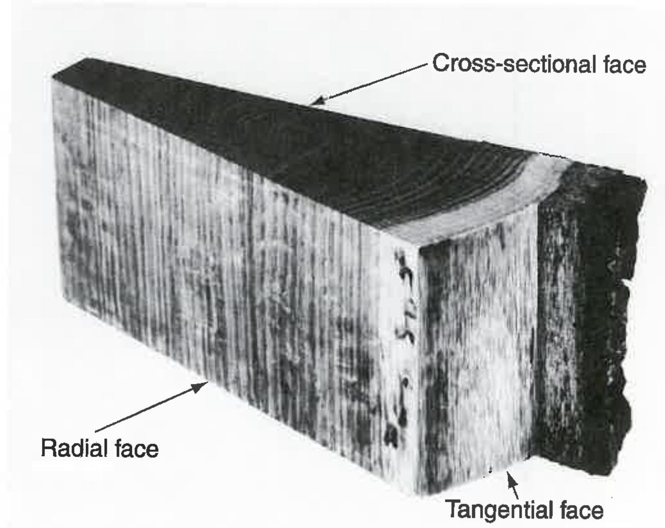


Figure 10-3. The three faces of wood. Cutting across each face produces a different grain pattern and different strength. (*Forest Products Laboratory*)

Softwood cell structure

Softwood cells are composed of vertical earlywood and latewood cells called tracheids, horizontal rays, resin ducts, pits, and lignin. See **Figure 10-4.**

Tracheids

Tracheids are vertical cells that are about 1/8″ (3 mm) long with pointed ends. They develop in fairly uniform rows and make up about 90% of the tree's cells. Liquids transported from the roots to the crown pass through tracheids.

Horizontal rays

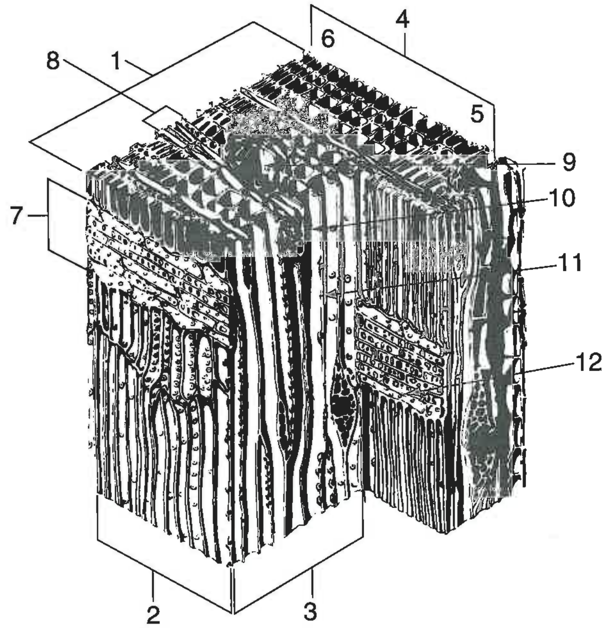
Horizontal rays carry nutrients to outer portions of the tree. There are wood rays and fusiform rays. ***Wood rays*** are one cell wide and transport sap across the radial face. ***Fusiform rays*** are several cells wide and are noted by horizontal resin ducts imbedded in the ray.

Resin ducts

Horizontal and ***vertical resin ducts*** are formed when a space between cells expands. The ducts fill with sticky resin which is released by cells surrounding the duct.

Pits

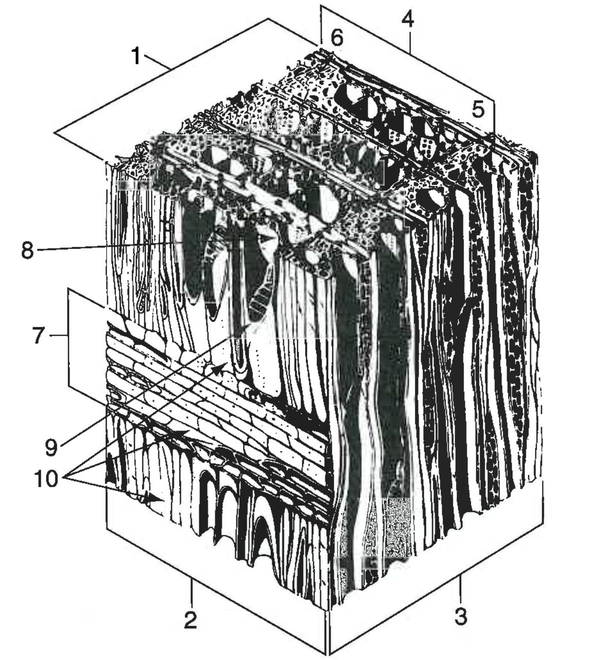
Pits are the passageways among tracheids and rays. They allow solutions to be passed from cell to cell. ***Border pits*** are between two tracheids and have a ring around them. ***Simple pits*** are between rays and tracheids and do not have a ring.



Softwood Cell Structure

1. Cross-sectional face
2. Radial face
3. Tangential face
4. Annual ring
5. Earlywood
6. Latewood
7. Wood ray
8. Fusiform ray
9. Vertical resin duct
10. Horizontal resin duct
11. Bordered pit
12. Simple pit

Figure 10-4. Cell structure of a softwood. Note how rays extend across the radial face and cell length is in the longitudinal direction. Also note the fusiform rays and resin ducts which are not found on the hardwoods. (*Forest Products Laboratory*)



Hardwood Cell Structure

1. Cross-sectional face
2. Radial face
3. Tangential face
4. Annual ring
5. Earlywood
6. Latewood
7. Wood ray
8. Vessel
9. Sieve plate
10. Parenchyma cells

Figure 10-5. Cell structure of a hardwood. Note how large open vessels replace the tracheids of softwood. (*Forest Products Laboratory*)

Lignin

Lignin is the substance that holds cells together. It is an adhesive resin. Lignin is dissolved during the papermaking process to separate the individual fibers (cells).

Hardwood cell structure

Hardwood cells are similar to softwood cells, but they also have their differences. Hardwood cells also are composed of vertical earlywood and latewood cells and wood rays. However, additional cells can be seen, including parenchyma cells and vessels. See **Figure 10-5**.

Fibers

Fibers are the vertical cells of hardwoods. They are about half as long as tracheids and more rounded on the ends. They make up about 50% of the volume of a hardwood tree.

Wood rays

Wood rays are the horizontal food and liquid passages. They are similar to softwood wood rays, but do not contain ducts as do fusiform rays.

Parenchyma cells

Parenchyma cells are smaller than normal fibers and rays. They are used for additional food storage.

Vessels

Vessels are elongated cells serving as the main passage for liquid moving from the roots to the crown. They are joined end to end, and separated by grill-like sieve plates. The size and length of vessels look like pores (openings) in finished lumber. This is why hardwoods are referred to as *porous*.

Diffuse- and ring-porous hardwoods

Hardwoods are classified as diffuse-porous and ring-porous. The hardwood shown in **Figure 10-6A** is a Bigtooth Aspen, which is a ***diffuse-porous*** hardwood. It has vessels that are about the same size in earlywood and latewood. Wood with this structure is called diffuse-porous because the vessels are diffused (scattered) throughout the annual ring.

Other hardwoods are called ***ring-porous***, such as the white oak shown in **Figure 10-6B.** The vessels in earlywood are considerably larger than those produced in latewood. The arrangement of large to small vessels forms rings that coincide with the annual rings.

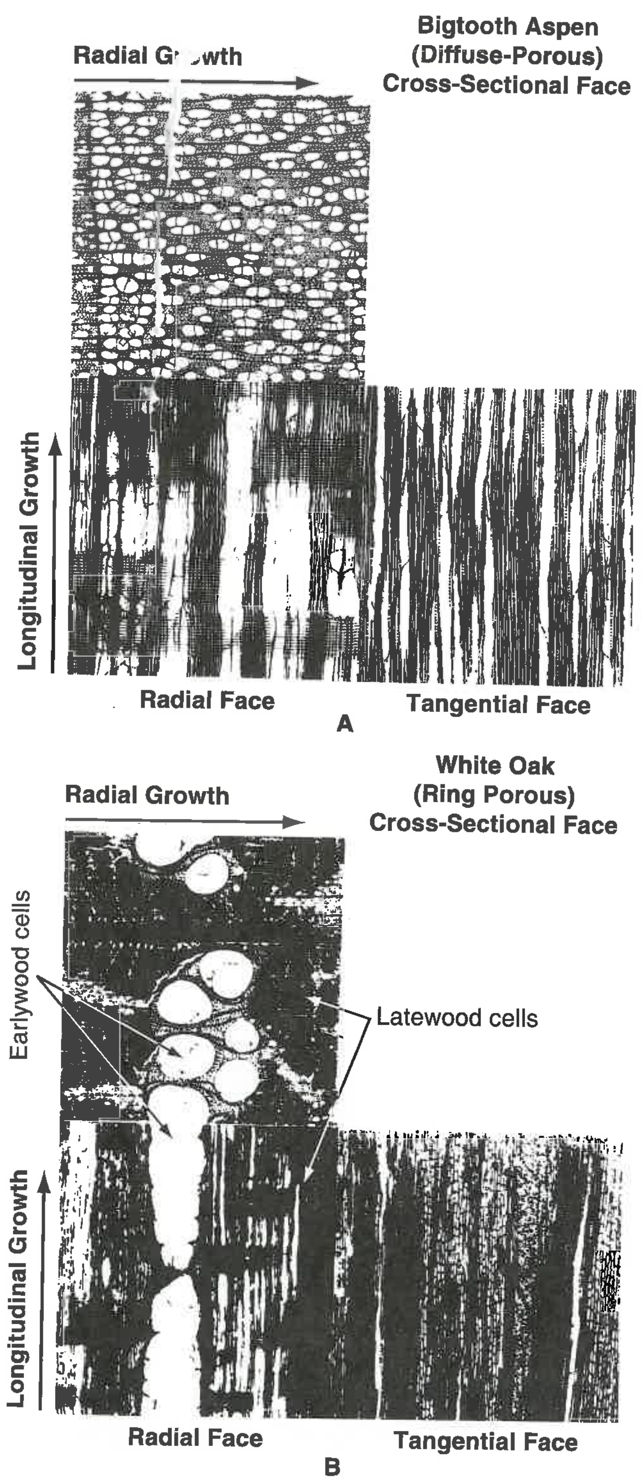


Figure 10-6. A—There is little difference between the size of earlywood and latewood cells in diffuse-porous hardwood. B—Cell size is clearly different in ring-porous hardwood. (*Forest Products Laboratory*)

Properties of Wood

Both hardwood and softwood trees have variations in characteristics, which are used to describe the properties of the wood species. These characteristics are color, weight, density, moisture content, and specific gravity.

Choose the wood with physical properties that comply with your design. Some aspects might be more important than others. The value you give these properties, or any other wood features, helps determine the wood you select. These properties include appearance, moisture content, shrinkage, weight, working qualities, and mechanical properties.

Appearance

The ***appearance*** of the wood determines the decorative effect of your product. Appearance includes color, grain pattern, surface texture, and natural defects.

Color

Wood is primarily brown in color. It might range from a light tan to a dark, reddish brown. See **Figure 10-7**. Most color comes from chemical pigments and minerals in the cells. The darkest colors are found in the heartwood where these materials are concentrated.

Figure 10-7. The natural wood colors, textures, and patterns create a personality for the room that compliments the home. (*Western Wood Products Assoc.*)

The difference between sapwood and heartwood colors is dramatic. Some cabinetmakers choose only heartwood or softwood to eliminate this contrast. Others like this contrast and choose lumber that is cut across both.

Another color change occurs after wood is cut. The chemicals in the cells combine with oxygen in a process called ***oxidation***. This causes the wood to darken. On the other hand, exposure to the sun causes the wood pigments to lighten.

Cabinetmakers frequently color wood with stain or oil. This helps to achieve a desired color or to enhance the grain pattern. Wood also can be bleached to remove color.

Grain pattern

The pattern of lines visible in sawn lumber is formed by the annual rings. It is called grain. The ***grain pattern*** forms a shape according to the cutting method. Generally, wood cut tangent to the annual rings has a *V* effect. Refer to tangential face in **Figure 10-8A.** Wood cut perpendicular to the annual rings will have straight grain. Refer to radial face in **Figure 10-8B**. These cutting methods will be discussed in *Chapter 11*.

Surface texture

The ***texture*** of cut lumber is determined by the cell structure of the wood. Large, open cells or pores in some woods, like ring-porous hardwoods, look like small pits in surfaced lumber. These woods are considered ***open grain***. Even after finishing, these pits can be seen. You can smooth the texture by filling pores with wood filler. Wood with smaller pores are called ***closed grain***. They do not require filler to achieve a smooth surface.

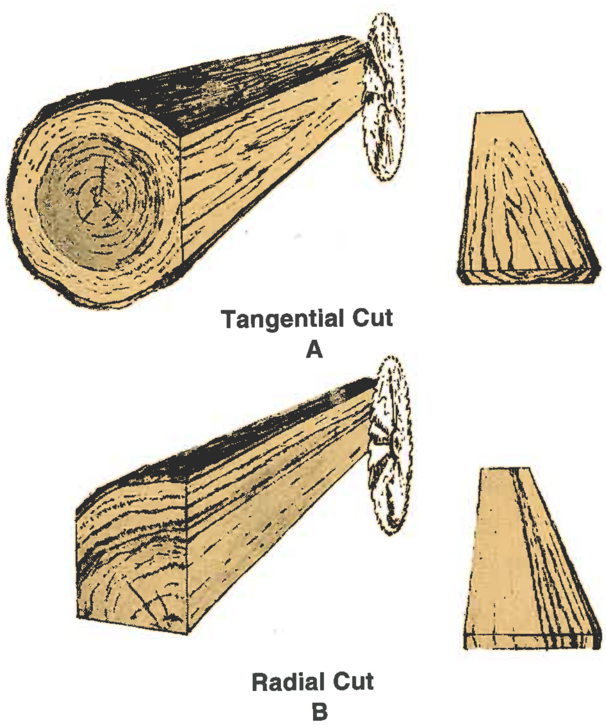


Figure 10-8. A—Tangential cut shows different layers of growth which look like *V* lines. B—Radial cut is perpendicular to annual rings producing straight lines.

Moisture content

Moisture content (*MC*) describes the amount of water in the wood cells. It is the most significant physical property of wood for cabinetmaking. It is a percent of the oven-dry weight of a wood sample. The oven-dry weight is obtained by removing most moisture by air or kiln drying. These processes, referred to as *seasoning*, are discussed in the next chapter. The final MC level may vary from 5% for hardwoods and up to 20% for construction grade softwoods.

Testing moisture content

Moisture content can be tested quickly with a moisture meter. See **Figure 10-9**. You can test MC levels in a sample of fresh wood without a moisture meter. First weigh a sample of green wood (freshly cut lumber). The initial weight of the sample is called the ***wet weight***. Then, place the sample in an oven at 214°F to 221°F. (101°C to 105°C). When the sample stops losing weight, you weigh it again. The sample's weight at this time is the ***oven-dry weight***. This drying process may take from 12 hours to 48 hours. The following formula and procedure is used to calculate the MC using the two measured weights:

$$MC(\%) = \frac{WW - DW}{DW} \times 100$$

Figure 10-9. Moisture content of wood can be determined by a moisture meter. Insert probes in the wood to obtain a reading. (*Western Wood Products Assoc.*)

1. Subtract the final oven-dry weight (*DW*) from the wet weight (*WW*).
2. Divide the answer by the oven-dry weight (*DW*).
3. Multiply the quotient by 100 to get the MC percentage.

Removing water

The water in green wood is located in both the cell cavity and cell walls. Water in the cell cavity it is known as ***free water***. Water in the cell walls is known as ***bound water***. As the wood dries, the free water is removed first. When the free water has evaporated, the wood is at its fiber saturation point. The MC is 25% to 30% depending on the wood species.

Drying beyond the fiber saturation point removes bound water. The cell walls begin to shrivel and harden. The piece of wood shrinks and distorts. The amount of drying necessary depends on the equilibrium moisture content.

Equilibrium moisture content

The ***equilibrium moisture content*** (*EMC*), or ***average moisture content,*** is a moisture percentage of interior woodwork. When processing any wood, its moisture level should be at the EMC.

The EMC percentage depends on the geographic part of the country. It is approximately 18% of the average relative humidity of a region when the temperature is 72°F (22°C). The EMC represents the moisture content that the air will give or remove from the wood. For example, if the average relative humidity of your region is 49%, the EMC is approximately 9%. The moisture level of your wood should have this same percentage. If the MC of your wood cabinet is 6%, your cabinet will take on moisture from the air. The wood might swell and warp. If the moisture of your cabinet is 12%, the wood loses moisture to the air. This would cause it to shrink and crack the joints.

The EMC remains fairly stable, changing only slightly with the seasons. These changes affect the surface cells of wood.

The critical time to maintain the wood's moisture content with the EMC is during production, before the finish is applied. The finish will limit the amount of moisture absorbed or lost. To assure that your wood is the same moisture content as the EMC, store it awhile. It is advisable to buy the wood at a lower moisture content. During storage, it absorbs moisture from the air to attain the EMC percentage.

The results of processing wood not at the EMC level is most apparent in wood joints. See **Figure 10-10**. If the wood takes on moisture, the joint will tighten. If it loses moisture content, the joint will loosen.

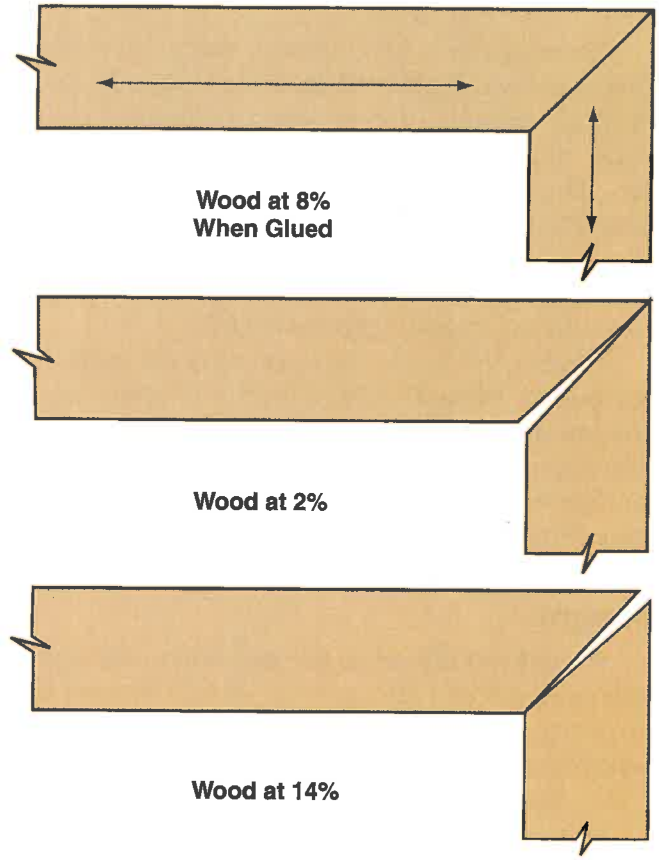


Figure 10-10. Changes in moisture content have harsh effects on wood joints. (*Forest Products Laboratory*)

The equilibrium moisture content for most of the United States is 8%. It is lowest in the southwestern states at 6%. Along the southeast and southwest coasts, and gulf states it may be 11%.

The moisture content of dried lumber ranges from 6% to 13%. It can be several percentage points higher when the lumber is used and stored outside. Be careful of using construction grade lumber, because the moisture content is often as high as 20%.

Shrinkage

Wood shrinks when the moisture level is below the fiber saturation point (25% to 30% percent moisture). The wood cells begin to shrivel. The wood will shrink in size 1/30" (0.8 mm) for every percentage point of moisture lost. The exact amount of shrinkage of a sample can be calculated using the following formula:

Shrinkage (%) =

$$\frac{\text{Wet Dimension} - \text{Dry Dimension}}{\text{Wet Dimension}} \times 100$$

Rate of shrinkage

Wood shrinks at different rates in different directions. See **Figure 10-11**. This is mainly due to the high amount of earlywood compared to latewood. Shrinkage is greatest in the tangential direction. The annual rings attempt to straighten out. Tangential shrinkage is 4% to 12% in hardwood and 4% to 8% in softwood. Radial shrinkage is about half as much. Longitudinal (length) shrinkage is insignificant, usually less than 0.3%.

Lumber cut from sapwood shrinks more than heartwood because of its high-moisture content. The method of cutting also affects the rate of shrinkage. Plain-sawed lumber shrinks twice as much across the face of the board than does quarter-sawed lumber.

Weight

Weight can influence the decision to use a given species of wood. Lighter wood should be used if the furniture will be move frequently. Weight is controlled by the following three factors:

- Moisture content
- Density
- Stored minerals and other materials

All of these factors vary. However, the weight of stored minerals is minimal and the moisture content is relatively stable. The primary factor for weight is the density of the wood.

Density

Density describes weight per unit of volume. For example, obtain samples of different wood species. Cut them to the same size. Be sure that they have the same moisture content, then weigh them. The heavier pieces are more dense than the lighter ones. Most species weigh between 20 lb and 45 lb per cubic foot.

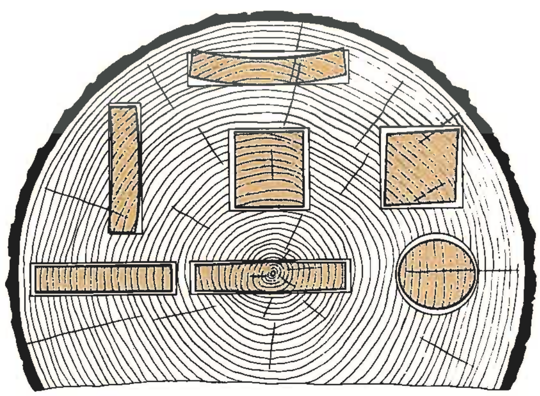


Figure 10-11. Shrinkage occurs in all directions. Note severe warp of tangentially-cut piece. (*Forest Products Laboratory*)

The standard measure of density is ***specific gravity*** (***SG***). This unit compares the weight of a volume of any substance with an equal volume of water at 4°C. The volume of water has a constant of 1 SG. For example, the SG of ash is .50; thus, a cubic foot of ash weighs .50 (one-half) as much as a cubic foot of water.

Wood is lighter than water. This is because of air inside dried wood cells. However, the cell wall material actually is heavier, or more dense, than water. If the cell structure is smaller, it will have heavier cell walls. There will also be less trapped air. Thus the specific gravity will be higher. Besides being heavy, a high specific gravity usually means the wood is strong. Lighter woods have larger, thin-walled cells.

There is a quick way to determine specific gravity of a wood. Weigh an oven-dry sample. Obtain a container with water in it. Mark the water level in the container. Then, submerge the sample in the container of water. Mark it again with the sample submerged. Determine the rise in water to calculate the volume of water displaced by the wood. Calculate the weight of the amount of water displaced. A cubic foot of water weighs 62.4 lbs. The formula to compute specific gravity is as follows:

$$SG = \frac{\text{Oven Dry Weight}}{\text{Weight of Displaced Volume of Water}}$$

If you know a wood species' specific gravity (found on a chart), you can estimate the final weight of the product. For example, you are going to build a cabinet out of white oak that has a specific gravity of .56. The project requires six pieces, 12" wide, 96" long, and 1" thick. There are 1728 cubic inches (cu. in.) in a cubic foot. To calculate the weight of the project, first calculate the number of cubic feet of wood needed using the following formula:

$$\text{cu. ft.} = \frac{\text{Pieces} \times \text{Width} \times \text{Length} \times \text{Thickness}}{1728}$$

Therefore,

$$\text{cu. ft.} = \frac{6 \times 12 \times 96 \times 1}{1728}$$

$$\text{cu. ft.} = \frac{6912}{1728}$$

$$\text{cu. ft.} = 4$$

Now calculate the weight of a cubic foot of white oak as follows:

Weight of a Cubic Foot of White Oak =
SG of Oak × *Weight of a Cubic Foot of Water*

Therefore,
Weight of a Cubic Foot of White Oak = .56 × 62.4

Weight of a Cubic Foot of White Oak = **34.94 lb**

The final weight of the project is then calculated as follows:

Final Weight = *Number of Cubic Feet of Wood* ×
Weight per Cubic Foot of Wood

Therefore,
Final Weight = 4 × 34.94

Final Weight = **139.76 lb (approximately)**

The final weight is approximate because hardware, finishing products, and other materials add additional weight.

Specific gravity varies among species of wood. Each species has a slightly different cell size and structure. The more condensed the cell structure, the higher the specific gravity.

Working qualities

Working qualities describe how a wood will act during processing. Will it splinter? Will it dull tools? How easily can it be sanded smooth? These qualities vary according to the specific gravity. Wood with low specific gravity is easier to process. Woods with high specific gravity tend to dull tools faster. Other factors of working qualities include dulling effects, reaction wood, and cell structure.

Dulling effect

The ***dulling effect*** is how the density of wood and stored minerals dull the tool. It varies between woods with different specific gravities. It is also different among the same species due to mineral deposits. During growth, a tree is constantly extracting water and minerals from the ground. One of these minerals is silica, similar to tiny sand particles. Large deposits of silica wear tools quicker.

Reaction wood

As a tree grows, it develops wood with distinctive properties called ***reaction wood***. Reaction wood is divided into compression wood and tension wood. Compression wood is found on the underside of limbs and leaning trunks. Tension wood is found on the upper side of limbs and leaning trunks.

Reaction wood tends to expand and twist as it is cut. See **Figure 10-12**. This causes two problems. The first problem is that the surface of reaction wood might feel rough after planing. A smooth finish may be hard to achieve. This occurs more often in low specific gravity (lighter weight) wood.

The second problem of reaction wood is it may pinch the blade during sawing. Sawing relieves internal stress. Reactions to stress relief cannot be predicted. The wood might twist and close the kerf on the blade. This is a serious hazard because the wood could be thrown toward you.

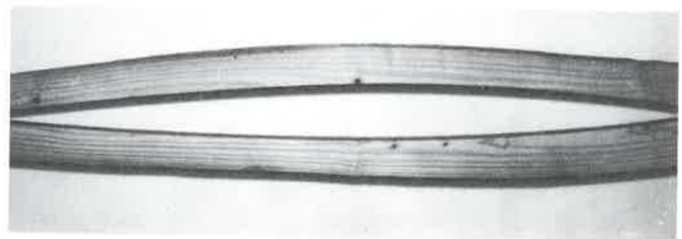


Figure 10-12. The distortion of reaction wood during cutting can be dramatic. (*Forest Products Laboratory*)

Cell structure

The size and bond of cells varies for different wood species. Woods with small, tightly bonded cell structure (usually having high specific gravity) tend to chip and tear. The bond is produced by overlapping fibers held together with the tree's *lignin*. Chipping can be reduced somewhat by using extremely sharp tools.

Mechanical properties

The mechanical properties of wood include strength and elasticity. These are partially affected by the moisture content in the wood. Remember, an increase in moisture content decreases strength and increases elasticity.

Strength

A number of properties affect strength. One is the ***anisotropic*** nature of wood, which means it is not equally strong in every direction. Wood's greatest strength is with the grain (longitudinal), not across the grain (tangential or radial). Long boards, such as shelves, should have the grain in lengthwise direction.

The specific gravity is also another strength factor. Generally, denser woods are stronger.

Elasticity

Elasticity is the capability for the wood to spring back after being dented or bent. Not all woods allow for bending without damaging the cell structure. Moisture permits wood to be bent into a permanent position. Wood is like a sponge. When wood is moistened, it expands and becomes flexible. Remove the water and it shrinks and becomes rigid.

Moisture can expand the wood to remove dents. For example, suppose you dented a piece while processing it. You can remove the dent with a wet cloth and iron. Place the wet cloth over the dent and gently rub with a warm iron. The moisture will enter the cells and expand them to their original position.

Moisture also assists bending wood pieces, such as chair backs. Soak the piece until it becomes supple. Then, place it in a form and clamp it. When dry, the wood will retain the new shape.

Summary

Wood has a natural beauty that makes it desirable for cabinetmaking and interior design. Wood also has structural qualities that meet the needs of construction.

Wood from deciduous trees is hardwood. Wood from conifer trees is softwood. This does not refer to the actual density or weight of the wood.

Growth in a tree occurs in the cambium. The cambium produces both bark cells and cells that carry nutrients to the tree. Growth in springtime is earlywood; growth in summer is latewood. Each growing season produces an annual ring.

The physical properties of wood include color, grain pattern, and surface defects. Most of these qualities are not seen until the tree has been cut into lumber.

The moisture content of wood has a significant effect on it. When the moisture content goes below fiber saturation point the wood begins to shrink. Shrinkage in lumber varies according to the section of the tree and how it was cut. The critical time to maintain an even moisture content is during processing.

Working qualities include dulling effect, reaction wood, and the density. The density of a wood describes weight per unit of volume. The more dense a wood is, the heavier and stronger it will be. Woods laden with minerals (dense woods), tension woods, and compression woods are harder to work.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Diagram the structure of tap and fibrous root systems.
2. The outer part of the cambium called the _____ generates new cells for the bark.
3. The light and dark colored areas formed by the earlywood and latewood growth are the _____.
4. The leaves of a deciduous tree will drop _____.
   a. in the fall
   b. in the spring
   c. not at all. They remain green all year.
   d. only during drought
5. The difference between hardwoods and softwoods is _____.
   a. hardwoods are harder than softwoods
   b. softwoods are harder than hardwoods
   c. softwoods dent easier than hardwoods
   d. hardwood has more cells per inch
6. Describe the layers seen in a cross-section of a tree.
7. The three terms that identify faces of wood are _____, _____, and _____.
8. List five physical characteristics of wood.
9. Both oxidation of wood cells and springwood becoming inactive cause the wood to _____.
10. What is the difference between free water and bound water in a wood cell?
11. What happens when free water is removed from a piece of wood?
12. What happens when bound water is removed from a piece of wood?
13. Construction grade lumber in not adequate for cabinetmaking because of its high _____.
14. The direction wood shrinks is _____.
    a. mostly longitudinal direction
    b. mostly in the radial direction
    c. mostly in the tangential direction
    d. equal in all directions
15. Sketch the four different samples of shrinkage.
16. Specific gravity is a measure of _____.
17. _____ is caused by compression and tension in the tree as it grows. It does cause problems in working wood.
18. What is the difference between open grain and closed grain wood species?
19. Two mechanical properties of wood are _____ and _____.
20. What is the method of removing dents in wood?

Lumber and Millwork

11

Objectives

After studying this chapter, you will be able to:

- Explain the sequence of steps used to convert trees to usable lumber.
- Describe the three methods of sawing.
- Explain hardwood and softwood grading practices.
- Order lumber and millwork.
- Identify various lumber defects.

Important Terms

air drying	lumber defect
board foot	molding
board lumber	plain sawing
button	plug
dimension lumber	quarter sawing
dowel	rift sawing
finial	sectional felling
finish lumber	spindle
harvesting	systematic felling
kiln drying	yard lumber

Wood is a worldwide resource for cabinetmaking and construction materials. Wood is a source for lumber, millwork, and manufactured wood products. Lumber is purchased in ***nominal size boards*** (1 × 3, 2 × 4, etc.) for softwood construction or ***random widths and lengths*** (***RWL***), which is for hardwoods used for cabinetmaking. Millwork includes manufactured dowels, moldings, and decorative wood pieces. Manufactured wood products include plywood, particleboard, and fiberboard.

All wood species are brought to market as lumber through a sequence of steps. These include harvesting, sawing, drying, and grading. Individuals or industries then order lumber and millwork to meet their needs.

Harvesting

Lumber begins its journey to you as a mature tree being harvested. Logging industries select and fell (cut) trees for market by sectional felling and systematic felling.

Sectional felling

Sectional felling is when large sections of a forest are cut at one time with heavy machinery. See **Figure 11-1**. Clearing large portions of a forest is less expensive than cutting individual trees. Sectional felling occurs most often in softwood harvesting. These trees grow faster and mature quicker than hardwoods. The cleared sections are replanted and will reach maturity within a person's lifetime. Seedlings are grown at tree farms and later transported to planned forests. See **Figure 11-2**. Replenishing wood resources is directed under the *American Tree Farm System*. This system assures wood will remain a renewable resource.

Figure 11-1. After felling, a log loader is used to stack the lumber. (*Western Wood Products Assoc.*)

Systematic felling

Systematic felling is when trees are singled out for harvesting. They may be selected because wood of that specie is needed. They may also be cut because they are diseased or infested with insects. Removal of these trees will allow those nearby to grow quicker and healthier.

Trees marked for systematic felling are notched and cut with a saw. The trees are cut near the ground.

Selective removal of smaller trees is done by hydraulic machines which both cut and transfer the tree. Single trees are difficult and more costly to harvest. Nearby small trees may be destroyed in the process. Large scale replanting is impossible.

Once the trees are felled, small branches are trimmed from the main trunk. The trunk is cut into logs suitable for transporting. This process is called ***bucking***. Logs are then transported to the sawmill by truck or railroad cars.

Most lumber mills are located within short distances from harvestable forests. They are also located near a body of water. See **Figure 11-3**. Logs can be stored in the water until sawing. Water prevents insect damage and end checking due to premature drying. Denser species which might not float are stacked and sprayed with water.

Sawing

At the lumber mill, logs are loaded onto a jack ladder and transported to a preparation area. There, they are washed and sometimes debarked in preparation for sawing. See **Figure 11-4.** Each log is placed on a carriage that moves it through a large band saw or circular saw. See **Figure 11-5.** The saw creates rough-edged planks. The angle at which the saw cuts through the log determines the grain pattern, amount of shrinkage during seasoning, and cost of the lumber.

Lumber is sawed by the three methods of plain sawing, quarter sawing, and rift sawing. Because of increased handling time, quarter-sawn and rift-sawn lumber are more costly than plain sawn lumber. Once the log is quartered for quarter-sawn and rift-sawn lumber, each piece must be loaded onto the carriage and positioned for sawing. In plain sawing, the log only needs to be rotated.

Plain sawing

Plain sawing cuts are made tangent to the annual rings. It is the most common method of sawing. See **Figure 11-6A**. Softwood cut by this method is called ***flat-grained***; hardwood lumber is called ***plain-sawed***.

Figure 11-2. New seedlings are replanted after sectional felling of softwood forests. (*APA, The Engineered Wood Association*)

Figure 11-3. Water may be used for transporting and storing logs. (*Western Wood Products Assoc.*)

Figure 11-4. Bark is removed before sawing. It will be used to make other products. (*Southern Forest Products Assoc.*)

Plain sawing is less costly and wasteful than any other method. The average width of the plank is greater. More nominal or RWL lumber can be produced per log. The wood is also easier to kiln dry.

Plain-sawed lumber is most likely to be lower quality and is apt to warp. Annual rings attempt to straighten during drying. Plain-sawed lumber also tends to check and split more than lumber sawn by quarter and rift methods. Knots often appear round, caused by saw cuts across branches.

The grain pattern appears as multiple *V-shapes,* because the saw is cutting through successive layers of growth. Each V-shape represents the earlywood and latewood of a single growing season.

Quarter sawing

Quarter sawing is cutting logs into four sections called quarters. Each quarter is then sawn at a angle between 65° and 90° to the annual rings. See **Figure 11-6B**. The grain pattern, for the most part will be straight lines. Cuts farthest from the center of the log will produce the most figured grain. Cuts near the center are perpendicular to the annual rings and will produce straight grain.

Quarter-sawed lumber twists and cups less than plain-sawed lumber. There are fewer checks and splits because cuts are parallel with wood rays. The rays appear as flakes running along the length of the board.

Figure 11-5. Logs are mounted on a carriage to be sawn. The carriage is moving the log along a band saw. (*Western Wood Products Assoc.*)

Rift sawing

Rift sawing also is cutting logs into quarters, but the quarters are sawn at approximately a 45° angle to the annual rings. See **Figure 11-6C**. The advantages gained by rift sawing over plain sawing are the same as those gained by quarter sawing. However, the straight grain pattern runs lengthwise and is very thin and decorative. Wood rays are apparent, as in quarter sawn, but are much longer.

Ripping

Once the logs are sawn, the flitches (longitudinal section of log) are ripped to width and crosscut to length. See **Figure 11-7**. Each cut must be

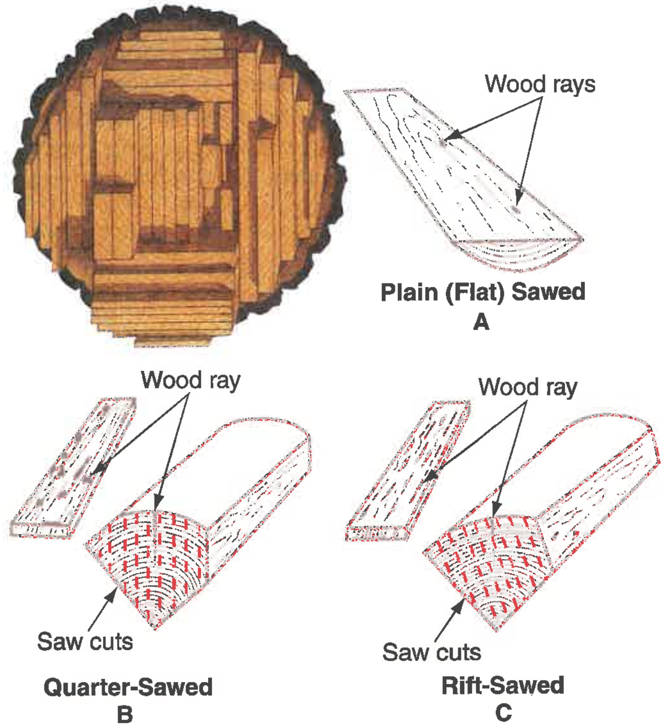


Figure 11-6. Each method of sawing produces different appearance and structural qualities. (*Georgia-Pacific Corp.*)

Figure 11-7. Flitches are ripped manually to maximize width. (*Forest Products Laboratory*)

determined by the sawyer to achieve the longest and widest possible board. The boards will have random lengths and widths.

Saw, dry, and rip process

Using newer sawing techniques such as the ***saw, dry, and rip*** (***SDR***) process, flitches are ripped after drying. The SDR approach is used to make structural grade lumber from low- to medium-density hardwoods. Using SDR and controlled drying, both warp and internal stress levels of the wood are reduced.

Drying

After sawing, lumber must be dried to reduce the moisture content. The drying process is called ***seasoning***. Wood is seasoned either by air drying or by kiln drying.

Air drying

Air drying (***AD***) requires that boards are stacked (separated by wood strips) and stacked for free air movement. Drying is done either outdoors or in a shelter. See **Figure 11-8**. When dried outdoors, the top of the stack is covered to prevent rainwater from entering the wood.

Beware of air-dried lumber. Even after years of sheltered protection, the moisture content may remain at 15% to 19%. Remember, cabinetmaking lumber should have from 6% to 7% moisture content. Always meter the stock when it is received.

Timetable for Air-Seasoning (in days)			
Hardwoods			
Ash	70-110	Gum	70-160
Basswood	30-60	Hickory	150-200
Beech	150-200	Mahogany	70-110
Birch	150-200	Maple	150-200
Cherry	150-200	Oak	180-300
Chestnut	85-125	Walnut	120-170
Elm	80-130		
Softwoods			
Red cedar	50-140	White pine	45-150
Cypress	200-275	Redwood	60-180

Figure 11-8. Reducing moisture content by air drying requires many days. (*Hoge Lumber Co., Hoadley, Western Wood Products Assoc.*)

Kiln drying

Kiln drying (***KD***) uses large ovens, called ***kilns,*** to reduce the moisture content of the lumber. Like air drying, the lumber is stacked and air is circulated through the lumber. See **Figure 11-9**. The temperature and humidity of the air are controlled to promote gradual, even drying. Steam is added at first to increase humidity. This prevents sudden surface drying that would cause checks and splits. The humidity is then reduced and the temperature gradually increased to a constant level until drying is complete. The time required to complete this process depends on the type of wood, efficiency of the kiln, and amount of wood to be seasoned. Most kiln drying is complete within 24 hours.

For many commercial purposes, lumber is air dried and then kiln dried. Air drying removes the free water to reach the fiber saturation point. No shrinkage occurs at this point. Controlled kiln drying then removes the bound water. During this time the lumber shrinks. For construction grade lumber, the moisture content is reduced to about 19%. For cabinetmaking lumber, the content is reduced to 5% to 10%. This lumber is stamped PKD (partially kiln-dried).

Identifying Lumber Defects

Lumber defects detract from the appearance and workability of the wood. The *Wood Handbook*, published by the ***Forest Products Laboratory***, contains information about the formation and nature of defects. Cabinetmakers need to know how defects affect both the aesthetic and structural properties of the wood. The three categories of defects are natural defects, defects caused by improper seasoning or storage, and defects caused by machining.

Natural defects

Wood contains various natural defects. Most are not seen until the wood has been cut and seasoned. Some affect the strength of the wood, while others make the appearance unique and desirable. Defects include knots, pitch pockets, bark pockets, and peck.

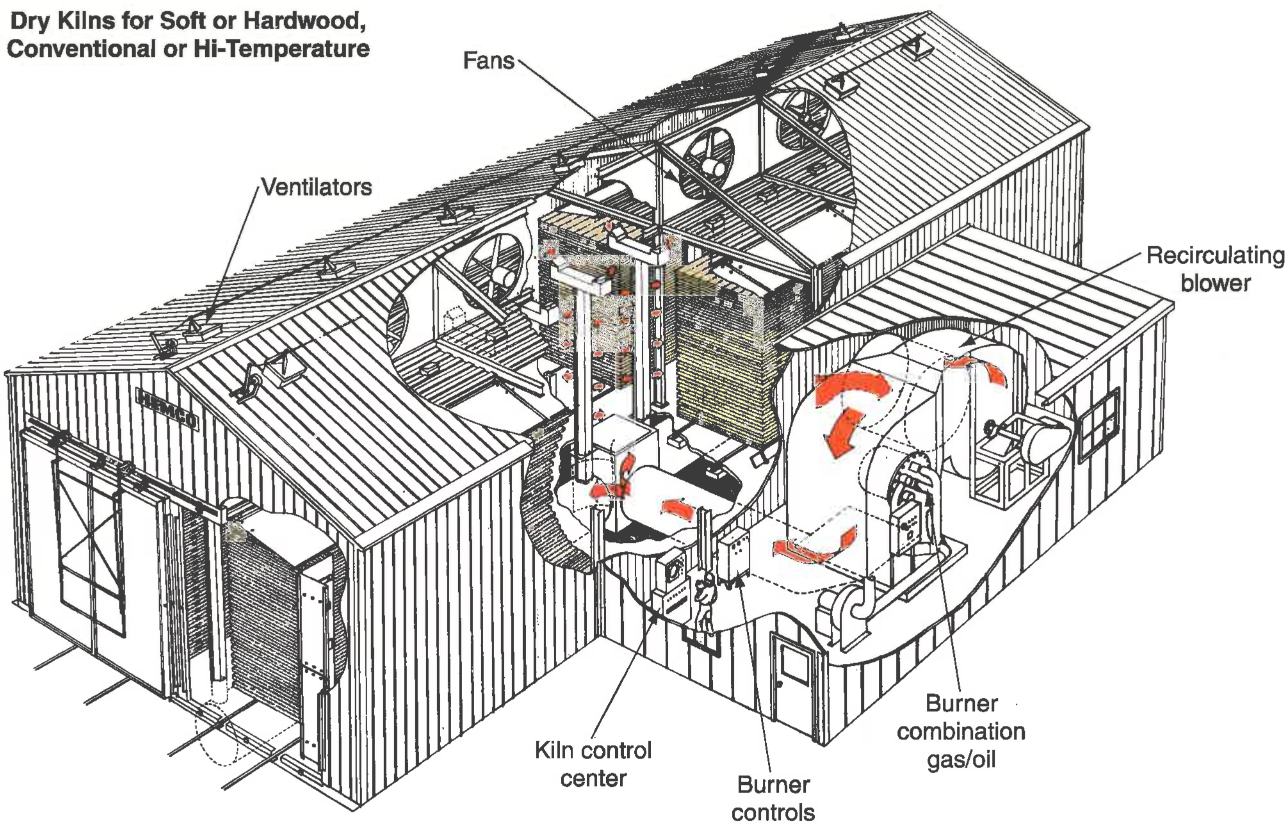


Figure 11-9. Kiln drying. Lumber is transported into kiln on rails and dried using circulating, heated air. (*Western Wood Products Assoc., and Harvey Engineering and Manufacturing Corp.*)

Knots

Knots are encountered by sawing across part of a log which had a branch. Branches grow from the pith across the trunk or stem. During growth, the tree stem forms around the branch. Although the knot itself is as strong as the wood, the grain pattern surrounding it weakens the lumber. The wood dries, shrinks, and may split. Wood fibers can separate and cause loose knots.

There are different shapes and types of knots. See **Figure 11-10**. *Round knots* called *branch knots*, are found in wood that was cut tangential to the annual rings. The cut gives a cross-section view of the branch. *Spike knots* are found in wood cut radically. The saw splits the branch through the center. Oval knots are found when the wood was cut at an angle to the branch.

Knots are further described as intergrown or encased. As long as a branch is alive, there is continuous growth at the intersection of the limb and trunk. Knots cut from live branches are called intergrown. They retain their contact with the surrounding wood and are called tight knots. If a branch dies, additional growth on the trunk will surround the branch. Knots cut from this area are encased by surrounding growth. They often become loose knots when they lose contact with the wood surrounding them.

A *checked knot* contains a split in the knot caused by seasoning. A *knot hole* results from a loose, encased knot that has been knocked out during seasoning or by rough handling or machining.

Pitch pocket

Pitch pockets are openings in the wood that contain solid or liquid resins, called pitch. See **Figure 11-11**. The pocket is formed by resin ducts. Pitch pockets are found in various softwoods, such as pine, spruce, and fir.

Figure 11-11. Pitch pockets include hardened resins. (*Western Wood Products Assoc.*)

Bark pocket

Bark pockets contain bark material that was enclosed during growth. See **Figure 11-12**. This barky section is undetected until the log is sawed. These sections are very weak and unattractive.

Figure 11-12. Bark pockets are formed when bark cells are enclosed during growth. (*Western Wood Products Assoc.*)

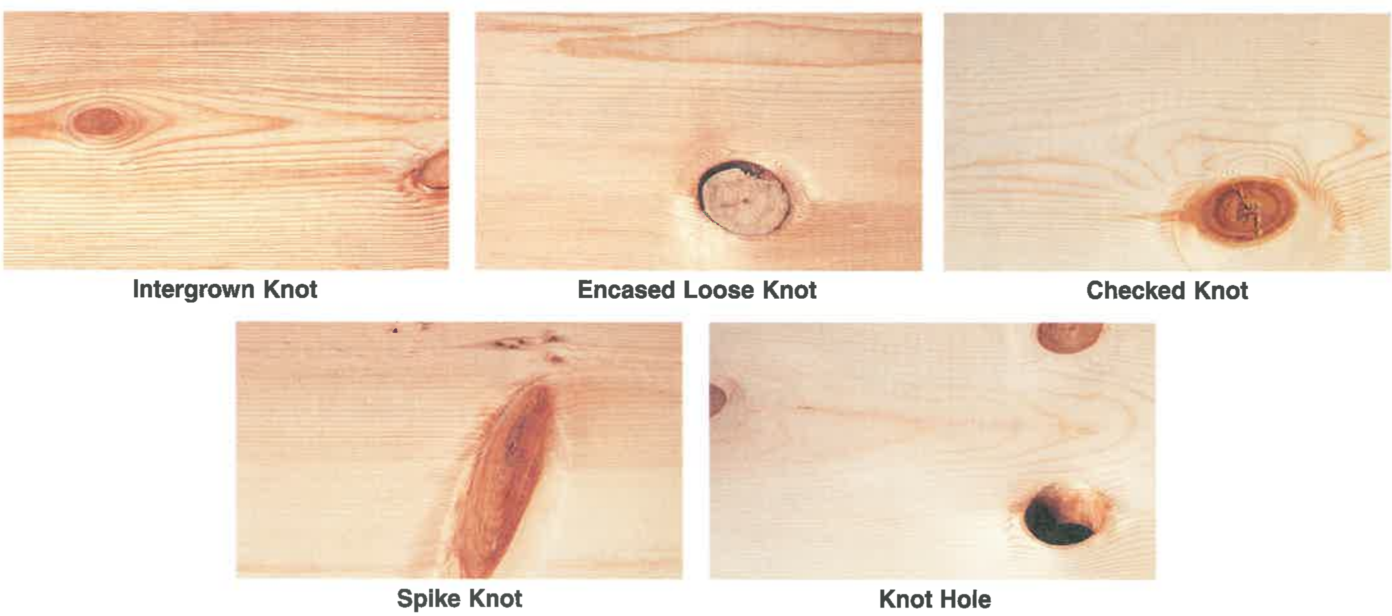


Figure 11-10. Knot defects come in all shapes and sizes. Intergrown knots are more stable than encased knots. (*Western Wood Products Assoc.*)

Other natural defects

Heartrot, peck, and grub holes are other natural defects. ***Heartrot*** is a form of decay that occurs while the tree is still alive. Certain decay fungi attack the heartwood (rarely the sapwood), but cease after the tree has been cut. The cypress family is especially susceptible. Fungi attacking bald cypress cause brown pockets called ***peck.*** See **Figure 11-13**. Those attacking Douglas fir cause white pockets.

Grub holes are voids in the wood left by insects. The insects burrowed through the wood while the tree was alive. Residue from the insect may also be found in the holes.

Figure 11-13. Peck is caused by fungus. Grub holes are caused by insects. (*Western Wood Products Assoc.*)

Defects caused by improper seasoning or storage

Various lumber defects are cased by improper seasoning and the resulting shrinkage. These include warp, splits, checks, shakes, honeycomb, blue stain, decay, and insect damage.

Warp

Warp is the curving of the wood either on the face, edge, or length of the board. The five types of warp are bow, crook, twist, kink, and cup. See **Figure 11-14.** A ***bow*** is a curve lengthwise along the face of the board from end to end. A ***crook*** is curve along the edge of a board from end to end. A ***twist*** is a corkscrew effect. A ***kink*** is a deviation along the board caused by a knot or irregular grain pattern. A ***cup*** is a curve across the face of the board from edge to edge.

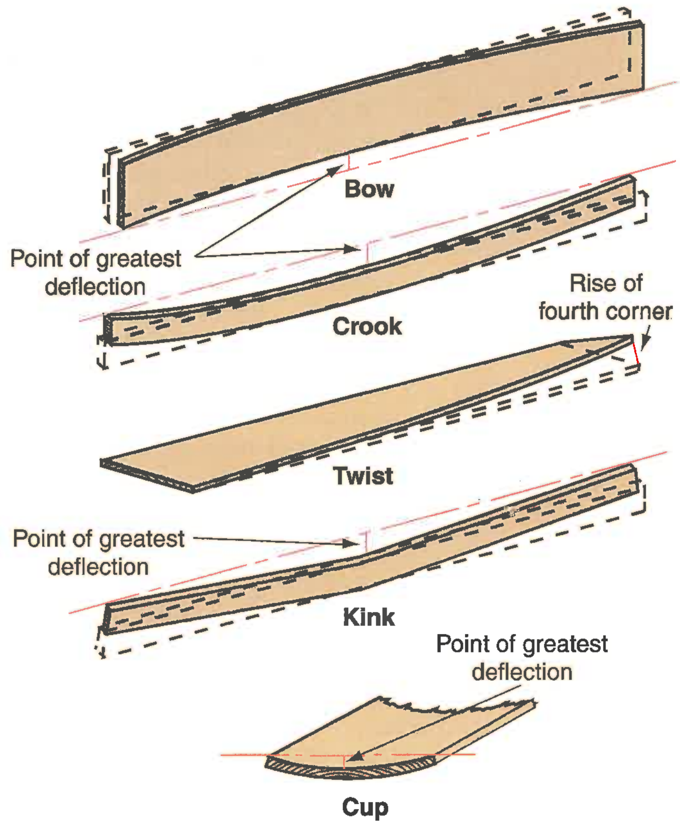


Figure 11-14. Warp is the result of uneven shrinkage. (*Forest Products Laboratory*)

Various types of warp occur during seasoning. Most are caused by the shrinkage of the wood cells. Internal stress in the wood is another cause of warping. Constant pressure from weight of a limb or leaning trunk causes reaction wood. The growth rings are compressed or spread apart. Natural irregularities during growth can also cause eccentric annual rings.

Warp also occurs as a result of improper storage. As different surfaces are exposed to moisture, the grain (wood cells) expands. Warp caused by improper storage can be minimized by stacking the lumber neatly and maintaining the average moisture content of the room. Wood is best stacked flat with ample sticking to prevent bowing. The weight of the wood minimizes cupping. If the wood must be stored outdoors, put it on a level foundation above the ground. Also cover it with tarpaulins or plastic.

The frequency and severity of warped stock in a given quantity of lumber is related to the wood species. See **Figure 11-15.** The grain patterns of some wood are more apt to cause warp than others.

Checks and splits

Checks and ***splits*** are separations of the wood fibers along the grain and across the annual rings. See **Figure 11-16.** ***Splits*** travel the length of the

Tendency to Warp	
Softwoods	
Low	Intermediate
Cedars	Bald cypress
Pine, ponderosa	Douglas fir
Pine, sugar	Firs, true
Pine, white	Hemlocks
Redwood	Larch, western
Spruce	Pine, jack
	Pine, lodgepole
	Pine, red
	Pine, southern

Hardwoods		
Low	Intermediate	High
Alder	Ash	Beech
Aspen	Basswood	Cottonwood
Birch, paper, and sweet	Birch, yellow	Elm, American
	Elm, rock	Sweetgum
Butternut	Hackberry	Sycamore
Cherry	Hickory	Tanoak
Walnut	Locust	Tupelo
American tulip	Magnolia, southern	
	Maples	
	Oaks	
	Pecan	
	Willow	

Figure 11-15. Tendency to warp is a major factor in the wood you choose.

wood. ***Checks*** are short separations, found in the end of seasoned boards. Checks and splits are caused when wood rays separate during seasoning.

Shake

Shakes are separations of the wood between two growth rings. Separation occurs while the tree is standing or when it is felled. Ring failure is also a separation of growth rings, but occurs during seasoning. It is caused by the weakening of the bond between rings because of high heat during seasoning.

Honeycomb

Honeycomb is internal voids in the wood rays caused by excessive heat during seasoning while free water is still present in the wood cells. See **Figure 11-17**. This usually is not detected until the lumber is being machined.

Blue stain

Blue stain is discoloration of the wood caused by a mold or fungus. See **Figure 11-18**. It occurs after the wood has been cut and left in an area of high humidity.

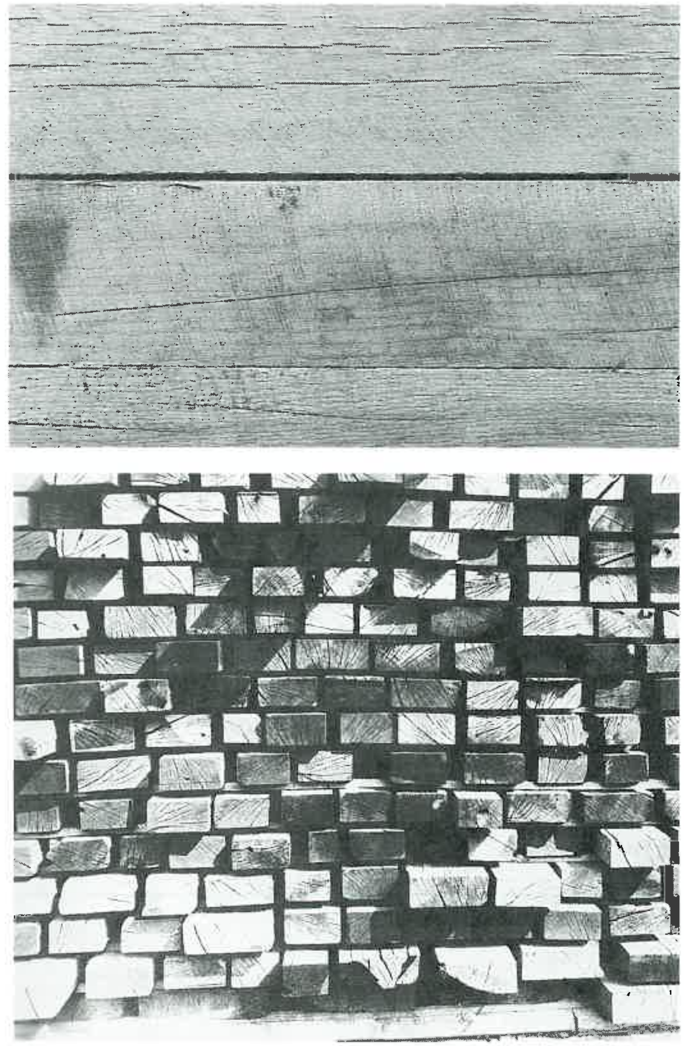


Figure 11-16. Top—Splits run the length of the board. Bottom—Checks are only found in the ends of the board. (*Forest Products Laboratory*)

Figure 11-17. Honeycomb is caused by separation of wood rays. Top—It is seen as voids in the end of cut lumber. (*Forest Products Laboratory*) Bottom—Honeycomb as depressions in surfaced lumber. (*Western Wood Products Assoc.*)

Figure 11-18. Abnormal coloring known as blue stain. (*Western Wood Products Assoc.*)

Blue stain is found mostly in sapwood and ranges from a bluish-black to brown in color. The mold or fungus causing blue stain penetrates into the sapwood and cannot be removed by surfacing. It doesn't affect the strength of the wood, however, it can detract from the appearance. The stain may completely cover the sapwood or may be specks, spots, streaks, or patches of different shades.

Decay

Decay is the disintegration of the wood fibers due to decay-producing fungi. It is found in both heartwood and sapwood. Decay causes the wood to become spongy and unsuitable for use. See **Figure 11-19.**

The two types of decay are brown rot and white rot. In ***brown rot,*** only the cellulose (material making up wood cells) is removed. The wood becomes brown in color and tends to crack across the grain. Brown rot that has dried is commonly called ***dry rot.*** With white rot, both the cellulose and *lignin* deteriorates. The wood loses color, but does not crack until the white rot is severe.

Serious decay occurs when the wood moisture content is above the fiber saturation point (30%). Wood exposed to rain, or in contact with the ground, typically decays very rapidly.

Figure 11-19. Decay ends the useful purpose of wood. (*Forest Products Laboratory*)

A less common form of decay is ***soft rot.*** Soft rot is caused by molds and not decay-producing fungi. It only affects the surface and can be removed by planing. It is found on wood exposed to both constant and intermittent moisture levels above 20%.

Insect damage

Worms and other insects bore into wood leaving small holes called ***wormholes.*** You can cover unwanted wormholes with wood filler. ***Pinholes,*** which are wormholes less than 1/4" (6 mm), are often left to enhance appearance of the wood. Minor defects in the wood make it unique.

Preventing stain, decay, and insect damage

Wood that is consistently exposed to insects or moisture levels above 20% should be protected. Chemical preservatives that poison the food supply for both insects and fungi are used to treat more susceptible woods. Commonly used chemicals are listed in **Figure 11-20.**

Preservatives can be applied by pressure treatment, hot-cold bath, cold-soaking, and brushing or spraying. Pressure treatment is the most effective because chemicals penetrate deep into the wood.

Defects caused by machining

Lumber defects or blemishes may appear during the manufacturing process. Most occur during surfacing. They are machine burn, raised grain, torn grain, wavy dressing, skip, and dog holes. See **Figure 11-21.**

Wood Preservatives

Common wood preservatives are rated here according to various characteristics. Symbols are:
★ = Usable
★★ = Better
★★★ = Best

Preservative	Toxicity	Odor	Color	Paintability	Soil contact	Permeability
Creosote	★★★	★	★	★	★★★	★★★
Penta	★★★	★★	★★★	★★★	★★★	★★★
Water soluble preservatives †	★★★	★★★	★★	★★★	★★	★★

†Containing fluor-chrome-arsenate-phenol, or chromated zinc chloride.

Figure 11-20. Wood preservatives can be used to prevent decay.

Figure 11-21. Various machine-caused defects occur during surfacing. (*Western Wood Products Assoc.*)

Machine burn

Machine burn is a darkening of the wood caused by heat. It occurs when dull tools are used. If the board stops during surfacing and the cutter head rubs in one place, a burn may occur. Too slow of feed can also cause burn.

Raised grain

Raised grain is a variation in surface texture caused by machining wood of high moisture content. As the cutter knives smooth the face, they press latewood into the softer earlywood. After leaving the surfacer, the earlywood recovers and expands, causing the grain to lift. Raised grain is most apparent in construction grade softwoods.

Torn grain

Torn grain occurs when wood fibers are torn from the board by the saw, shaper, jointer, or planer. Torn grain occurs most in softer wood and around knots where the grain pattern is irregular.

Wavy dressing

Wavy dressing results when boards are fed into the surfacer faster than the knives can cut. Each knife makes a small arc in the wood. You can feel a slight rippled texture even though rough sawn spots have all been removed.

Skip

A ***skip*** is a section of a board which is unsurfaced. Skips appear when the board is not flat. The sawyer may not cut the board straight. The board may also warp. Slight depressions are formed. These areas are not hit by the surfacer and the texture remains rough.

Dog hole

A ***dog hole*** is a scar in the board caused by the metal hook (dog) that grips a log while it is sawed. It differs from torn grain because of the amount of wood removed. A dog hole may be ¼" (6 mm) deep. Torn grain is only a surface blemish.

Grading

After seasoning, lumber is graded according to quality. Lumber grading is a matter of judgment and experience. See **Figure 11-22**. Graders rate each piece according to the size of board and amount of defect free lumber in it. The clear cuttings, or yield, of a board needed to achieve a certain grade will differ between hardwood and softwood. It can also differ between species.

Hardwood grading

Hardwood is graded as factory, dimension, or finished market lumber. ***Factory grades***, also called cutting grades, specify the amount of clear lumber that can be cut from a board. They are established by the ***National Hardwood Lumber Association*** (***NHLA***). These pieces will have random lengths and widths and slight variations in thickness. However, the wider and longer the board, the better the grade. ***Dimension grades*** are surfaced to specific thickness and/or cut to specific lengths and widths. They are more expensive, thus, specified less frequently. Factory grades are quality lumber for moldings and trim, which are covered in detail later in this chapter.

Factory grades

As previously mentioned, ***factory grades*** are based on the amount of clear lumber that can be cut in given lengths from a single board. Each grade requires that the board be at least 3″ (76 mm) in width. Smaller boards are used for making moldings. Smaller scraps are processed into particleboard and fiberboard. **Figure 11-23** shows a large board with three cuttings. A board may exceed the minimum percentage of clear wood and minimum dimension of boards cut. It is graded as ***Firsts and Seconds***, commonly referred to as ***FAS***. The different grades and minimum specifications are indicated on **Figure 11-24**. The specifications listed can vary according to species. The percentage of clear wood may differ. Check with your lumber company first to determine the specifications for the specie you plan to purchase.

Figure 11-22. Graders inspect each board for size and clearness. (*Southern Forest Products Assoc.*)

FAS is the top grade for hardwoods. The board must be at least 84% clear. It is graded on the poorer face of the board so that you know the other side is as good or better. ***FAS 1-Face*** lumber maintains the same specifications as FAS. However, it is graded on the better surface of the board. It may contain some pitch pockets or wane. ***Wane*** is bark incorporated in the wood or on the edge of the board. ***Selects*** lumber is the same as FAS 1-Face except the minimum length is reduced by 2′ (610 mm) and the minimum width is reduced by 2″ (50 mm).

FAS 1-Face and Selects lumber are used in products where only one face of the board will be seen. Chests, dressers, and other storage cabinets require only the outer face to be free from defects.

The ***No. 1 Common*** lumber is also called the ***Thrift*** lumber because you get the most clear lumber for your money. However, clear cut lengths can be as short as 2′ (610 mm). The board must be 66% clear, yet most exceed 75% clear. Thrift grade is an excellent choice for small to medium size projects.

Grades not listed in **Figure 11-24** include ***No. 2 Common*** and ***No. 3 Common***. These grades have the same dimensions as No. 1 Common lumber, but No. 2 Common requires only 50% clear wood, and No. 3 Common requires only 25% clear wood. These lumber grades are unsuitable for cabinetmaking purposes.

Combination grades

Most lumber companies have ***combined grades*** to sell lumber that is not often requested. For example, people shy away from FAS grades because of price. The ***FAS 1-Face and Better*** combination grade includes FAS 1-Face and FAS grade boards. They are sold at a price lower than the FAS grade. Consumers purchase this combination grade knowing that they are getting better grade lumber along with FAS 1-Face wood. The ***Selects and Better*** grades include shorter length boards along with higher grades.

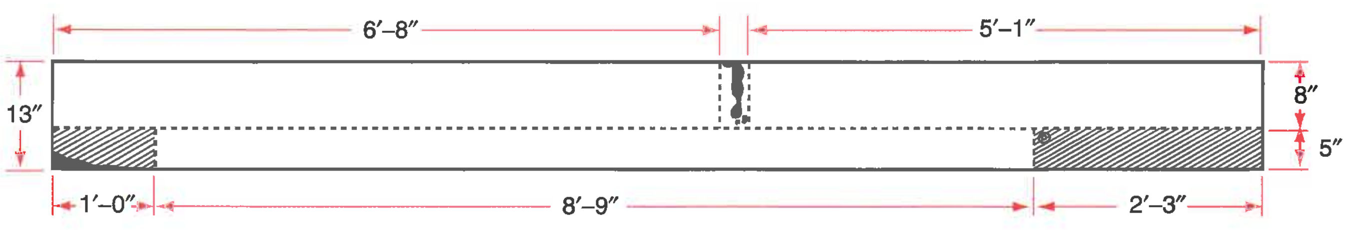


Figure 11-23. Size of clear cuttings determine the grade of the board.

Generalized NHLA Hardwood Grade Minimums (Does not show species variations.)						
Grade	Side Graded	Minimum Size Length	Width	Minimum Cutting Sizes	Maximum Waste in Board	Price Estimate
FAS	Poorer	8′+	6″+	4″ × 5′ or 3″ × 7′	Up to 16%	Highest
FAS 1-Face	Better	8′+	6″+		Up to 16%	– 5%
Selects	Better	6′+	4″+		Up to 16%	–10%
#1 Common (Thrift)	Poorer	4′+	3″+	4″ × 2′ or 3″ × 3′	Up to 34%	–30%

Figure 11-24. General hardwood grading rules. Some species vary in clear cutting sizes.

Dimension grades

Dimensioned hardwoods are flats and squares. ***Flats*** refer to nominal, surfaced standard sizes which are wider than they are thick. Examples are 1 x 2, 1 x 4, 2 x 4, etc. ***Squares*** are 2 x 2, 3 x 3, etc. Dimension grade hardwoods are graded according to appearance as follows:

- Clear—two sides
- Clear—one side
- Paint. May consist of two pieces attached by finger joints
- Core. Used between veneers for lumber core plywood
- Sound. Includes defects

Rough sawn squares are clear, select, or sound grades. Surfaces on squares are clear, select, paint, or second grades.

Few cabinetmakers specify dimension grade hardwood because it is expensive. You might use clear squares for turning on a lathe.

Figure 11-25. Boards are sorted according to grade. (*Southern Forest Products Assoc.*)

Softwood grading

Softwood grading also applies to appearance. In addition, softwoods are graded according to use and moisture content. See **Figure 11-25**. The two categories are construction and remanufacture grades.

Construction grades

Construction grade lumber is the least expensive and most available. It is also called *yard lumber.* The moisture content is 19% making it likely to warp, split, and check when it further dries. It will also bleed liquid sap that did not harden during seasoning. Construction grade lumber has a variety of building construction applications. Construction grades are classified as finish, board, or dimension lumber.

Finish lumber

Finish lumber is less than 3″ (76 mm) thick and 12″ (305 mm) or less in width. It is used where appearance is important, such as flooring, siding, wall covering, etc. Grades are:

- ***A Select.*** Fewer defects and are used where clear and stained finishes will be applied
- ***B Select.*** Fewer defects and are used where clear and stained finishes will be applied
- ***C Select.*** Suited for painted finishes
- ***D Select.*** Suited for painted finishes

Board lumber

Board lumber is less than 2″ thick and 2″ to 12″ wide (50 mm thick and 50 mm to 305 mm wide). It is used for general construction. Boards are graded from No. 1 board to No. 5 board. Inspect them closely to determine finishing capabilities. Higher numbered grades contain additional knots and pitch pockets.

Dimension lumber

Dimension lumber is used for structural framing and has a nominal size of 2″ thick by 2″ wide (50 mm by 50 mm). Dimension lumber is divided into the three areas of light framing, structural light framing, and structural joists and planks.

Light framing grades are used where high strength is not required. Grades for light framing are as follows:

- Construction
- Standard
- Utility
- Economy

Grades for structural light framing are as follows:

- Select structural
- No. 1
- No. 2
- No. 3
- Economy

The nominal size of structural joist and plank lumber is 2″ to 4″ thick and 6″ wide (50 mm to 102 mm and 152 mm wide).

Remanufacture grades

Remanufacture grade lumber is divided into factory and shop grades. The moisture content ranges from 6% to 12%. This lumber is more suited to cabinetmaking than construction grade materials.

Factory grade

Nominal sizes of ***factory grade*** lumber is 1″ to 4″ (25 to 102 mm) thick and 5″ (127 mm) or more in width. It is used for sash and door construction. It has good appearance for any type of finish. The grades are as follows:

- No. 1 and No. 2 Clear Factory
- No. 3 Clear Factory
- No. 1 Shop
- No. 2 Shop
- No. 3 Shop

Although the word *shop* is used, it is not the shop grade of softwood. This is a quality level for factory grade lumber.

Shop grade

You can purchase ***shop grade*** softwoods in a variety of sizes and quality. Ratings include Select, Molding, Cutting, and Common grades.

- ***Select grades*** include A through D Select. Grade D is recommended for painting. Others may be finished as desired. Select grades are more often specified as follows:
  - ***B and Better***—Clear on both sides.
  - ***C Select and Better***—Clear on one side.
  - ***D Select***—Contains numerous small, tight, knots.
- ***Molding grade*** exhibits characteristics of both Select and Shop grades. Pieces are long, narrow, and clear strips used for trim and molding.
- ***Cutting grades*** fall in sequence below Select grades. They contain a few too many small knots. Grades, as for hardwoods, depend on the amount of clear lumber that can be cut from a board. Cutting grades are:
  - ***Third Clear***—A few small knots.
  - ***No. 1 Shop***—More hard knots and smaller cutting yields.
  - ***No. 2 Shop***—Not recommended for cabinetry.
  - ***No. 3 Shop***—Not recommended for cabinetry.
- ***Common grades*** contain knots. They are for knotty furniture or paneling and utility purposes such as shelving. They are graded No. 1 Common through No. 5 Common. Combination grades are usually marketed for Common grade softwoods. They include:
  - ***No. 2 Common and Better***—Tight knots.
  - ***No. 3 Common***—Larger defects including spike knots, pith, and shakes.
  - ***No. 4 and No. 5 Common***—These contain many defects.

Local lumber yards typically supply only construction grade softwoods. Few handle remanufacture grades. Their open sheds are not suitable for remanufacture lumber, which must maintain a low moisture content. Heated sheds would add to lumber cost. Although not recommended for cabinetmaking, construction grades can be used if left to dry indoors for some time. Before using, check the moisture content to see if it meets the equilibrium moisture content.

Ordering Lumber

Ordering hardwood and softwood lumber involves specifications. You have to deal with qualities, quantities, and species.

Qualities

Quality refers to hardwood and softwood grades. Be familiar with grading policies of the National Hardwood Lumber Association and ***Western Wood Products Association,*** which deals with softwood. Before ordering, check with your lumber company for any special grading practices.

Quantities

Most lumber used in cabinetmaking is sold by quantity, not by single boards. Only construction grade softwoods, dimension grade hardwoods, and some shop grade remanufacture softwoods are sold by nominal widths and lengths. Unless you specify width and length, lumber will be sent in *random widths and lengths* (RWL).

Because boards are sawn in random widths and lengths to minimize waste, boards may not be the same size. Thus, measure lumber quantities by volume, not size. This measure is the board foot or cubic meter.

Board feet

A ***board foot*** is 12″ long by 12″ wide by 1″ thick. The total volume is 144 cubic inches. The board footage of any piece of lumber can be determined by multiplying the thickness, width, and length in inches, then divide by 144. You can also multiply the thickness and width in inches, the length in feet, and divide by 12. However, there are some rules to follow.

- Board thickness under ¾″ (18.5 mm) is figured as square foot measure (multiply width times length). Thickness is not taken into account.
- Thicker boards, 1″ or over, are marked to the nearest ¼″. It is a practice to express the thickness of cabinet grade lumber in quarters of an inch. For example, 1¼″ = 5/4″, and is verbally stated as five-quarters.
- Thickness is based on measurement before surfacing.

The general formula for calculating board footage is as follows:

$$bd\ ft = \frac{N \times T(\text{in}) \times W(\text{in}) \times L(\text{in})}{144}$$

or, if you use feet for length use the following formula:

$$bd\ ft = \frac{N \times T(\text{in}) \times W(\text{in}) \times L(\text{ft})}{12}$$

Where,
bd ft = board feet
N = number of pieces of that size
T = rough thickness in inches (1″ for pieces less than 1″)
W = rough width in inches
L = length in inches or feet

Examples

How many board feet are in one piece of 1″ rough cherry, 6″ wide, and 48″ long?

$$bd\ ft = \frac{1 \times 1 \times 6 \times 48}{144}$$

$$bd\ ft = \frac{288}{144}$$

$$bd\ ft = \mathbf{2}$$

How many board feet are in four pieces of 6/4″ by 12″ by 8′ rough sawn oak?

$$bd\ ft = \frac{4 \times 6/4\ (1.5) \times 12 \times 8}{12}$$

$$bd\ ft = \frac{576}{12}$$

$$bd\ ft = \mathbf{48}$$

How many board feet are in three pieces of surfaced cherry, 1″ rough cherry surfaced to ¾″, 5½″ × 4′?

$$bd\ ft = \frac{3 \times 1 \times 6 \times 4}{12}$$

$$bd\ ft = \frac{72}{12}$$

$$bd\ ft = \mathbf{6}$$

Cubic meter

Countries following the metric system use the cubic meter for volume measurements of random widths and lengths lumber. A ***cubic meter*** (m^3) contains 423.77 board feet. For those accustomed to the board foot, it is best to convert metric measurements. For example:

Suppose you purchase plans that call for .12 m^3 of oak. A local lumber yard states the price for that amount will be $86.50. How much is that per board foot?

$$.12\ m^3 \text{ lumber} \times 423.77 = 50.86 \text{ total bd ft}$$

Therefore,

$$price\ per\ bd\ ft = \frac{86.50}{50.86}$$

$$price\ per\ bd\ ft = \mathbf{\$1.70}$$

Special lumber processes

Special lumber processes include the surfacing performed, type of seasoning, preservatives, and milled pattern lumber.

Surfacing

Lumber is either rough or surfaced when you buy it. ***Surfacing*** removes from 1/8″ to ¼″ (3 mm to 6 mm) from the nominal (rough) size. Standard surfaced thicknesses are developed by the ***National Hardwood Lumber Association*** and the ***American Lumber Standards Committee***. See **Figure 11-26**.

Lumber is surfaced on the sides you specify. See **Figure 11-27**. It can be left rough or have one edge sawed straight. Keep in mind that you pay for surfacing. Order only the surfacing services you cannot perform. Several codes for surfacing condition are as follows:

- ***S1S.*** Surfaced one side; edges and back rough.
- ***S2S.*** Surfaced two sides; edges rough.
- ***S4S.*** Surfaced both sides and both edges.
- ***RGH.*** No surfacing.
- ***SLR1E (Straight-Line Ripped One Edge).*** In addition to surfacing, the SLR1E process rips a straight edge. This might save you time when gluing boards edge to edge because you do not have to joint the edge first.

Standard Surfaced Thicknesses		
Rough Thickness	S2S Hardwoods (NHLA standard)	S2S Softwoods (WCLB standard)
3/8	3/16	5/16*
1/2	5/16	7/16*
5/8	7/16	9/16*
3/4	9/16	11/16*
1	13/16	3/4
1-1/4	1-1/16	1
1-1/2	1-5/16	1-1/4
1-3/4	1-1/2	
2	1-3/4	1-1/2
2-1/2	2-1/4	2
3	2-3/4	2-1/2
3-1/2	3-1/4	3
4	3-3/4	3-1/2

Figure 11-26. Nominal (rough) and standard surfaced thickness, expressed in inches. *There has been no standard established, but material of these sizes may be available.

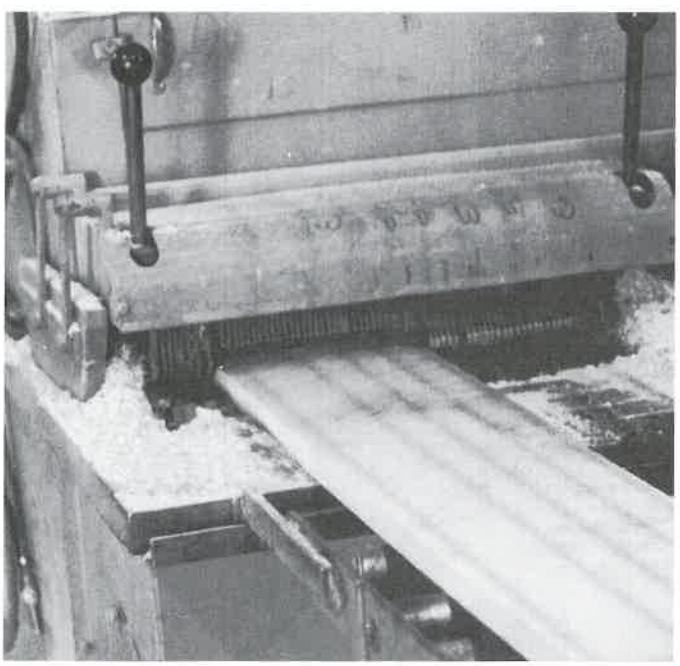


Figure 11-27. Lumber is surfaced on one, two, or four sides. (*Hoge Lumber Co.*)

Seasoning

Another condition that is always specified on the order form is the type of seasoning. As a cabinetmaker, you will always want to specify KD (kiln dried). If you do not, you might receive air dried (AD) lumber with high moisture content.

Preservatives

Wood subject to excessive moisture or insects is frequently impregnated with preservatives. Oil- or water-base preservatives are used to prevent decay and repel insects. Most are applied under high pressure to penetrate layers of wood cells. See **Figure 11-28**. Window sash, stair treads, and other millwork exposed to moisture are usually dipped or sprayed with chemicals.

Pattern lumber

Beyond surfacing and seasoning, lumber can be specified with milled ends and edges, such as tongue-and-groove or rabbet joints. Milled boards are referred to as ***pattern lumber*** and used for floors, siding, and decorative purposes.

Lumber with a tongue-and-groove on the edges is marked *T & G*. To specify tongue-and-groove on both ends and edges, as found in oak flooring, mark

Figure 11-28. Wood preservatives are applied in a high pressure container. (*Georgia-Pacific Corp.*)

T & G & E-M. This lumber often is referred to as matched or end-matched. Lumber with rabbet joints to permit accurate edge fitting is called ***ship lapped***. Other effects are available to decorate both interiors and exteriors. See **Figure 11-29**.

Species

There are hundreds of species of trees from which lumber is obtained. Each has different physical and mechanical properties. Some trees are more abundant than others. Many grow in North America, while others grow on other continents.

Tree species have both common and botanical names. For example, ash is a common name for a familiar tree. There are six common species within the ash family. They are white ash, green ash, blue ash, black ash, pumpkin ash, and Oregon ash. Except for Oregon ash, most grow in the eastern half of the United States.

The species of wood you choose depends on many factors including color, grain pattern, and strength. You might choose a wood to match other furniture or to fulfill a structural requirement. The various wood species are covered in *Chapter 12*.

Written orders

A typical lumber company order blank is shown in **Figure 11-30**. Note the categories for board feet, thickness, etc. Both single grades and combination grades are specified. Dimensions are specified for several.

Millwork

Millwork consists of specialty items frequently processed from molding grade lumber. Example items are molding, trim, and specialty items. Only a few wood species are processed into millwork items. These species have excellent machining properties and are less likely to warp. Matching colors of millwork to lumber is sometimes a problem because not every species is produced as millwork. You may wish to produce millwork of the same wood species or to fit a particular design.

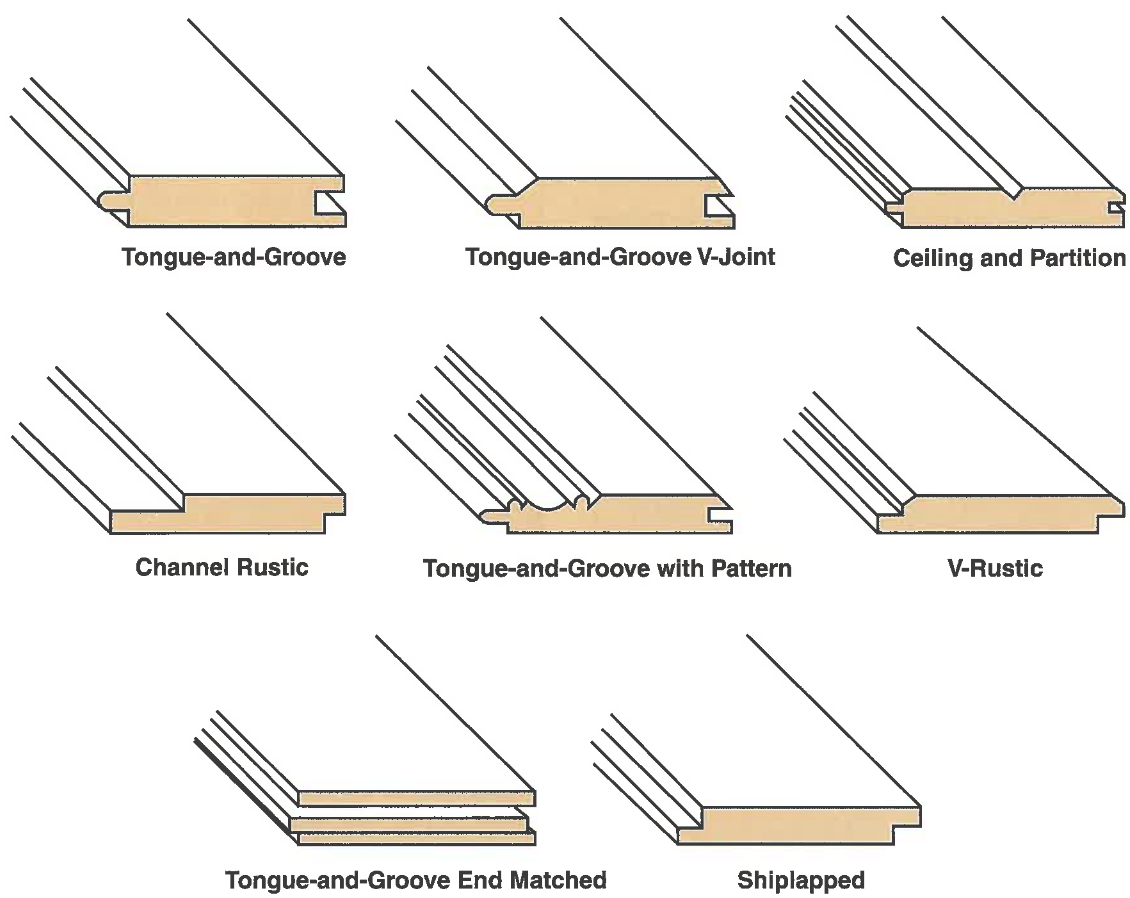


Figure 11-29. Pattern lumber is shaped for special uses, such as flooring and paneling.

ORDER BLANK

DATE 10 May 1982 SCHOOL DISTRICT No. 213 ORDER No. 369

CHARGE TO Board of Education

CITY Anytown STATE Kansas 66132

SHIP TO Anytown High School 220 Main Street

CITY Anytown STATE Kansas 66132

ORDERED BY John Doe (913) 545-1234 TITLE I.A.I.

TERMS OF SALE: WE SELL OPEN ACCOUNT TO BOARDS OF EDUCATION AND TO MEMBERS OF SCHOOL FACULTIES.

HAVE YOU SHOWN QUANTITY–GRADE–KIND OF WOOD–THICKNESS RGH OR S2S THANK YOU

LUMBER

FEET	THICKNESS	CHECK ONE	GRADE AND KIND OF LUMBER
200	1"	RGH ☒ S2S ☐	No. 1 Com. (Thrift Grade), Basswood, K-D
250	1"	RGH ☐ S2S ☒	No. 1 Com. & Btr. Aromatic Red Cedar, K-D
100	1"	RGH ☐ S2S ☒	Selects & Better Cherry, SLR1E, K-D
400	1"	RGH ☐ S2S ☒	Selects Pin Mark Natural Philippine Mahogany, K-D
300	5/8"	RGH ☐ S2S ☒	3rd Clear (Thrift Grade) Ponderosa Pine, K-D
200	1"	RGH ☐ S2S ☒	Same
150	1x12"	RGH ☐ S2S ☒	No. 2 Com. & Btr. Ponderosa Pine, S4S, K-D
100	1"	RGH ☐ S2S ☒	No. 1 Com. & Selects (Thrift Grade) Pecan, K-D
100	5/8"	RGH ☐ S2S ☒	Clear 1 Face Steamed Walnut 4' & 5', S2S to 1/2", K-D
100	1"	RGH ☐ S2S ☒	FAS 1 Face & Btr. Steamed Walnut 6' & Lgr., K-D
150	1"	RGH ☐ S2S ☒	No. 1 Com. (Thrift Grade) Steamed Walnut, K-D
200	1"	RGH ☒ S2S ☐	No. 1 Com. & Selects (Thrift Grade) Willow, K-D
100	1"	RGH ☐ S2S ☒	Selects & Btr., Northern Birch, 6' to 11', K-D
50	1"	RGH ☐ S2S ☒	Sel. & Btr. Birdseye Hard Maple, S2S to 7/8", K-D

PLYWOOD — SQUARES — DOWELS — ETC.

PIECES	SIZE	DESCRIPTION OF WOOD	GOOD 1 SIDE OR GOOD 2 SIDES (PLYWOOD ONLY)
4	1/4x48x96"	Natural Birch Plywood	G1S
2	3/4x48x96"	Premium Walnut, Sound Walnut Back, Solid Jointed Veneer Core	G1S-So.Bk.
12	2x2x30"	Walnut Furniture Squares	Clear
20	3/8x36"	Hardwood Dowel Rods	
1-Pkg.	9x11" Sheets	Garnet Finishing Paper	220-A
1	1-Gallon	Paxbond Liquid White Glue	
1	1-Gallon	Clear Deft Wood Finish, Semi-Gloss	

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FRANK PAXTON LUMBER COMPANY
. . . serving the schools since 1914.

Figure 11-30. Filling out the order form properly saves time and confusion.

Molding and trim

Molding and *trim* decorates the edges of most cabinetry, furniture, doorways, and windows. Each shape has its own name and varies in size. See **Figure 11-31**. Typical uses for molding are shown in **Figure 11-32** and **Figure 11-33**.

Molding grades

Wood moldings are available in two grades. These grades are P-Grade and N-Grade. Finger joints are used for edge gluing.

P-Grade is intended for paint finishes or veneering. P-Grade moldings may contain two pieces of wood.

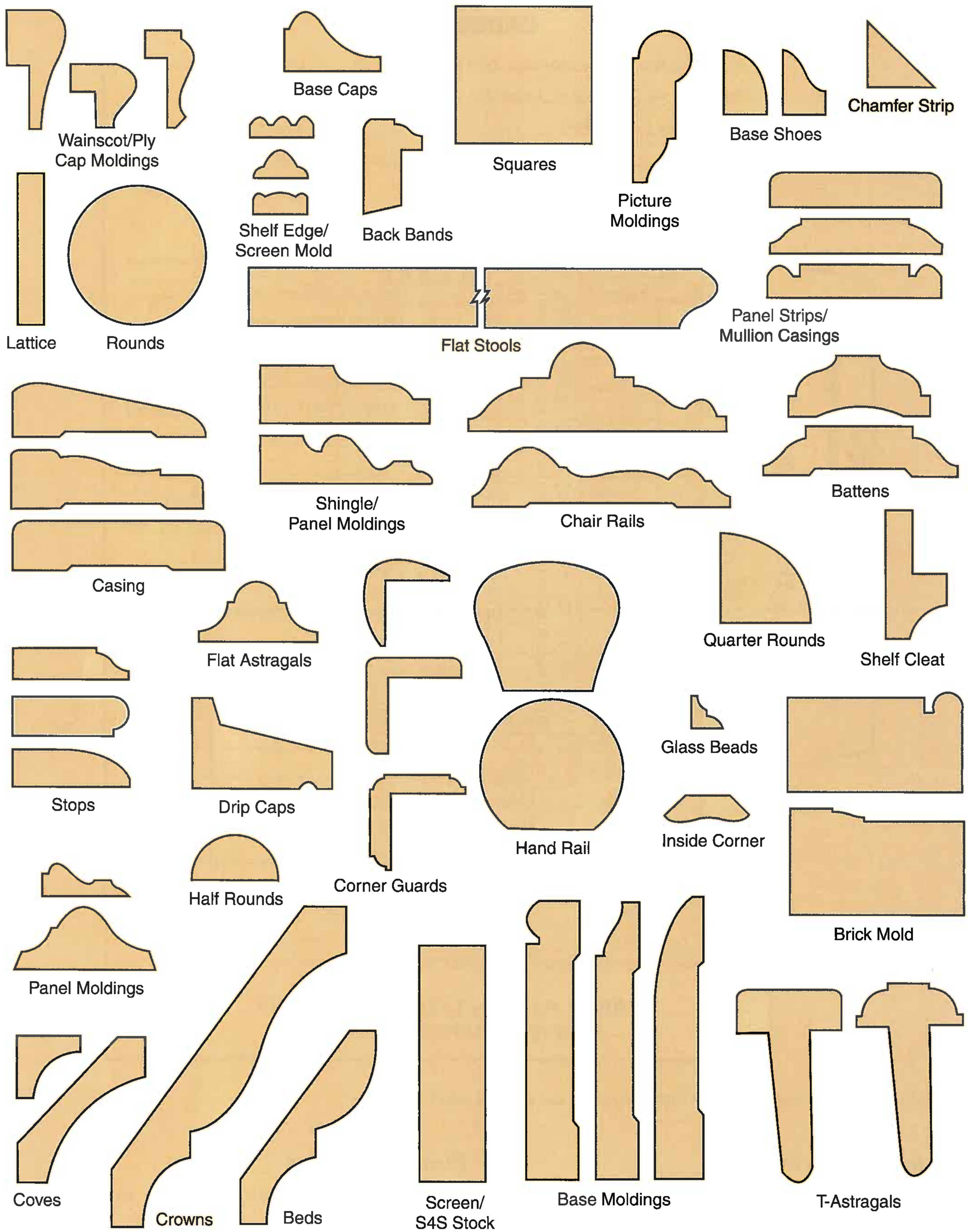


Figure 11-31. Many molding shapes are available.

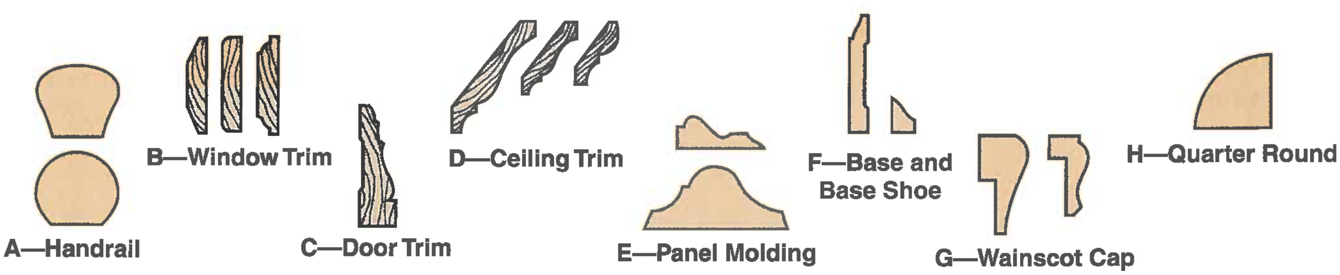


Figure 11-32. Moldings are used as decoration for interiors. (*Congoleum Corp.*)

N-Grade is suitable for natural or clear finishes. The exposed face must be one continuous piece of wood. Based on one 2″ face by 12′ long piece (50 mm by 3.66 m), N-Grade molding may have the following defects:

- A small spot of torn grain, 1′ of medium pitch, light skip in dressing on back.
- One small and one very small pitch pocket.
- One short tight, seasoned check and a light snipe at one end.
- Medium stain in occasional (10%) pieces for one-third the area in an otherwise perfect surface.

P-Grade molding should be the same quality as N-Grade, except that stain is not a defect. Glue joints (laminated or finger joints) must be precision machined and assembled with tight joints. Patching, filling, or plugging is permitted as long as the molding still has a paintable surface.

When ordering millwork, you may specify the type, grade, size, and length. Lengths begin at 4′ and continue in 2′ increments. An example order for molding might be: *4 pieces cove molding—¾″ × 1¾″ × 12′*. Many millwork suppliers provide a catalog showing the patterns and sizes available,

Figure 11-33. Moldings are used on this cabinet to add interest to the piece.

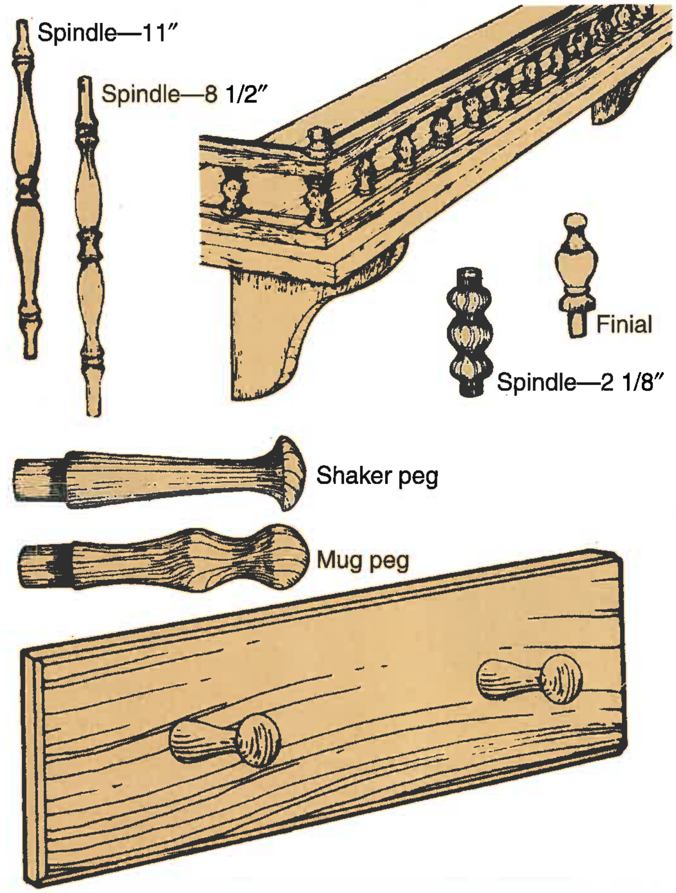


Figure 11-34. Finials add decoration. Spindles add to the appearance, but also perform a structural function.

each identified with a pattern (or catalog) number. You may then order your material with less chance for error. When it is desired to have continuous pieces without joints, it is best to order in this manner. An order for larger quantities may be placed specifying total lineal feet desired, as opposed to number of pieces.

Specialty Items

There are a number of millwork items you can make or buy. Those you buy can save production time. However, they may not be of the specie of wood you are using. Some of these items are legs, spindles, finials, dowels, plugs, buttons, and carvings.

Legs, spindles, and finials

The legs on most tables are produced by millwork companies. ***Spindles*** are used as both support and decoration on stair rails, baby cribs, etc. See **Figure 11-34.** A sample order might read: *1 set (4 per set)—#5936 spindles, 24″ (610 mm).*

Finials are ornaments, such as decorative knobs. William and Mary furniture had finials at the top of arches. Finials are inserted into a hole usually at a peak or on a post for ornamentation.

Dowels

Dowels are round stock used primarily to strengthen joints. A short piece of dowel is glued into two matching holes. Sizes range from 1/8″ to 1″ (3 mm to 25 mm) in diameter, and are usually 36″ or 48″ (914 mm or 1219 mm) long.

Dowels are ordered in bundles of 25 to 1000, depending on diameter size. The ends are usually color coded according to size to prevent mix-up. Precut dowels (dowel pins) come in straight flutes or spiraled grooves. See **Figure 11-35**. These permit glue to spread evenly inside the hole. Straight flute dowel pin diameters range from ¼″ to 7/16″ (6 mm to 11 mm) and lengths from 1¼″ to 2½″ (32 mm to 64 mm). Spiral groove dowel pin diameters range from 5/16″ to ½″ (8 mm to 13 mm) and lengths from 1¼″ to 4″ (32 mm to 102 mm). Metric dowel pins are available in 8 mm diameter and 25 mm, 30 mm, 35 mm, and 38 mm in length.

A longer form of round stock is available to use in a closet as a clothes rod. It is called ***drapery rod***. The diameter is over 1″ (25 mm), most often 1¼″ (32 mm). Lengths vary in feet like molding.

Plugs and buttons

Plugs and buttons are used to cover holes over countersunk screws. ***Flat-head plugs*** fit flush with the face of the wood. ***Round-head plugs*** have a slightly curved surface. See **Figure 11-36.**

Buttons, frequently called *screw hole buttons*, also cover the screw but overlap the edge of the hole. This has advantages over plugs. Buttons will cover chipped edges of a countersunk hole. They can also be removed to tighten the screw if the wood shrinks.

Manufactured wood carvings

Wood carvings can decorate an otherwise plain surface. See **Figure 11-37.** Some are actually carved. Others are produced by pressing wood or wood fibers in a mold. Molded shapes look like hand carved decorations. Carvings will accept both stain and filler.

Summary

Lumber begins its journey to you as a mature tree being harvested. Logging industries select and fell trees for market by sectional felling and systematic felling. Sectional felling is when large sections of a forest are cut at one time with heavy machinery. Clearing large portions of a forest is less expensive than cutting individual trees. Systematic felling is when trees are singled out for harvesting. They may be selected because wood of that specie is needed.

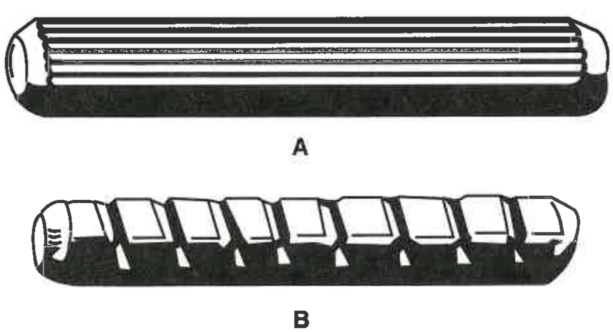


Figure 11-35. A—Dowels are made in varying diameters and lengths. B—Dowels may be straight or spiral fluted.

Figure 11-36. Plugs and buttons cover counter bored holes.

At the lumber mill, logs are loaded onto a jack ladder and transported to a preparation area. There, they are washed and sometimes debarked in preparation for sawing. Lumber is sawed by the three methods of plain sawing, quarter sawing, and rift sawing. Because of increased handling time, quartersawn and rift-sawn lumber are more costly than plain sawn lumber. After sawing, lumber must be dried by air drying or by kiln drying to reduce the moisture content. The drying process is called seasoning.

Lumber defects detract from the appearance and workability of the wood. Cabinetmakers need to know how defects affect both the aesthetic and structural properties of the wood. The three categories of defects are natural defects, defects caused by improper seasoning or storage, and defects caused by machining.

After seasoning, lumber is graded according to quality. Lumber grading is a matter of judgment and experience. Graders rate each piece according to the size of board and amount of defect free lumber in it. The clear cuttings, or yield, of a board needed to achieve a certain grade will differ between hardwood and softwood. It also can differ between species.

Ordering hardwood and softwood lumber involves specifications. A cabinetmaker must deal with qualities, quantities, conditions, and species when ordering materials.

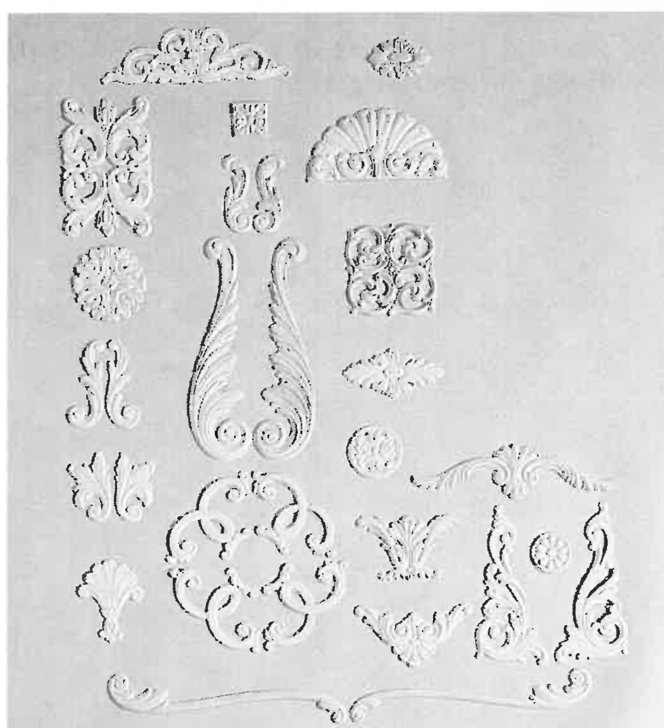


Figure 11-37. Manufactured wood carvings include many shapes and sizes. (*The Woodworker's Store*)

Millwork consists of specialty items frequently processed from molding grade lumber. Example items are molding, trim, and specialty items, such as legs, spindles, finials, dowels, plugs, buttons, and carvings. Only a few wood species are processed into millwork items. These species have excellent machining properties and are less likely to warp.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Why is wood considered a renewable resource?
2. Two methods of harvesting are _____ and _____.
3. List the three methods of sawing logs. Give advantages and disadvantages of the boards produced by each.
4. After lumber is sawed, it is dried to reduce the _____.
5. The moisture content of construction grade lumber is approximately _____%.
   a. 2
   b. 10
   c. 20
   d. 30
6. List five classifications of knots.
7. Three defects caused by mold and fungus are _____, _____, and _____.
8. Illustrate five types of warp.
9. List three wood defects caused by improper seasoning.
10. Describe the lumber defects often incurred during surfacing.
11. Identify four hardwood factory grades for cabinet making lumber.
12. An example of finished market grade lumber is _____.
    a. a surfaced 2 × 4
    b. RWL hardwood
    c. dimension grade hardwood
    d. molding
13. Two grading systems for softwoods are _____ and _____.
14. What is the difference between factory grade hardwood and factory grade softwood?
15. Remanufacture grade softwoods have a moisture content that ranges from _____% to _____%.
    a. 6;12
    b. 10; 20
    c. 25; 30
    d. None of the above.
16. Lumber grading systems are established by _____ and _____.
17. Random Widths and Lengths (RWL) lumber is sold by _____.
18. Determine the board feet in two pieces of ½″ × 8″ × 6′ of rough sawn, kiln-dried Willow which is FAS grade. Write an order for the wood.
19. Determine the board feet in three pieces of 1 1/32″ thick × 9 ½″ × 10′ kiln-dried White Pine, which is surfaced on two sides and A Select finish grade. Write an order for the wood.
20. Explain the difference between spindles, finials, and dowels.

12

Cabinet and Furniture Woods

Objectives

After studying this chapter, you will be able to:

- Identify wood species based on viewing a sample.
- Classify woods according to certain characteristics, such as color, hardness, texture, and grain pattern.
- Describe present and potential applications for each wood species.
- Select woods that may be substituted for another, more expensive wood.

Important Terms

closed grain
color
cross grain
density
dimensional stability
genus
hardwood
luster
machining/working qualities
open grain
softwood
species
texture

Wood is the most versatile material used by humans when shaping their living environment. In an age of synthetic and metal surroundings, wood still serves many needs. It forms the shape of our houses and decorates our interiors. It provides structure for case goods that store our belongings.

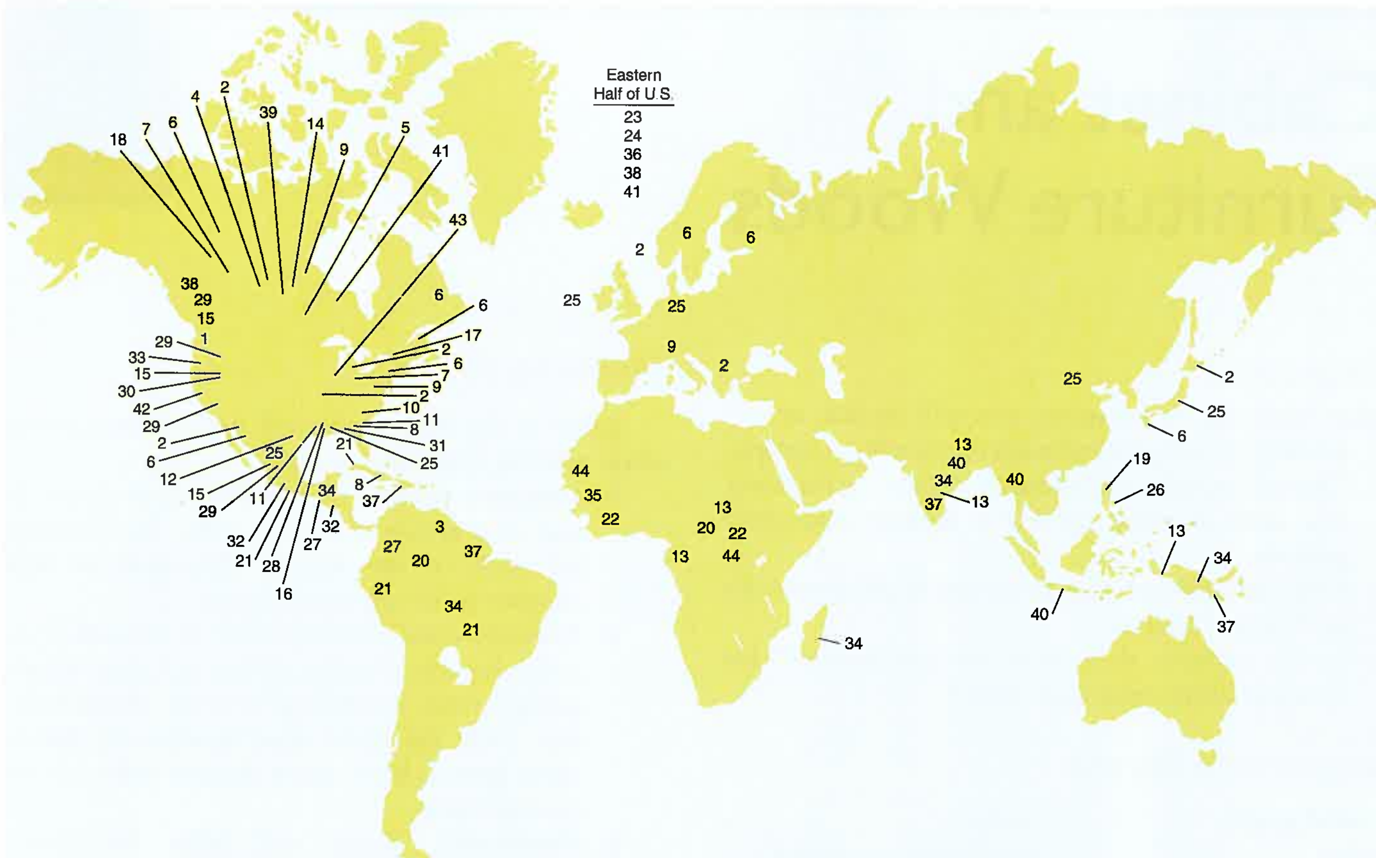
Besides being a structural material, wood conveys an aesthetic beauty which few materials can match. Today, as in centuries past, hardwood furnishings are preferred by those who want the finest that nature can offer. Although wood grain plastics may cover much of today's furniture, they cannot fully imitate solid wood.

Various species of wood grow in all parts of the world. See **Figure 12-1**. Each has different properties, including color, density, flexibility, etc. Woods of the same species even may differ in color and hardness. Identifying wood species requires careful analysis. You must look at grain pattern, pores, color, odor, weight, and hardness. Wood for furniture should be less likely to warp or shrink and have a pleasing appearance.

Terms to Know

Some of the terms you will need to remember when reading this chapter are:

- ***Common name***. The general name given to one or a group of tree species. The heading for each of the woods discussed in this chapter is the common name.
- ***Genus/species***. Classification of the tree. This is the botanical name, given in Latin, which groups trees according to their characteristics. Only the most used species are listed. Most genera have more species than can be covered here.
- ***Hardwood***. Wood cut from deciduous (broadleafed) trees.
- ***Softwood***. Wood cut from coniferous (pine and evergreen) trees.
- ***Earlywood***. Growth that occurs in the spring.
- ***Latewood***. Growth that occurs in the summer.
- ***Annual ring***. A ring caused by the addition of earlywood and latewood growth to the trunk of a tree.
- ***Open grain***. Wood that has large pores which are cut open during machining.
- ***Closed grain***. Wood that has small pores.
- ***Cross grain***. Growth that occurs at an angle to the normal grain direction. Cross grain is difficult to surface.
- ***Texture***. The smooth or rough feel of the wood surface. Wood with open grain is usually more coarse than that with closed grain.
- ***Dimensional stability***. A measure of how likely the wood is to swell or shrink when exposed to moisture. A high level of dimensional stability is preferred.
- ***Density***. Discussed in *Chapter 10*, density is a measure of the mass of the wood.
- ***Luster***. Woods with high luster appear shiny when sanded smooth.
- ***Heartwood***. The inner layers of a tree that consist of inactive cells.
- ***Sapwood***. The outer layers of a tree that carry food and water.



1 Alder, Red
2 Ash
3 Banak
4 Basswood
5 Beech
6 Birch
7 Butternut
8 Cedar, Aromatic, Red
9 Cherry
10 Chestnut
11 Cottonwood
12 Cypress, Bald
13 Ebony
14 Elm, American
15 Fir, Douglas
16 Gum, Red
17 Hackberry
18 Hickory
19 Lauan (Philippine Mahogany)
20 Limba
21 Mahoganies, genuine
22 Mahogany, African
23 Maple, Hard
24 Maple, Soft
25 Oak, Red and White
26 Paldao
27 Santos Rosewood (Pau Ferro)
28 Pecan
29 Pine, Ponderosa
30 Pine, Sugar
31 Pine, Yellow
32 Primavera
33 Redwood
34 Rosewood
35 Sapele
36 Sassafras
37 Satinwood
38 Spruce
39 Sycamore
40 Teak
41 Tulip, American (Yellow Poplar)
42 Walnut, American
43 Willow
44 Zebrawood

Figure 12-1. Wood is a world-wide natural resource. Many of the species grow in North America.

- *Color*. Color is always associated with the heartwood, as it is preferred by cabinetmakers. The color of sapwood may also be given.
- *Machining/working qualities*. Tells how easily the wood can be cut, surfaced, sanded, or processed by other means.

Wood Species

There are well over 100,000 species of wood in the world. More than 4000 have been put to use. The most popular species found in cabinets, furniture, molding, and paneling are discussed in this chapter. Most of those listed are hardwoods. Selected softwoods are covered because they are used for various millwork or specialty products. A summary of the characteristics of each wood species is included at the end of the chapter.

Red alder

Genus: ALNUS. Principal lumber species: *rubra*. See **Figure 12-2**.

Characteristics: ***Red alder*** is relatively lightweight for a hardwood. Yet, it has fine texture and good impact resistance. There is no apparent difference in earlywood and latewood. The heartwood is a pale roseate color and the luster is low. The sapwood is a slightly lighter color. Red alder has fine machining and finishing qualities and will stain easily to blend with more expensive woods.

Red alder is a member of the birch family found from Alaska to southern California. It grows mainly in moist areas of Oregon and Washington. It is a good utility furniture wood. Exposed parts are typically stained to blend with walnut, mahogany, or cherry

Figure 12-2. Red alder. *(Fine Hardwood Veneer Assoc.)*

veneers. Its stability and superior tack holding power makes it perfect for upholstery framing.

The wood is used mainly west of the Rockies. High shipping costs make it noncompetitive with similar native woods in midwestern and eastern U.S.

Ash

Genus: FRAXINUS. Principal lumber species: *americana* (white ash); *nigra* (black ash); *pennsylvanica* (red ash) or (green ash). See **Figure 12-3.**

Characteristics: ***Ash*** is a heavy, hard, strong, and tough wood. It machines and bends well. The contrast between earlywood and latewood is very apparent. The grain pattern is straight. White ash heartwood is cream to light brown; the sapwood is lighter. Black ash heartwood is dull to greyish-brown. Sapwood is off-white to light tan. Other species are light brown to tan with variations in heartwood and sapwood color.

The ash belongs to the Olive family. There are about 70 species in the genus, including shrubs as well as trees. These are found in the northern hemisphere only, except in extremely cold areas. Eighteen species are native to the U.S. The three species, *americana*, *nigra*, and *pennsylvanica*, supply nearly 98% of the ash lumber.

White ash is one of the best known and most useful hardwoods. The wood is hard, and strong compared to its weight. It is able to resist a succession of shocks that would destroy other woods of the same density. White ash can be found as ball bats, hockey sticks, tool handles, and boat oars. It is also used in furniture designs that require little bulk but great strength. Ash has no taste, making it useful for food containers.

White ash, green ash, and red ash are commonly sold as *white ash*. Black ash is sold as northern brown ash or brown cabinet ash. The grain pattern is similar to that of the white ash, but color is more distinct. Brown cabinet ash is more beautiful in furniture and wall paneling than is white ash.

All ash species are noted for stability. They are less apt to warp, shrink, or make other dimensional changes than most native hardwoods.

Banak

Genus: VIROLA. Principal lumber species: in Central America, *koschnyi*; in northern South America, *sebifera* and *surinamensis*.

Characteristics: ***Banak*** is a medium-textured, low-density wood. It has a light, pinkish-brown color and medium to high luster. It generally is straight-grained and easy to work. It glues easily and holds fasteners well. Fine finishes can be applied with a handsome, but plain, appearance.

A large volume of banak is entering the U.S. as a mahogany substitute. It is used widely in the production of wood moldings, core stock for doors, and paneling. It is too soft for purposes where

Figure 12-3. Left—Ash has a fairly straight grain pattern. Right—This contemporary style with European influence uses ash solids and veneers. (*Fine Hardwood Veneer Assoc.*)

strength and impact damage are considerations. When kiln-dried, it weighs only about 2½ pounds per board foot. It does not resist decay because of its starchy composition, but is available at a reasonable cost. It is a good softwood substitute.

A wood related to banak is sold in the U.S. as virola. Virola is of the genus Dialyanthera, and the principal lumber species are otoba and gordonifolia. The two genera, Dialyanthera and Virola (banak wood) are closely related. Both are members of the nutmeg family. The woods are similar in characteristics, except that banak is slightly firmer in texture. It also has somewhat better machining characteristics.

Basswood

Genus: TILIA. Principal lumber species: *Americana*. See **Figure 12-4**.

Characteristics: ***Basswood*** is one of the softest and lightest hardwoods in regular commercial use. It has fine, even grain, and exceptional stability. It has little contrast between earlywood and latewood. Heartwood is a very light brown and sapwood is nearly white. Basswood has good machining and sanding characteristics.

Figure 12-4. Basswood is a widely used soft hardwood.

Basswood is a member of the linden family, and is sometimes called *linn*. It is favored for technical uses, including venetian blinds, drawing boards, picture frame moldings, and wooden toys. These items favor basswood's clean looking, attractive, lightweight qualities. Machining must be done carefully as the wood is apt to split. Like ash, it has no taste, making it suitable for food containers. It is largely used as veneer core stock for plywood.

Basswood is found in the eastern U.S., half of which is located in the Lake Superior region. Northern basswood has some advantages over southern lumber, probably due to slower growth. It is soft, even textured, and relatively free from internal stress.

Beech

Genus: FAGUS. Principal lumber species: *grandifolio*, only one in U.S. and Canada. See **Figure 12-5**.

Characteristics: ***Beech*** is a heavy, hard, strong wood with good resistance to abrasive wear. Beech bends easily and is not apt to split. It is a good substitute for hard maple, although the surface is slightly coarser in texture and darker in color. Beech machines cleanly, and can be abraded smoothly to a medium luster. It can be finished comparable to more expensive woods. It has a pale to rich reddish-brown heartwood and lighter sapwood. It is odorless and tasteless.

Figure 12-5. Beech. (*Fine Hardwood Veneer Assoc.*)

There are seven or eight species in the world, only one of which is grown in the U.S. Beech is related to oak and chestnut. It grows in the eastern one-third of the U.S., and adjacent Canadian provinces. The greatest production is in the central and middle Atlantic states. Beech also is popular in Europe and Japan.

Some users feel that northern beech machines and finishes more beautifully than southern specimens. The difference, although small, may be due to different soil and climate.

Beech is used for a number of purposes. These include flooring, furniture (especially provincial styles), crates, boxes, millwork, turnings, handles, and food containers. Like hard maple, but less costly, beech is valuable as flooring. It is able to withstand heavy foot traffic. It accepts a variety of stains and is well suited to lacquer or varnish finishes.

Birch

Genus: BETULA. Principal lumber species: *alleghaniensis* (yellow birch); *lenta* (sweet, black, or cherry birch); and *papyrifera* (paper, canoe, or white birch). See **Figure 12-6**.

Figure 12-6. Top—Yellow birch. Bottom—Paper birch is less decorative than other related species. (*Fine Hardwood Veneer Assoc.*)

Characteristics: ***Birch*** is a moderately heavy, hard, and strong wood. It has excellent machining, bending, and finishing characteristics. Birch has reddish-brown heartwood and yellowish-white sapwood that often has a trace of pink tint.

Yellow birch grows in southeastern Canada, the Great Lakes States, New England, and the Appalachian region as far south as Georgia. Commercially, it is the most important of the birches.

Sweet birch is found from Newfoundland and Ontario, through New England, to the southern Appalachians. It is a little denser and deeper in color than yellow birch. Where the two are cut together, they are sold simply as birch.

Birch species are decorative, except for paper birch that grows in much the same range as sweet birch (in Maine). Sapwood makes up the greater portion of the tree. It is ideal for turning. *Paper birch* is somewhat hard, uniform in texture, with fine grain. It is one of the best woods for dowels, spools, handles, etc. Other turned products include toothpicks, clothespins, and shoepegs.

Birch is particularly popular for furniture, flooring, doors, and interior trim. It is a good cabinet wood when strength and hardness are desired. It is sometimes available as *selected white birch* (all sapwood one face), and *selected red birch* (all heartwood one face). Most users prefer birch that contains portions of both heartwood and sapwood, available as *natural birch.*

Birch is also the most popular of the decorative plywood veneer faces. Vast amounts of birch plywood are consumed every year, much of which is imported from Japan. *Japanese birch* looks the same as American birch.

Butternut

Genus: JUGLANS. Lumber species: *cinerea;* only species. See **Figure 12-7**.

Characteristics: ***Butternut*** is relatively soft and weak. It does not bend well and is likely to split. The texture is rather coarse, but it sands well and can be polished to a satin luster. Because of its low density, it is easy to work and will machine well. Butternut has light brown or fawn heartwood and slightly lighter sapwood.

Figure 12-7. Butternut has a light brown heartwood. It is easy to work and machines well. (*Fine Hardwood Veneer Assoc.*)

Butternut is a member of the walnut family. It is better known for its edible nuts than its lumber. The tree grows from southern New Brunswick and Maine, through the upper peninsula of Michigan, to eastern South Dakota. It is then found southward into northern Arkansas and the mountains of Alabama and Georgia.

When butternut grows in open spaces, the trunk is short. It branches out just above the ground. Occasionally found in forests, the trees may reach heights of 100′ (30.5 m) and diameters of 4′ (1.2 m). The supply of butternut is diminishing. The tree is short lived as the widely branched crown is weak and susceptible to breakage by storms or heavy loads of snow. Injuries leave the trees open to fungus diseases and insects.

The grain pattern of butternut closely resembles that of its relative, black walnut. Yet, butternut is much softer and lighter in color. It is sometimes called *white walnut*. It is preferred by some architects and designers over black walnut for wall paneling because of its light, cheery color. Butternut is often used in making church altars.

Butternut is a good cabinet wood, although relatively weak. It is used for interior trim, cabinets, and boat trim (due to its natural oils).

Aromatic red cedar

Genus: JUNIPERUS. Principal lumber species: *virginiana*. See **Figure 12-8**.

Characteristics: ***Aromatic red cedar*** trees are softwoods. The tree is an evergreen, with closed-grain wood. It has medium density and is brittle, yet very durable. The wood has a pleasing and lasting scent. The heartwood is red and the sapwood is white.

Figure 12-8. Aromatic red cedar serves as a liner for chests and closets.

Red cedar, or aromatic cedar, is not actually part of the cedar family. It belongs to the cypress family. In fact, the wood we call cypress does not belong to the cypress family. This shows how names and families do not always match.

Red cedar is cut from small timber. The lumber is therefore small in width and only average in length. It is very knotty and contains a great deal of sapwood. Red cedar cannot be bought as clear lumber, heartwood, or in wide widths.

Aromatic cedar gives off a unique scent. Most persons have smelled it when opening a cedar chest or cedar-lined closet. In spite of popular belief, the aroma does not repel moths. Cedar is also used for novelty furniture, wall paneling, and pencil slats. The sawdust is distilled for the aromatic oils.

Cherry

Genus: PRUNUS. Lumber species: *serotina*. See **Figure 12-9**.

Characteristics: ***Cherry*** is a medium weight, hard and stable wood. It is closed grain with visible annual growth. Cherry machines and sands to a glasslike smoothness. It can be bent when moistened. The heartwood is reddish-brown, sometimes with greenish cast; the sapwood is yellowish-white.

Lumber from any fruit trees is commonly called *fruitwood*. Cherry falls into this category. Like all fruit trees, cherry belongs to the rose family. Under poor growing conditions a Prunus serotina is a small, scrubby tree. In the rich moist soil of the Appalachian regions it may reach heights of 100′ (30 m) or more. Diameters of 4′ to 5′ (1.2 m to 1.5 m) are fairly common.

Figure 12-9. Cherry is one of the most popular hardwoods. It sands exceptionally smooth and has a high luster. (*Fine Hardwood Veneer Assoc.*)

Cherry is regarded as one of the top furniture hardwoods. In this country, it is second only to walnut. Although one of the finest cabinet woods, cherry is relatively scarce. The once large timber resource has been cut. Top quality cherry is rarely found. Woodworkers face having to dispose of knots and other defects.

Chestnut

Genus: CASTANEA. Principal lumber species: *dentata.* See **Figure 12-10.**

Characteristics: ***Chestnut*** is a low-density, coarse-textured, durable hardwood. It machines easily. The wood has prominent open-grained annual growth rings.

Figure 12-10. Most chestnut trees were killed by fungus. Wood which is left is quite wormy. (*Fine Hardwood Veneer Assoc.*)

Chestnut was once an important timber tree of the Appalachian region. Due to the chestnut blight, a parasitic fungus, the species has been almost entirely destroyed. The remaining timber, standing dead for several decades, is quite wormy.

The wood, from dead trees, is still used for wall paneling, chests, etc. It gives a distinctively rustic effect. At one time, it provided material for interior trim, furniture, shingles, and fence posts. It is one of the most durable native hardwoods.

Cottonwood

Genus: POPULUS. Principal lumber species: *deltoides* (eastern cottonwood); *heterophylla* (swamp or river cottonwood); *trichorcarpa* (black cottonwood); and *balsarnifera* (balsam poplar or Balm of Gilead). See **Figure 12-11.**

Characteristics: ***Cottonwood*** is soft and lightweight. It is a closed-grained hardwood that is coarse

Figure 12-11. Cottonwood is soft and light in weight, but difficult to split. (*Fine Hardwood Veneer Assoc.*)

in texture and difficult to split. It machines easily but contains minerals which dull cutting edges on most tools. Carbide-tipped tools are used with cottonwood. Cottonwood is low in luster and finishes poorly because of the minerals. The heartwood is very light brown, often with a grayish tint. The sapwood is lighter. The annual rings are hardly visible.

Eastern cottonwood is scattered over the entire eastern half of the U.S. *Swamp* or *river cottonwood* is abundant in the south Atlantic and Gulf regions of the Mississippi Valley. *Black cottonwood* is the largest hardwood tree of the West Coast. It grows from southern Alaska to southern California. It is sometimes called western poplar. It is also called balsam poplar in Canada, Alaska, and along the northern border of the U.S.

Cottonwood is used primarily for boxes and food crates. Resistance to splitting and little taste or odor are important for these uses. Other uses include mill products, woodenware, core stock for plywood, and pulp for paper. Cottonwood is hard to finish with beauty.

Cottonwoods are in the true poplar family, a branch of the willow family. The tree we commonly know as *yellow poplar* is really a magnolia. Its name has recently been changed to *American tulipwood.* Cottonwoods are in the same genus as the aspens and poplars. Cottonwood and aspen are almost identical. Aspen is used only as pulp in papermaking.

Cypress

Genus: TAXODIUM. Principal lumber species: *distichurn.* See **Figure 12-12.**

Characteristics: ***Cypress*** is lightweight, soft, and easily worked. It is rather coarse in texture. The heartwood of deep swamp and yellow cypress is a light orange-brown color. *Tidewater cypress* is darker and redder. The heartwood of cypress, particularly

Figure 12-12. Cypress is very durable when placed in a decay-promoting environment.

Figure 12-13. Ebony is a very dark, dense hardwood.

tidewater cypress, has a reputation for durability. However, careful seasoning is necessary to prevent hairline checking.

Bald cypress is the name commonly given to this species, yet it is not a true cypress. It belongs to a family that includes redwood. It grows in swamps and streams. You find it from southern New Jersey to Texas in a wide coastal strip. From there, growth is found up the Mississippi Valley to southern Indiana and Illinois. The most valuable timber, tidewater cypress, grows along gulf swamps close to the sea.

Durability, when exposed, sets cypress apart from most other American woods. Cypress is excellent for exterior use as siding, water tanks, small boats, etc. In the areas that produce cypress, the best grades are widely used for millwork of all kinds. It is somewhat weak for furniture, but is attractive as wall paneling.

Cypress trees over 200 years old are subject to attack by fungus. The fungus produces the lumber defect known as *peck*. The fungus dies when the tree is cut, leaving residue and holes. *Pecky cypress* is widely used for greenhouse benches because it is not affected by soil organisms. It is also used as paneling to give a rustic effect.

Ebony

Genus: DIOSPYROS. Principal lumber species: *celebica* (macassar ebony). See **Figure 12-13**.

Characteristics: ***Ebony*** is a dense, closed-grain hardwood with very distinctive grain pattern. Its color is dark brown to black with large portions streaked with yellowish-brown or gray. The density of ebony makes it very hard to work.

Several species of the Diospyros genus are available. Macassar ebony, from the East Indies, is the most common because of its pronounced grain pattern. Solid black ebonies are found in Gaboon, Angola, and Sri Lanka.

Ebony is commonly used for inlays and marquetry. It also is turned into decorative handles and other ornamental work.

Elm

Genus: ULMUS. Principal lumber species: *fulva* (slippery elm or red elm); *racemosa* (rock, cork, or hickory elm); *americana* (American or white elm). See **Figure 12-14**.

Figure 12-14. Top—American elm. Bottom—Red elm. Both are scarce due to Dutch elm disease. (*Fine Hardwood Veneer Assoc.*)

Characteristics: ***Elm*** is very strong and tough for its weight. A medium-density wood, elm is both elastic and shock resistant. It machines well, but the texture is rather coarse. Annual rings are clearly defined. Elm stains and fills well. The heartwood color is pale brown, and occasionally dark brown. Slippery or red elm wood is light with a grayish hue.

White elm is the most known elm species. It once lined streets of most cities from the Midwest eastward. The wood is used in manufacture of baskets, particularly rims and bent handles.

In recent years, the white elm has been subject to *Dutch elm disease*. The disease kills all growth of the tree.

Slippery elm or *red elm* is sold as *northern gray elm*. It is the best elm for cabinet work. This is due to its soft and even texture. It is also light and uniform in color.

Rock elm is more dense and shock resistant than other elm species. It is used mainly for industrial purposes requiring strength.

Douglas fir

Genus: PSEUDOTSUGA. Principal lumber species: *menziesii*. See **Figure 12-15**.

Characteristics: ***Douglas fir*** is a soft, coarse-textured, nonporous softwood. The annual rings are clearly marked by the color of earlywood and latewood. It works easily, but has low luster. Heartwood color varies from pinkish-yellow to reddish-brown, depending on conditions of growth. The sapwood is lighter.

Figure 12-15. Douglas fir has widespread use for plywood and mill products.

Douglas fir is a valuable timber tree. It produces large amounts of softwood lumber and veneer. Inland growth produces smaller timber that is harder and redder in color. It tends to have cross grain in it and is knotty.

Coastal timber grows up to 325′ (99 m) high and 17′ (5.2 m) in diameter. It produces most of the lumber known as Douglas fir or Oregon pine. Timber size permits the manufacture of vast amounts of lumber from each felled tree. Each results in a variety of grades. The best logs are cut into veneer for use as Douglas fir plywood. Lumber is widely used for mill products including doors, sash, interior trim, and moldings.

Inland California Douglas fir grows in the mountains and tends to be softer and of more even growth than coastal timber. It is redder in color and is sometimes marketed as *California red fir*.

Red gum

Genus: LIQUIDAMBAR. Principal lumber species: *styraciflua* (red or sweet gum, sap gum); only species. See **Figure 12-16**.

Characteristics: ***Red gum*** is moderately hard and strong. It has closed grain and will finish with beauty. It is easily machined, but has poor dimensional stability. Red gum heartwood is brown or reddish-brown, sometimes figured with dark markings. Sapwood is an off-white color.

Figure 12-16. Red gum is often figured with dark markings. (*Fine Hardwood Veneer Assoc.*)

Gum is one of the most important timber trees of the southern U.S. It is an example of the change brought by advances in technology. Seventy-five years ago the *sweet gum* was regarded as having little or no value. It was difficult to season. Newer drying techniques permit gum to be processed into furniture and other products. It is one of the most used hardwoods.

Gum has a wide band of sapwood in the trunk. Only mature trees have any heartwood at all. Very large trees can produce the clear, selected red wood favored by woodworkers. However, you must cut out knots and other defects.

Sap gum is not another species. It is red gum with too much sapwood to qualify as selected red gum. Occasionally, you find boards that are all sapwood, but most contain heartwood and sapwood. Selected red gum is all or nearly all heartwood on one face.

Gum is grown across the entire southeastern U.S. It favors moist, rich soil and grows best in river bottoms close to the Gulf, southern Atlantic regions, and the Mississippi Valley. Maximum size is about 150′ (45.7 m) high and 5′ (1.5 m) in diameter.

Gum stains well to match other lumber. In furniture, it is often used with more valuable woods. Most flush doors produced in the South have gum veneer faces. Large quantities of gum are processed into plywood and veneer each year.

Hackberry

Genus: CELTIS. Principal lumber species: *occidentalis* (hackberry); and *laevigata* (sugarberry). See **Figure 12-17**.

Characteristics: ***Hackberry*** is a medium density hardwood. It is creamy white with a grayish hue. There is little difference in color between heartwood and sapwood. The annual rings are clearly visible. It is widely used for interior trim and cabinetry.

Figure 12-17. Hackberry, a member of the elm family, is often substituted for American elm. (*Fine Hardwood Veneer Assoc.*)

Hackberry is common, though scattered, throughout the eastern half of the U.S. Sugarberry grows mostly in the southeastern states and is more plentiful. However, the hackberry name is still used for sugarberry lumber.

Hackberry species are members of the elm family. They are gaining popularity as elm substitutes because of similarities to elm. Hackberry is plentiful. Elm is becoming scarce due to Dutch elm disease. Hackberry is resistant to the disease.

Hackberry that is not handled properly will develop sap stain. Sap stain is noted by odd coloring. The wood must be seasoned quickly with caution to prevent this. When care is taken, hackberry is one of the most beautiful American hardwoods.

Hickory

Genus: CARYA. Principal lumber species: *ovato* (shagbark hickory); *laciniosa* (big shellbark hickory); *tomentosa* or *alba* (mockernut hickory); and *glabra* (pignut hickory). See **Figure 12-18**.

Figure 12-18. Hickory is strong and elastic. It is valued for bent laminations, such as skis. (*Fine Hardwood Veneer Assoc.*)

Characteristics: ***Hickory*** is a very hard, elastic, and strong hardwood. It is the toughest American wood and provides the strength for athletic equipment, ladder rungs, etc. It machines, turns, and steam bends well. It has distinct growth rings. The heartwood is light reddish-brown or tan and the sapwood is creamy white.

Hickory and *pecan* are members of the walnut family. The two are so closely related that individual specimens of hickory and pecan are difficult to identify. An inspector of the National Hardwood Lumber Association will not attempt to separate the two once they are mixed.

Hickory and pecan are slow growing trees. They require 100 years or more to attain timber size. They are scattered across the eastern half of the U.S. and are often found growing with other hardwoods.

Hickory timber is valuable because of its toughness and elasticity. It is used for molded and bent laminations that require great strength. One example is skis. It is also famous for its use in smoking meats. The *hickory flavor* given smoked food is unique.

Lauan

Genus: SHOREA (red and tanguile lauans); PENTACME (white lauan). Principal lumber species: *negrosensis* (red lauan); *contorta* (white lauan); *polysperma* (tanguile). See **Figure 12-19**.

Characteristics: ***Lauans*** are a medium-density, coarse-textured hardwood with red tint. *Tanguile* is a dark reddish-brown; red lauan is red to brown; and white lauan is light brown to light reddish-brown. Tanguile has a coarse texture and white lauan has cross grain in it. Red lauan has larger pores, whereas tanguile has smaller pores and finer texture.

Figure 12-19. Red lauan is more commonly known as Philippine mahogany.

Lauan grows in the Philippines, West Malaysia, Sarawak, Brunei, and Indonesia. *Red lauan* is often called *Philippine mahogany*, although not related to the mahogany family. The Philippine islands were the principle source of Lauan, but they no longer produce logs in commercial quantities. The forests have been logged out. Lauans are more coarse grained and stringy compared to tropical American and African mahoganies. They require a greater amount of sanding to produce a finished surface. They are also much less stable under moisture changes.

Lauan is most commonly used as a veneer core for hardwood plywood. Lauans offer a less expensive alternative to African and American mahoganies for furniture, doors, moldings, and cabinets.

Limba

Genus: TERMINALIA. Principal lumber species: *superba*. See **Figure 12-20**.

Characteristics: ***Limba*** has a medium hardness and texture. It machines, glues, and finishes well. It is pale yellow to light brown with large pores. This coloring is often called *natural blonde*, a tint that is desired in contemporary furniture. Limba is open grain, but finishes well with the application of filler.

Figure 12-20. Limba, because of its blonde color, is often selected for contemporary furniture.

Limba comes from Congo and Zaire. It is currently not produced in volume but has great potential.

Genuine mahoganies

Genus: SWIETENIA. Principal lumber species: *rnacrophylla* (tropical American mahogany); *mahagoni* (Cuban mahogany). See **Figure 12-21**.

Characteristics: ***Mahogany*** is a moderately dense and hard wood with great strength in comparison to its weight. It is stable and durable in situations favoring decay. It has unsurpassed working, bending, and finishing characteristics. It has large open pores that need filler for most finishes. It has an even texture with visible annual growth rings. The color is medium reddish-brown but darkens over time to be a deep, rich, golden brown or reddish brown.

Figure 12-21. Genuine mahoganies are valued for their appearance, texture, and working qualities.

Many woodworkers regard genuine mahoganies as premier cabinet woods. It has all the characteristics for fine furniture, interior trim, and cabinetry. It is a superb carving and turning wood.

Only the genus Swietenia may be sold as *mahogany*. Any other genus must have a prefix, such as *African mahogany*. *Philippine mahogany* is not a mahogany at all; it is a lauan and should be sold as such.

Both Cuban and tropical American mahoganies have highly figured grain. Cuban mahogany is heavier and harder than similar species. It is extremely durable and wears exceptionally well.

African mahogany

Genus: KHAYA. Principal lumber species: *ivorensis*. See **Figure 12-22.**

Characteristics: ***African mahogany*** has much the same qualities as genuine mahoganies. All are related botanically, hence, are similar in cell structure and appearance. Woodworkers consider American mahogany superior in working, finishing, and other technical properties. African is more figured with crotch, swirl, and broken stripe grain patterns.

Figure 12-22. African mahogany, although coarser and harder to work with, is often selected over genuine mahogany because of its figured grain pattern. (*Fine Hardwood Veneer Assoc.*)

The texture of African mahogany is more coarse than genuine mahogany. It will accept stain better. Be careful when finishing furniture that uses genuine mahogany for structure covered with African mahogany veneer for appearance. Exposed parts of the genuine mahogany will finish differently than the African mahogany veneer.

Hard maple

Genus: ACER. Principal lumber species: *saccharum* (sugar maple); and *nigrum* (black maple). See **Figure 12-23.**

Characteristics: ***Hard maple*** is a heavy and strong wood. It is famous for resistance to abrasive wear. Hard maple has visible, but not prominent, annual growth rings. The wood has no odor or taste. It does not require filling because the texture and grain are very fine. Heartwood color is very light brown or tan, sometimes with darker mineral streaks. Softwood is white or off-white. The saccharum and nigrum species are so closely related that both are sold as hard maple.

Figure 12-23. Hard maple has an indistinct grain pattern. (*Fine Hardwood Veneer Assoc.*)

Hard maple is the most valuable and most plentiful member of the maple family. It grows in the eastern U.S. and Canada. The best wood comes from near the Great Lakes, the St. Lawrence Valley, and northern New England. The tree is also called *sugar maple* because of the sweet sap that flows from it during early spring. This sap is the source of maple syrup.

The excellent technical properties of hard maple make it suitable for industrial uses. Its resistance to wear makes it a leader for flooring. Well-made hard maple furniture often outlasts the owner. It is suitable for turnery, wooden dishes, and a variety of mill products.

Some trees develop special grain figures such as curly grain, mottle, and bird's eye. Mottled grain is a less distinct grain direction because wood rays cut across the grain. Bird's eye grain has no visible grain direction; dark circles cover the board in a scattered pattern. It was once thought that bird's eye figure was caused by birds pecking at the wood. Although this claim has been disputed, no cause for bird's eye has been found.

Soft maple

Genus: ACER. Principal lumber species: *rubrum* (red or swamp maple); and *saccharinurn* (silver or white maple); *negundo* (box elder). See **Figure 12-24.**

Characteristics: ***Soft maple*** has medium density and hardness. It is stable and has good machining

Figure 12-24. Soft maple is often wormy. (*Fine Hardwood Veneer Assoc.*)

and finishing properties. The grain is fine textured since the pores are small. Growth rings are not distinct. The color of the heartwood varies from pale tan to reddish-gray, sometimes streaked. Sapwood is off-white to white.

Soft maple is not actually soft compared to most woods. However, it is softer than hard maple. Soft maple trees are found across most of the eastern half of the U.S. *Silver maple* is less abundant than red maple except in the Mississippi Valley.

Most soft maple is used in the furniture industry. Higher maple grades are used to produce colonial style furniture. Lower grades are used in boxes, crates, and other shipping containers. Maple is odorless and tasteless, permitting its use for handling food.

Particularly in the South, soft maple contains spot worm holes. Thus, specifications for southern maple include *WHAD* (worm holes a defect) or *WHND* (worm holes no defect). The worm holes in WHAD are small and may be easily filled. Worm holes are never so numerous in either grade that they detract from a painted finish.

The *box elder* is a third soft maple that furnishes limited amounts of lumber. Most box elder trees branch out near the ground. Tall trees are seldom found. Lumber from box elder trees is mixed with other soft maple lumber.

Oak

Genus: QUERCUS. Principal lumber species: *rubra* (red oak); *alba* (white oak); and *robur* (English brown oak). See **Figure 12-25**.

Characteristics: ***Oak*** is a very heavy, hard, and strong hardwood. It works, turns, carves, and bends well considering its density. Sanding and finishing

Figure 12-25. Oak, especially white oak, is a popular choice for contemporary furniture. (*Fine Hardwood Veneer Assoc.*)

qualities are excellent. It is also dimensionally stable. Oak has large pores that usually require filler before finishing. The heartwood color of red oak is reddish or light reddish-brown. White oak heartwood is light tan or light brown.

The oaks comprise the most important group of hardwoods in the U.S. None is more widely accepted for contemporary designs. Many different species are included in the oak family. Most are marketed as either red or white oak. Distinctions between the two are as follows:

- ***Red oak***
  - The heartwood tends to be a reddish color.
  - Vessels of heartwood have few tyloses (mineral and chemical deposits); thus, the wood is not waterproof.
  - Pores in latewood are few.
  - Annual rings are widely separated resulting in a coarser textured wood.
  - Heartwood is not durable when conditions may cause decay.
- ***White oak***
  - The heartwood tends to be tan or brownish.
  - Vessels of heartwood contain abundant tyloses which block pore openings and make the wood waterproof.
  - Pores in latewood are small and numerous.
  - Annual rings are compact resulting in a finer textured wood.
  - Heartwood is durable under conditions favoring decay.

Oak is related to beech and chestnut. However, the Quercus family is unique. It is the only genus that bears acorns. It is also one of the few groups that includes both hardwoods (covered here) and softwoods (called *live oak*). The range of growth extends across the U.S. with concentrations east of the Great Plains and on the West Coast.

Oak has been selected for almost every application requiring wood. Oak is a common material for contemporary furniture because of its light color. It is also a standard for hardwood flooring due to durability as well as beauty. In addition to appearance products, oak is a utility wood. It has been used for food crates, bridge timbers, and railway crossties.

Either red or white oak will serve equally well for most purposes. The only exception is to use white oak in areas where decay is likely. White oak pores are filled with mineral and chemical deposits (tyloses). The deposits add to water resistance and durability in moist conditions.

Oak has many wood rays. As discussed in *Chapter 11*, the method of cutting will either expose the rays, or reduce their appearance. *Quarter-sawn* oak is cut through the rays. The rays then appear as large flakes. *Rift-sawn* oak is cut across the rays. The cross-sectioned rays appear very thin. This effect is called *comb grain* because it looks much like hair.

Paldao

Genus: DRACONTOMELUM. Principal lumber species: *dao*. See **Figure 12-26**.

Characteristics: ***Paldao*** is gray to reddish-brown with varied grain effects, usually dark, irregular stripes. Pores are very large and partially plugged. It is a fairly dense hardwood, comparable to walnut.

Figure 12-26. Paldao is comparable to walnut in appearance and working qualities. It is considered an *exotic wood* and used primarily for architectural woodwork.

Paldao is one of the finest Philippine cabinet woods. It is not related to lauan (Philippine mahogany), nor does it resemble that species. It looks much like a striped walnut, although it would never be mistaken for walnut. It also has odd finishing qualities. The wood brightens when finishing materials are applied.

Paldao is found in limited quantities. It is considered an *exotic* wood and is used mainly for architectural work.

Pecan

Genus: CARYA. Principal lumber species: *illinoensis*. See **Figure 12-27**.

Characteristics: ***Pecan*** is very heavy, hard, and elastic. It machines, turns, and steam bends well. The annual rings are very distinct. The heartwood color is light to dark reddish-brown; the sapwood is white.

Pecan is essentially a southern wood. It is found in Louisiana, eastern Texas, Mississippi, and Arkansas.

Although pecans and hickories are closely related, there are slight differences. Pecan is not quite

Figure 12-27. Pecan is related and comparable to hickory. *(Fine Hardwood Veneer Assoc.)*

as tough as hickory, but is still harder than other species. Generally, the heartwood of pecan is a little darker than hickory and tends to be more red in color.

Pecan has great strength, resistance to abrasive wear, and good finishing qualities. It is an excellent furniture wood.

The pines

Pines comprise the most valuable commercial group of timber trees in the world. They supply wood for construction and cabinetmaking and pulp for making paper.

Thirty-five species of pine have been classified. Of these, 28 supply lumber for use in various applications. All are softwood, nonporous, and have visible annual rings. Those discussed here have applications in cabinetmaking and millwork.

Ponderosa pine

Genus: PINUS. Principal lumber species: *ponderosa*. See **Figure 12-28**.

Characteristics: Even though ***ponderosa pine*** is a nonporous softwood, the soft texture can be coarse or fine. It depends on the region where the tree was harvested. Ponderosa pine has excellent dimensional stability and is easy to work. It has a low density, and is easily marred. The heartwood is light in color, varying from creamy white to straw, sometimes with an orange tint. The sapwood is white.

Ponderosa pine grows in mountainous regions from British Columbia to Mexico and from California to Nebraska. Stands form great forests. A variety of grades are produced by these stands.

Ponderosa pine is the most important mill species. Many large sash and door plants manufacture products entirely from ponderosa pine. Trim, moldings, and cabinets are also produced from the wood. Large amounts of ponderosa pine plywood are produced.

Most ponderosa pine products are painted. Traditionally stain has not been used because the wood absorbs it in varying amounts. Newer, gel-based stains that control the amount of absorption allow fine finishes to be applied to pine. A lacquer or varnish topcoat is applied over the stained wood for protection.

Lower grades of ponderosa pine may have many knots. These grades have gained popularity as *knotty pine* wall paneling and cabinet doors in recent years. Common grades of ponderosa pine with mainly knot defects are used for this purpose. Lower grades are cut to common grade dimension lumber and used for light construction and inexpensive shelving.

Sugar white pine

Genus: PINUS. Principal lumber species: *lambertiana*. See **Figure 12-29**.

Characteristics: ***Sugar white pine*** is easy to work and used to a great extent for mill products. The texture is fine, soft, and uniform. It works well with

Figure 12-28. Ponderosa pine.

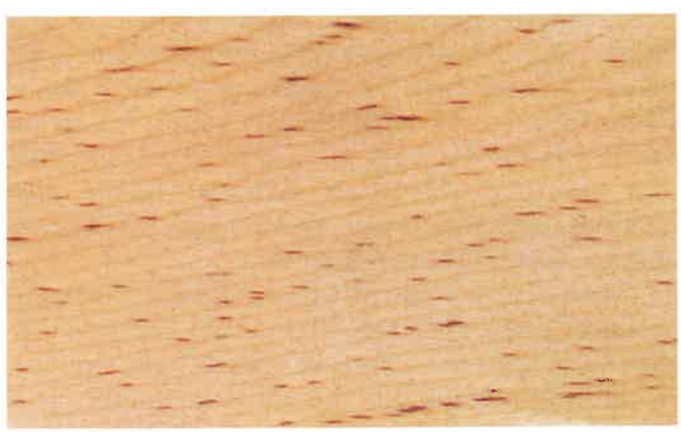


Figure 12-29. Sugar pine.

hand tools, making it the choice product for pattern making in the foundry industry. The heartwood is light tan or brown. The sapwood is white. Like any true white pine species, sugar pine offers considerable durability when exposed to decay.

Sugar pine is the tallest of the pine trees. Older trees have reached 250′ (76 m) high and had 12′ (3.7 m) diameters. The species is found in Oregon and California, with 80% of the stand in California.

The large, coarse knots in sugar pine make it unsuitable for knotty pine wall paneling. Lower grades are used for light construction, boxes, and crates.

Southern yellow pine

Genus: PINUS. Principal lumber species: *palustris* (longleaf pine); *elliottii* (slash pine); *echinata* (shortleaf pine); and *taeda* (loblolly pine). See **Figure 12-30**.

Characteristics: ***Southern yellow pine*** includes a number of southern pine softwood species. The wood ranges from clear to knotty. It is generally heavy, strong, stiff, and hard. The texture is rather coarse, with clear annual rings. The heartwood is reddish-brown. It is small compared to the large ring of yellowish-white sapwood that surrounds it.

Figure 12-30. Southern yellow pine.

Southern yellow pine species grow in the eastern U.S. Most forest replanting is done with yellow pine so that the species are always abundant. There is no separation of yellow pines by species. Rather, species are grouped into longleaf and shortleaf categories. *Longleaf yellow pine* includes the palustris and elliottii species. The other species are sold as shortleaf pines.

There are very few differences between the two. Longleaf pines are somewhat harder and stronger than short leaf types. However, single trees can vary in hardness according to the soil, water supply, and climate where they grew.

Yellow pines have great commercial value. They are the source of pulpwood for papermaking and timber for most construction materials. Smaller amounts are fabricated into almost any object that can be made of wood. Often, yellow pine is selected instead of other woods because it is inexpensive and readily available.

Primavera

Genus: CYBISTAX. Principal lumber species: *donnell-smithii*. See **Figure 12-31**.

Characteristics: ***Primavera*** is a moderately lightweight hardwood. It has medium to coarse texture and straight to slightly wavy grain. It is odorless and tasteless. The wood ranges from yellowish-white to yellowish-brown.

Figure 12-31. Primavera resembles mahogany in grain pattern. However, it is much lighter in color.

Primavera was formerly marketed as white mahogany. The grain pattern and texture of primavera resemble that of most tropical woods, mahogany in particular. If it were not for the lighter color of primavera, the two could be mistaken.

The wood has excellent finishing properties. It is used much like other fine cabinet woods. Boards with highly figured grain patterns are often used for inlays.

Primavera is found in southern Mexico, Guatemala, El Salvador, and Honduras. Most of the wood that reaches the U.S. is grown in Guatemala.

Redwood

Genus: SEQUOIA. Principal lumber species: *sempervirens*. See **Figure 12-32**.

Characteristics: ***Redwood*** is soft and light in weight. The texture and density of redwood varies greatly, but the majority is fine textured. Redwood

Figure 12-32. Redwood is very resistant to decay. It is widely used for siding and outdoor furniture.

is seasoned slowly but then is not affected by dimensional change. It is easy to work and one of the most durable of all softwoods. It is free from resin, thus, it takes and holds finish well. The heartwood is cherry-red to reddish-brown and has very low luster. The sapwood is off-white with visible annual growth.

There are two kinds of giant sequoias. One is redwood. The other is the *big tree* (*sequoia gigantea*). The big tree is no longer cut for lumber. The trees are protected and allowed to reach several hundred feet high. They are found along the western slopes of the Sierra Nevada mountains in central California.

The redwood is found in a narrow strip along the Pacific coast. The redwood may reach heights above the big tree. The diameter of the redwood, however, is less than that of the big tree.

Most sequoias never die of old age. They are felled by storms or destroyed by fire. Their immense trunks may also grow off balance until the tree is overturned by weight.

Redwood is valuable for many purposes. The only limit is weakness across the grain. Its greatest strength is with the grain, and is one reason why redwood is often used for columns. Redwood is best suited for areas exposed to decay. It is resistant to moisture and can be used for all exterior purposes, including siding, picnic tables, and fences. It is also used in millwork and furniture, but in limited quantities.

Redwood trees sometimes produce large lumps (called burls) on the side of the tree. Sawed burl veneer has beautiful swirling grain patterns. Burls taken from high on a large tree can weigh many tons. However, the usable veneer is seldom over 20% of the total cut from a typical burl.

Rosewood

Genus: DALBERGIA. Principal lumber species: *nigra* (Brazilian rosewood); *latifolio* (East Indian rosewood); *stevensonii* (Honduras rosewood); *greveana* (Madagascar rosewood); and *grenadillo* (Santo Domingan rosewood). See **Figure 12-33**.

Characteristics: ***Rosewood*** is a beautiful and valuable hardwood. It is noted by the deep reddish-brown to nearly purple colored heartwood. Small burls, black streaks, or mottlings enhance the appearance. Rosewood is easy to work as it is soft and light, and the grain is closed. Sharp tools must be used during cutting since the wood is splintery. A natural high polish can be obtained because of oils in the wood.

Figure 12-33. Brazilian rosewood is available in limited amounts for inlaying.

All true rosewoods are members of the Dalbergia genus. They grow in Asia, Madagascar, Brazil, and Central America. The Brazilian rosewood, noted for its dazzling beauty, is becoming scarce. All the species are rated as valuable, and are used in limited amounts. Most are cut as inlay and veneer for fine furniture and cabinet work. Entire boards are rarely available.

Santos rosewood

Genus: MACHAERIUM. Principal lumber species: *spp*. (spp. is the abbreviated plural of species; the machaerium genus includes over 80 trees.) See **Figure 12-34**.

Characteristics: ***Santos rosewood***, or Pau Ferro, is a heavy, hard, Bolivian and Brazilian hardwood. It is a fine textured wood, having small pores that are barely visible. The heartwood is a lustrous chocolate brown to purple to black color. The sapwood is cream color. Sapwood is sharply, although irregularly, defined from heartwood. The grain pattern is variable. It resembles, and is an excellent substitute for, Brazilian rosewood.

Figure 12-34. Santos rosewood, also known as Pau Ferro, is similar to Brazilian rosewood, but with a more purplish tint.

Sapelle

Genus: ENTANDROPHRAGMA. Principal lumber species: *cylindricum*. See **Figure 12-35**.

Characteristics: ***Sapelle*** can be used as a substitute for mahogany. It is somewhat tougher, harder, and heavier than *African mahogany*, but works fairly well. There is considerable variation in grain pattern. Most often, it is straight with light portions jutting out from the stripes. This pattern is called stripe and bee's wing.

Figure 12-35. Sapelle is one of many mahogany substitutes.

Sapelle is one of Angola's most common timbers. It is related to the genuine mahoganies although it is not of the same genus. It has the color, grain, and figure of mahogany but is 10% to 15% heavier with less dimensional stability.

Sapelle is used mainly in Europe for furniture, cabinets, case goods, and interior decoration. It is readily available as both lumber and veneer.

Sassafras

Genus: SASSAFRAS. Principal lumber species: *albidum*. See **Figure 12-36**.

Figure 12-36. Sassafras replaces chestnut for many applications. (*Fine Hardwood Veneer Assoc.*)

Characteristics: ***Sassafras*** is one of the few soft hardwoods with decorative grain character. It is easy to work, but is brittle. Take care not to lift the grain when planing. The pattern is somewhat like ash. The general texture is like ash or hackberry, but much softer. Sassafras also resembles chestnut, except that the lighter color tends to have a yellowish tint instead of grayish.

Sassafras is a beautiful wood for cabinets, rustic wall paneling, and novelty pieces of furniture. It is sometimes used for exterior furniture and siding.

The wood is found in limited amounts over most of the eastern half of the U.S. However, it is so widely scattered that large harvests are not likely. In good climates, trees up to 100′ (25.4 m) tall and 3′ (0.9 m) in diameter have been cut. The average tree is much smaller.

Satinwood

Genus: CHLOROXYLON. Principal lumber species: *swientenia* (East Indian satinwood); also *Zanthoxylum flavum* (Santo Domingan or West Indies satinwood). See **Figure 12-37**.

Figure 12-37. Satinwood has an oily texture and appearance.

Characteristics: ***Satinwood*** is a very hard, dense hardwood. It has interlocking grain that tends to check. The pattern is rippled or stripe and bee's wing figure. It is golden yellow in color when cut, but deepens to rich golden brown with age. When freshly cut, it has a strong coconut odor and oily texture and appearance.

Santo Domingan satinwood is found in Puerto Rico, Honduras, the Bahamas, and in southern Florida. Almost all antique furniture including satinwood is the Santo Domingan type. *East Indian satinwood,* grown in Sri Lanka and southern India has come into some use. However, it is harder, paler in color, and more figured. The cost of satinwood limits its use to fine furniture inlay and banding.

Spruce

Genus: PICEA. Principal lumber species: *sitchensis* (Sitka spruce); *engelmanni* (Engelmann spruce); the following are marketed as eastern spruce; *canadensis* (white spruce); *rubens* (red spruce); and *mariana* (black spruce). See **Figure 12-38**.

Figure 12-38. Only spruce species labeled as Eastern spruce are suitable for cabinet and millwork.

Characteristics: ***Spruce*** is a nonporous evergreen softwood. It is soft and relatively weak, although Sitka is fairly strong compared to its weight. The machining qualities of eastern and Engelmann spruce are fair, but are poor for Sitka spruce. Dimensional stability of spruce is excellent. The texture is uniform, with visible annual rings. The color of heartwood is light tan or reddish-brown, and the sapwood is off-white.

All spruces are members of the pine family and close relatives of fir trees. Many spruces are trimmed for landscaping because of their beauty.

Sitka spruce grows along the coastal region from Alaska to northern California. It is an important construction material for Alaska. It is also suitable for mill products and can be used for any purpose requiring a softwood. Poor machining qualities prevent this species from being used in fine cabinet work. The grain is likely to tear unless processed with high speed, sharp machinery.

Engelmann spruce is a highly ornamental tree of little commercial importance. It is relatively weak and used for cabinetwork that requires little durability. The wood grows in the Rocky Mountains from the Yukon to Arizona. Nearly half the stand is in Colorado.

White spruce, red spruce, and *black spruce* can be found all over the northern U.S. Often these species grow together. They are mixed during harvest and sold simply as eastern spruce. The wood is used for general carpentry, crates, ladder rails, mill products, and light construction.

Sycamore

Genus: PLATANUS. Principal lumber species: *occidentalis*. See **Figure 12-39.**

Characteristics: ***Sycamore*** is one of the softer hardwoods. It has a medium density and average hardness and strength. The grain is closed but the texture is still rather coarse. Its color is flesh pink to brownish-pink with slightly lighter sapwood.

Figure 12-39. The interwoven wood fibers of sycamore make it hard to split. (*Fine Hardwood Veneer Assoc.*)

The sycamore is the largest broadleaf tree. Specimens 170′ (52 m) tall and 14′ (4.3 m) in diameter have been recorded. The average full grown tree is 120′ (36 m) high and 2′ to 4′ (0.6 m to 1.2 m) in diameter. Most sycamore grows in the lower Ohio and Mississippi Valleys.

The interwoven fibers of sycamore make it hard to split. It is also hard to work. It is processed best on high speed equipment.

Quarter-sawn lumber displays a very attractive small flake figure. Large quantities of rotary-cut sycamore veneer are used by the packing industry for fruit and vegetable containers. Lumber is fabricated into inexpensive furniture, usually stained to imitate maple. It is a good utility wood for building cabinets, especially hidden parts. One of the principal uses of the wood is for drawer slides.

Teak

Genus: TECTONA. Principal lumber species: *grandis*. See **Figure 12-40**.

Characteristics: ***Teak*** is quite hard and strong. It is not difficult to work if you use carbide tools. Ordinary tools dull quickly because of minerals and silicates in the wood. It is usually straight grained, although some lumber is highly figured. Once seasoned, it is dimensionally stable. The color is tawny yellow to dark brown, often with light streaks. The wood is similar to fine walnut except that teak feels oily because of the high amount of silicates in the wood.

Figure 12-40. Teak is common in Modern Scandinavian and Oriental furniture styles. Lumber supplies are limited, but it is readily available as veneer.

Teak is imported from Myanmar, India, and Thailand. It is available as veneer but limited as lumber. Teak is resistant to decay, but because of cost it is not widely used for exterior applications. It is mostly used for interior woodwork and contemporary, Scandinavian, and Oriental furniture styles. Teak is also used extensively for pricey outdoor furniture, particularly garden benches.

American tulipwood

Genus: LIRIODENDRON. Principal lumber species: tulipifera. **Figure 12-41**.

Characteristics: ***American tulip*** is a moderately soft, low density, open grain hardwood. The texture is fairly fine and uniform because the pores are small. Use of a filler is optional. There is very little difference between earlywood and latewood so annual rings are not distinct. The heartwood is pale olive-brown to yellow-brown; sapwood is off-white to grayish white. American tulip works well with either hand or machine tools and is relatively stable.

Figure 12-41. American tulipwood has many uses, ranging from plywood veneer, to furniture components and interior trim. (*Fine Hardwood Veneer Assoc.*)

American tulip is a new name for yellow poplar. The name was recently changed for two reasons. First, the tulipifera species is not a poplar; it is a member of the magnolia family. Second, the yellow poplar of other countries is not near the quality of the American species. Thus, foreign countries have refrained from buying the American species. The name change is intended to boost sales.

The American tulip is found throughout most of the eastern U.S. Trees are too widely scattered for mass harvesting in some areas. The best timber growth is in the Ohio Valley region and on mountain slopes in North Carolina and Tennessee. In second growths of Appalachian and eastern stands, there is a thick band of sapwood that is nearly white. Sapwood lumber is often called *whitewood*.

American tulipwood is free from resin. It kiln dries well, glues easily, is stable, and does not split when nailing. It is soft enough to be a favorite wood for working with hand tools. It is easily stained to look like more costly woods.

As veneer, American tulipwood is used for faces, cross-banding, and backs of plywood. As lumber, it is used for furniture component parts, turnery, interior trim and millwork, cabinetry, and exterior trim and siding.

American walnut

Genus: JUGLANS. Principal lumber species: *nigra*. See **Figure 12-42**.

Characteristics: ***Walnut*** is moderately dense and hard. It is strong in comparison to its weight.

Figure 12-42. Walnut is a popular American hardwood. The grain pattern may be straight (top) or wavy (bottom).

Walnut has excellent machining properties and superb finishing qualities. It has open pores that require filling. The annual growth rings are clearly marked and the texture is fine and even. The grain pattern is highly figured, often with crotch, swirl, stump, and burl wood. The wood polishes to a high luster. The heartwood has varying colors of brown, often with a purplish tint.

Walnut is the most valuable furniture and cabinet timber of the U.S. The beauty of walnut is admired by almost everyone. Most homes possess at least one article made of walnut. The principal uses of walnut are furniture, gun stocks, interior trim, cabinets, fixtures, instrument cases, etc. Large quantities are made into veneers for walnut-faced plywood.

Most walnut is plain-sawed or flat-sliced (for veneer). Occasionally, walnut is quarter-sawn or sliced. This method produces *pencil stripe* walnut. Quarter sawing displays the edge of the annual growth rings. They appear like a series of narrow bands or lines. Walnut crotches and stumps are valuable and always cut into veneer. Veneer results in more square footage of wood per log.

Walnut is found as isolated trees as opposed to dense forest stands. Growth is found over the entire U.S. east of the great plains. The best stands are in the middle west, Mississippi and Ohio Valleys, Tennessee, and the lower Appalachian Mountains.

Walnut logs often are hauled over great distances to mills. This raises the cost of the lumber. The walnut log is relatively short, usually sawn into 6′ to 10′ (1.83 m to 3.05 m) length. Top grades average about 7″ (178 mm) in width. Lumber mills that specialize in walnut steam the wood in walnut sawdust to darken the sapwood. The sapwood never quite reaches the color of heartwood. However, a skilled finisher can blend the two perfectly.

Willow

Genus: SALIX. Principal lumber species: *nigra* (black willow). See **Figure 12-43.**

Characteristics: ***Willow*** is one of the softest American hardwoods, resembling basswood in density. It is very easy to work but is inclined to look and feel *fuzzy* after machining. Willow stains well, especially to resemble walnut. The wood has fairly uniform grain, yet it is somewhat coarse. The color of the heartwood varies from light

Figure 12-43. Black willow is the only willow species of sawn timber size. It has been mostly used for plywood, but with careful finishing, can resemble walnut. (*Fine Hardwood Veneer Assoc.*)

gray to dark brown or dark reddish-brown. It sometimes has a purplish tint, much like walnut. The sapwood is nearly white, with grayish to light tan cast. Willow is one of the easiest of all woods to glue.

There are many species of willow in the U.S. Only one, black willow, produces trees of saw timber size. It develops best in the rich bottomlands of the lower Ohio and Mississippi Valleys. It is found to some extent all over the eastern half of the country, mostly in areas with much water. Willow grows rapidly, reaching maximum size of 130′ (40 m) and diameter of 3′ (0.9 m).

The main use of willow for some time has been plywood core stock, crates, and boxes. It is gaining popularity for inexpensive furniture, mill products, and wall paneling. It is very easy to work and presents a handsome appearance. Careful finishing will make the wood closely resemble walnut.

Zebrawood

Genus: MICROBERLINIA. Principal lumber species: *brazzavillensis*. See **Figure 12-44**.

Characteristics: ***Zebrawood*** is noted for its pronounced light gold and dark brown stripes. It is a heavy, hard wood with somewhat coarse texture The wood finishes to a high luster, but is used sparingly because of its bold appearance. The figure may be straight to wavy, depending on how the wood is cut. Zebrawood grows in Cameroon, Gaboon, and Angola.

Zebrawood is considered an exotic wood. It is used mainly for inlays because of its high cost. The bright, bold features of the wood make it an attractive addition to fine furniture.

Figure 12-44. Zebrawood is considered an *exotic* wood, with its light gold and dark brown stripes. It is used sparingly because of its bold appearance.

Summary

Wood is the primary material in shaping our living environment. It is used for tables, chairs, walls, and entire structures. Wood has so many uses because it is both functional and attractive. Functional qualities include hardness, flexibility, and shock resistance. Aesthetic qualities include color, texture, and grain pattern. The chart in **Figure 12-45** summarizes the characteristics of each wood species. Your selection of a wood will be based on those qualities that you feel are most important.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Why are common names used to describe most woods rather than the genus/species name?
2. Name two woods which are substituted for mahogany.
3. A very hard, strong wood used for baseball bats, hockey sticks, and tool handles is _____.
4. Any wood that is made into food containers must be _____.
5. Name two woods commonly installed as hardwood floors.
6. One of the best woods for dowels, spools, spindles, and other turnery is _____.
7. Chests and closet liners are often made of _____ because of the wood's unique scent.
8. Considered one of the top furniture hardwoods, _____ can be sanded to a glasslike finish.
9. Lumber from _____ is the most wormy.
10. Name two woods especially resistant to moisture and decay.
11. White elm has become scarce because of _____.
12. A wood commonly substituted for elm is _____.
13. A very hard, elastic wood, often used for bent laminations (such as skis), is _____.
14. Lauan, also known as _____, is an inexpensive substitute for mahogany.
15. Name two characteristics which make genuine mahoganies different from African mahogany.
16. *Bird's eye* figuring is common in _____ lumber.
17. Define WHAD and WHND. What wood do these terms refer to?
18. Suppose you were building an outdoor flower box made of oak. Would you choose red oak or white oak?
19. Pecan is closely related to _____.
20. List various applications of the three common pines discussed.

21. Name three decorative woods you might use as inlay.
22. American tulipwood is a new name for _____.
23. Only one species of willow in the U.S. produces trees of sawn timber size, and that is the _____ willow.
24. List four of the most popular woods for cabinet and furniture making.
25. Select five woods with the best working/machining qualities.

Wood Characteristics	Specific Gravity	Weight (Pounds per cubic ft. at 12% moisture content)	1. Excellent 2. Good 3. Average 4. Fair 5. Poor — Working Properties: Planing	Drilling	Sanding	Turning	Gluing	Nail and Screw Holding (Includes Split Resistance for Nailing)
Species								
Alder, red	0.41	28	2					
Ash	0.49	34	3	2	2	2	2	3
Banak	0.44	30	1	3	3	3	3	2
Basswood	0.37	24	2	1	1	4	1	1
Beech	0.64	45	1	1	2	3	1	2
Birch	0.62	43	2	2	2	1	2	2
Butternut	0.38	27	1	2	2	2	2	4
Cedar, Aromatic Red	0.37	26	4	1	1	1	2	4
Cherry	0.50	35	1	3	2	3	2	5
Chestnut	0.43	30	1	1	1	1	2	3
Cottonwood	0.40	28	1	1	3	2	1	2
Cypress, bald	0.46	32	2	1	2	2	1	1
Ebony	1.22	63	4	2	2	2	1	3
Elm, American	0.63	44	3	4	4	3	4	2
Fir, Douglas	0.48	34	3	3	2	3	2	3
Gum, red	0.52	35	3	2	2	4	2	3
Hackberry	0.53	37	2	3	3	2	2	2
Hickory	0.72	50	3	2	2	2	2	3
Lauan (Philippine Mahogany)	0.49	35	2	3	2	3	3	4
Limba	0.49	35	1	2	1	2	2	2
Mahoganies, genuine	0.49	35	2	1	1	2	2	3
Mahogany, African	0.49	35	2	2	1	2	2	2
Maple, hard	0.63	38	3	2	1	2	2	2
Maple, soft	0.54	44	3	2	2	2	4	5
Oak, red or white	0.62	43	3	2	2	2	3	4
Paldao	0.59	44	3	2	2	3	3	3
Pecan	0.66	46	3	3	2	3	3	3
Pine, Ponderosa	0.39	28	1	3	2	3	3	4
Pine, sugar	0.35	26	2	1	2	2	2	2
Pine, yellow	0.40	28	2	1	2	2	2	2
Primavera	0.40	30	2	2	3	2	2	3
Redwood	0.40	28	1	2	1	1	2	2
Rosewood	0.75	50	3	1	1	2	1	3
Santos Rosewood (Pau Ferro)			4	4	4	4	4	3
Sapele	0.54	40	2	2	2	2	2	2
Sassafras	0.46	32	3	2	2	3	2	4
Satinwood	0.83	67	3	4	3	4	3	3
Spruce	0.40	28	2	2	3	3	1	3
Sycamore	0.49	34	3	3	3	3	3	2
Teak	0.62	43	4	4	4	4	4	3
Tulip, American (Yellow Poplar)	0.42	30	2	2	2	2	1	1
Walnut, American	0.55	38	2	2	2	3	3	3
Willow	0.39	26	2	3	3	2	1	1
Zebrawood	0.62	48	3	3	3	4	2	4

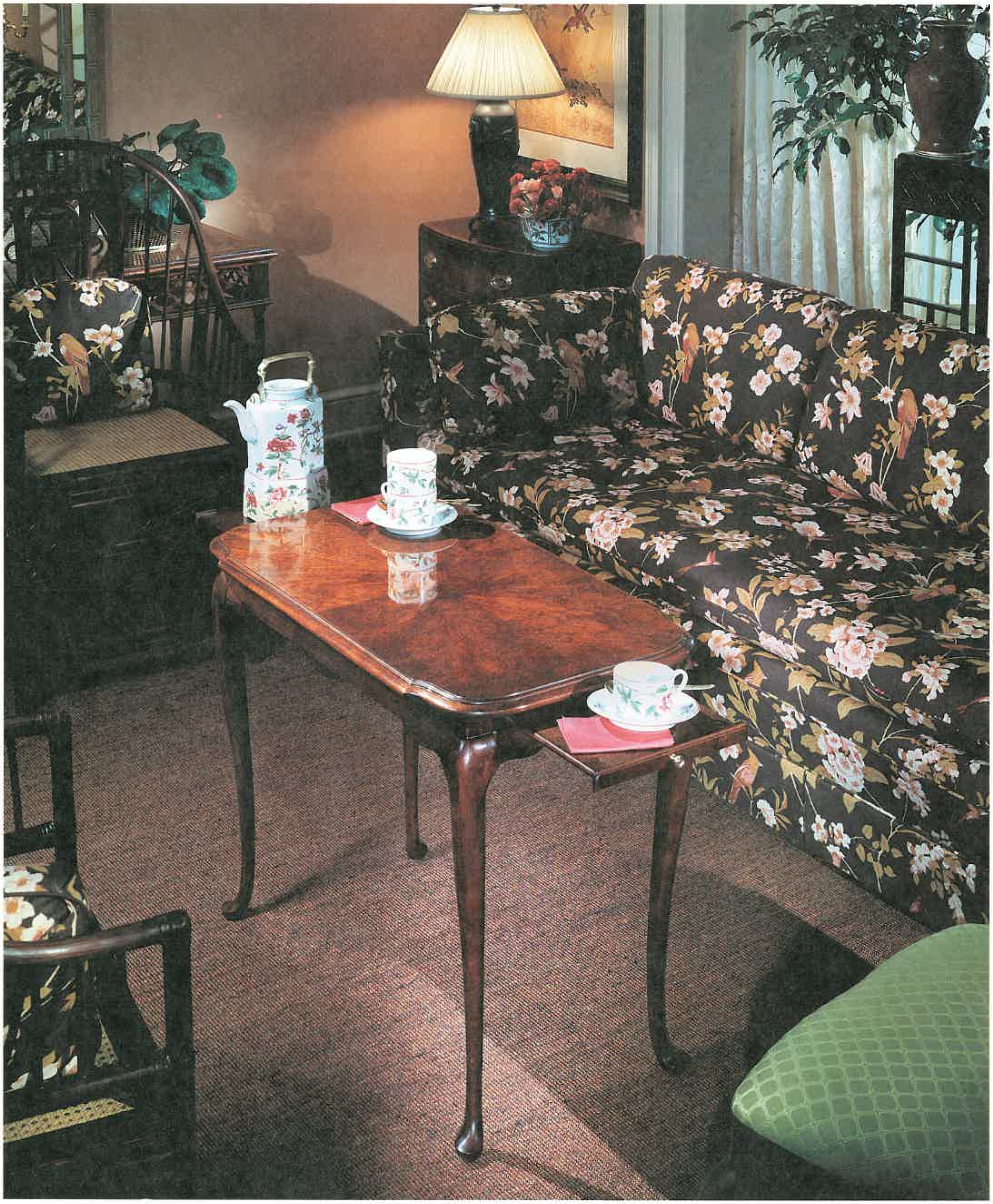
Figure 12-45. Summary of wood characteristics.

1. Excellent 2. Good 3. Average 4. Fair 5. Poor							
	Physical Properties						
	Bending Difficult (1) to Easy (5)	Hardness Hard (1) to Soft (5)	Compression Strength Weak (1) to Strong (5)	Shock Resistance Low (1) to High (5)	Stiffness Limber (1) to Stiff (5)	Availability L (Lumber) V (Veneer)	Cost Expensive (1) to Inexpensive (2)
Species							
Alder, red							
Ash	3	2	4	1	3	L	5
Banak	4	2	4	4	4	LV	3
Basswood	4	5	3	2	3	L	3
Beech	5	5	2	2	1	L	5
Birch	4	2	4	5	4	LV	4
Butternut	2	2	4	4	4	LV	3
Cedar, Aromatic Red	2	4	2	4	2	LV	2
Cherry	3	3	2	1	1	LV	3
Chestnut	2	3	4	4	4	LV	2
Cottonwood	4	4	2	3	2	L	2
Cypress, bald	2	4	1	2	2	LV	5
Ebony	2	4	3	4	3	L	3
Elm, American	1	1	4	5	5	L	1
Fir, Douglas	5	2	3	4	4	LV	4
Gum, red	3	4	2	4	4	LV	4
Hackberry	3	2	3	4	4	LV	3
Hickory	3	2	3	4	3	LV	4
Lauan (Philippine Mahogany)	4	4	5	5	4	LV	3
Limba	3	3	3	4	3	LV	3
Mahoganies, genuine	2	3	3	4	3	L	3
Mahogany, African	3	3	3	4	3	LV	2
Maple, hard	3	3	3	4	3	LV	2
Maple, soft	2	1	5	5	5	LV	3
Oak, red or white	4	2	5	4	2	LV	3
Paldao	1	4	4	4	4	LV	3
Pecan	2	3	4	4	4	LV	2
Pine, Ponderosa	4	4	4	4	4	LV	3
Pine, sugar	3	4	2	2	3	L	4
Pine, yellow	5	4	2	1	2	L	3
Primavera	3	3	4	4	4	L	4
Redwood	3	3	3	4	3	LV	3
Rosewood	3	3	2	4	4	L	3
Santos Rosewood (Pau Ferro)	2	1	5	4	4	V	1
Sapele	3	3	5	4	4	V	2
Sassafras	2	3	2	4	4	L	3
Satinwood	4	3	4	4	4	V	1
Spruce	4	4	2	2	3	L	4
Sycamore	3	3	3	4	3	L	3
Teak	4	2	4	4	4	LV	1
Tulip, American (Yellow Poplar)	4	4	3	2	3	LV	5
Walnut, American	2	3	4	4	4	LV	2
Willow	4	5	1	4	2	L	5
Zebrawood	4	1	4	4	4	V	1

Figure 12-45. *(Continued)*

Finishing Selected Wood Species								
Species	Wood	Type		Recommended Finishes				
	Softwood	Hardwood		Filler	Stain	Build-Up Topcoat	Penetrating Oil	Paint
		Open Pores	Closed Pores	(R = Required for Flat Surface)	(O = Optional)			
Alder, red			●		O	■	■	
Ash		●		R	O	■	■	
Banak	●				O	■	■	
Basswood			●					■
Beech			■		O	■	■	
Birch			●		O	■	■	
Butternut		●		R	O	■	■	
Cedar, Aromatic Red	●					■	■	
Cherry			●		O	■	■	
Chestnut		●		R	O	■	■	
Cottonwood			●					■
Cypress, bald	●					■		■
Ebony			●			■		
Elm, American		●		R	O	■	■	
Fir, Douglas	●					■	■	■
Gum, red			●		O	■	■	
Hackberry		●		R	O	■	■	
Hickory			●		O	■	■	
Lauan (Philippine Mahogany)		●		R	O	■	■	
Limba		●		R	O	■	■	
Mahoganies, genuine		●		R	O	■	■	
Mahogany, African		●		R	O	■	●	
Maple, hard			●		O	■	●	
Maple, soft			●		O	■	■	
Oak, red or white		●		R	O	■	■	
Paldao		●		R	O	■	■	
Pecan			●		O	■	■	
Pine, Ponderosa	●				O	■	■	■
Pine, sugar	●				O	■	■	
Pine, yellow	●				O	■	■	
Primavera		●		R	O	■	■	
Redwood	●				O	■	■	
Rosewood			●			■		
Santos Rosewood (Pau Ferro)			●		O	■	■	
Sapele		●		R	O	■	■	
Sassafras		●		R	O	■	■	
Satinwood			●		O	■	■	
Spruce	●							■
Sycamore			●		O	■	■	
Teak			●			■		
Tulip, American (Yellow Poplar)			●		O	■		■
Walnut, American		●		R	O	■	■	
Willow			●		O	■	■	
Zebrawood			●			■		

Figure 12-45. *(Continued)*



Each wood has distinctive characteristics that make it identifiable. This furniture exhibits the deep, rich reddish brown characteristic of mahogany.

13

Manufactured Panel Products

Objectives

After studying this chapter, you will be able to:

- Describe the materials found in each category of manufactured panel products.
- List the methods used to grade panel products.
- Explain the use of various panel products for cabinets and fine furniture.

Important Terms

composite board
composite panel
engineered board product
fiberboard
hardboard
hardwood plywood
mende particleboard
oriented strand board
particleboard
performance-rated structural wood panel
plywood
prefinished plywood panel
prehung wallpaper panel
simulated wood grain finish panel
waferboard

Manufactured panel products are widely used by cabinetmakers to create large surfaces for case goods. They reduce the need for edge gluing lumber to make wide boards. Production time is reduced without sacrificing quality.

Panel products are typically more stable than solid lumber. They warp less because they are constructed with layers of thin wood or wood fibers. There is no continuous grain pattern in a panel. This keeps distortion at a minimum. Some panels are even moisture resistant.

The faces may be rough, textured, smooth, or finished. See **Figure 13-1**. The appearance of higher grades is suitable for clear finish. Lower grades contain defects. Veneered panels look like solid wood lumber. Those made of wood chips or fibers do not resemble real wood. Selection is based on whether the panel is to be hidden or visible.

The edges of veneered and nonveneered panel products reveal their composition. Edges are either hidden in the joint or covered with wood tape, plastic strips, or edging.

There are three categories of panel products. These products are structural wood panels, appearance panels, and engineered board products.

Structural Wood Panels

Structural wood panels are selected when stability and strength are required. They are typically used for roof, wall, and floor sheathing for building construction, and for cabinetmaking when the product requires more stability than beauty. Laminations, such as printed vinyl or high-quality veneer, enhance the appearance.

Structural wood panels are manufactured in various ways. Plywood is made by bonding layers of wood veneer with adhesive. Waferboard, composite board, structural particleboard, and oriented strand board are all made of wood chips or fibers bonded under pressure.

Figure 13-1. The smooth finish of this walnut paneling blends well with the style of the room. (*Georgia-Pacific Corp.*)

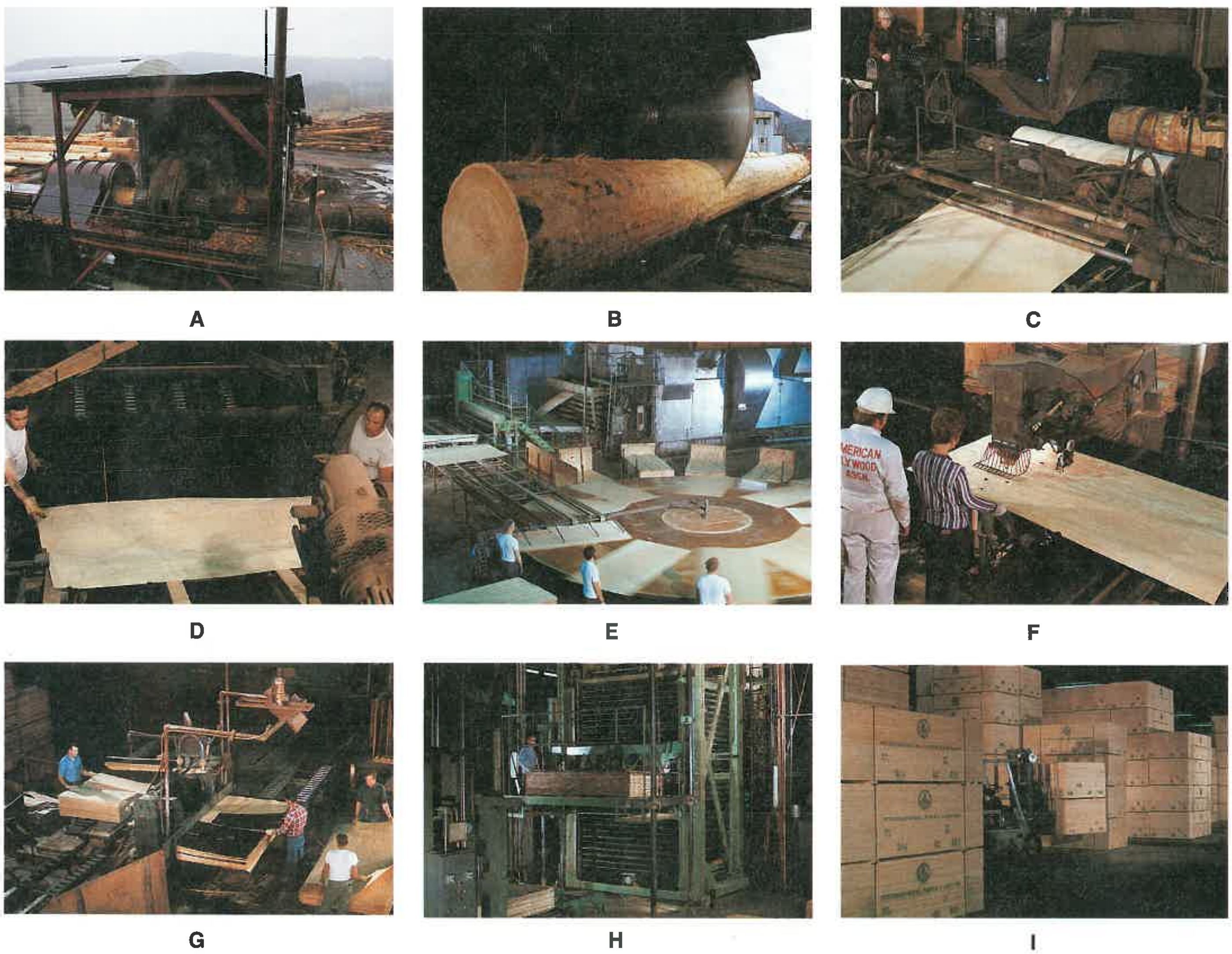
Plywood

Plywood is the most common structural panel. It is manufactured with a core material sandwiched between two thin wood sheets, called *face veneers*.

The veneers are cut on a lathe. This process involves rotating a debarked log (a peeler block) against a knife. The veneer is sheared from the log in long sheets that are cut to size. The sheets are sorted according to defects. Defects may be patched later. See **Figure 13-2.**

Face veneers are sheets applied over the core material. The core may be lumber, particleboard, or veneer plies. Glue is applied to the layers, which are then clamped under heat and pressure until cured. The panel is then trimmed to size and shipped.

Pound for pound, plywood is stronger than steel. Unlike solid wood, which is strong along the grain and weak across the grain, plywood is strong in all directions. The grain direction is altered 90° for each successive layer of wood, with both face veneer's grain oriented in the same direction. These two properties



A—Bark is removed from the log by knurled wheels.
B—Debarked log is cut into 8 ft. sections, called peeler blocks.
C—Peeler blocks are placed on a lathe. The log is rotated against a stationary knife. Veneer is sheared from the peeler block in long sheets.
D—The clipper cuts veneer sheets into various widths. These sheets are then sent to the dryer.
E—Once dried to a moisture level for gluing, sheets are sorted according to defects.
F—Defects are removed and football-shaped patches are inserted.
G—Glue sheets are placed between layers of veneer. Liquid glue applied by a glue spreader may also be used.
H—The layers of veneer and glue are placed in a hot press. They are bonded into panels under heat and pressure.
I—After bonding, panels are trimmed, sanded, and stacked for inspection. After inspection, they are graded, strapped, and shipped.

Figure 13-2. The steps taken to manufacture plywood. (*APA–The Engineered Wood Association*) strengthen the panel and equalize tension of the grain patterns. It also gives plywood its resistance to checks and splits. Nails and screws can be inserted close to edges without splitting the panel.

Structural plywood is manufactured from softwood. ***Hardwood plywood*** has hardwood veneer over a hardwood or softwood core. Although structurally sound for cabinetry, hardwood plywood is considered an appearance product.

The core for structural plywood varies according to use. The two most common cores are veneer and lumber.

Veneer-core plywood

Veneer-core plywood is made of three, five, seven, nine, or more layers of veneer, depending on the desired properties of the completed panel. The thickness of the veneers and the quantity of plies used determine the total panel thickness. See **Figure 13-3**. The veneer thickness may vary from 1/50″ to ¼″ (0.5 mm to 6 mm). Thinner veneers become face layers while thicker ones may make up core plies. Alternating grain direction of successive layers increases strength and reduces warpage.

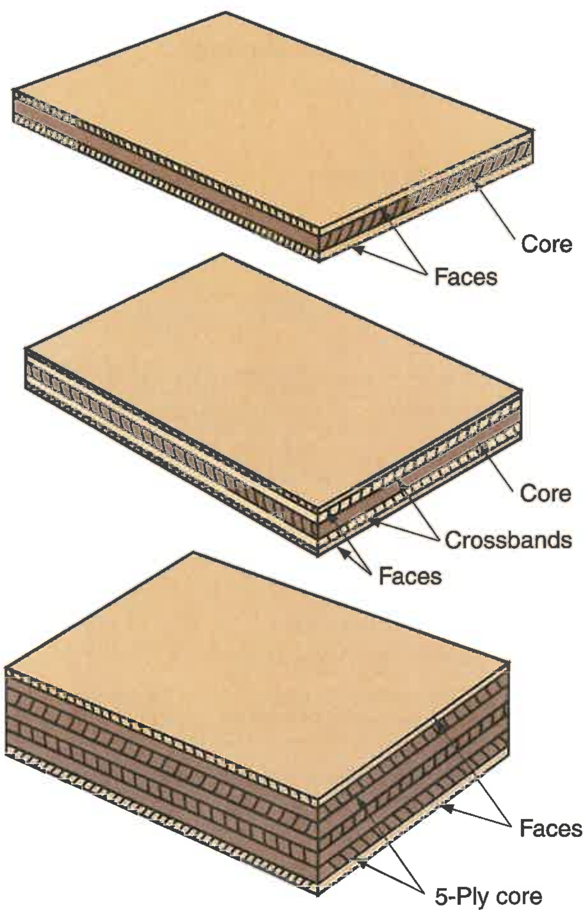


Figure 13-3. An illustration of veneer-core plywood showing three-, five-, and seven-ply versions.

Panel thickness of veneer-core plywood range from 1/8″ to 1 3/16″ (3 mm to 30 mm). Common thicknesses range from ¼″ to ¾″ (6 mm to 19 mm). Three-layer, or ***three-ply***, panels are usually ¼″ (6 mm) thick. Front and back faces are bonded to a single core. Five plies (two faces and three cores) are used for panels from 5/16″ to ½″ (8 mm to 13 mm). Seven plies are used for panels up to ¾″ (19 mm) and nine plies are used for thicker panels. The most used, and therefore readily available, panel size is 4′ × 8′ (1220 mm × 2440 mm). Smaller and larger sizes are available.

Veneer plywood is much less expensive than lumber core. It also has greater structural value. Select veneer plywood when the appearance of the edge is not a concern. Veneer core edges may show core voids and defects.

Plywood with hardwood face veneers is available with as many as five plies in a 1/8″ (3 mm) thick panel. American, Finnish, and Russian plywood panels are available with a greater number of plies per given thickness than those described in the previous paragraph. Some examples are three plies—3 mm (1/8″), five plies—6 mm (¼″), seven plies—9 mm (3/8″), nine plies—12 mm (½″), 11 plies—15 mm (5/8″), and 13 plies—18 mm (¾″). The core materials have virtually no voids allowing the edges to be finished in clear coatings. American manufacturers will produce these plywoods in any popular species. However, maple is the species normally stocked by distributors. The Finnish and Russian products are birch.

Thin veneer 3-ply birch plywoods are available in the following thicknesses: 1/64″ (0.4 mm), 1/32″ (0.8 mm), 3/64″ (1 mm), and 1/16″ (1.5 mm). Versions with five plies are available in thicknesses of 5/64″ (2 mm), 3/32″ (2.5 mm), 1/8″ (3 mm), and 5/32″ (4 mm). A 9-ply version is 13/64″ (5 mm).

Lumber-core plywood

Lumber-core plywood has a solid wood center and thin veneer faces. The core may be thin laminated strips of wood or wider boards. If there are veneer layers between the core and the back and front faces, they are called ***crossbands***. See **Figure 13-4**. The crossband grain is at 90° to the faces. Thicker panels are obtained with two lumber cores separated by a crossband. Standard panel size is 4′ by 8′ (1220 mm by 2440 mm) Thickness can range from 5/8″ to 2″ (15.5 mm to 50 mm).

Lumber core plywood is chosen when solid edges are important, such as:

- The edges of the product may be exposed. The cut edges of lumber core plywood are solid.
- Edges will contain jointwork. Machined edges of lumber core plywood are solid wood.
- Hardware will be attached. Lumber core has excellent edge screw holding properties.

Particleboard

Particleboard is the most stable and least expensive material. However, it has poor screw holding capabilities in edges. Core construction can be seen on the edges, but these are usually hidden with wood tape. It is approximately the same price as veneer-core plywood, but much less expensive than lumber-core plywood.

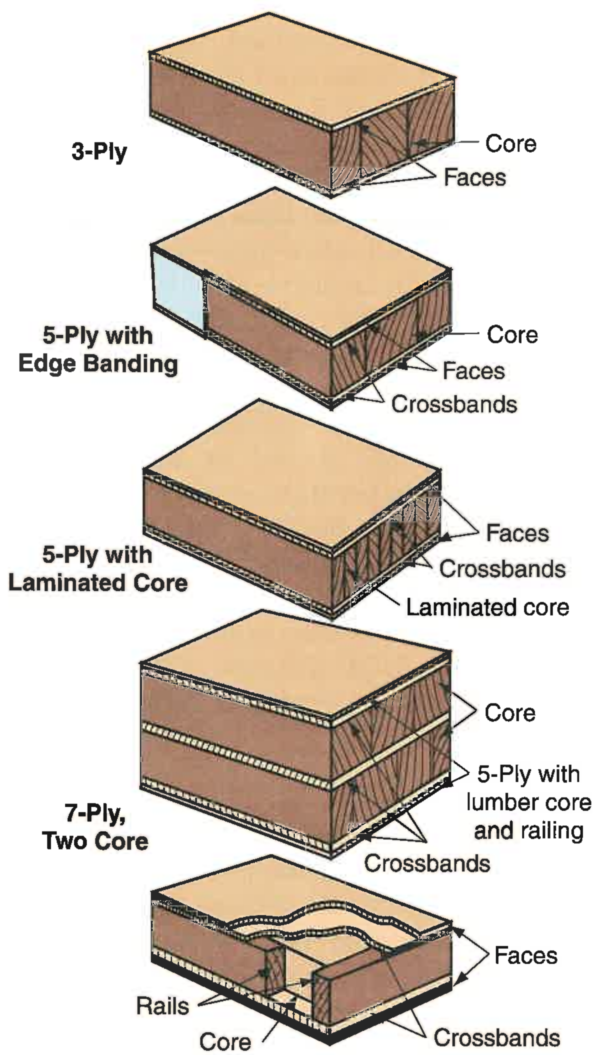


Figure 13-4. Lumber-core plywood includes layers of solid wood and veneer. Banding may be applied to hide edges. Panels with rails permit machining the edges. (*Forest Products Laboratory*)

Surface smoothness

The face veneers of plywood may be smoothed. The panel may be sanded on one side (S1S) or both sides (S2S). They may also be touch sanded or fully sanded. When touch sanded, only the rough sections and wood splinters are removed. Fully sanded panels are ready for finish.

U.S. structural plywood grades

Structural plywood can be performance or nonperformance grades. Performance grades classify veneer and nonveneer panels for the construction industry. They are designed to meet requirements for spanning roof or floor joists. These grades are discussed later in the chapter.

Most plywood applications do not require the strength of performance-grade panels. Nonperformance plywood grades focus mostly on defects. However, they do meet standard strength requirements. The grade is stamped on the face and edge of the plywood panel. See **Figure 13-5.** It gives important information about the:

- Type of wood species of the front and back faces
- Quality of the faces
- Type of adhesive used to bond the plies
- Manufacturer of the product
- Mill number

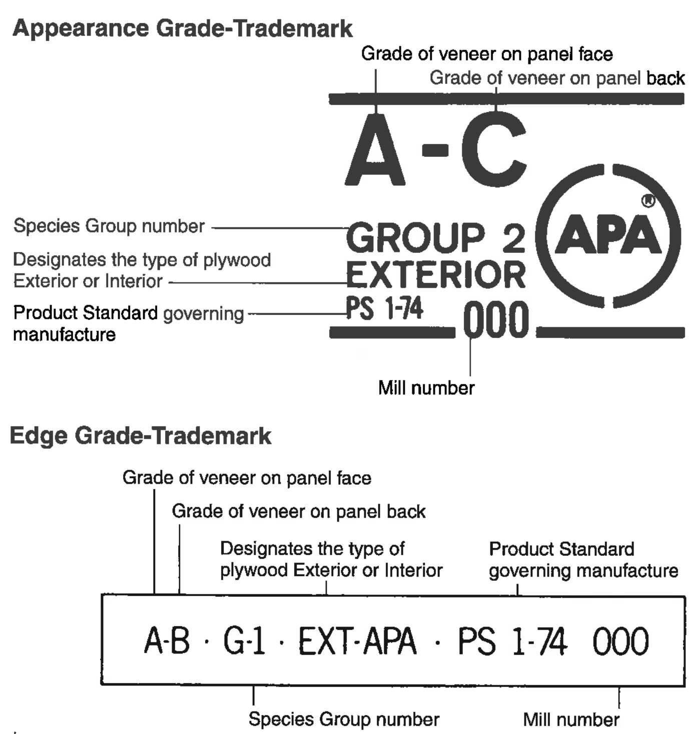


Figure 13-5. Plywood is stamped with a grade trademark of APA–The Engineered Wood Association. The mark provides information on the wood species, quality, and recommended use. (*APA–The Engineered Wood Association*)

Standards are established by manufacturers' associations such as ***APA—The Engineered Wood Association*** and the ***Douglas Fir Plywood Association*** (***DFPA***). Governmental specifications are made by the ***National Bureau of Standards*** (***NBS***).

The ***group number*** in the grade stamp indicates the weakest species used for face veneers. For sanded panels, the group number indicates the exact species group. Group 1 contains the strongest and stiffest woods. See **Figure 13-6**.

The quality of the two faces is given by ***veneer grades,*** which refer to the number of defects and the method by which they are patched. The grades are indicated by letters separated by a hyphen. See **Figure 13-7**. An example of this is A-C plywood. The grade of the front face veneer is A. The grade of the back face veneer is C. Suppose only the front face side will be seen. You might choose an N grade as the front face and a C or D grade as the back face. The recommended environment where the panel is used is indicated by either INT (interior) and EXT (exterior).

Canadian structural plywood grades

Canadian structural plywood is manufactured according to rules set by the ***Canadian Standards Association*** (***CSA***). Panels must meet CSA standards to be certified by the ***Council of Forest Industries of British Columbia*** (***COFI***)

The CSA has adopted the metric system for sizing panel products. Sizes are comparable to those of U.S. grades. See **Figure 13-8**. Most existing structures in Canada were constructed with standards similar to those of the U.S. Studs were 16" (406 mm) on center. Now they are installed on 400 mm centers.

Veneer Grades	
N	Smooth surface "natural finish" veneer. Select, all heartwood or all sapwood. Free of open defects. Allows not more than 6 repairs, wood only, per 4×8 panel, made parallel to grain and well matched for grain and color.
A	Smooth paintable. Not more than 18 neatly made repairs, boat, sled, or router type, and parallel to grain, permitted. May be used for natural finish in less demanding applications.
B	Solid surface. Shims, circular repair plugs and tight knots to 1 inch across grain permitted. Some minor splits permitted.
C Plugged	Improved C veneer with splits limited to 1/8 inch width and knotholes and borer holes limited to 1/4 x 1/2 inch. Admits some broken grain. Synthetic repairs permitted.
C	Tight knots to 1-1/2 inch. Knotholes to 1 inch across grain and some to 1-1/2 inch if total width of knots and knotholes is within specified limits. Synthetic or wood repairs. Discoloration and sanding defects that do not impair strength permitted. Limited splits allowed.
D	Knots and knotholes to 2-1/2 inch width across grain and 1/2 inch larger within specified limits. Limited splits are permitted. Limited to interior grades of plywood.

Figure 13-7. Face veneers are graded by the wood characteristics such as knots and splits. Some defects are patched. (*APA–The Engineered Wood Association*)

Species Group Classification					
Group 1	Group 2		Group 3	Group 4	Group 5
Apitong Beech, American Birch Sweet Yellow Douglas Fir 1 Kapur Keruing Larch, Western Maple, Sugar Pine Caribbean Ocote Pine, Southern Lablolly Longleaf Shortleaf Slash Tanoak	Cedar, Port Orford Cypress Douglas Fir 2 Fir California Red Grand Noble Pacific Silver White Hemlock, Western Lauan Almon Bagtikan Mayapis Red Lauan Tangile White Lauan	Maple, Black Mengkulang Meranti, Red Mersawa Pine Pond Red Virginia Western White Spruce Red Sitka Sweetgum Tamarack Yellow-Poplar	Alder, Red Birch, Paper Cedar, Alaska Fir, Subalpine Hemlock, Eastern Maple, Bigleaf Pine Jack Lodgepole Ponderosa Spruce Redwood Spruce Black Englemann White	Aspen Bigtooth Quaking Cativo Cedar Incense Western Red Cottonwood Eastern Black (Western Poplar) Pine Eastern White Sugar	Basswood Fir, Balsam Poplar, Balsam

Figure 13-6. Species used for face veneers of plywood are grouped according to their strength. Group 5 contains the weakest species. (*APA–The Engineered Wood Association*)

The 1200 mm by 2400 mm panels fit the new standards. The 1220 mm by 2440 mm panels are made for use in structures based on the old system.

The COFI certification mark contains information necessary when selecting the panel. See **Figure 13-9.** The species designation refers to one of two species groups used in COFI plywood. One is Douglas Fir and the other is Canadian Softwood. See **Figure 13-10**. The COFI mark also indicates mill and CSA standard governing manufacture. The COFI mark does not indicate the veneer ply grade. It is simply an assurance to the buyer that the plywood meets CSA standards. The standards insure that the panel will perform in a satisfactory and predictable manner.

Metric Dimensions of COFI Exterior Plywood	
Thickness	
Sheathing and Select Grades	*Sanded Grades*
7.5 mm replaces 5/16″	6 mm replaces 1/4″
9.5 mm replaces 3/8″	8 mm new thickness
12.5 mm replaces 1/2″	11 mm new thickness
15.5 mm replaces 5/8″	14 mm new thickness
18.5 mm replaces 3/4″	17 mm replaces 11/16″
Size	
1220 mm × 2440 mm replaces 48″ × 96″	
1200 mm × 2400 mm new size	

Figure 13-8. The Canadian Standards Association has adopted the metric system for plywood dimensions. (*Council of Forest Industries of British Columbia*)

Veneer ply grades designate the face, back, and inner plies. They also note the type of defects in the panel. The face and back veneers may be sanded, unsanded, or covered with resin-fiber overlay. See **Figure 13-11**.

Adhesives

The adhesive that bonds the layers determines, in part, where the plywood is used.

- ***Type I fully waterproof adhesives.*** Used for exterior plywood. Type I panels are used for siding and sheathing. They are installed in other areas exposed to excessive moisture and microorganisms. Type I adhesives include melamine-resin, phenolic-resin, and resorcinol-resin.

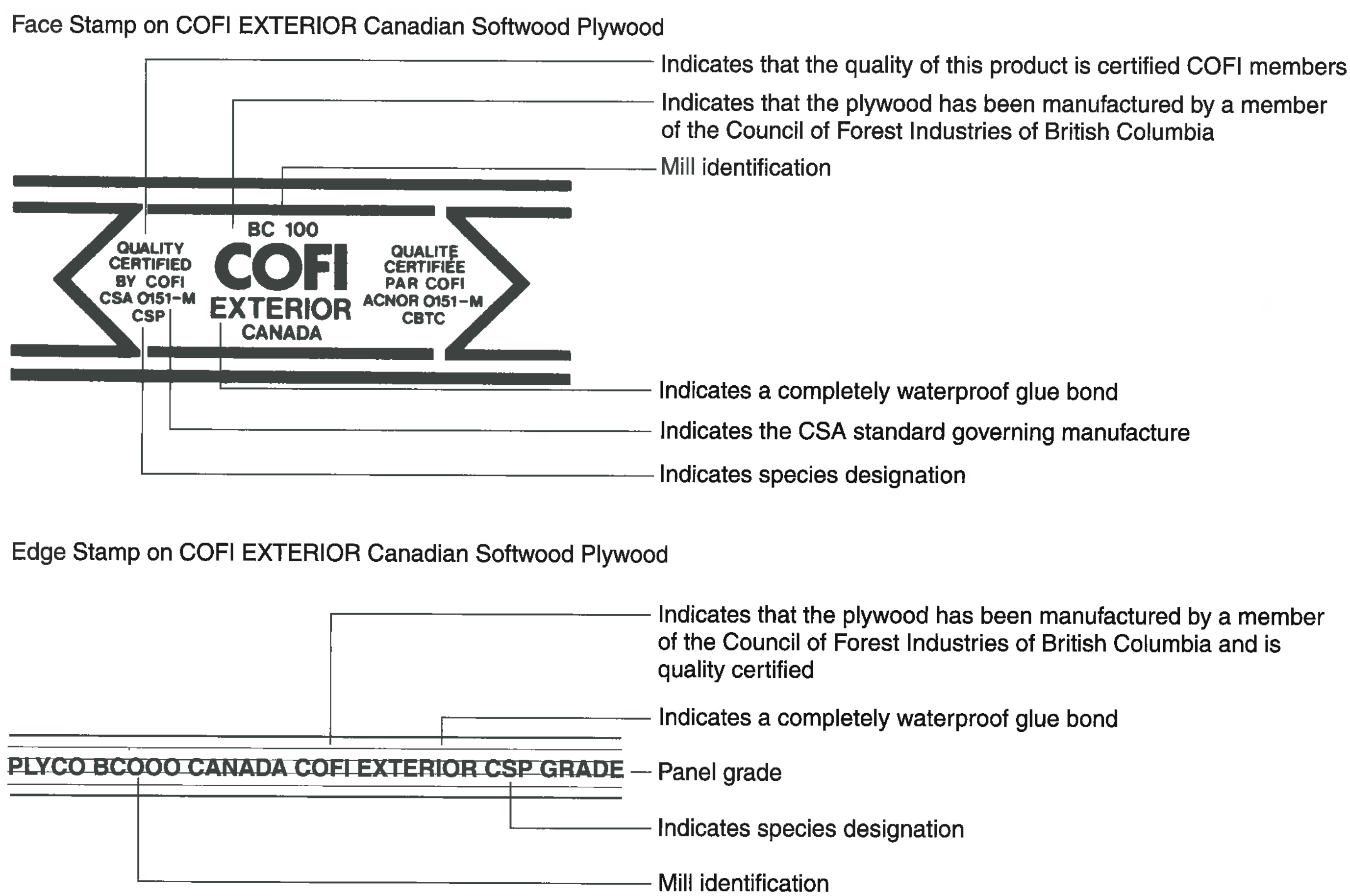


Figure 13-9. COFI Canadian plywood grade stamp contains information on wood species, glue bond, and CAS standard. (*Council of Forest Industries of British Columbia*)

Species Used in COFI Plywood			
Douglas Fir Plywood (DFP)		Canadian Softwood Plywood (CSP)	
Faces and Backs	*Inner Plies*	*Faces and Backs*	*Inner Plies*
Douglas Fir *Backs of 6 mm, 8 mm, 11 mm, and 14 mm good one side grade may be: Western Hemlock True Fir Sitka Spruce Western White Spruce Western Larch Lodgepole Pine	Douglas Fir Western Hemlock True Fir Sitka Spruce Western White Spruce Western Larch Western White Pine Ponderosa Pine Lodgepole Pine	Western Hemlock True Fir Sitka Spruce Western White Spruce Western Larch Lodgepole Pine	Douglas Fir Western Hemlock True Fir Sitka Spruce Western White Spruce Western Larch Western White Pine Ponderosa Pine Lodgepole Pine

Figure 13-10. Canadian plywood is divided by species into two areas. Inner plies contain the same species for both DFP and CSP. (*Council of Forest Industries of British Columbia*)

- ***Type II moisture resistant adhesives.*** Used for interior plywood grades. The bond retains its strength when occasionally exposed to wetting and drying. Interior plywood is installed where the moisture content will not exceed 20 percent.
- ***Urea resin.*** The most widely used interior plywood adhesive. It is inexpensive, extremely flexible, and provides an excellent bond. It is often called urea formaldehyde resin. Formaldehyde is added to the resin to speed up curing time. However, formaldehyde gas is an eye and respiratory irritant. The U.S. Environmental Protection Agency has recommended that lower levels of formaldehyde be used to prevent *outgassing*. Interior plywood bonded with exterior glue is recommended. The face veneers are interior quality, yet safer glues are used for bonding.
- ***Type III moisture resistant adhesives.*** They retain their strength only when occasionally subjected to moisture. Thorough wetting of the plywood will cause separations of the layers. It has some industrial applications as crating panels, and upholstered furniture blanks.

Composite panel

A ***composite panel*** consists of wood chip or fiber core faced with softwood veneer. See **Figure 13-12**. Besides veneer, printed vinyl and paper are used. Composite panels are used in both construction and cabinetmaking. Lower grades serve as floor underlayment as well as roof or wall sheathing. Grades suitable for finishing are installed as wall paneling or frame and panel cabinetry.

Waferboard

Waferboard is made of wood wafers and resin adhesive. See **Figure 13-12**. Wood wafers are high-quality chips of wood approximately 1″ to 2″ long of varying widths. The adhesive is generally a ***phenolic resin*** based product that is waterproof. Panels designed for interior use are fabricated with Type III adhesives. The chips and adhesive are mixed and then formed into panels with heat and pressure. Edges are trimmed to square the waferboard.

Waferboard faces often differ. One side might be smooth and slick. The other could have a screenlike texture. The textured side is suitable for veneer or printed plastic laminations.

Structural particleboard

Structural particleboard, often called *flakeboard*, is composed of small wood flakes, chips, and shavings bonded together with resins or adhesives. See **Figure 13-12**. Particleboard is manufactured much like waferboard. However, the wood chips are much smaller. The chips are mixed with glue, then pressed into panels.

Structural particleboard is especially made to withstand the stress and environment required for building materials. A common application is floor underlayment. Higher density layers on the surfaces contain smaller wood chips, extra resin, and wax. The increased density gives the panel greater strength and water repellency.

Particleboard is typically found in 48″ by 96″ (1240 mm by 2440 mm) sheets. Larger sizes are available. Thickness may be from ¼″ to 2¼″ (6 mm to 57 mm).

Regular Grades of COFI Exterior Plywood					
Grade*	Veneer Grades: Face	Veneer Grades: Inner Plies	Veneer Grades: Back	Characteristics	Typical Applications
Good Two Sides (G2S)	A	C	A	Sanded. Best appearance both faces. May contain neat wood patches, inlays, or synthetic patching material.	Furniture, cabinet doors, partitions, shelving, concrete forms, opaque paint finishes.
Good One Side (G1S)	A	C	C	Sanded. Best appearance one side only. May contain neat wood patches, inlays, or synthetic patching material.	Where appearance of one exposed surface is important. Shelving, built-ins, DIY projects. Concrete forms.
Select — Tight Face (SEL TF)	B†	C	C	Unsanded. Permissible face openings filled. May be cleaned and sized.	Underlayment and combined subfloor and underlayment. Hoarding. Construction use where sanded material is not required.
Select (SELECT)	B	C	C	Unsanded. Uniform surface with minor open splits. May be cleaned and sized.	
Sheathing (SHG)	C	C	C	Unsanded. Face may contain limited size knots, knotholes, and other minor defects.	Roof, wall, and floor sheathing. Hoarding, Construction and packaging uses where sanded material or uniform surface not required.
High Density Overlaid (HDO – 0/ – 0)	B†	C	B†	Smooth resin-fiber overlaid surface. Further finishing not required.	Bins, tanks, boats, furniture, signs, displays, forms for architectural concrete.
Medium Density Overlaid (Specify one or both sides) (MDO1S, MDO2S)	C†	C	C†	Smooth resin-fiber overlaid surface. Best paint base.	Siding, soffits, paneling, built-in fitments, signs, any use requiring superior paint surface.
COFIFORM COFIFORM SP	A A B C	C C C C	A C C C	Douglas fir panels specially constructed to provide improved and premium strength and stiffness. Available in regular sanded and unsanded grades and specialty grades with resin-fiber overlays or surface coatings of epoxy resin, modified polyurethanes, or other proprietary compositions. Also available with factory-applied release agent.	For premium performance applications, particularly in wet service conditions. Concrete formwork and selected structural engineering use and special service industrial applications.
COFIFORM PLUS COFIFORM SP PLUS				Special construction Douglas Fir panels with exceptional stiffness and strength. Strength properties exceed those of COFIFORM panels.	

**All grades, including overlays bonded with waterproof phenolic resin glue.*
†Permissible openings filled.

Figure 13-11. Using various veneer grade combinations, Canadian manufacturers produce panels for a variety of uses. (*Council of Forest Industries of British Columbia*)

Oriented strand board

Oriented strand board (***OSB***) is manufactured with strands of wood that are layered perpendicular to each other. OSB is a cross between waferboard and plywood. Like plywood, layers are in alternating directions. However, layers are high-quality wood chips, not veneer. OSB is similar to waferboard, except that chips are arranged in a pattern, not at random. See **Figure 13-12.** Three layers of chips are bonded with phenolic resin under heat and pressure.

OSB ranges in thickness from ¼″ to 23/32″ (6 mm to 18 mm). Thinner sheets have many applications, such as dividers, shelving, cabinet backs, etc. Sheets from 3/8″ to ½″ (10 mm to 13 mm) serve as roof deck, wall, and subfloor sheathing. Sheets above ½″ (13 mm) are used for single-layer flooring.

OSB has excellent dimensional stability and stiffness. It is frequently sanded smooth on both sides unless used for roof sheathing. Then, one side is given a textured, skid-resistant surface. When processing OSB, make cuts with carbide tipped blades. The high density of the board will quickly dull normal tools.

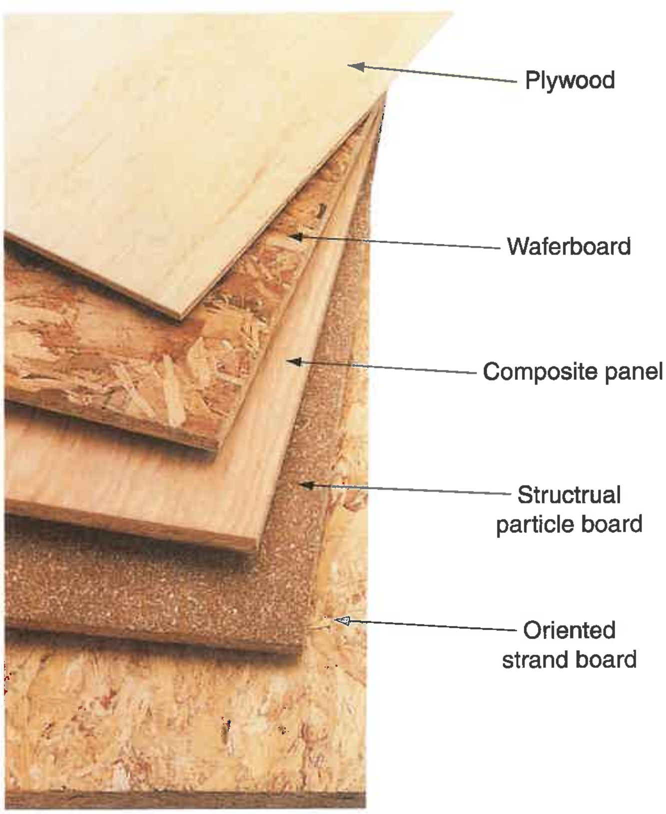


Figure 13-12. Structural OSB panels are selected for stability and strength. They serve many applications in building construction. (*Georgia-Pacific Corp.*)

Performance ratings

Performance-rated structural wood panels are designed to span specified distances. Applications include flooring, roof sheathing, and other building construction. Any structural wood panels may be performance rated if they pass test standards. These must meet or exceed U.S. Product Standards.

Standards met by performance-rated panels require rigid control of strength properties, dimensional stability, and bond durability. These are affected by the following:

- Wood species used to manufacture the panel
- Size, shape, and orientation of wood particles (for nonveneer panels)
- Board density
- Adhesive type

The performance rating is stamped on the panel. It indicates certification met through testing done by the *Engineered Wood Association*. See **Figure 13-13.**

Appearance Panels

Appearance panels may replace lumber in cabinets and fine furniture. They are fabricated to match the grain pattern of a particular wood species. The texture may be smooth or patterned. Most modern cabinet construction is done with unfinished hardwood plywood panels. They provide the appearance and strength of solid hardwood, yet are much less expensive.

Other appearance panels are used primarily as wall covering. They include:

- Prefinished hardwood and softwood veneered plywood
- Simulated woodgrain finish on plywood
- Simulated woodgrain finish on wood fiber substrate
- Prehung wallpaper paneling

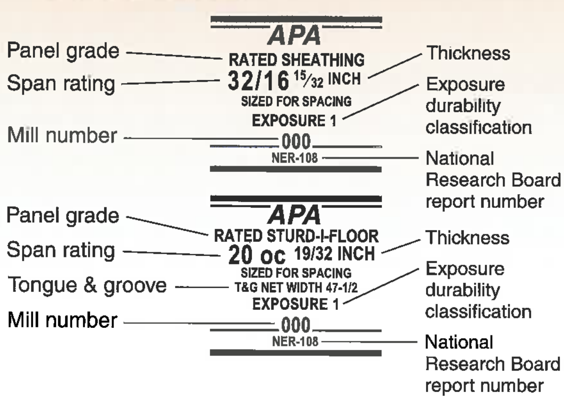
Hardwood plywood

Manufacturers of hardwood plywood concentrate on appearance grade plywoods. See **Figure 13-14.** The panels have hardwood face veneers over lumber, veneer, particleboard, or specialty cores. Hardwood plywood is manufactured much the same as softwood. They both consist of similar cores and adhesives. Hardwood plywood differs in the way face veneers are cut and arranged. The face veneers are matched to create some type of design.

Cabinet manufacturers choose hardwood plywood for many purposes. These include cabinets, fine furniture, and wall paneling. There is a wide selection of thicknesses, veneers, species, and grades.

Protected or Interior Use	
Grade Designation	**Description & Common Uses**
APA Rated Sheathing EXP1 or 2	Specially designed for subflooring and wall and roof sheathing, but can also be used for a broad range of other construction and industrial applications. Can be manufactured as conventional veneered plywood, as a composite, or as a non-veneered panel. For special engineered applications, including high load requirements and certain industrial uses, veneered panels conforming to PS 1 may be required. Specify Exposure 1 when long construction delays are anticipated. Common thicknesses: 5/16, 3/8, 7/16, 1/2 (15/32), 5/8 (19/32), 3/4 (23/32).
APA Structural I & II Rated Sheathing EXP 1	Unsanded panel grades for use where strength properties are of maximum importance: structural diaphragms, box beams, gusset plates, stressed-skin panels, containers, pallet bins. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. Made only with exterior glue (Exposure 1). STRUCTURAL I more commonly available. Common thicknesses: 5/16, 3/8, 1/2 (15/32), 5/8 (19/32), 3/4 (23/32).
APA Rated Sturd-I-Floor EXP 1 or 2	Specially designed as combination subfloor-underlayment. Provides smooth surface for application of carpet and possesses high concentrated and impact load resistance. Can be manufactured as conventional plywood, as a composite, or as a reconstituted wood panel (waferboard, oriented strand board, structural particalboard). Available square edge or tongue-and-groove. SPAN RATINGS: 16, 20, 24. Specify Exposure 1 when long construction delays are anticipated. Common thicknesses: 19/32, 5/8, 23/32, 3/4.
APA Rated Sturd-I-Floor 48 oc (2-4-1) EXP 1	For combination subfloor-underlayment on 32- and 48-inch spans and for heavy timber roof construction. Manufactured only as conventional plywood. Available square edge or tongue-and-groove. SPAN RATING: 48. EXPOSURE DURABILITY CLASSIFICATIONS: Exposure 1. Thickness: 1 1/8.
Exterior Use	
APA Rated Sheathing EXT	Exterior sheathing panel for subflooring and wall and roof sheathing, siding on service and farm buildings, crating, pallets, pallet bins, cable reels, etc. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. Common thicknesses: 5/16, 3/8, 1/2 (15/32), 5/8 (19/32), 3/4 (23/32).
APA Structural I & II Rated Sheathing EXT	For engineered applications in construction and industry where resistance to permanent exposure to weather or moisture is required. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. Unsanded. STRUCTURAL I more commonly available. Common thicknesses: 5/16, 3/8, 1/2, 5/8 (19/32), 3/4 (23/32).
APA Rated Sturd-I-Floor EXT	For combination subfloor-underlayment under carpet where severe moisture conditions may be present, as in balcony decks. Possesses high concentrated and impact load resistance. Can be manufactured as conventional veneered plywood, as a composite, or as a nonveneered panel. Available square edge or tongue-and-groove. Common thicknesses: 5/8 (19/32), 3/4 (23/32).

Typical APA Performance-Rated Panel Registered Trademarks



Typical All-Veneer Products Meeting PS1 Requirements

(Specify when required for engineered applications)

The Exposure 1 rating on a panel means that the panel is intended for protected consturction applications where ability to resist moisture during long construction delays or where exposure to conditions of similar severity is required.
The span rating which shows a pair of numbers separated by a slash mark indicates maximum span for roof sheathing (left) and maximum span for subfloor (right).
The span rating with O.C. indicates maximum span "on center" of joists.

Figure 13-13. Any structural panel may be performance rated. The performance-grade trademark is given to panels which meet special strength requirements. (*Georgia-Pacific Corp.*)

Figure 13-14. Hardwood plywood is fabricated with hardwood face veneers for use where appearance is important. (*Georgia-Pacific Corp.*)

Face veneer

The *face veneers* of hardwood plywood may be cut from a number of wood species. Ash, birch, cherry, elm, gum, mahogany, maple, oak, pecan, rosewood, teak, and walnut are readily used. The appearance is determined by the following:

- Species
- Portion of the tree where the veneer was cut
- Method of cut
- Method of matching

These topics will be discussed in the next chapter.

Core construction

Hardwood plywood cores may be veneer, lumber, or particleboard. Some cores are combinations of veneer and particleboard. Specialty cores include fiberboard, acoustical, fire-resistant, and lightweight materials.

- ***Fiberboard*** cores are more dense core than those of particleboard. The edges can be easily machined and closely resemble real wood when left exposed.
- ***Acoustical cores*** deaden sound transmission. Many acoustical panels are suitable for veneer lamination.
- ***Fire-resistant cores*** are chemically impregnated or made with mineral materials.
- ***Lightweight cores*** make use of lightweight materials and the honeycomb structure used by bees. ***Honeycomb cores*** have large strength to weight ratios. Typical core materials include kraft paper and aluminum. Other lightweight cores are made of wood coils and grids.

Thickness

The most popular thicknesses in hardwood plywood are ¼″ (6 mm) and ¾″ (19 mm). Thicker plywood is for casework. Thinner sheets are for backs and drawer bottoms. You can buy 3/8″ (10 mm) panels. However, these panels are made with top grade veneer and are more expensive.

Hardwood plywood grading

Standards for hardwood plywood are set by the ***Hardwood Plywood & Veneer Association*** **(*HPVA*)**. The hardwood plywood grade is established by the quality of the two face veneers. Face veneers are graded by the number of defects. No. 1 veneer has few defects. No. 4 contains unlimited defects. See **Figure 13-15**.

- ***Specialty hardwood plywoods*** refer to special orders between manufacturers and purchasers. Special cuts of veneer can be ordered. The method of matching the veneer may also be specified. Specialty plywoods are ordered for architectural purposes. The grade is stamped on the face and edge of the panel. See **Figure 13-16**.
- ***Premium A-1*** and ***Premium A-2*** are the finest stock grades of hardwood plywood. Premium grade veneer is applied to the front face. A Premium (or Good) grade veneer is applied to the back face.
- ***G1S-So. Bk.*** (Good 1 Side—Sound Back) is the next grade. The front face veneer of the wood species you choose has a rating of No. 1 Good. The back veneer is No. 2 Sound. The back veneer is the same wood species as the front, but has some defects. Unless specified, a veneer core of any species of wood will be used. It may not be entirely sound; inner plies frequently have knot holes that show as voids in edges of cut panels. Voids can be filled with wood putty.
- ***G1S*** (Good 1 Side) front face veneer is No. 1 Good as was the G1S–So. Bk. grade. However, the back is No. 3 Utility (or Reject) of any species the manufacturer selects.

Hardwood Plywood Veneer Grades		
Grade	**Face Veneer**	**Allowable Defects**
1	**Premium**—Book matched or slip (repeating grain figure but unmatched joints) matched for pleasing effect.	Burls, pin knots, slight color streaks, and inconspicuous small patches in limited amounts.
1	**Good**—Unmatched, but sharp contrasts in color, grain and figure not permitted.	Burls, pin knots, slight color streaks, and inconspicuous small patches in limited amounts.
2	**Sound**—Free from open defects.	All appearance defects permitted so long as smooth and sound. Smooth patches permitted.
3	**Utility**—(or Reject)	All natural defects; including open knots, wormholes and splits, maximum size of which are defined.
4	**Backing**	Defects practically unlimited; only strength and serviceability are considered.

Figure 13-15. The grading system for hardwood plywood face veneers includes five categories. The grade may be given by number or face veneer designation. (*Paxton Lumber Co.*)

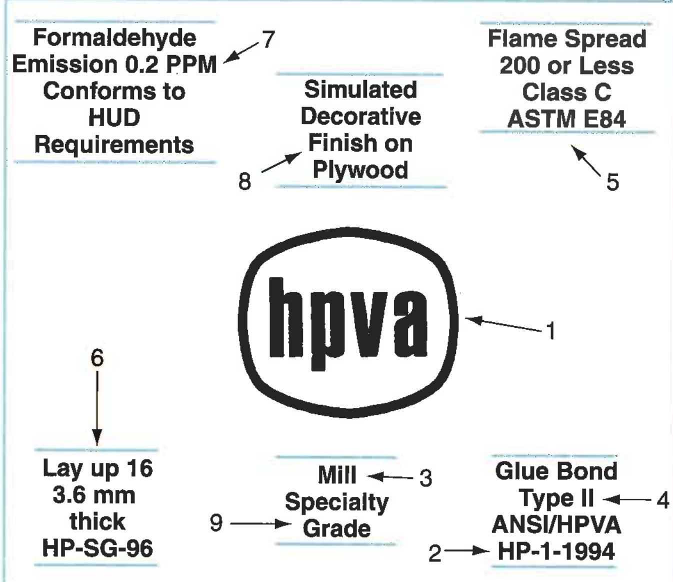
- *Craftsman* or *Shop* grades apply to panels where the front face has unmatching veneer. It may have sharp contrast in color and/or grain pattern.

Any grade combination of face and back veneers can be obtained for hardwood plywood. Dealer stocks are usually limited to those discussed, but specialty orders can be made.

Ordering hardwood plywood

The types of plywood stocked by lumber dealers varies according to region. A variety of cores, veneer species, veneer cut, and veneer match are available. Check with your dealer for the panels they have or can order. When ordering, include the following specifications:

- Number of panels (not square or board feet).
- Width, length, and thickness.
- Number of plies (for veneer core; if choice is given).
- Core construction (if other than veneer).
- Species of front face veneer.



Typical grade marks used on hardwood plywood include: (1) The trademark of the HPVA (Hardwoood Plywood & Veneer Association). (2) The standard governing the manufacture. (3) The HPVA mill number. (4) Plywood glue type. (5) The flamespread rating. The lower the number, the slower the flamespread. Asbestos sheet is 0, and red oak is 100. Drapes, rugs, newspapers, clothing, etc., have a flamespread of about 200. (6) Structural description. (7) Formaldehyde emissions. (8) Species of wood on face or finish type. (9) Veneer grade of face. Grade of veneer on back is sometimes shown following grade of face; this is optional.

Figure 13-16. Hardwood plywood panels are graded using the HPVA grade mark.

- Method used to cut front face veneer (if choice is given).
- Method of matching front face veneer (if choice is given).
- Grade (if grade is G1S, specify wood species of back veneer).
- Adhesive type.

The following orders are examples that will be understood by any plywood dealer.

- 5 pcs. 3/4" x 48" x 96", lumber core, plain sliced Walnut, slip matched, G1S, Ext.
- 3 pcs. 1/4" x 48" x 96", 3 ply, half-round sliced Red Oak, G1S—Sound Red Oak Back, Int.

Prefinished plywood paneling

Prefinished plywood panels are used primarily as wall covering and are offered in a variety of styles, colors, and textures. See **Figure 13-17**. Both hardwood and softwood veneers are used.

Prefinished panels range from 5/32" (4 mm) to 7/16" (11 mm) thick. They are made of three or five ply construction. Thin panels are usually applied over gypsum board covered walls. Thicker panels are sturdy enough to be attached directly to wall studs.

Face veneers are either rotary cut or plain sliced. Commonly used species are pine, fir, oak, birch, and walnut. The face veneers are finished with a topcoat for protection against moisture and wear.

Prefinished plywood panels frequently are textured with grooves running the length of the panel. The panel looks like multiple boards of varying widths.

Simulated woodgrain finish paneling

Simulated woodgrain finish panels are plastic laminates over either plywood or wood fiber substrate. Examples are hardboard, MDF, or particleboard. The appearance is much the same as prefinished plywood panels. See **Figure 13-18**. The panel is coated with acrylic finish for moisture protection and wear resistance.

The wood fiber substrate used on some simulated finish panels can be damaged by moisture and heat. Do not install them in hot or moist areas.

Prehung wallpaper paneling

Prehung wallpaper paneling combines the ease of panel installation with the design appeal of patterned wallpaper. See **Figure 13-19**. The paper is laminated onto a plywood or a wood fiber substrate. Grooves add texture to the appearance of the panel. Like other panels, an acrylic finish may be applied to the surface for protection.

Engineered Board Products

Engineered board products are designed and manufactured to meet specific purposes. They may be installed for strength, appearance, or cost criteria

Figure 13-17. Prefinished paneling is used for wall decoration. (*Georgia-Pacific Corp.*)

Figure 13-18. Simulated wood grain paneling looks much like real wood. (*Georgia-Pacific Corp.*)

Figure 13-19. Prefinished wall paneling can replace wallpaper. (*Georgia-Pacific Corp.*)

not available in other *natural* wood products. Many engineered board products have applications in the furniture industry for strong and durable panels.

Engineered board products are manufactured by various methods. For medium- and high-density fiberboard, wood fibers are mixed with resin. Then they are bonded by either radio frequency (RF) adhesion or heat. Low-density fiberboard and particleboard are fabricated by heat and pressure. The fiber and resin mixture and amount of pressure determine the strength of the board.

Fiberboard

Fiberboard is a very dense, strong, and durable material that is commonly used for case goods. Fiberboard is manufactured from refined wood fibers separated by either steam or chemicals. The fibers are randomly arranged into a continuous mat that is cut into sheets called wetlaps. The sheets are cured under pressure by heat or radio frequency (RF) bonding. RF bonding performs much like a microwave oven. The panel is *cooked* from the inside out. This provides a continuous density throughout its thickness. The amount of pressure determines panel density. Cured sheets are trimmed to dimension and packaged for shipping.

Fiberboard is classified into three densities. Each has specific applications in the furniture industry.

High-density fiberboard (hardboard)

High-density fiberboard (HDF), commonly called *hardboard,* is an extremely rugged material. Advantages over less dense panels include increased durability, strength, and resistance to abrasion. It is widely installed for drawer bottoms, cabinet backs, and paneling.

The strength of hardboard permits thin panels—1/8", 3/16", and ¼" (3 mm, 5 mm, and 6 mm)—to be fabricated. See **Figure 13-20**. Panel measurements are typically 4' wide by 8', 10', 12', or 16' long. Panels can be surfaced on either one side (S1S) or two sides (S2S). The unsurfaced side of S1S has a screen-like texture.

Types of hardboard

Hardboard is classified into three types. These types are standard, tempered, and service.

- ***Standard hardboard.*** The strongest of the three. It has good finishing qualities.
- ***Tempered hardboard.*** Standard hardboard with chemical treatment applied to the surface to increase strength, stiffness, and moisture resistance. This treatment makes it darker in color.

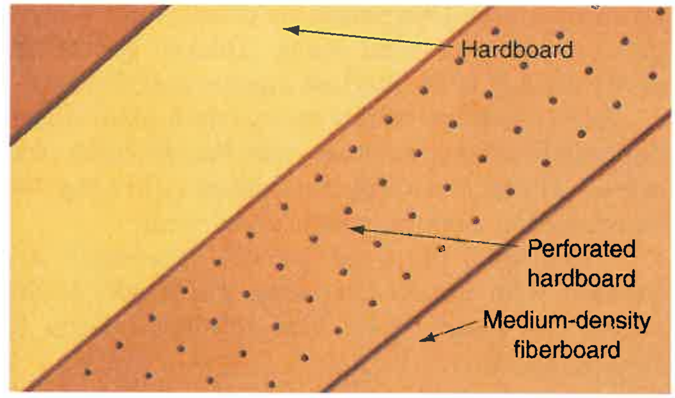


Figure 13-20. Fiberboards may replace lumber or plywood for many applications. (*Georgia-Pacific Corp.*)

- ***Service hardboard.*** Weaker and lighter than standard hardboard. Use it for lightweight applications. Dimensions of service hardboard may be 4' by 4' in addition to normal 4' by 8' size.

Specialty panels

Hardboard can be purchased in specialty panels. These include perforated, striated, embossed, grooved, and laminated.

- ***Perforated.*** Round, evenly spaced holes are drilled or punched. See **Figure 13-20.** Perforated hardboard is often called *pegboard.* Metal hangers (pegs) can fit into the holes to support tools, cooking utensils, etc. It then serves as a wall covering and storage panel.
- ***Striated.*** Closely spaced grooves are applied for texture.
- ***Embossed.*** Textured patterns, such as basket weave, are pressed into the board.
- ***Grooved.*** *V* or channel grooves are cut into the board for appearance purposes.
- ***Laminated.*** Hardboard is commonly used as the wood fiber substrate for simulated wood grain appearance panels.

Medium-density fiberboard

Medium-density fiberboard (MDF) is manufactured in much the same way as hardboard, but in greater thickness. Materials used for the construction of MDF are small particles of hard woods, soft woods, and a combination. Some manufacturers now use recycled paper. MDF is also formed with less pressure. See **Figure 13-20**. The added thickness, lack of grain pattern, and smooth texture of MDF make it ideal for replacing solid lumber. Surface stability and resistance to cracking due to the elimination of joints are added advantages. It is the base material for stained, painted, printed, or laminated applications. MDF is commonly used for furniture tops, drawer fronts, moldings, cabinet construction, shelving, and various millwork.

The random orientation of fibers in MDF means it is equally strong in any direction. There are no problems of grain direction as with solid lumber and plywood. The lack of fiber direction also improves other factors. Warping is almost eliminated. Sawing or machining MDF produces fairly smooth edges. Careful surface preparation is still required for high-grade products.

MDF is available in thicknesses ranging from 3/8″ (10 mm) to 1¾″ (44 mm). Standard sizes are either 49″ (1245 mm) or 61″ (1549 mm) wide, with lengths 97″ to 193″ (2464 mm to 4902 mm), in 24″ (610 mm) increments. Some manufacturers provide to the industry panels with nominal sizes as large as 5′ by 24′ (1245 mm by 7341 mm). MDF is manufactured approximately one inch larger than the nominal size to allow for trimming to finished dimensions . For example; a 4′ wide panel measures 49″.

Low-density fiberboard

Low-density fiberboard (***LDF***) is a lightweight panel commonly found in the upholstery industry. It provides more bulk than strength. It is approximately half the weight of MDF. Panel sizes typically are 1″ by 49″ by 97″ (25 mm by 1245 mm by 2464 mm).

Industrial particleboard

Industrial particleboard is composed of either small wood flakes and chips, or fibers. These are bonded together with resins or adhesives. See **Figure 13-21**. Three layers of wood chips are used. The two surface layers have smaller chips for smooth texture and increased impact resistance. High-quality manufacturing ensures dimensional stability and machinable edges.

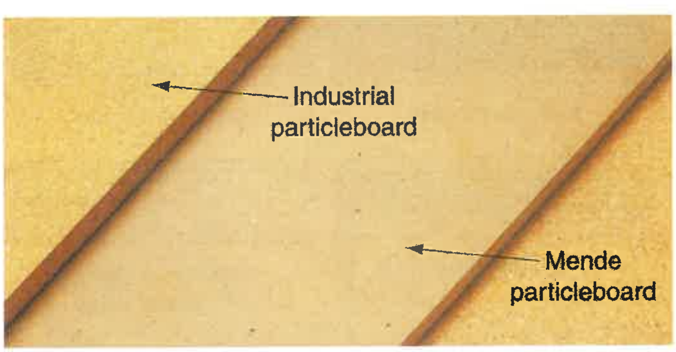


Figure 13-21. Particleboard is common in cabinets and furniture. It is often covered with a plastic laminate. (*Georgia-Pacific Corp.*)

Because of its smooth surface, industrial particleboard is often used as substrate material for laminations. Cabinets, furniture parts, countertops, tabletops, and drawer fronts are commonly made of particleboard. It is not as dense as hardboard or MDF. However, it adequately resists denting, cracking, and chipping. It is also less expensive.

Industrial particleboard is fabricated in dimensions suited to cabinetmaking. Standard panels are 49″ (1245 mm) or 61″ (1549 mm) wide, in lengths from 97″ to 121″ (2464 mm to 3073 mm), in increments of 24″ (610 mm). Some manufacturers provide the industry with panels as large as 5′ by 24′ (1245 mm × 7341 mm). Besides these large sheets, shelving and countertop panels are available in 13″, 17″, 25″, and 31″ widths. Industrial particleboard is available in 1/8″ (3mm), ¼″ (6mm), ½″ (13 mm), 5/8″ (16 mm) ¾″ (19 mm), 1″ (25 mm), 1 1/8″ (29 mm) 1¼″ (32 mm), and 1½″ (38 mm) thicknesses.

Industrial particleboard is manufactured 1″ (25 mm) larger than the nominal dimension to allow for trimming to finished dimensions. Beware of using particleboard for long span shelving. It has a tendency to sag, especially in spaces with high heat or humidity.

Mende particleboard

Mende particleboard is a low cost alternative to fiberboard. It is less dense than hardboard. It is manufactured in 5/32″ (4 mm) to ¼″ (6 mm) thick sheets. These are suitable for use as drawer bottoms, cabinet backs, picture frame backs, and as substrate for simulated wood grain paneling. See **Figure 13-21**. It is available in 97″ (2464 mm) sheets that are 49″ (1245 mm) or 61″ (1549 mm) wide.

Working with Panel Products

Panel products replace solid wood for many cabinets. However, when working with panel products, special considerations are required.

Storing panel products

Panels should be stored flat, never upright. Leaning the panel against a wall causes it to warp. The edges might also be damaged.

Panels are subject to moisture just like solid wood. A conditioned environment will reduce dimensional changes of the panel that could cause warping.

Sawing

Panels with veneer cores may be sawn using either a handsaw or a power saw. When using a stationary table saw or handsaw, make sure the good face of the panel is facing up. The bottom will tend to chip. This will prevent splintering of the face veneer. If you are using a radial arm saw or portable circular saw, this rule is reversed—place the good face down. This is because splitting occurs as the teeth exit the panel. Top quality, sharp saw blades with teeth of alternate top bevel design will greatly lessen the chipping.

Planing

Rarely do panel products need to be planed. Faces are manufactured smooth and the thickness is uniform. If panels are sawn properly, the edges should be straight. If you have to straighten the edges, you may use a panel saw, straight edge with a router, or a jointer. Remove any staples in the edge. Staples are placed in the edges of panels at several points between the factory and the shop to attach inventory papers, routing tags, and delivery slips.

Machining

Hardboard, medium-density fiberboard, and particleboard are often machined for use as countertop or molding. Shaping these materials is the same as shaping solid wood. Since there is no grain in these panels, they will machine very smoothly. They will also not splinter.

When shaping an edge that will be exposed, remember to leave room for edge treatment. Wood tape and most plastic laminates are 1/32″ to 1/8″ (0.8 mm to 3 mm) thick. Plastic and wood edges are also applied that are up to 3 mm thick.

Sanding

Most unfinished panel products are relatively smooth before they reach you. However, they are not ready for finishing. Depending on the application, you may want to sand the sawn panels before assembly. If you machine an edge, this will also require sanding. The same methods of sanding are used on both solid wood and panel products. However, when sanding plywood or other veneer face panels, do not sand heavily. The veneer is very thin. Removing too much wood will expose the core.

Using screws or nails

The nail or screw holding ability a panel has is related to its density. Panels that are light and weak will not hold fasteners as well as heavier and stronger panels. The weakest part of a panel is its edge. There is practically no holding ability in the edges of plywood, waferboard, oriented strand board, or particleboard. Higher density fiberboards have limited edge strength.

The face of a panel has good to excellent screw holding strength. Again, it depends on the density of the panel. For example, mende particleboard is limited in screw holding power. It should be used only when strong joints are not needed. Reinforcement with solid lumber may be required.

The nail or screw you use should be proportional in size to the panel. As a rule of thumb, the length of the fastener should be at least twice as long as the thickness of the panel. For example, when nailing ¾″ plywood onto a solid wood frame, use a 1½″ fastener.

To reduce splitting, predrill a hole. For a nail, use a bit slightly smaller than the nail's diameter. More than one hole size may be needed. Refer to *Chapter 16*.

Nails and screws should be countersunk into the face material. A plug, button, or wood dough may be put over the fastener to hide it. When using wood dough, apply it higher than the panel surface. Then sand it flush with the panel when it is dry.

Applying edge treatment

The edges of panel products are usually covered to hide the core composition. Many different edging materials can be used. You can use wood, metal, and plastic. The form of the edging and the method of bonding will differ. Common applications are shown in **Figure 13-22**.

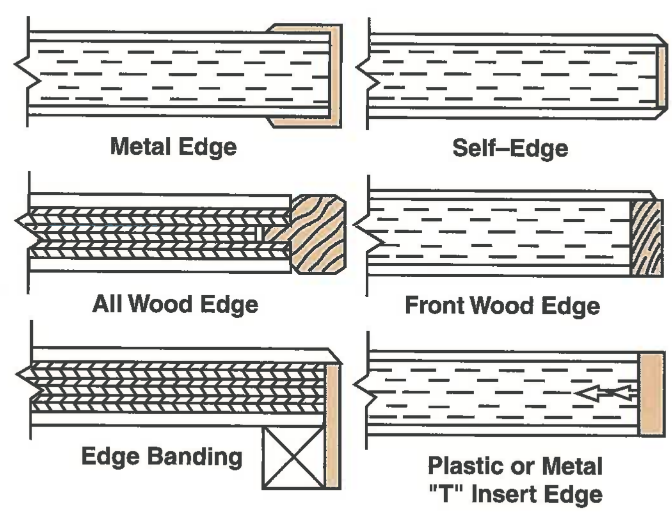


Figure 13-22. Plastic, wood, or metal edging is applied to the edges of panel products. It hides the composition of the panel. Do not use metal edging of this type where food is prepared.

Summary

Manufactured panel products are widely applied in case goods and fine furniture. Most consumers seldom know whether the product they are buying is solid lumber or a veneered or laminated panel product. For the most part, it doesn't matter. Most manufactured panels are stronger than solid lumber.

The three types of manufactured panel products are structural wood panels, appearance panels, and engineered board products. Most structural wood panels are used in building construction. These are performance-rated panels. Others are used in cabinetmaking. Veneered panels, such as plywood and composite board, can be used in assembling case goods.

Most interior woodwork is made with appearance panels. Hardwood plywood is a common material for modern cabinets and fine furniture. It has the appearance, strength, and durability of solid lumber, yet is much less expensive. Other appearance panels, such as prefinished plywood, simulated wood grain, and prehung wallpaper paneling, make good wall covering.

Engineered board products are fabricated for special purposes. Hardboard and mende particleboard are used as drawer bottoms, cabinet backs, and other applications requiring thin panels. Medium-density fiberboard is often used as a substitute for lumber moldings, drawer fronts, and various millwork.

Industrial particleboard is used for countertops and tabletops. Its smooth surface permits high-quality laminates to be applied.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. The surface of panel faces may be _____, _____, _____, or _____.
2. Which structural wood panels may be used for cabinetmaking?
3. Explain the manufacture of plywood.
4. Name several plywood cores for structural and hardwood plywood. What are the advantages and disadvantages of each?
5. Waferboard and oriented strand board are bonded by the adhesive _____ resin.
   a. melamine
   b. phenolic
   c. resorcinol
   d. urea formaldehyde
6. What is the danger of urea formaldehyde resin?
7. List the information found on a plywood grading stamp.
8. A disadvantage of hardwood plywood compared to solid lumber is that _____.
   a. edges must be hidden or taped
   b. face veneers do not look like solid lumber
   c. hardwood plywood is weaker than lumber
   d. screws cannot be used with plywood
9. Why might exterior adhesive be used on interior grade plywood?
10. Describe how the following products might be used in cabinet construction.
    a. structural plywood
    b. composite panel
    c. waferboard
    d. oriented strand board
    e. hardwood plywood
    f. prefinished plywood paneling
    g. hardboard
    h. medium-density fiberboard
    i. industrial particleboard
    j. mende particleboard

Manufactured panels are used for the manufacture of wall coverings and cabinetry. (*Wood-Made Cabinetry*)

14

Veneers and Plastic Overlays

Objectives

After studying this chapter, you will be able to:

- List the various methods of cutting veneer.
- Describe the grain pattern produced by each method of cutting veneer.
- Match veneer sheets into pleasing patterns for inlaying or overlaying.
- Identify characteristics and applications of rigid and flexible plastic overlays.

Important Terms

backup roller
burl
butt wood
crotch
flexible plastic bandings
flexible plastic overlays
flitch
half-round cutting
high-pressure decorative laminate
matching
peeler block
plastic overlays
quarter sawing
rigid plastic overlay
rotary cutting
stay-log cutting
stump wood
veneer bandings
veneer edgebanding
veneer inlay

Veneers and plastic overlays are used in most cabinetry and fine furniture manufactured today. An ***overlay*** is any thin, sheet material that typically covers a core material, such as plywood, MDF, or particleboard. The core material is known as the ***substrate***.

When the product has a wood veneer, simulated wood melamine or vinyl laminated on its surface, it looks as if it were constructed with solid lumber. Decorative designs such as natural stone and solid colors provide other attractive appearances.

Plastic overlays have an advantage over wood veneer. Plastics provide a nearly indestructible covering that requires no additional finish. Plastic overlays are fabricated from layers of synthetic materials. They may be rigid or flexible. Wood grain, solid colors, simulated stone, or other decorative designs may be printed in them.

Veneer and plastic overlays are frequently used to create decorative surfaces and edges. See **Figure 14-1**.

Figure 14-1. Veneer inlays are placed in diagonal directions to add beauty to this tabletop.

The art of veneering (inlaying and overlaying) has existed for centuries. Veneer murals unearthed in Egypt date back to 1500 BC. During the Dark Ages, veneering was abandoned, but in the 17th and 18th century a revival of veneering was seen in European traditional furniture. Today, most veneer is used as overlay for cabinet surfaces. The *art* of veneering is not so common in modern design. Straight line and plain designs are the preferred styles.

Veneer is cut from many wood species. Most softwood veneer is used to make structural plywood for building construction. Hardwood veneer is used for cabinetmaking and architectural purposes. See **Figure 14-2**. *Wood* cabinets are seldom made from either lumber or plywood. Thermally fused melamine particleboard panels are the primary materials. Hardwood veneer on a substrate combining particleboard and softwood veneer is also replacing plywood. Hardwood veneer is also laminated to thin plywood or fiberboard to be installed as paneling.

Figure 14-2. The walls of this residential study are paneled with MDF covered with mahogany wood veneer. (*Chuck Davis Cabinets*)

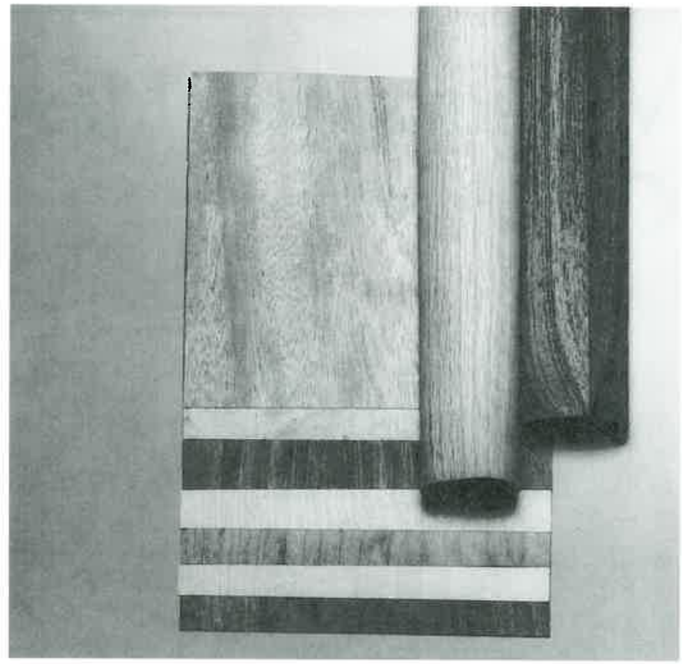


Figure 14-3. Thin, flexible veneer is easily bent around curved surfaces. Flat veneer is less versatile.

Types of Veneers

There are two types of veneer. These are flat and flexible. See **Figure 14-3**.

Flat veneer

Flat veneer is sold in thicknesses from 1/32″ to 1/28″ (0.8 mm to 1 mm). The most common is 1/28″ (1 mm). Despite the name, flat veneer may not always be truly flat. During the drying process, shrinkage of the wood cells causes the veneer to shrivel. The veneer can be straightened by moistening and then pressing it. Lay the damp veneer on a flat surface and cover it with a panel. Additional weight on the panel will help it to dry flat.

Flexible veneer

Flexible veneer is much thinner than flat veneers. Typically it is 1/60″ (0.4 mm) thick. Most imported veneers are flexible. Rare woods are cut thin to obtain more square footage from the log.

A plastic backing is usually bonded to flexible veneer to keep it from tearing. The backing serves three additional purposes:

- It keeps the veneer flat.
- It prevents the glue coating from rising to the surface ruining the finish.
- It prevents finishes from penetrating and dissolving adhesives.

A hot-melt glue coating might be applied to the backing. When the veneer is trimmed and ready to be laminated to a substrate, it is heated. The glue melts and bonds the veneer. Pressure on the veneer while it cools assures a good bond. A roller or weight may be used.

Cutting Veneer

Veneer is cut from select logs that have few defects. The logs are first debarked and cut to length to form ***peeler blocks***. Peeler blocks may then be halved or cut into additional sections depending on the appearance of the veneer to be produced. These sections are referred to as ***flitches.*** Before cutting, the peeler block or *flitch* is moistened and heated to ensure an easy, smooth cut.

The appearance of veneer depends greatly on the grain pattern. The grain pattern, in turn, is determined by the way the veneer is cut. Certain species, such as oak, are cut by several different methods to bring out the natural beauty of the wood.

There are six methods for creating veneer. They fall into the following three categories:

- **Rotary cutting.** Turning the log on a lathe.
- **Slicing.** Reciprocally moving the flitch against a knife. Slicing includes flat slicing and quarter slicing.
- **Stay-log cutting.** Swinging the flitch against the knife. Stay-log cutting includes rift, half-round, and back cutting.

Figure 14-4 shows each of the six methods of veneer cutting and the resulting grain pattern.

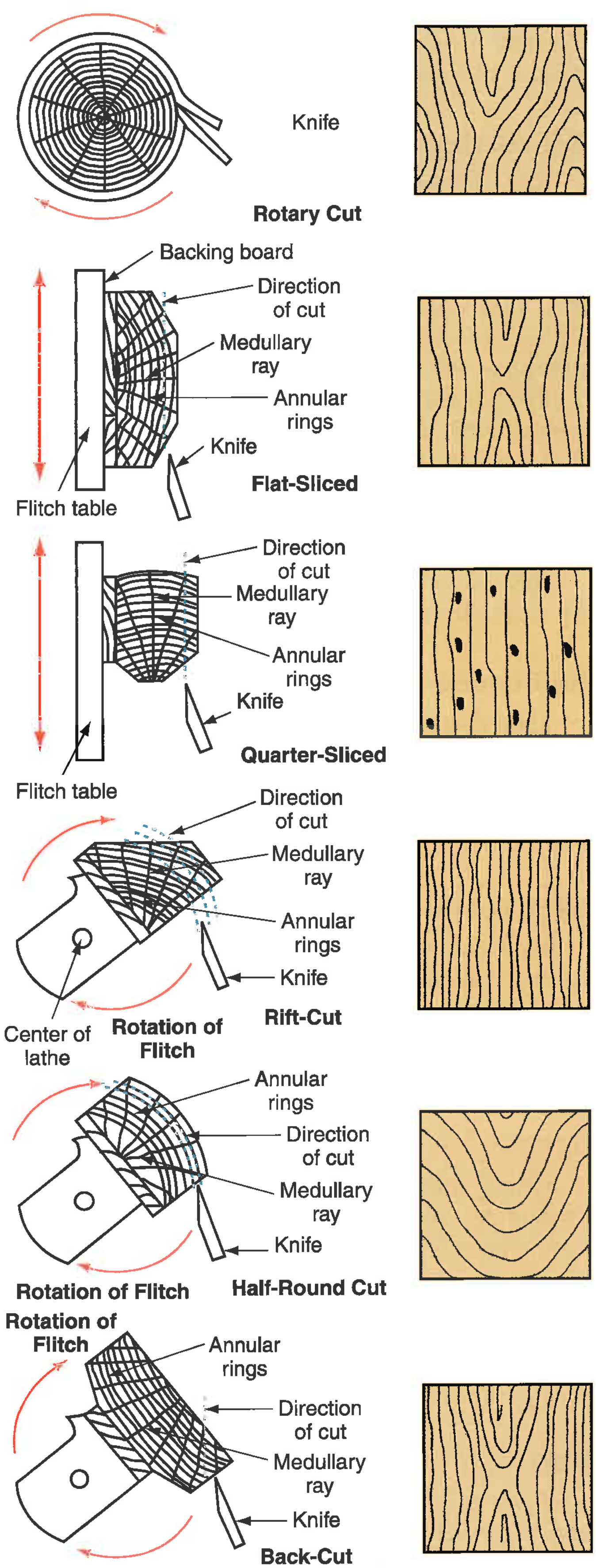


Figure 14-4. The method of cutting veneer greatly affects the veneer's grain pattern.

Rotary cutting

Rotary cutting means turning the log against a sharp, stationary knife. Sheets of veneer are peeled off the log like paper towels off a roll. The log is turned either by chucks or by a backup roller.

Chuck turning involves inserting spear-like chucks in the ends of the log. Sometimes, the log binds against the knife, but the chucks keep turning. This is called ***spinout***. When it occurs, the remainder of the peeler block is waste.

Backup roller turning technology eliminates using chucks in the ends of the log. Instead, rollers are placed against the back of the log to push it against the knife. See **Figure 14-5**. The rollers also rotate the log. Because the chucks are not in the way of the knife, more veneer can be cut from a log. There is also less chance of spinout.

Nearly 90% of all veneer is made using the rotary method. Compared to slicing and stay log cutting, the rotary method is much faster. It also produces the most square feet of veneer from a single log.

The grain pattern created by rotary cutting is rippled in birch or maple veneer. Veneer of other species has a marble-like figure. The grain pattern of most rotary cut veneer is spread out. Tighter grain patterns are preferred for furniture. Softwood veneer for plywood may be rotary cut, but little hardwood veneer is cut by this method. Birch and maple are exceptions.

Flat slicing

Flat sliced (or *plain sliced*) veneer is created approximately parallel to the annual growth rings. Some or all the rings form an angle of less than 45°

Figure 14-5. Backup rollers turn the log as they press it against the knife. Continuous cutting action produces long sheets of veneer.

with the surface of the piece. The log for flat slicing, called the ***peeler block***, is cut in half, or ***flitched***. The flitch (a half section) is then secured to a ***flitch table***. A knife as long as the flitch table advances under the flitch. The flitch is then moved down against the knife. As the flitch table moves up and down, the knife advances forward peeling off succeeding sheets of veneer. The sheets are log length. The width is as wide as the section of the flitch contacting the knife. See **Figure 14-6.**

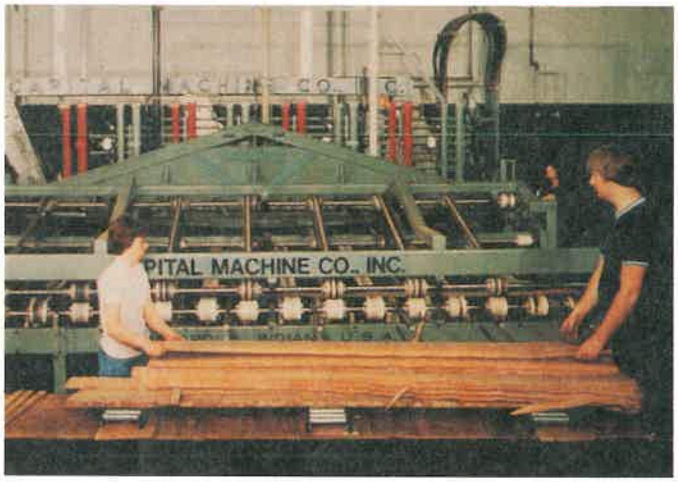


Figure 14-6. Flat sliced veneer exits the slicer and is stacked. It is later sent to a dryer.

Flat slicing is a popular method for cutting most hardwood species of veneer. The grain figure of veneer from the center of the log has wavy lines surrounding an oval tipped figure. Out from the center, the veneer appears as rippled stripes.

Quarter slicing

Logs are sawed to bring out the grain structure produced by medullary or pith rays, which are especially conspicuous in oak. When sawed into four flitches, the sawn edge is at a right angle to the annual rings. Hence, the name ***quarter slicing***. The edges are trimmed so they can be attached to the flitch table. The method of slicing is similar to flat slicing. However, the cuts are made at right angles to the annual rings.

Quarter slicing produces a striped grain figure. The lines may be straight or slightly wavy. Hardwood veneers produced in this manner are called *quarter-sliced*, and softwood veneers are called *straight-grained*. Flakes can be seen in the veneer where cuts were made through wood rays. Flakes are especially noticeable in oak veneer.

Quarter sliced oak veneer is relatively expensive. The time incurred by the sawyer and slicer, and the amount of waste produced, is extensive.

Rift cutting

Rift cutting is used exclusively for species such as the oak family, which have heavy wood ray growth. The rift or comb grain effect is made by cutting about 15° off perpendicular to the wood rays. Up to twenty-five percent of the exposed surface of each piece of veneer may contain medullary ray flake.

Flitches for rift cutting are quarter sections of a peeler block. The flitch is attached off center to a ***stay-log lathe*** that swings the flitch across the knife. The arc on which the veneer is cut is greater than the curve of the annual rings. This produces the extremely thin grain pattern.

Rift oak veneer is somewhat less expensive than if it were quarter sliced.

Half-round cutting

Half-round cutting is a method of stay log cutting which produces a large, *U-patterned* grain. Flitches are mounted off center in the lathe. The cutting arc is greater than the annual rings. Thus, cuts are made through more of each growth layer.

Back cutting

Back cutting is not a common method of veneer slicing. Flitches are placed backwards on a stay log lathe. The core of the half log is on the outer diameter and is cut first. The grain pattern resembles that of flat slicing, except that lines are much closer.

Special Veneers

Grain pattern is primarily created by the method of cutting. However, the area of the tree from which the veneer is cut, also affects the grain pattern. Rotary and half-round cut veneer comes from the lower portion of the trunk. Sliced veneer is taken from the upper portion of the trunk. Decorative veneers are cut from burl, crotch, and stump (butt) wood. See **Figure 14-7.**

Burl

Burls are lumps formed by new growth on a tree. Although the real reasons are not known, they may be to heal an injury. A branch might have broken off or another injury could have stunted tree growth. The new thick, twisted, fibrous cells may

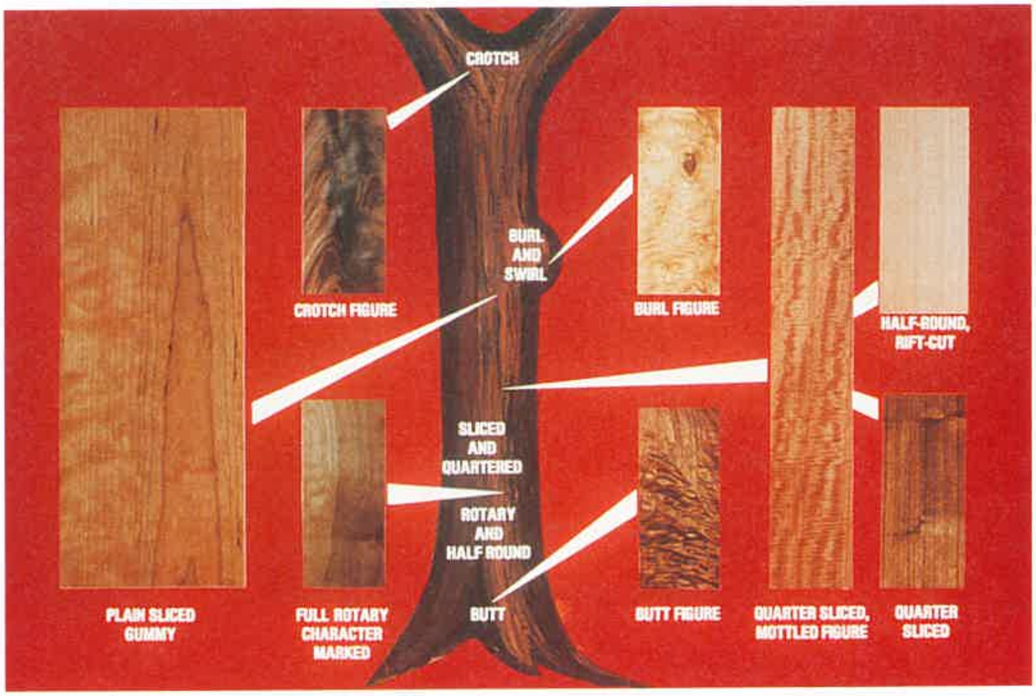


Figure 14-7. Certain portions of the tree are cut into veneer differently. Highly figured veneers are cut from crotch, burl, and stump wood.

follow the pattern created by the injury. The cause may be the result of a disease, fungus, or virus that attacked the cambium. Veneer sliced from burls has a circling, wavy, knotty pattern.

Crotch

A ***crotch*** is located where a branch separates from the main trunk. *Crotch wood* has a very distinctive and desirable pattern. Growth rings of the branch and trunk combine in a twisted pattern that is typically a darker color.

Stump

Stump wood, also called *butt wood,* is at the base of the trunk. The weight of the growing tree compresses the wood cells in this area. Stump veneer has a wrinkled line pattern. There is little difference between layers of a growth.

Clipping and Drying Veneer

Once the veneer is cut, it may go directly to a clipper or be stored temporarily on reels or on horizontal storage racks. A ***green clipper*** trims the veneer to various widths and removes defects.

After clipping, the veneer passes through large drying chambers. The veneer moves through the chambers on a conveyer system. Heating elements and fans reduce the moisture content. Some mills have dryers immediately behind rotary cutting lathes. The continuous sheet of veneer passes through the dryer as it comes off the lathe.

Veneers are generally dried to a moisture content below 10%. This is close to the recommended equilibrium moisture content for most parts of the country. This moisture level is also suitable for manufacturing plywood.

After drying, the veneer is *dry-clipped* to length in preparation for shipping. It may be spliced or taped together with other sheets to produce hardwood face veneers. Matching may be done during the splicing and taping process.

Matching

Veneer matching produces interesting, decorative designs. Hardwood face veneers are matched before being bonded as plywood. You may also choose to match veneers when inlaying or overlaying.

Matching is done by splicing veneers together with the grain pattern in specific directions. The veneers you use should be consecutive slices from a log. The color and grain pattern of successive slices are the same. There are many established patterns that are used to create veneer designs. See **Figure 14-8.** These established patterns are as follows:

- ***Book match.*** Uses successive sheets of veneer. Every other one is turned over. This gives the appearance of an open book.
- ***Slip match.*** The veneer is placed side by side. This provides pattern repetition.

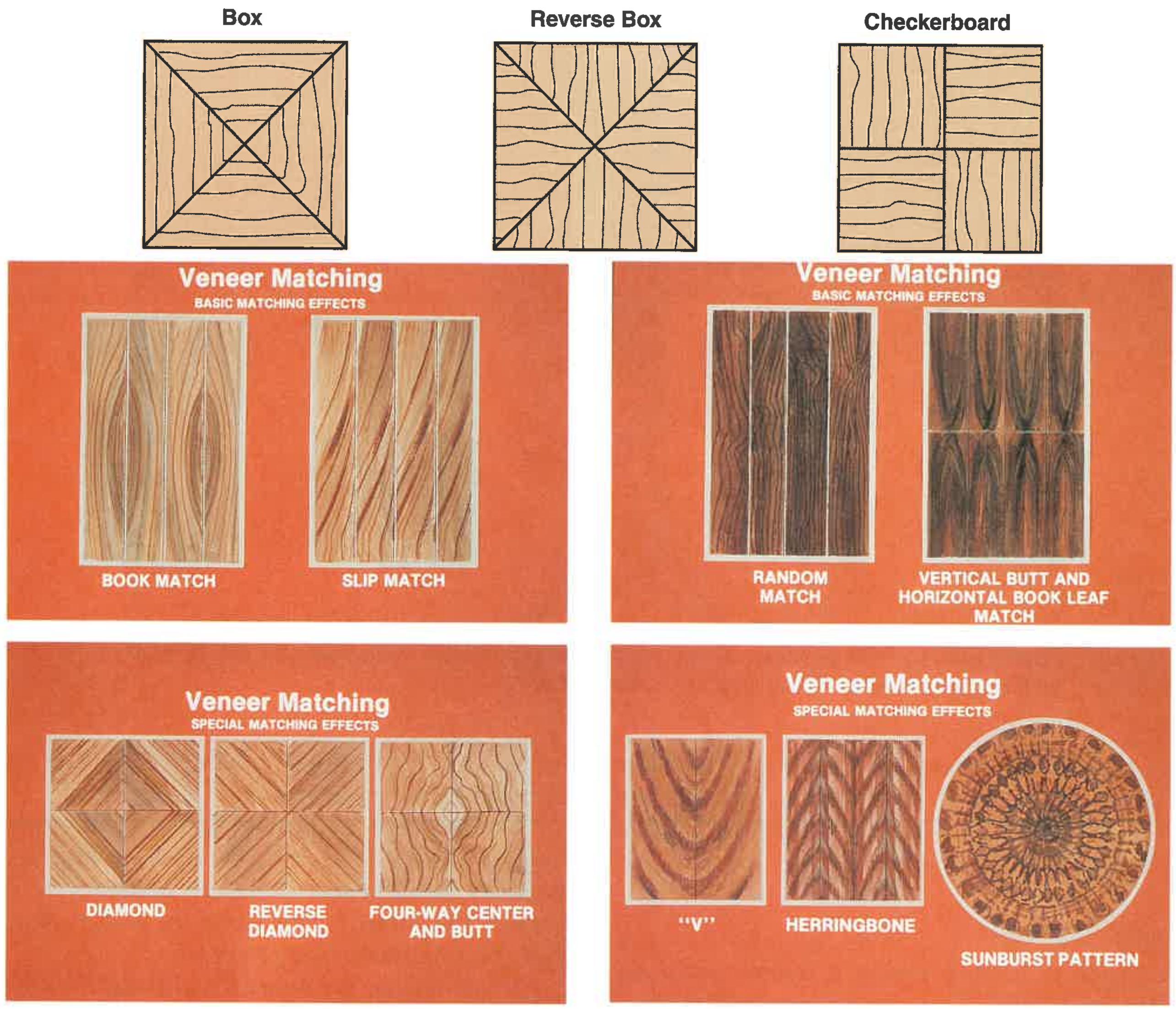


Figure 14-8. Veneer sheets are matched to form various decorative patterns.

- ***Diamond match.*** Veneer is cut at a 45° angle from the original veneer sheet. Four pieces each make 90° angles with the adjacent piece.
- ***Reverse diamond match.*** The grain pattern points toward the outer four corners.
- ***Four-way center and butt match.*** Uses four pieces of veneer that are matched with a common center, joined side-to-side and end-to-end.
- ***Vertical butt and horizontal book leaf match.*** Consists of two book matches butted together end-to-end.

Other matches include ***checkerboard, herringbone, box, reverse box, V,*** and ***random***. You may wish to create a unique method of matching.

Veneer Inlays

Veneer inlays are made by cutting veneer into a pattern and bonding it in a routed wood backing. See **Figure 14-9**. Using various wood species, colors, and grain patterns produces a pleasing effect. You may make or buy inlays.

Inlays are made by first preparing a pattern. Veneer is then cut according to color and grain to suit the pattern. The cutouts are assembled and paper is glued over the top. The outline of the pattern is routed into a solid wood substrate. The wood side of the assembled cutouts is glued into the routed depression. Pressure with a sandbag or vacuum press ensures solid adhesion. After the glue dries, the paper is moistened and removed. Then the surface is ready for sanding and finishing.

Veneer bandings

Veneer bandings are small pieces of veneer assembled into thin strips. The pieces are arranged in a decorative pattern. See **Figure 14-10**. Bandings are usually 1/20″ (1.3 mm) thick, 36″ (914 mm) long,

Figure 14-9. Veneer inlays outline the drawers of this secretary.

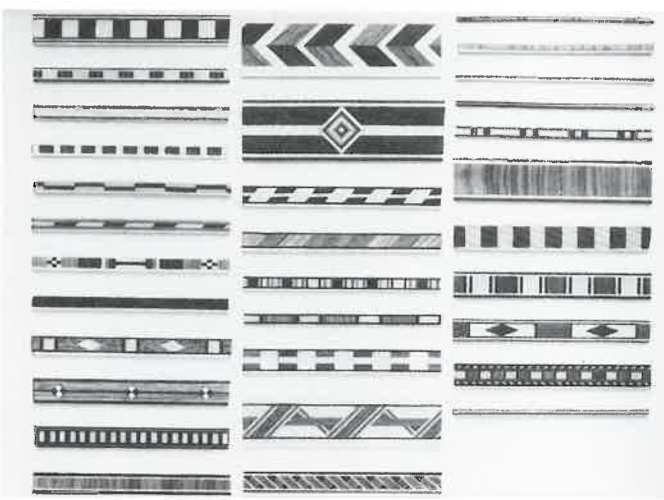


Figure 14-10. Veneer bandings come in preassembled patterns to be used for inlay. (*The Woodworkers' Store*)

and have varying widths. They may be inserted and bonded into routed grooves or applied to the surface. During the finishing process, wood inlays and bandings must be protected. Cover them with masking tape. You may not want stain and filler applied to them.

Edgebanding

Edgebanding is an overlaying process in which you cover the edges of manufactured panel products. Also, the material that is applied in the process may be called edgebanding. See **Figure 14-11.**

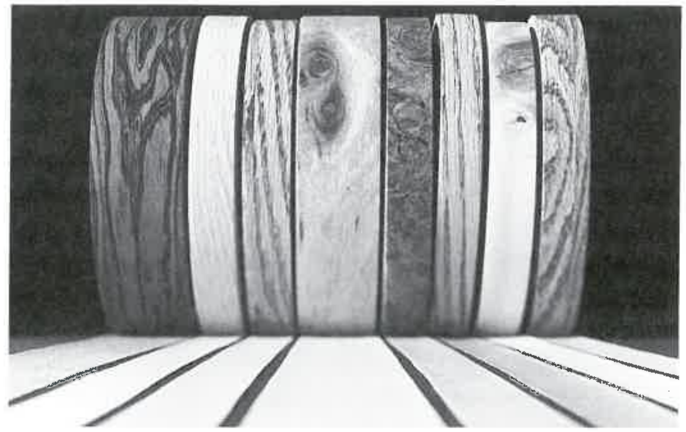


Figure 14-11. Veneer edgebanding is sold in rolls. The veneer may have fleece or paper backing. The veneer edgebanding may be bought with hot-melt glue already applied to the backing, or the glue may be applied by an automatic edge banding machine. (*Woodtape, Inc*)

Besides veneer and thin wood, there are many other edgebanding materials, such as plastics like PVC (polyvinyl chloride), melamine, polyester, ABS (acrylonitrile butadiene styrene).

When applying edgebanding, the panel faces typically have already been laminated with veneer, thermofused melamine, or high-pressure decorative laminates (HPDL). Panel edges should be relatively smooth and without noticeable chipping. Generally, cutting the material on a stationary power saw equipped with saw blade designed for the workpiece material will produce an acceptable edge. If not, cut the workpiece slightly oversize, and use a straightedge and router fitted with a straight bit to trim the workpiece to size.

You can either cut veneer for edgebanding, or use a manufactured edgebanding. Strips of cut veneer are bonded with adhesive and held in place with an edge clamp. The process is similar to veneering. Using edgebanding is easier. As previously mentioned, manufactured edgebanding is made of several different materials.

For a 3/4" (19 mm) workpiece, the edgebanding is typically 7/8" (22 mm) wide. Rolls can be bought from 1/2" to 10" (13 mm to 254 mm) wide. Edgebanding may or may not have a hot melt glue coating on the back.

Veneer, melamine, and polyester edgebandings are applied to the edges of the panel with a hand iron, a household iron, or an edgebanding machine. Contact cement may be used to apply veneer that has a suitable backing.

Due to relatively low melting properties, PVC edgebanding cannot be applied with an iron. You must use either an automatic edgebander that applies heated hot melt glue or an edgebander that blows heated air against the preapplied glue and workpiece. **Figure 14-12** shows the PVC, melamine, polyester, ABS, and wood veneer edge-banding process.

Plastic Overlays

Plastic overlays are rigid or flexible. They are widely used to cover many kitchen, bath, home office cabinets, and built-in case goods. See **Figure 14-13**. They are also used for counter and table surfaces, wall covering, and trim. Plastic overlays provide a tough, durable surface that resists water, stains, and many household chemicals.

Wood grain patterns, geometric shapes, simulated stone and solid colors are available. Many of these are available in more than one type of overlay.

Because the producers of plastic overlay are represented by two different organizations, two categories have evolved. High-pressure decorative laminates (HPDL) are produced by the standards established by members of the ***National Electrical Manufacturers Association*** (*NEMA*), and all other overlays, including edgebandings, may be produced by the standards established by members of the ***Laminating Materials Association*** (*LMA*).

Rigid plastic overlays

There are two specific forms of rigid plastic overlays. In addition to HPDL, there are low-pressure decorative laminates (LPDL).

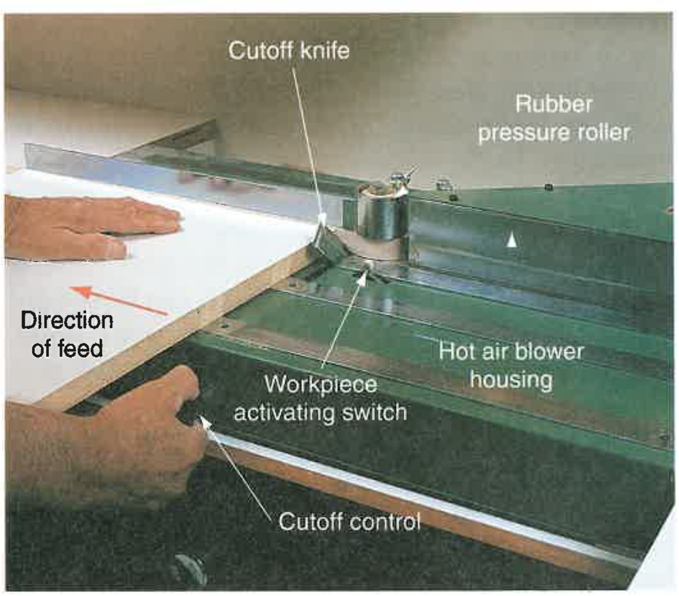


Figure 14-12. Edgebanding is applied to panel products. The operator has completed application and is pulling the knob to activate the cutoff knife. (*Chuck Davis Cabinets*)

High-pressure decorative laminates

Originally, HPDL was produced during World War I as a substitute for *mica*, which was used as an electrical insulation. Hence, the trademarks of Formica® and Micarta®. In the woodworking industry, it has been put to many uses, including countertops, vertical facing, and flooring.

HPDL consists of phenolic resin impregnated layers of kraft paper. ***Kraft paper***, much like brown wrapping paper, gives the panel thickness and rigidity. A *decorative pattern sheet* impregnated with melamine resin is added to provide color and texture. A clear sheet of *melamine treated paper* covers the pattern sheet. HPDL thickness is determined by the number of layers of kraft paper, and the amount of resins absorbed by them. The layers are consolidated under heat and pressure into a plastic–like material. See **Figure 14-14**. A hydraulic press consolidates these layers under pressure as high as 1000 pounds per square inch (psi), using thermosetting resins at 265°F (130 °C) or more, to form the rigid laminate. A steel *caul* plate is inserted in the press for each sheet of HPDL and contributes the surface texture to the decorative face. The reverse side of the caul plate contributes a rougher surface to back of the adjacent sheet of laminate. This makes it easier to bond the laminate to a substrate.

Figure 14-13. The surfaces of the cabinets, countertops, and table are covered with high-pressure decorative laminate (HPDL). The laminate covers particleboard construction. (*Whirlpool*)

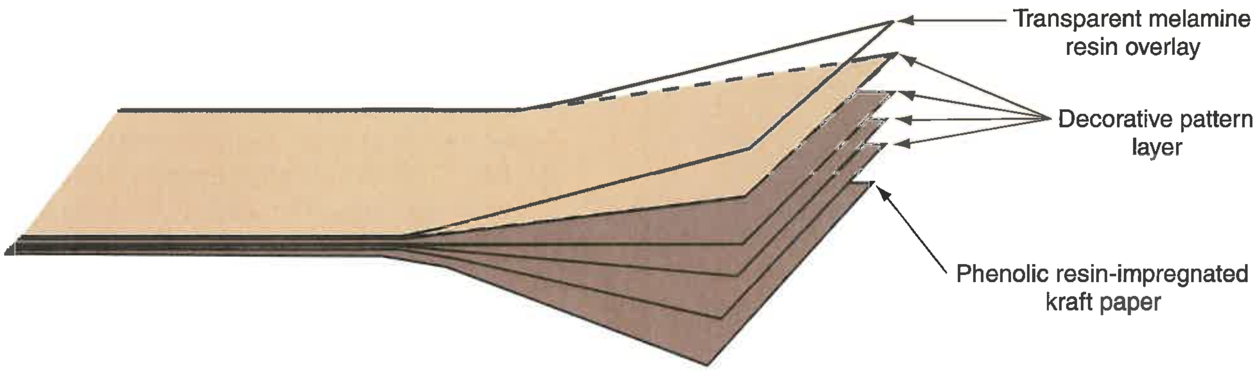


Figure 14-14. HPDL are composed of layers of resin and kraft paper.

Finishes

The finish, or surface texture, involves both appearance and performance. Finishes range from very low reflectance to mirror gloss. See **Figure 14-15**.

A soft, mildly reflective texture is referred to as *matte, suede*, or *velvet*. It is used for horizontal work surfaces because of high durability, low light reflectance, low maintenance, and the ability to hide fingerprints.

Manufacturers produce many woodgrain patterns with a soft finish similar in both appearance and feel to waxed wood. This material is widely used for interior passageway doors and cabinetry in the kitchen, bath, and in home and commercial offices.

Patterns that give the look of natural stone have many applications. However, they are used primarily for kitchen and bath countertops.

For vertical applications, high-gloss, mirror-gloss, or polished textures will create added design possibilities for the modern consumer. These high-gloss textures are easy to care for, but scratches are more visible—especially on dark colors.

Due to the demand for a variety of appearances, manufacturers have produced many different finishes for various applications. Check their brochures before ordering.

Thickness standards

NEMA has established standards for 11 thicknesses for HPDL sheets. See **Figure 14-16**. Consider the thicknesses and the performance properties in relation to your design and the intended use of the product.

Types

HPDL are divided into five basic types (grades or applications). They are general purpose, vertical, postforming, cabinet liner, and backing sheet.

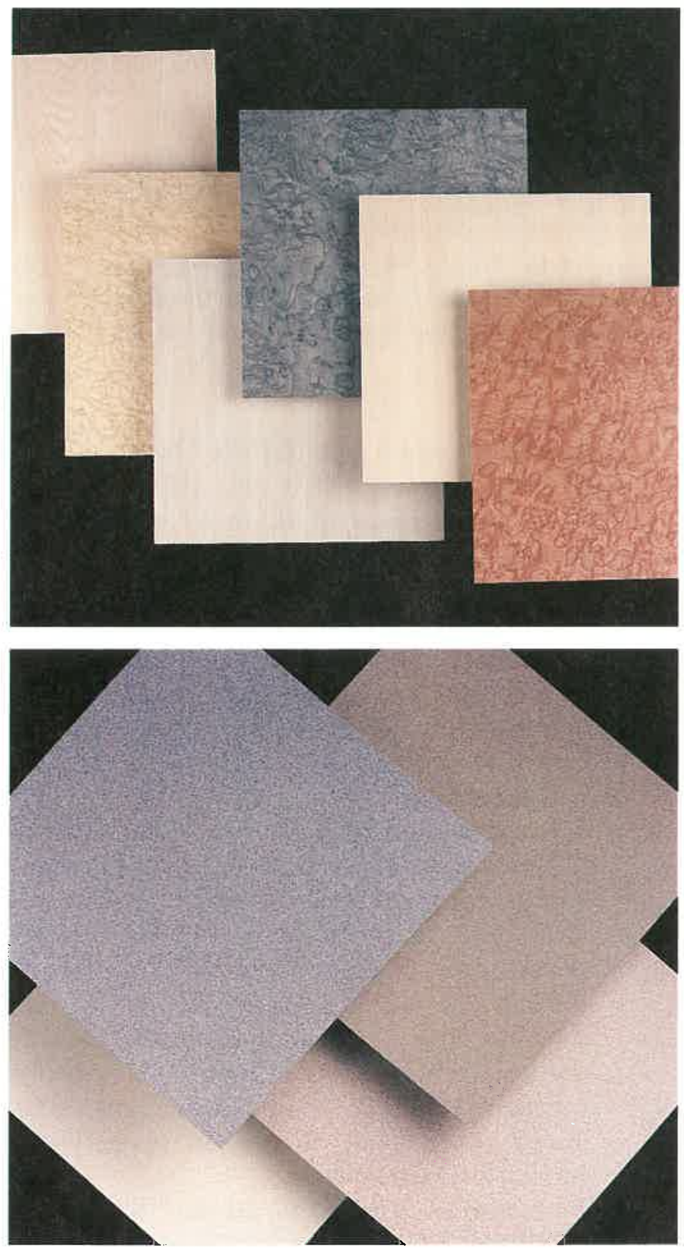


Figure 14-15. Laminate finishes may have woodgrain, glossy or orange peel textures. A variety of colors are available. (*Sterling Engineered Products, Inc.*)

Thickness		NEMA Product Type
0.020″	±0.005″	GP20 General Purpose CL20* Cabinet Liner BK20* Backer
0.028″	±0.005″	GP28* General Purpose
0.030″	±0.005″	PF30* Postforming
0.032″	±0.005″	FR32 Fire-Rated
0.038″	±0.005″	GP38 General Purpose
0.042″	±0.005″	PF42* Postforming
0.050″	±0.005″	GP50* General Purpose BK50 Backer FR50 Fire-Rated
0.062″	±0.005″	SP62 Specific-Purpose HW62 High-Wear FR62 Fire-Rated
0.080″	±0.008″	HW80 High-Wear
0.120″	±0.008″	HW120 High-Wear
0.125″	±0.008″	SP125 Specific-Purpose

Figure 14-16. NEMA Standard thicknesses for HPDL sheets. The asterisk (*) indicates that the material has attained the broadest application and availability for woodworking uses.

- ***General-Purpose type (GP50).*** This type is the most widely used. It is also called *Standard Grade*, and is resistant to impact and stains. It is suitable for both horizontal and vertical surfaces with outstanding wear resistance. The nominal thickness is .05″ (1.27 mm). The thickness permits a wide variety of patterns and finishes. General–Purpose type laminates are used for countertops, residential and commercial furniture, case goods, vanities, and store fixtures.
- ***Vertical type (GP28).*** This type is designed for use as wall panels and cabinet surfaces. The nominal thickness is .028″ (0.71 mm). This type is for vertical surfaces where thinner and lighter material is needed or desired. It is not as durable as General-Purpose type. Vertical type laminate sheets are for cabinet doors, laminated interior passageway doors, wall panels, bath enclosures, and toilet partitions. You can cut strips for use as edgebanding.
- ***Postforming type (PF30, PF42).*** This type is fabricated so that the material can be heated and bent in small curves. It is especially applicable to countertops, cabinet doors, and drawer panels that include curved corners and edges. See **Figure 14-17**. Many laminators offer panels with laminate wrapped 180° on two edges. Nominal thicknesses are .030″ (0.76 mm) and .042″ (1.07 mm). Although thinner than some General-Purpose types, the .042″ (1.07 mm) Postforming type maintains the same qualities. The .030″ (0.76 mm) thickness grade weighs less and is bonded to light-duty surfaces that are not subject to impact. There are four advantages to using formed surfaces:
    - Maintenance is easy when the curved surface eliminates seams.
    - Durability is enhanced by eliminating sharp 90° corners, which is where most chip damage occurs.
    - Radius edges are safer. Toddlers, handicapped, and the elderly benefit from the elimination of sharp corners.
    - Curved lines let the designer improve product appearance.
- ***Cabinet Liner type (CL20).*** These laminates are made for the interior of cabinets and closets. Cabinet liner thickness is 0.020″. This type provides a decorative surface where there will be little wear.
- ***Backing Sheet (BK20, BK50).*** These laminates are applied to the opposite side of a substrate covered by a decorative laminate. If plastic laminate is applied to only one side, a plywood and particleboard panel is likely to warp. They are nondecorative and economical. They prevent an exposed substrate surface from taking on moisture and humidity. Backing grade laminates are less expensive and provide minimal wear resistance.

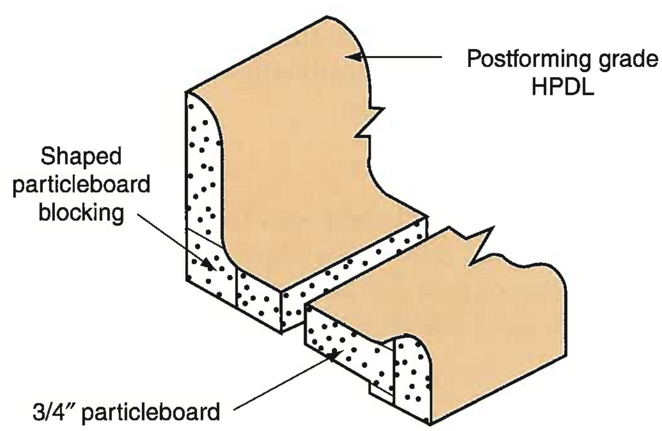


Figure 14-17. Many cabinet tops are made of postforming Grade HPDL that are heated and bent around shaped substrate. Particleboard is a popular substrate.

Special types

Beyond the types presented in the previous section, HPDL may have special treatments. These increase fire resistance, chemical resistance, or ease of fabrication. They also reduce so called *static cling.*

* ***Fire-rated decorative laminates.*** These are applied to wall and door covering where building codes specify fire resistant materials. They are designed to resist flame spread for a certain amount of time. Fire resistant laminates are commonly used in the corridors, elevators, stairwells, entries, fixtures and cabinetry of public buildings.
* ***Chemical-resistant laminates.*** These are designed for laboratory applications. They are available in both forming and nonforming types. The forming types are recommended for counters subject to repeated chemical attack. Some nonforming types are also fire resistant.
* ***Static-dissipative laminates.*** HPDL is a good insulator and does not store static electricity. Panels are suitable for environments where the accumulation and retention of static electricity must be avoided. However, the *static-dissipative laminates* are used in modern industrial clean rooms and elsewhere for applications where electrostatic charges are hazardous. The HPDL sheets have a conductive layer either as a backing or enclosed in the laminate. These sheets are connected to suitable grounding equipment. Laminates of this special grade are installed on cabinets for computers, photo equipment, instrument monitoring devices, and other sensitive electronic equipment.
* ***Metal-faced laminates.*** These are metal veneers with a kraft paper and phenolic resin backer. The surface may be an interior-type anodized aluminum, copper, and nickel alloys. The advantage of metal-clad laminates is the ease of fabrication as compared to conventional sheet metal. These sheets may be fabricated with normal woodworking equipment and the same gluing properties as other HPDL sheets.

Sheet size

Sheet widths are available in nominal widths of 30″ (762 mm), 36″ (914 mm), 48″ (1219 mm), and 60″ (1524 mm), with lengths of 96″ (2438 mm), 120″ (3048 mm), and 144″ (3658 mm). Most manufacturers provide an extra ½″ (13 mm) in width and length to allow for cutting and trimming edges. Not all sizes are available in all types and textures.

Edges

The thickness of rigid plastic results in a dark brown line on outside corners where vertical and horizontal panels meet. The edge can be a part of the design or be covered with other edging material. Covering reduces possible damage. Postforming grades are used to *wrap* radius edges to reduce or eliminate the brown lines. See **Figure 14-18.**

Adhesives

Plastic laminates are always fastened to a substrate material such as particleboard. See **Figure 14-19.** They

Figure 14-18. Postforming of radius edges and matching PVC edgebanding eliminates the dark brown line. The top and bottom edges of the drawer front serve as the drawer pulls. (*Chuck Davis Cabinets*)

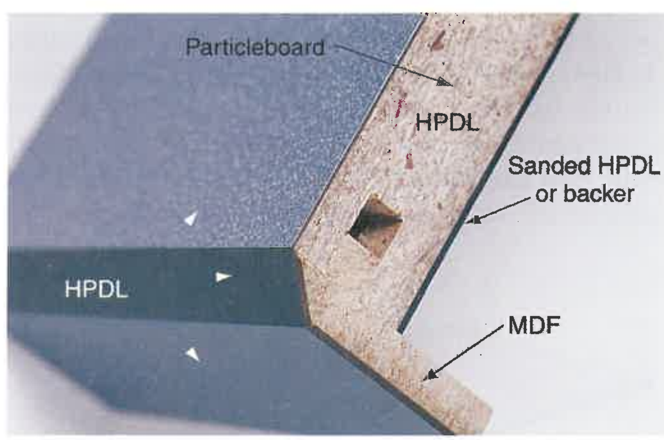


Figure 14-19. Laminates are typically bonded to a particleboard substrate. The particleboard supplies strength. Thin substrates are typically medium density fiberboard. The laminate provides the desired appearance. (*Chuck Davis Cabinets*)

are not rigid enough to provide structure. Various adhesives attach laminate to the substrate.

Rigid glues, such as urea formaldehyde and resorcinol, need constant pressure over time to ensure adhesion. ***Contact cements*** are called pressure sensitive. They are made of water emulsion or solvent based neoprene. These cements require momentary pressure to bond. Use a roller or mallet. ***Hot-melt glue*** is a nonsticky solid substance until heated. When melted, hot-melt glue is applied between the laminate and the substrate. The layers are pressed together and cooled to ensure a secure bond. Hot-melt glue is commonly used for edge banding applications with an edgebander.°

Low-pressure decorative laminates

The ***low-pressure decorative laminates*** (LPDL) discussed here are thermally fused melamine. Decorative paper is soaked in melamine resins and applied to a substrate with heat and pressure. The resin in the paper remelts and bonds to the internal part of the board. Heat and pressure create a cross-linking process of the resin. To remove the melamine from the surface of the board would destroy the board.

The major use of LPDL panels is for the interiors of cabinets. Other popular uses include office furniture, closet systems, restaurant tabletops or booth counters, and commercial display fixtures. Colors and patterns are available to match many of the HPDL products to provide a broader application of the panels.

Flexible plastic overlays

Flexible plastic overlays are made from layers of vinyl and are used for cabinet surfaces and floor coverings. See **Figure 14-20**. Polystyrene and other plastics are also used in producing flexible overlays. Flexible overlays resist chips, scratches, and most household chemicals. They are easily cut with a mat knife. You can adhere flexible overlays to both flat and curved surfaces using contact cement.

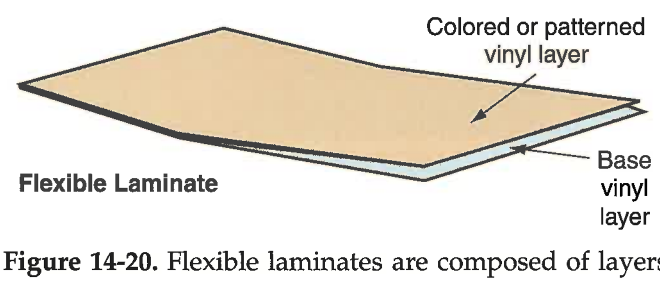


Figure 14-20. Flexible laminates are composed of layers of vinyl or other flexible plastics.

Various solid colors and patterned surfaces are fabricated. Some flexible overlays have reflective surfaces. They may appear to be polished brass, copper, or some other material. See **Figure 14-21**.

Flexible plastic banding

Flexible plastic bandings are thin, narrow strips that decorate cabinet edges and corners. See **Figure 14-22**. There are many patterns, shapes, and textures available. PVC is available in solid colors, woodgrains, and patterns. Solid colors will match most HPDL and many LPDL panels that are available. Paintable fiber bandings are available. Melamine edgebanding is also available in many colors and patterns.

Figure 14-21. These fabricated tables feature suede-finish laminates with glossy edgebanding. (*Sterling Engineered Products, Inc.*)

Figure 14-22. Flexible plastic edgebanding may be solid color or wood grain. (*Sterling Engineered Products, Inc.*)

Summary

Veneers and overlays dominate the cabinetmaking industry for product surfaces. They cover wood product panels, such as particleboard. They create finished, mar-resistant surfaces to countertops, tabletops, and case goods. Veneers and overlays provide a durable, low-cost alternative to solid lumber.

The veneer cutting method determines the grain pattern. The rotary cutting method is used nearly 90% of the time. It produces the most square footage of veneer from a log. Other cutting methods may have exclusive applications for a certain wood specie. Once the veneer is cut, it is clipped and dried.

Veneer is often matched to produce pleasing effects. Commonly assembled matches include book, slip, and diamond.

Plastic overlays are almost indestructible. High-pressure decorative laminates are rigid overlays manufactured using layers of resin soaked paper bonded under heat and high pressure. Thermally fused melamine is manufactured by bonding resin soaked paper to the substrate under heat and pressure. Flexible overlays are made from vinyl. Both rigid and flexible overlays provide durable, stain-resistant surfaces. Wood veneer and plastic overlays are also used for edgebandings and trim. Veneer bands are often inlaid into routed grooves in solid wood.

Using veneers and overlays will greatly reduce the cost of your product. When installed carefully, they will provide years of durable service.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Why might veneer or plastic overlay be used for a cabinet instead of solid wood?
2. Veneer thinner than 1/32" is typically referred to as _____ veneer.
   a. flat
   b. flexible
   c. stump
   d. softwood
3. What is a flitch?
4. Name the six methods of cutting veneer. Describe the veneer's grain pattern produced by each method.
5. Comb grain refers to _____.
6. Diagram the grain patterns of veneer cut from burl, crotch, and stump wood.
7. Sketch six common methods used for matching veneer. Plan and diagram two additional matches of your own design.
8. Veneer bandings are primarily used for _____.
   a. inlay
   b. overlay
   c. wood edging
   d. wood facing
9. Veneer edgebanding is used to cover _____.
10. Explain the difference between rigid and flexible plastic overlays.
11. What are the five types of rigid plastic overlays? What applications are each used for?
12. Besides the five types of rigid plastic overlays mentioned in question 11, what four special types of rigid plastic overlays are also available?
13. Three adhesives used to apply plastic overlay to a substrate are _____, _____, and _____.
14. Low-pressure decorative laminates, or thermally fused melamine panels, are mostly used for _____.
15. What are flexible plastic bandings?

Plastic laminates are used to cover the surfaces of the cabinets, countertops, and table. (*Sterling Engineered Products, Inc.*)

Glass, Plastic, and Ceramic Products

15

Objectives

After studying this chapter, you will be able to:

* Describe the various forms of glass, plastics, and ceramics used in cabinetmaking.
* Install sheet glass and plastic as panels and windows.
* Cut and assemble glass into leaded panels.
* List the various plastics and their applications.
* Install ceramic tile for counter surfaces, floors, and walls.

Important Terms

annealing	polishing
ceramic	scoring
fracturing	slate
glass	thermoplastic
grinding	thermoset plastic
plastic	wainscoting

Glass, plastic, and ceramic products are both functional and attractive cabinet components. Glass sheets are used for windows. Plastic may be molded to replace real wood, made in sheets to replace glass, or to be used as countertops. Ceramic tile adds beauty while it protects countertops and other surfaces.

Glass, Plastics, and Ceramics

Glass is made primarily of silica (sand), soda ash, and limestone. Other ingredients may be added for strength or decoration. The mixture is melted at about 2800°F (1538°C). It is then made into flat sheets, molded into knobs, pulls and decorations, or spun into thread.

Sheet glass is annealed after it is formed. The glass is reheated, but not melted, to remove internal stress. ***Annealing*** helps assure a controlled break when cutting the glass.

Flat glass may be tempered to increase strength. The glass is reheated and quenched (cooled) quickly. Tempered glass will break, and will shatter into many tiny, mostly harmless granular pieces. Shower doors, for example, must be tempered.

The use of glass dates back several thousand years. Vases, windows, and mirrors are early products. Glass blowing was the main method for making glass containers. Stained glass was developed almost 1000 years ago. About 300 years ago, glass began to be molded into containers. Today, glass is mounted in cabinet doors and installed as shelves. See **Figure 15-1**. It may also serve as a protective surface for wood products.

Plastics are synthetic compounds also called resins. Two forms of plastic are thermoplastic and thermoset. ***Thermoplastic*** materials may be reheated and reformed many times. Plastic for windows is usually thermoplastic. ***Thermoset plastics*** are formed into products during manufacturing by a chemical reaction. Door and drawer knobs are examples. If they are reheated, they distort beyond use.

Figure 15-1. Curio cabinets use glass doors and shelves to permit display of china. (*Thomasville*)

Early thermoset plastics, made at the turn of the 20th century, were known as celluloid and bakelite. Since then, plastics have improved and their applications have increased.

Most plastics for cabinetry are available in sheet and molded forms. See **Figure 15-2.** However, some plastics can be bought as liquid resin with a separate hardener. You may create a mold, mix the resin and hardener, and cast a plastic product that fits your needs.

Ceramic products are made of pottery clay. Moistened clay may be molded into a shape. The moisture is then allowed to evaporate and the clay object fired (baked) in a kiln. The object becomes very hard and somewhat brittle. Next, a glasslike decorative and protective substance, called ***glaze***, is applied to the object. It is again fired to melt and harden the glaze.

The earliest known use for ceramics was pottery. Clay was molded into containers and baked over coals. Nearly 5000 years ago, glazed clay tiles were common in Egypt. Thin, flat tile decorated walls and floors.

Ceramic tile is found with many modern cabinets. The tile is typically applied to countertops. See **Figure 15-3**. Tile surfaces are hard, smooth, and durable. They resist heat, moisture, stains, and scratches. Another type of tile is slate. ***Slate*** is a form of rock, which is mined and later fractured into tile. Then it may be sawed into rectangular shapes and installed in the same manner as ceramic tile.

Forms of glass, plastics, and ceramics

Glass, plastics, and ceramics are available in one or more forms. They may be sheet, molded, or spun into fibers. When combined with wood and hardware, they serve many cabinetmaking needs.

Sheet glass and plastic

Sheet glass and plastic serve as windows, tabletops, and shelves. When colored, they can create stained-glass effects. Semitransparent sheets are installed as light-diffusing panels. Mirrored plastic and glass reflect images and provide a sense of depth. A reflective metallic substance is applied to the back of the glass or plastic sheet.

Molded glass, plastic, and ceramic

Molded forms of glass, plastic, and ceramic create almost unlimited parts for cabinets and furniture. Glass and plastic are formed to make moldings, legs, spindles, knobs, pulls, and entire pieces of furniture. Ceramics are molded and glazed to become tile, knobs, and pulls. Ceramic tile may also be molded into decorative shapes.

Spun glass fibers

One unique glass material is called ***fiberglass***. Clear or colorful glass is spun into thread-like fibers. Fibers can be woven into mats and *cloth* rolls. They may also be cut into short pieces called ***rovings***.

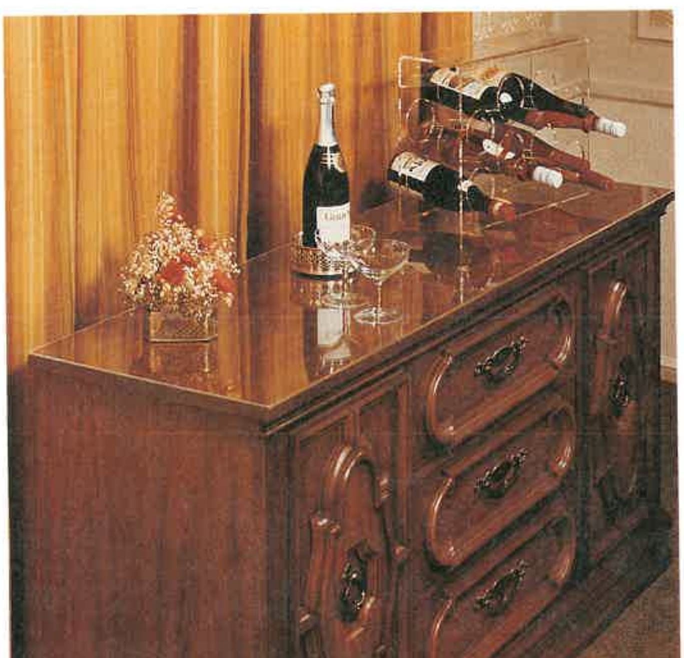


Figure 15-2. Sheet plastics are often used to protect surfaces. The wine rack is formed sheet plastic. (Rohm and Hass)

Figure 15-3. Ceramic tile provides an attractive and durable surface for this kitchen counter. (*Mid-West Tile*)

Mats, cloths, and rovings are bonded with liquid polyester resin mixed with a hardener. Cloth and mats are coated with layers of resin. Rovings are sprayed over liquid resin. Repeated coatings of fiber and resin are placed in or over a mold. When the resin cures, the very strong and durable fiberglass object can be removed.

Selecting Glass Sheets

Sheets of glass are selected for decorative and/or functional effects. The four kinds of basic glass manufactured are flat, decorative, tinted, and mirror.

Flat glass

Flat glass is the most common glass found in cabinetry. It is used in doors, on tabletops, and as shelves.

The glass-making process has changed. Years ago, flat glass was manufactured by rolling softened glass. If the rollers or rolling tables were dirty or scratched, the glass surface would not be completely flat. Today, flat glass is made through a floating process. ***Float glass*** is manufactured by spreading molten glass over molten tin. The tin, as a liquid, is smoother than the rolling tables were. As a result, the process creates a flat, smooth, and polished lower surface. Since the upper surface is untouched by rollers, it is smooth also.

Flat glass is manufactured in different strengths and thicknesses. Two forms are sheet and plate glass. ***Sheet glass***, for the most part, is single or double strength. The thickness of single strength glass is slightly less than 1/8″ (3 mm). Double strength glass is about 5/32″ (4 mm). Other thicknesses from 1/16″ to 7/16″ (2 mm to 11 mm) are available. Install the single strength glass only in frames. Double strength material is appropriate for windows and shelves.

Plate glass is thicker and often stronger than sheet glass. It may also have been tempered. It varies in thickness from ¼″ to 1¼″ (6 mm to 32 mm).

The edges of flat glass sheets are either hidden or visible. Visible edges must be ground before you install these components as doors, shelves, etc. The appearance of the ground edges may be enhanced by polishing. This is the normal treatment for premium products. All grinding and polishing must be done before tempering.

Decorative glass

Decorative glass is popular for cabinets. Some is made by altering the normal manufacture of glass. Four types of decorative glass are patterned, etched, cut, and enameled.

* ***Patterned glass.*** It is made by feeding the glass through rough or patterned rollers. The surface of the glass is embossed and becomes translucent. When looking through pattern glass, images are distorted or appear as shadows. Pattern glass is typically 1/8″ and 7/32″ (3 mm and 6 mm) thick and may be tempered to reduce the danger of jagged pieces when broken. It is installed in partitions, shower stalls, or wherever privacy is desired without blocking light.
* ***Etched glass.*** It is glass treated with acid that removes a thin layer of the surface. The pattern produced can be very decorative. See **Figure 15-4**.
* ***Cut glass.*** It is made by using carbide or diamond sharp cutting tools to score the glass. The cuts reflect light in different angles for a brilliant effect.
* ***Enameled glass.*** It has translucent or solid colored surfaces. Special paint is applied to the surface. The colors are more distinct than those in tinted glass.

Tinted glass

Tinted glass is made by adding coloring agents to molten glass. It reduces the amount of light that will pass through the glass without distorting the image. Tinted glass is used for tabletops, doors, and windows. In architectural design, tinted glass reduces heat from sunlight and prevents glare. The most common tints are bronze or gray.

Figure 15-4. Etched glass installed in these doors enhances and complements the displayed crystal. (*Chuck Davis Cabinets*)

Mirror glass

Mirror glass is coated on one side with a highly reflective metallic substance, frequently silver with a film thickness of .0012". The reflective material is then covered by a protective coating of thermosetting enamel. Reflective glass is commonly used in the back of cabinets to give depth. It is also used as wall tile.

Installing Glass Sheets

Glass is installed after the cabinet has been assembled and finished. Glass installation includes cutting and mounting. You cut glass by scoring and fracturing. Mounting involves positioning the glass in sliding and hinged doors, securing it in frames, and installing it as shelves. Edges of unframed glass must be ground and possibly polished. In some cases, drilling might be necessary. Always wear safety glasses and leather gloves when working with glass.

Cutting glass

Glass is not really *cut*. It is scored (scratched) and fractured. *Scoring* is done with a carbide steel wheel or diamond-point glass cutter. It may be done by hand or with a machine. See **Figure 15-5**. Scoring is accomplished by pushing or pulling the wheel across the glass surface with slight pressure. Too little pressure will not score the glass. Too much pressure will chip (flake) the glass around the score line.

Figure 15-5. Glass is scored with a glass cutter. A straight edge serves as a guide for scoring straight lines. (*The Fletcher-Terry Co.*)

Use a lubricant to reduce the amount of glass surface flaking. A good fluid lubricant is a mix of 50% light oil and 50% kerosene. Wipe the surface of the glass before scoring with a rag soaked with lubricant.

Scoring

As previously mentioned, scoring can be done by hand or with a machine. Straight and curved cuts can be done by each method.

Scoring a straight line by hand

1. Place a straightedge about 1/8" (3 mm) from where the break is desired.
2. The cutter wheel must be kept perpendicular to the glass panel. Holding it at an angle will cause an irregular break. Keep the cutter against the straightedge.
3. Push or pull the cutter across the surface of the glass. See **Figure 15-6.** Use enough pressure to score the glass. Lubricate the cutter wheel to keep it operating freely.

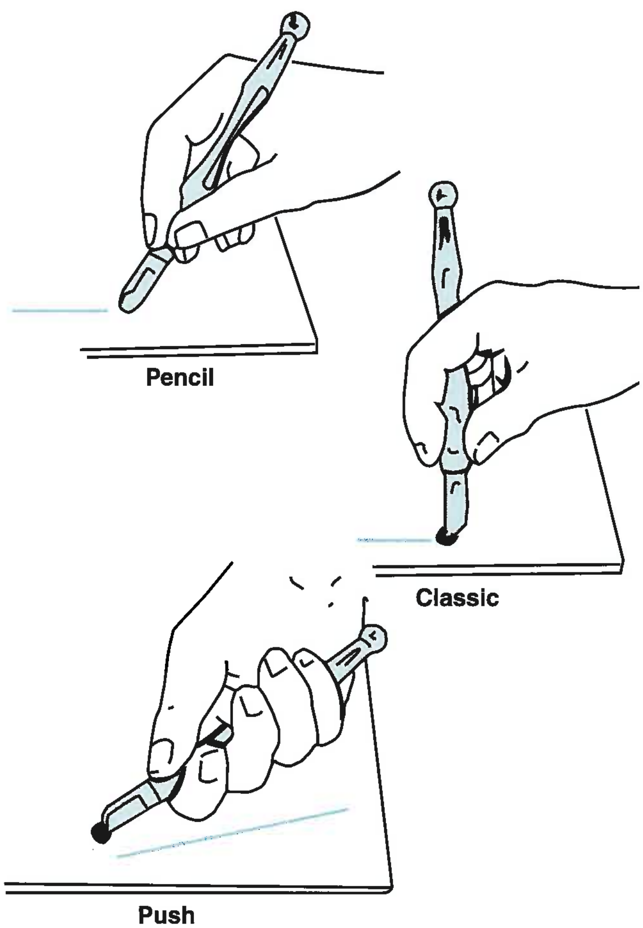


Figure 15-6. The glass cutter may be pulled or pushed across the glass. Three common ways of holding the cutter are shown. (The Fletcher-Terry Co.)

Scoring a straight line by machine

1. Clamp the glass in the machine, making sure the desired cut is aligned with the cutter.
2. With firm pressure, pull the cutter downward across the glass. See **Figure 15-7**.

Scoring a circle by machine

1. Set the glass circle cutter to the proper radius.
2. Place the glass on the cutter table.
3. Press down on the swivel knob as you move the cutter. See **Figure 15-8A**.
4. Make straight line radial scores by hand from the circle to the edge of the glass. See **Figure 15-8B**. Radial scores permit waste to be removed to cleanly fracture the workpiece you need.

Scoring a curved line by hand

1. Prepare a paper pattern of the curve you need.
2. Place the glass over the pattern.
3. Trace and score the pattern with the glass cutter. See **Figure 15-9**.
4. Use radial scores where necessary.

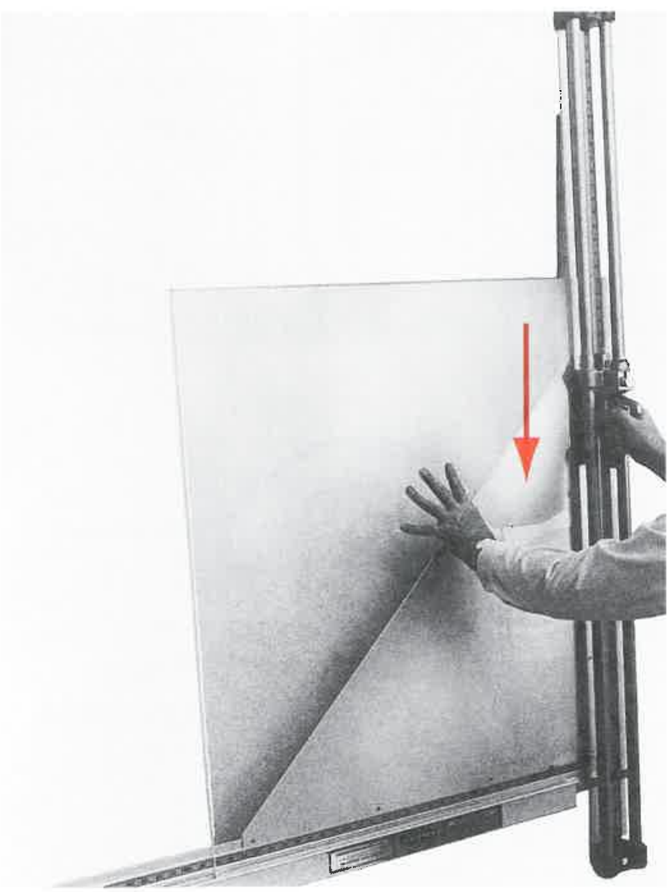
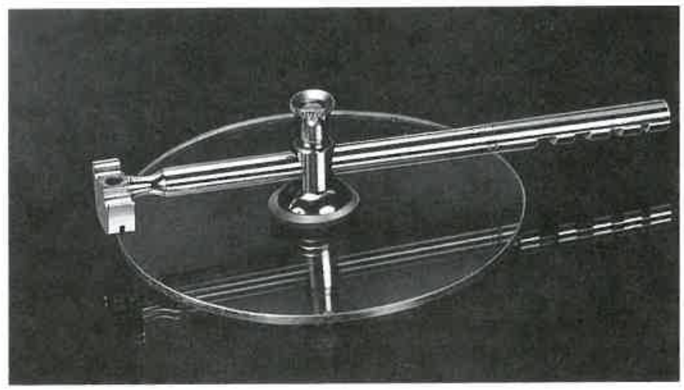


Figure 15-7. A glass cutting machine assures a straight cut. (*Brodhead-Garrett*)

Fracturing

After scoring, the glass is fractured. ***Fracturing*** is done either by bending or tapping the glass to remove the waste from the good piece of glass. It is necessary to fracture the glass immediately after scoring it. Glass has a tendency to *heal*, making it very difficult to break cleanly. Fracturing by bending is for straight line and some curved line scores. Tapping is done for both curved and straight line scores.



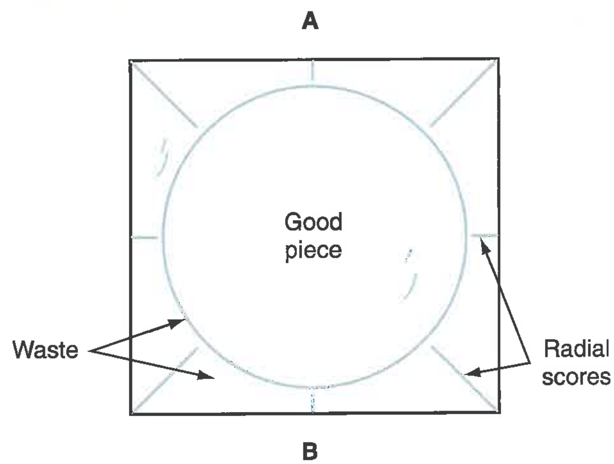


Figure 15-8. Cutting circles. A—The swivel knob has a rubber bottom that keeps the cutter from moving while you score the glass. (Brookstone Co.) B—Radial scores help separate the waste material, making it easier to remove the glass circle.

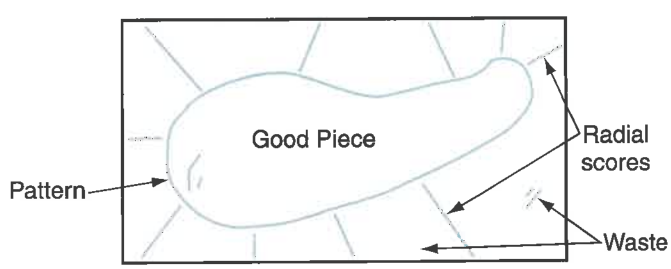


Figure 15-9. For irregular curves, place the glass over the pattern. Score along the pattern, then make radial scores to remove waste around the workpiece.

Fracturing by bending glass clamped to a scoring machine

1. Grip the free edge of the glass with your gloved hand.
2. Bend the glass away from you with firm, even pressure.
3. If the glass was scored by hand, grip on each side of the score with gloved hands. Bend the outer ends of the glass away from you. See **Figure 15-10**.

Fracturing by bending with pliers

1. Grip the glass with the pliers, making sure the tip of the pliers is right next to the score line.
2. Place the pliers perpendicular to the score mark and squeeze with firm pressure. See **Figure 15-11**.
3. Bend the glass to fracture it.

Fracturing by tapping

1. Place the glass on the edge of a table with the score line just overhanging the edge.
2. Grip the unsupported piece of glass with your gloved hand.

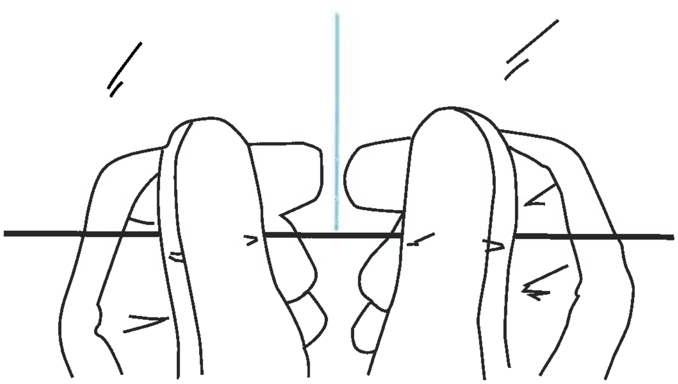


Figure 15-10. Small straight line fractures are made by bending the piece on both sides of the score line.

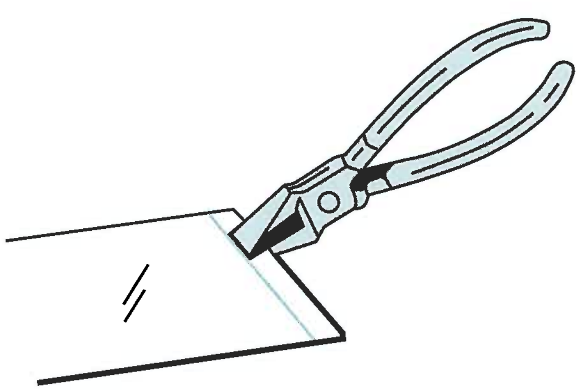


Figure 15-11. Pliers are used to remove small chips that cannot be fractured by hand.

3. Tap the underside of the glass with the glass cutter handle.
4. Start at one end of the scored line. The glass should begin to fracture as you tap under the score. See **Figure 15-12**.

Trimming

At times the glass needs to be trimmed slightly.

1. Score glass again along the original score line.
2. Bend the excess with glass nippers or one of the grooves in the cutter head. See **Figure 15-13**.

Drilling glass

Drilling holes for fasteners or hardware is the least desirable mounting process. Drilling creates heat by friction. Heat can cause the glass to fracture.

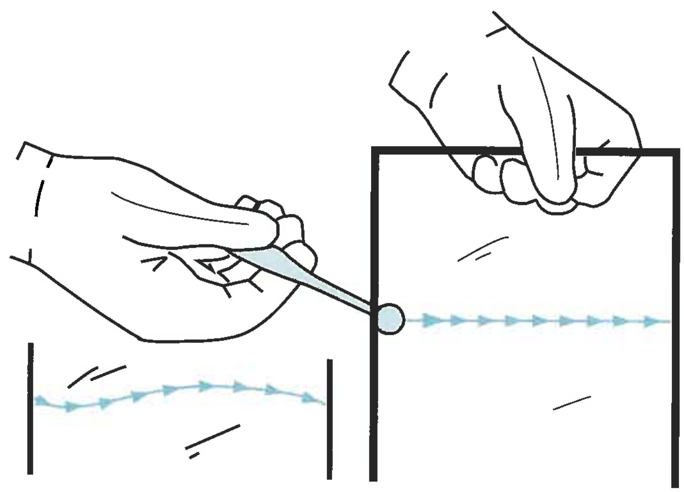


Figure 15-12. Both straight and curved scores can be fractured by tapping the glass. Use the handle end of the glass cutter.

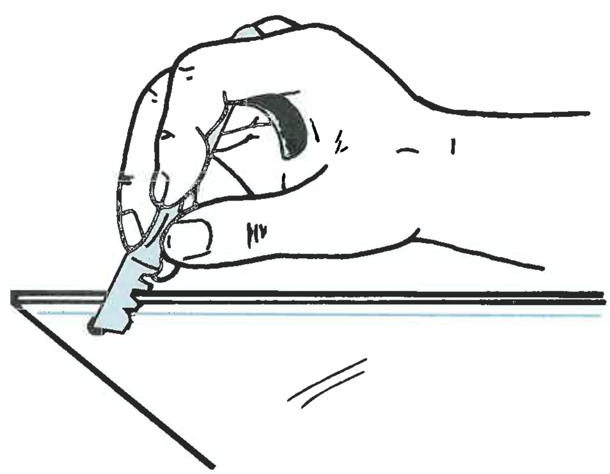


Figure 15-13. Many glass cutters have grooves for trimming jagged edges.

If you must drill holes, use a carbide tipped glass drill. See **Figure 15-14**. Turn it at a relatively slow speed. Water should be put on the drill and glass to help prevent heat buildup.

Grinding and polishing glass

Grinding and polishing shape and smooth glass edges. The processes are simple, but much equipment is necessary. ***Grinding*** removes large amounts of glass with abrasive belts. A coolant flows over the point of operation to prevent heat buildup. Grinding is done to create inset pulls for sliding glass doors. Pulls can be ground in plate glass ¼" (6 mm) or thicker. ***Polishing*** restores a smooth finish by buffing the ground area with a fine abrasive belt.

Mounting

Mounting is the process of securing the glass. Different mounts include securing glass in a frame, attaching glass to a cabinet with hardware, and bonding glass (usually a mirror) to surfaces.

Securing glass in a frame

Secure glass in a frame with wood or plastic moldings and button retainers. See **Figure 15-15**. Glass may also be pressed into a bead of silicone and allowed to set for 12 hours or more.

Figure 15-14. A glass drill has a spearlike point. It drills by scraping the glass rather than cutting it. (*Brookstone Co.*)

When using moldings, a rabbet joint is cut on the inside of the frame where the glass sits. The molding is placed over the glass. It is secured to the frame with either finishing nails, brads, or staples.

Flexible plastic moldings can replace wood moldings as retainers. A groove is made in the frame just behind where the glass is placed. The plastic molding is then inserted into the grove.

Plastic button retainers are installed with screws. The glass sits in the rabbet joint and the button pivots over the glass. Tightening the screw holds the glass in place.

Mounting glass with hardware

Sheet glass, without a frame, is commonly installed as entertainment center doors. The glass is held in place with a glass door hinge. Set screws hold the glass in place. A felt or rubber pad is placed between the metal hinge and the glass. Various types of glass door hinges are available. These are explained in *Chapter 17*.

Bonding mirror glass to surfaces

Mirrors in the shape of 12"× 12" (300 mm x 300 mm) tiles are common wall decorations. Mirror tile is attached with a special mastic adhesive. Mastic is a very thick paste that dries slowly. When installing tile mirrors, proceed as follows:

1. Place one to three tablespoons of mastic near each corner of the tile. See **Figure 15-16**.
2. Press the tile against the wall or other surface.
3. Adjust all tile so the edges are even.

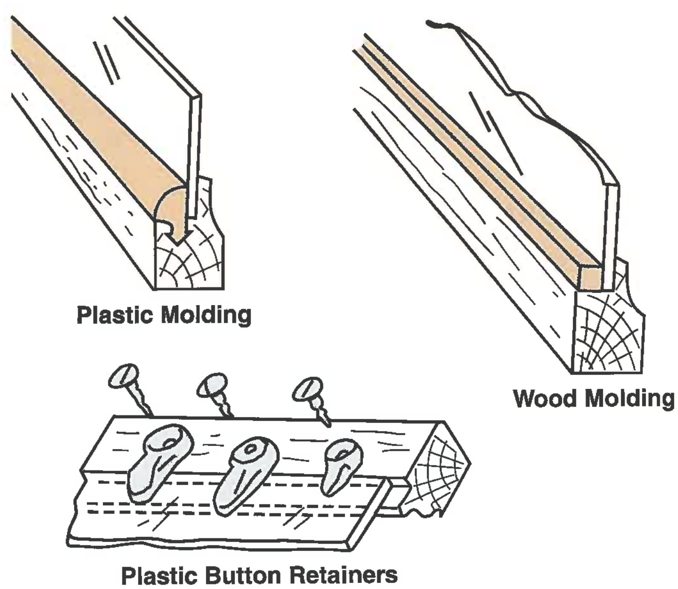


Figure 15-15. The glass is placed in a rabbet joint cut in the frame. Moldings or button retainers secure the glass.

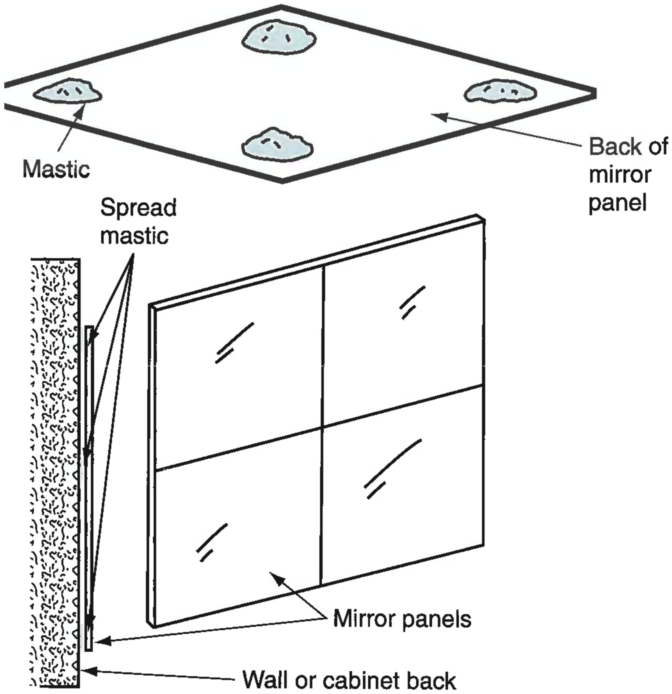


Figure 15-16. Mastic is placed in four corners of the tile back. Once mounted, the mirror tile can be adjusted slightly.

Installing Leaded and Stained Glass Panels

Leaded and stained glass panels have gained popularity in contemporary design. They are made by assembling small pieces of clear or colored glass in lead strips. Leaded glass refers to panels using colorless glass. Stained glass includes colored glass or metal oxides fused to the glass to give color. Leaded and stained glass are most popular in cabinet doors. See **Figure 15-17**. The steps included in preparing and installing stained glass panels are laying out full size patterns, cutting glass, fitting lead came to the glass, soldering the lead joints, mounting the glass in the frame, and grouting along the lead seams.

Laying out patterns

Create a full-size pattern from a refined sketch of the finished panel. If the panel will contain several colors of glass, label each section of the pattern according to the glass color. Separate each section with two lines 1/8" (3 mm) apart. See **Figure 15-18A**. This allows for lead between the glass components.

Cutting glass

Cut the glass freehand or with a guide (straightedge, French curve, etc.). You might also use a circle cutter. For irregular curves you will need to trace a pattern. Place the glass over the pattern and score

Figure 15-17. This cabinet contains doors with stained glass panels.

the curve freehand. Fracture the glass by either the bending or tapping methods.

Small, compound curves may be difficult to shape. More than one break may be necessary. For these, make the break into sections. Score and fracture each section as you go.

Fitting lead came

Glass is held together with lead came and solder. ***Lead came binder*** is *H-shaped* to fit between pieces. ***Lead came edges*** are *U-shaped* to fit on the outer edge. See **Figure 15-18B**.

✳ Warning

When handling lead, keep your hands away from your mouth or food. Lead poisoning can be fatal.

Preparing to fit came

Glass and came are assembled on a flat surface. Use a piece of plywood larger than the pattern. Then, proceed as follows:

1. Place the pattern on a plywood base.
2. Attach two hardboard strips to form a corner. Make sure the corner is square.
3. Cut two pieces of edge came to length. Cut miters on the edges of the came.

4. Clean the came with steel wool so it is bright and shiny. This will assure a secure solder bond when assembling the panel.
5. Place the pieces to form the first corner of the panel.

Assembling panels

Start fitting the panel together in the prepared corner. Set one piece of glass at a time. When you begin, proceed as follows:

1. Place the corner section of glass into the corner created by the two pieces of came edge.
2. Bend the came binder to fit where curved pieces of glass meet. Came must be long enough to solder to other lead came strips.
3. Cut each piece of lead with a utility knife. Remember to clean each joint with steel wool.
4. Add glass and surrounding came binder until all pieces are laid in place. See **Figure 15-18C**.
5. Enclose the glass panel with the other two pieces of came edge. Make sure the ends are mitered so they fit together properly.
6. Clamp or nail two more hardboard strips that hold the entire panel in place.

Soldering lead joints

Soldering is a simple, but important operation. Stability of the stained glass panel depends on the quality of the solder joint. Make sure you have a well-fit joint, sufficient heat, proper flux, and quality solder.

A joint is bonded by melting the proper solder over the connection. ***Solder*** contains a mix of lead and tin. For lead came work, use 40/60 wire or bar solder. It contains 40% tin and 60% lead. This mixture melts at a lower temperature than the lead came. Using less heat, the glass is less likely to crack.

Melt the solder with a soldering gun or iron. See **Figure 15-19**. Select a gun or iron in the 75 watt to 100 watt range. Before soldering the joint, apply flux to the joint. ***Flux*** keeps oxygen away from the heated joint. Without flux, the cleaned joint will blacken. The black formation is an oxide (rust-like coating). Solder will not adhere to the oxide. A rosin-type paste flux is recommended. Some solder comes with rosin flux in the core.

Begin soldering at the joints in the center of the pattern. Work toward the sides and corners. To solder a joint, proceed as follows:

1. Place flux on the joint.
2. Preheat the joint with the flat tip of the soldering gun.

Figure 15-19. A soldering gun or iron melts the solder to bond the lead came.

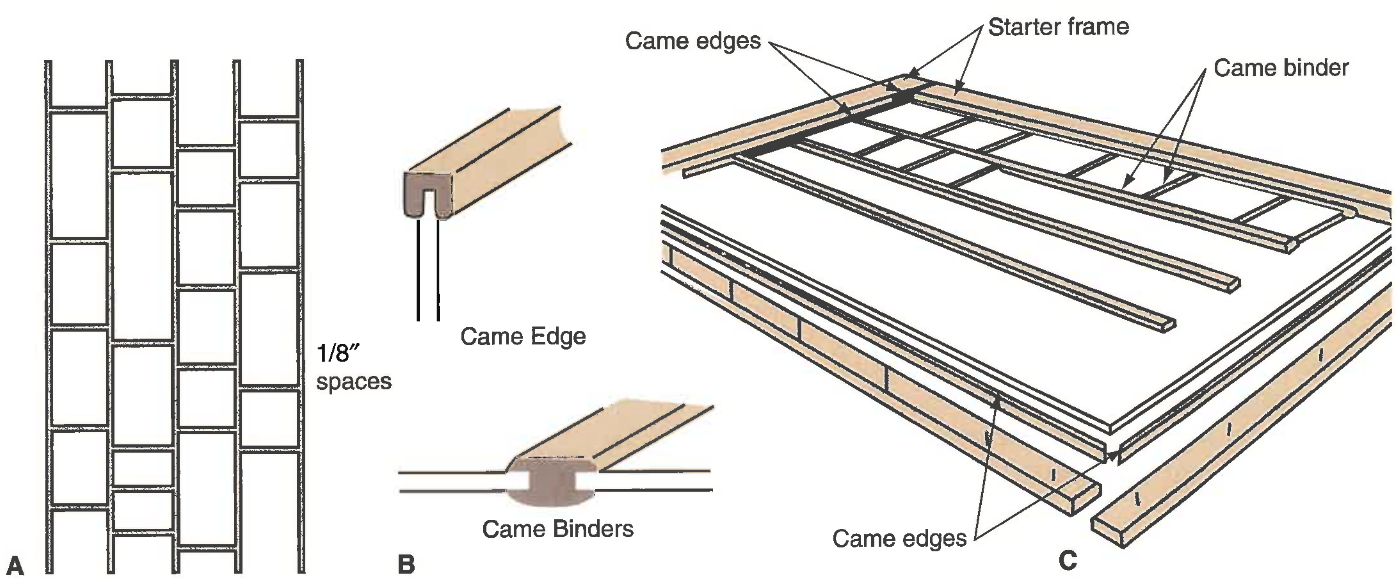


Figure 15-18. A—The pattern for glass pieces is laid out with space allowance for lead came. B—Lead came fits between glass pieces and on the outer edge of the panel. C—Assemble the panel in a wood frame.

3. Touch the solder to the lead and soldering gun tip.
4. Melt enough solder to flow across the joint.
5. Remove the solder and tip from the joint.
6. Allow the joint to cool.

Complete the joints on one side of the assembly. Then place a piece of plywood over the glass assembly and turn over the panel, frame, and plywood as one unit. Solder the joints on the panel's other side.

Mounting glass assemblies

You should have a wood frame prepared to receive the glass assembly. A finish should be applied to the wood before mounting the glass. Stained glass panels are very heavy, so the frame should be strong enough to support the weight. Make the frame with mortise and tenon, lap, or dowel joints.

Trim excess lead and solder from the lead edging where it will touch the frame. Excess lead prevents the glass from fitting flush with the frame. Add molding around the glass panel to secure it in the frame.

Stabilizing assemblies

Stained glass assemblies may need reinforcement in the frame. The glass sections or entire panel might shift as the door is opened and closed. A 1/4" (6 mm) steel stabilizing rod is recommended. One rod for each 2 sq ft (1858 sq cm) of glass area is helpful. Locate the stabilizer close to the center on the back side. Mark where it touches the lead. Solder fine copper wires to the lead at these points. Anchor the rod under the molding on the back side. (Notch or drill the molding as necessary.) Wrap the wires around the rod and twist the ends together. Snip the wires to 1/4" (6 mm) long. Solder the wires against the rod. See **Figure 15-20**.

Grouting

Grout is pressed into the space between lead came and glass to help hold the pieces tight. Grout may be cement-type, resinous, or a combination of both. *Cement grouts* consist of Portland cement. ***Resinous grouts*** are epoxy based and possess high bond strength. However, they are harder to apply. Mix the grout to a creamy texture with an appropriate thinner. Then press it between the lead and glass on both surfaces with a putty knife. See **Figure 15-21**. Using a rag soaked with the appropriate thinner, wipe off excess grout before it dries.

Selecting Plastic Materials

Plastic is an excellent substitute for wood and glass. It can be molded to look and feel like wood. As a sheet material, it may replace flat glass. Sheets may also be assembled as furniture. See **Figure 15-22**.

Common plastics

There are many different types of plastic materials applied in cabinetmaking. **Figure 15-23** includes the properties and cutting methods for the most popular plastics.

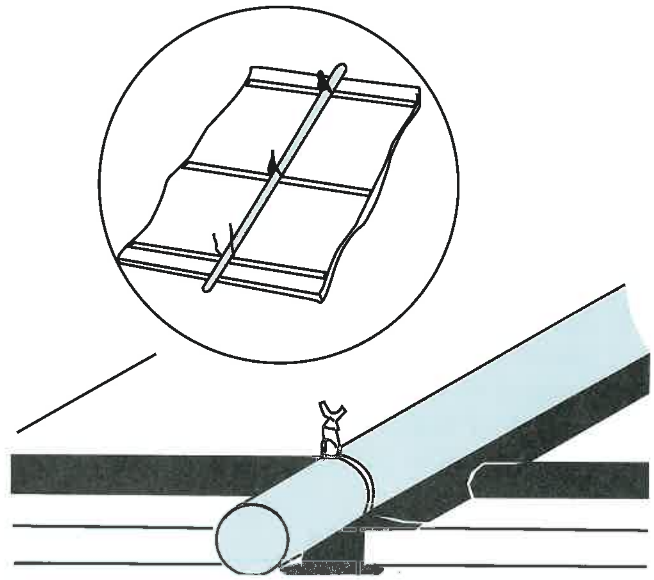


Figure 15-20. A steel rod stabilizes the leaded panel assembly. Copper wires soldered to the lead came fasten the rod.

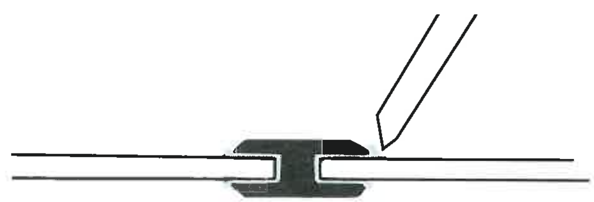


Figure 15-21. Press grout between came and glass pieces.

Figure 15-22. Tinted acrylic plastic is the structure for this furniture. (*Rohm and Haas*)

Thermoplastics							
Major Resin (Plastic)	**Common Name**	**Natural Color**	**Important Properties**	**Applications**	**Impact Resistance (Ft./Lb./In. for 1/8 in. sheet)**	**Scratch Resistance**	**Machining Properties of the Plastic in Solid Molded Form**
Polymethyl Methacrylate	Acrylic	Clear	Weather resistant, colorable, bonds well, transmits light, good surface luster.	Transparent panels for windows, skylights. Containers, rods, tubes, lenses.	Fair	Good	Good
Acrylonitrile-Butadiene-Styrene	ABS	Light Tan Opaque	High impact resistance, rigid, tough, tolerates high temperatures, medium chemical resistance, will burn, can be hard or flexible.	Tables, chairs, shower stalls, molded furniture, appliances, plumbing, can be electroplated.	Fair to Excellent	Fair to Good	Good to Excellent
Polyamides	Nylon	Opaque White	Tough, resists abrasion and chemicals, high surface gloss, colorable, water repellent, fair electrical properties.	Drawer slides, bearings, gears, hinges, rollers, textiles.	Fair to Excellent	Excellent	Excellent
Polycarbonates	High Impact	Clear	Toughest of all plastics, high impact strength, good heat and chemical resistance, weathers well, easily colored.	Window glazing, lighting globes, bottles, coffeepots, sunglass lenses.	Good to Excellent	Good to Excellent	Excellent
Polyethylene		Translucent Milky White	Flexible, tough, will not tear, resists chemicals, feels waxy, easily colored. Ranges from flexible (low density) to rigid (high density).	Molded furniture, containers, housewares, electrical components.	Fair to Excellent	Fair to Good	Good
Polypropylene		Translucent Milky White	High impact resistance, lightweight, good flex life, chemical resistance, easily colored, scratch resistant.	Bottles, housewares, appliance housings, hoses, containers with integral hinges (flip top caps), radio and TV cabinets.	Fair to Excellent	Excellent	Good
Polystyrene		Clear	Water resistant, brittle, yellows with exposure, often used as foam, tasteless and odorless, harmed by cleaning fluid, has a definite metallic ring when tapped.	Tile, sheets for wall coverings, molded furniture parts, plastic plates and cups, packaging containers, insulation, molded imitation wood products.	Fair to Excellent	Fair	Good
Polyvinyl Chloride	Vinyl PVC	Light Blue Clear	Good strength and toughness, average chemical resistance, can perform well in low temperatures.	Simulated leather, adhesives, floor tile, outdoor furniture, door and window trim, laminations.	Fair to Excellent	Good	Excellent
Thermosetting Plastics							
Melamine Formaldehyde Urea Formaldehyde (Amino resins)		Pastel, Urea may be White	Durable, hard, abrasion and chemically resistant, easily colored to a glossy finish. Urea may absorb water. Melamine is more water-resistant, but more brittle.	Melamines are used for decorative laminates, countertops, switch plates, dinnerware, doorknobs. Urea is used as a wood adhesive, but also molded into furniture parts.	Fair to Good	Fair to Good	Fair
Phenol Formaldehyde		Dark Gray Opaque	Hard, rigid, heat resistant, brittle, low cost, excellent insulating properties, resistant to most chemicals.	Widely used for high impact plastics, bonds panel products, such as plywood, fiberboard, and particleboard.	Fair to Excellent	Good	Fair to Good
Polyesters		Clear	Can be made thin when used with fiberglass, antistatic, stiff and hard, colorable, weather and chemically resistant.	Polyester resin is best known as an adhesive to bond with glass fibers to form fiberglass. Polyester laminated glass mats are used for furniture, boats, airplanes, and automobile panels.	Good	Good	Good

Figure 15-23. Characteristics of the most common plastics applied in cabinetmaking.

Circular Sawing Molded Plastic			Band Sawing Molded Plastic			Drilling		Typical Fillers Used	Common Solvent Cements for Thermoplastics
Blade (type)	**Teeth (per inch)**	**Speed (ft. per min.)**	**Blade (type)**	**Teeth (per inch)**	**Speed (ft. per min.)**	**Speed**	**Point Angle**		
Thermoplastics									
Hollow Ground	4-6	3000	Metal	5-7	2000-4000	1500-2500	95	None used	Methylene Chloride Ethylene Dichloride Softened by alcohol
Combination	4-6	4000	Wood (skip tooth)	5-7	1000-3000	500-900	118	Glass fibers	Methyl Ethyl Ketone
Hollow Ground	8-10	5000	Wood (skip tooth)	4-6	1000	900-1500	70-90	Glass fibers	Resists solvents
Hollow Ground	4-6	8000	Metal	10-18	1500	300-800	118	Glass fibers	Methyene Chloride
Hollow Ground	4-6	9000	Wood (skip tooth)	4-6	1200-1500	1000-3000	70-90	Metal powders	Resists solvents
Hollow Ground	8-10	9000	Wood (skip tooth)	4-6	1200-1500	1000-3000	70-90	Glass fibers	Resists solvents
Hollow Ground	4-6	2000	Metal	10-18	3000-4000	1500-2500	95	Glass fibers	Methyl Ethyl Ketone Methylene Chloride
Hollow Ground	4-6	3000	Metal	6-9	2000-3000	900-2000	118	Clay	Methyl Ethyl Ketone
Thermosetting Plastics									
Carbide Tip	8-10	5000	Metal	10-18	2000	600-2000	90	Cellulose pulp, glass fibers	
Carbide Tip	8-10	3000	Metal	10-18	1500	600-2000	90	Wood flour, glass fibers, cotton flock, metal powders	
Carbide Tip	8-10	5000	Metal	10-18	4000	1000-2000	90	Clay, glass fibers, woven cloth	

(**Figure 15-23** *Continued*)

Acrylic plastic

Acrylic plastic is a rigid plastic often used for cabinetmaking. The most common form of acrylic is in sheet form. Acrylic sheets replace glass in many applications. Sheets of 1/16" and ¼" (2 mm and 6 mm) are used most, but thicker materials are available for machining. Acrylic sheets may be clear, tinted, or colored. Other forms of acrylic are squares, round rods, and tubing.

Acrylic is a strong thermoplastic material. It has 6 to 17 times the impact resistance of glass. It can be heated and bent easily. If you make a mistake when bending, reheat the acrylic. It will flatten and can be formed again.

Acrylic plastic is sold with a protective paper masking on it because it will scratch. Make all of your layout marks on the paper. Leave the paper on while cutting the sheet. Remove the paper only when you are preparing to heat form or mount the plastic.

Polyester resin

Polyester resin is a thermoset plastic. It is available as molded parts or liquid ingredients. Molded items include door knobs, pulls, etc. These only have to be installed. Liquid polyester resin is used with fiberglass and as a casting and coating material.

Fiberglass

Fiberglass is a mixture of polyester resin and glass fibers. Fibers are blown over, or layered between, a resin coating. When cured, the mixture is rigid. Fiberglass is molded into furniture, boat hulls, and other structural panels.

Laying up

Laying up polyester with fiberglass requires a sealed mold, glass fibers, liquid resin, hardener, and dye (not necessary). Layers of fiber and resin are placed inside or outside a sealed mold. The mold may be investment or reusable. An investment mold can become part of the product, or it may be destroyed during component removal. Reusable molds allow you to make duplicate parts. Sides of molds must be tapered to free the component after curing. To cast parts with a reusable mold, proceed as follows:

1. Measure and cut the fiber mat or cloth slightly larger than the mold.
2. Coat the reusable mold's surface with mold release. (Use silicon or wax.)
3. Coat the mold with resin premixed with hardener.
4. Place the mat or cloth on the wet resin.
5. Smooth the fiber material with a rubber squeegee to remove wrinkles and air bubbles.
6. Apply a coat of resin over the fibers immediately.
7. Allow the assembly to cure completely.
8. Abrade the surface and add more topcoats to achieve the desired total thickness.
9. Remove the finished component after it is totally cured.

Casting

Liquid polyester resin can be cast. Casting resins are mixed with a hardener to cure the plastic. You may include plastic dye or pigments during the mixing process to add color.

Pour the mixture into a prepared mold, which means the inside of the mold is coated with mold release. Use spray silicone or paste wax as a release. If a mold release is not applied, the resin will adhere to the mold. The plastic will set in a few hours and cure in a day.

Coating

Liquid polyester resin is also used as a coating. It is extremely durable and resistant to mild acids, alcohol, etc. Mix the resin, color, and hardener as if you were casting. Brush the mixture over a sealed surface. Use a natural hog's hairbrush with a wood handle. Synthetic brushes might soften or even melt. Apply polyester resin as you would any other topcoating. Abrade the cured surface between coats. For further information on topcoating, see the chapters on finishing.

Clean the brush immediately after each coating. Use acetone or lacquer thinner. These solvents will not dissolve natural brushes.

Polyethylene

Polyethylene is a translucent or opaque thermoplastic material. It resists impact and tears. Polyethylene is available in rigid and flexible forms. Rigid polyethylene is available as sheets, rods, and tubes. Flexible polyethylene sheets are also being used in cabinetry. See **Figure 15-24**.

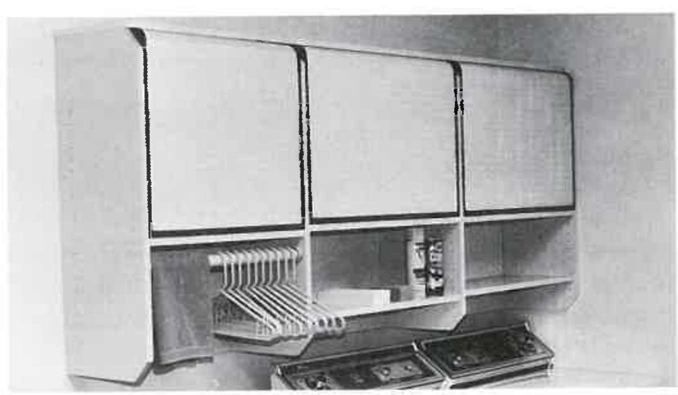


Figure 15-24. These tambour doors are made of flexible polyethylene. (*Coroplast, Inc.*)

Polystyrene

Polystyrene is a thermoplastic material. It can be molded into components or complete pieces of furniture. With proper mixing, it can resemble wood grain. Polystyrene is generally brittle and has poor resistance to chemicals. Additives blended with the resin during manufacture can increase its flexibility.

Polyurethane

Polyurethane is a resin much like vinyl. However, it can be either a thermoplastic or thermoset plastic. It is prepared either as a rigid molding material or flexible material. Polyurethane can be molded and colored to look and feel like real wood. It is an inexpensive way of duplicating carved wood.

Liquid polyurethane is used as a wood finish. When dry, the finish resists impact, scratches, and most chemicals. Flexible foam polyurethane is used as furniture cushioning. Polyurethane components can be assembled with various adhesives.

Installing Plastic

Plastic is an easy material to cut, drill, form, and finish. For most operations, you can use common woodworking tools. In sheet form, it can be assembled and mounted much like glass. Before cutting or drilling, lay out the pattern on the protective paper cover on the plastic.

Cutting plastic

Plastic can be cut two ways. First, it can be fractured like glass. Score the surface with a plastic cutter. Then bend the plastic over a large dowel rod. See **Figure 15-25**. The plastic should break cleanly along the scored line.

Plastic can also be cut using a circular saw, band saw, or saber saw. See **Figure 15-26**. It is cut much like manufactured panels or lumber. See **Figure 15-23** for the type of saw blade, number of teeth, and cutting speed. Special saw blades are recommended for cutting certain plastics.

Drilling plastic

Standard twist drills commonly are used to drill plastic. Special drill bits for plastic reduce the amount of cracking. Refer to **Figure 25-58**. A drill press, portable power drill, boring and insertion machine, as well as a hand drill are all satisfactory. While drilling, always place a ***backer board*** under the plastic. See **Figure 15-27**. This lessens damage caused by the drill breaking through the lower surface.

A

B

Figure 15-25. Steps in fracturing plastic. A—Score with a plastic cutter. B—Fracture by bending over a dowel. (*Chuck Davis Cabinets*)

Forming plastic

Thermoplastic sheets up to ¼" (6 mm) thick can be formed easily. Plastic can be formed in one or more directions at the same time. Straight line bending is easiest with an electric strip heater. See **Figure 15-28**. Bending in more than one direction requires heating the plastic in an oven. Preheat the oven to the appropriate temperature. See **Figure 15-29**. Heat the plastic until it is pliable. Remove it from the oven with insulated gloves. Place it in a form or mold. While the plastic cools, it must be held securely in the mold.

Finishing

Finishing should be necessary only on the sheet edges. The surface was protected by the paper coating. On the edges, saw or fracture marks might need to be removed. The process involves:

A B C

Figure 15-26. Sawing plastic. A—Circular sawing with a carbide tipped blade of alternate top bevel tip design. (The guard has been removed to show the operation.) B—Sawing straight lines with a saber saw using a clamped straight edge. C—Saber sawing curves along a layout line. (*Chuck Davis Cabinets*)

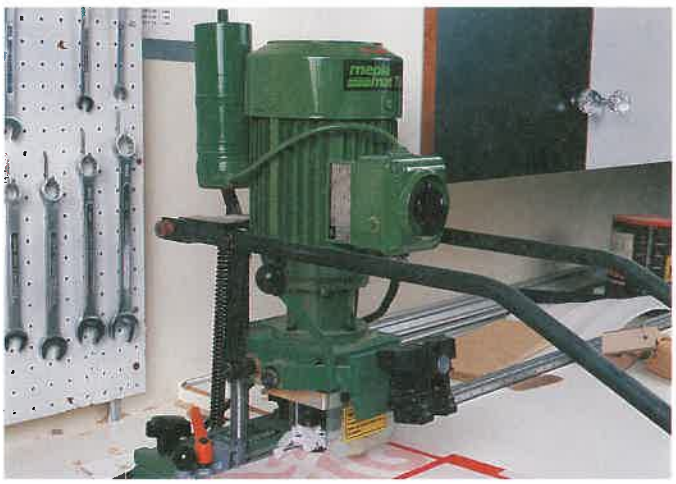


Figure 15-27. Place a board under the plastic while drilling. When boring holes for Euro-hinges, the backer must be thick enough for the plastic to contact the stops. (*Chuck Davis Cabinets*)

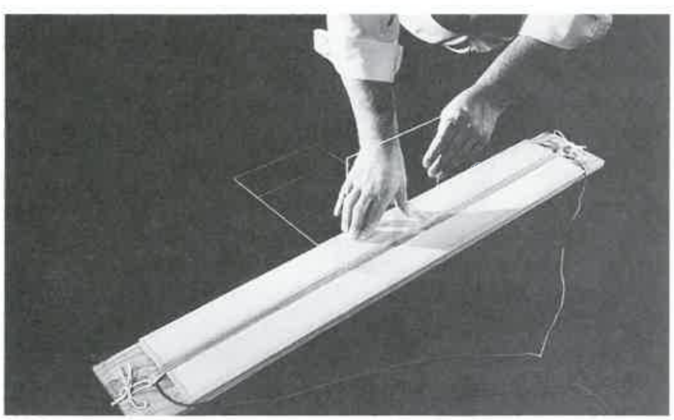


Figure 15-28. This electric strip heater provides the correct amount of temperature for thermoforming acrylic plastic. (*Rohm and Haas*)

Sheet Plastics for Thermoforming		
Thermoplastic	**Forming Temperature**	**Formability**
Acrylic	260° to 360°F	Good
ABS	300° to 350°F	Good
Polycarbonates	440° to 475°F	Good
Polystyrene	365° to 385°F	Excellent
Polyvinyl Chloride	225° to 355°F	Excellent

Figure 15-29. Thermoplastics can be softened by heating them to the proper temperature.

1. Scraping with the back of a hacksaw blade or similar smooth, sharp tool. See **Figure 15-30A**.
2. Sanding with several grit sizes of wet-or-dry abrasive paper. See **Figure 15-30B**.
3. Sand with 360 grit sandpaper to remove saw marks. (Abrade the sheet's surface where solvent will be applied. The rough texture provides for better bonding.)
4. Finish with 500 to 600 grit paper before polishing.
5. Polish with a cotton buffing wheel and buffing compound. See **Figure 15-30C**.
6. Buff across any surface scratches.
7. Use light pressure to prevent heat buildup that will melt the plastic.

Assembling

Assemble plastics by bonding or mechanical fastening. Cements or solvents are applied to bond

A B C

Figure 15-30. Finishing the edges of sheet plastic. A—Using the edge of a cabinet scraper. B—Sanding with abrasive paper. (*Chuck Davis Cabinets*) C—Polishing with a buffing wheel. (*Rockwell International*)

plastic together. (Use those which are not health hazards.) Machine screws may be used for mechanical fastening. Before assembling, align the workpieces to check their fit.

Cement bonding

Cements adhere to the plastic and will also fill small spaces in the joint. Apply cement to one workpiece. See **Figure 15-31**. Press both together and maintain pressure until the cement has dried. The cement's container lists drying time. The dried assembly should be clear and free of air bubbles in the joint.

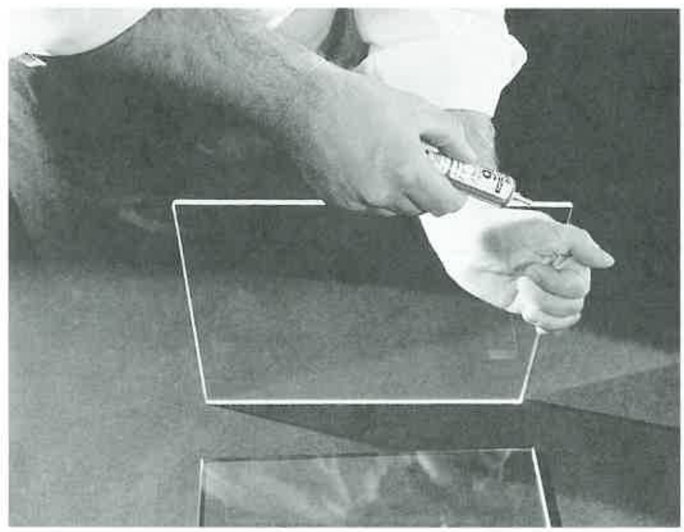


Figure 15-31. Plastic cement is applied to one surface. Use the proper cement for the type of plastic. (Rohm and Haas)

Solvent bonding

Solvents dissolve the plastic so the joint surfaces become softened and the plastic *flows* together. Then when the solvent evaporates, the joint hardens and the assembly or bonding is complete. This bonding process is referred to as ***cohesion***.

A bonding solvent is thin and watery allowing it to spread quickly. It fills only the tiniest of spaces. The components must be matched very accurately. You may tape them together before applying the solvent. See **Figure 15-32**. Apply the solvent in corners very carefully. Avoid touching the surfaces. The adhesive will soften any plastic it contacts. The adhesive evaporates rapidly. Air pockets are apt to remain. Pressure must be maintained on the joint until the solvent has dried.

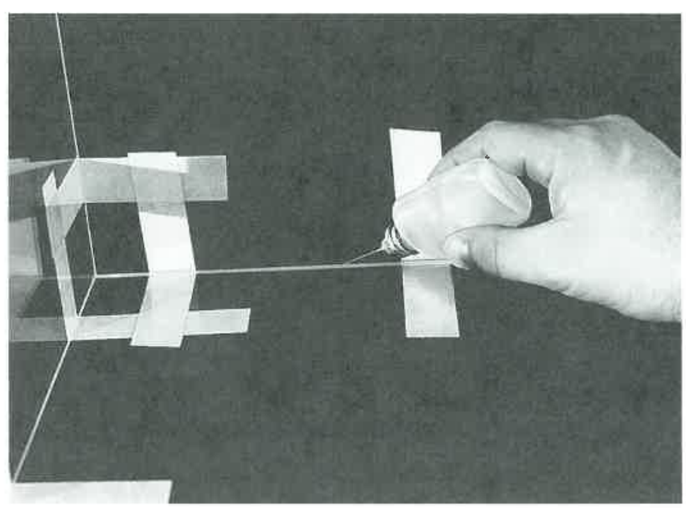


Figure 15-32. Using a special applicator apply solvents precisely on the joints to be bonded. (*Rohm and Hass*)

Mounting plastic

Plastic, like glass, makes good doors and shelves. Both can be mounted with the same hardware. Unlike glass, most plastic can be drilled and threaded easily for machine screws.

Solid Surface Material Tops

Solid surface material is a plastic that is used as an alternative to wood, veneer, or laminate countertops. It is tough and needs little care. It is cleaned using common household cleaning products. The surface resists scratches and impact damage. Sheets of solid surface material are available in ¼″, ½″, and ¾″ (6 mm, 13 mm, and 19 mm) thicknesses. It can be installed on furniture, bathroom vanities, and kitchen cabinets. See **Figure 15-33**. It is also used for tub and shower surrounds, window sills, wainscoting, elevator interiors, and thresholds.

Molded sinks are available to be integrated into the countertop by the installer. Cutouts are required for sinks and cooktops. Solid surface material countertops are usually made from ½″ (13 mm) sheets. It can be made to look thicker than the sheet material. You can bond two narrow strips of solid surface material to the underside of the countertop edge. Use spring clamps spaced no more than 2″ (50 mm) apart. This will provide a 1½″ (38 mm) built-up edge that will be attractive and hide supporting underlayment. You may also insert wood inlays or contrasting colored solid surface material between sections of solid surface material. Wood inlays should be backed up with the solid surface material and should never be sandwiched together. See **Figure 15-34**. The corners may be further shaped using a router.

Most manufacturers require the distributor to verify that the purchaser of the material has completed training in the techniques and methods of working with their brand of solid surface material before sale. There are many manufacturers of solid surface material. Their products are sold under trademarks such as Avonite®, Corian®, Fountainhead®, Surell®, and Gibralter®. Each varies somewhat in chemical composition and physical properties.

Figure 15-33. Solid surface material often replaces laminates for countertops. Solid surface material can be cut, drilled, and shaped with carbide tipped woodworking tools. (*Chuck Davis Cabinets*)

Fabrication equipment, tools, and supplies

Solid surface material countertops are cut and machined with portable and stationary woodworking equipment and various hand tools. See **Figure 15-35**. However, every cut must be accurate, curves must be precise, and seams must be near perfect. Quality work will produce nearly invisible seams.

Stationary equipment

The stationary equipment for producing solid surface tops are:

- **Table saws.** Should be a minimum 3 horsepower (hp) with adequate out-feed tables, blades should have the following characteristics:
  - 10″ (254 mm) blade, 80 tooth, C-4 carbide, triple chip, 5° positive rake.
  - 12″ (305 mm) blade, 100 tooth, triple chip, 5° positive rake.
  - Alternate top bevel grind, but will require sharpening more often.
- **Cut-off saws.** Minimum 1½ hp.
- **Shapers.** Minimum 7 hp.
- **Jointers.** Minimum 3 hp for a 6″ (152 mm) jointer and 5½ hp for 11″ (279 mm) jointer.

Portable power equipment

For the best results and longest life of your portable power equipment always use the following:

- **Router.** With C-3 hardness carbide bits and ½″ (12 mm) shanks. See *Chapter 26*.
  - For cutting—3 hp minimum.
  - For seaming and edge profiling—1½ hp minimum.
- **Laminate trimmer.** For removing of excess adhesive from seams.
- **3/8″ electric drill.** Use industrial quality, high speed steel twist drills.
- **½″ electric drill.** An assortment of hole saws.
- **Electric hot-melt glue gun.** The glue stick should provide the longest possible open time.
- **Belt sander with a dust bag.** Belt sanders generate heat and may damage some products. To remove excess seam adhesive, use the laminate trimmer instead.
- **Electric orbital sander.** 10,000 orbits per minute.

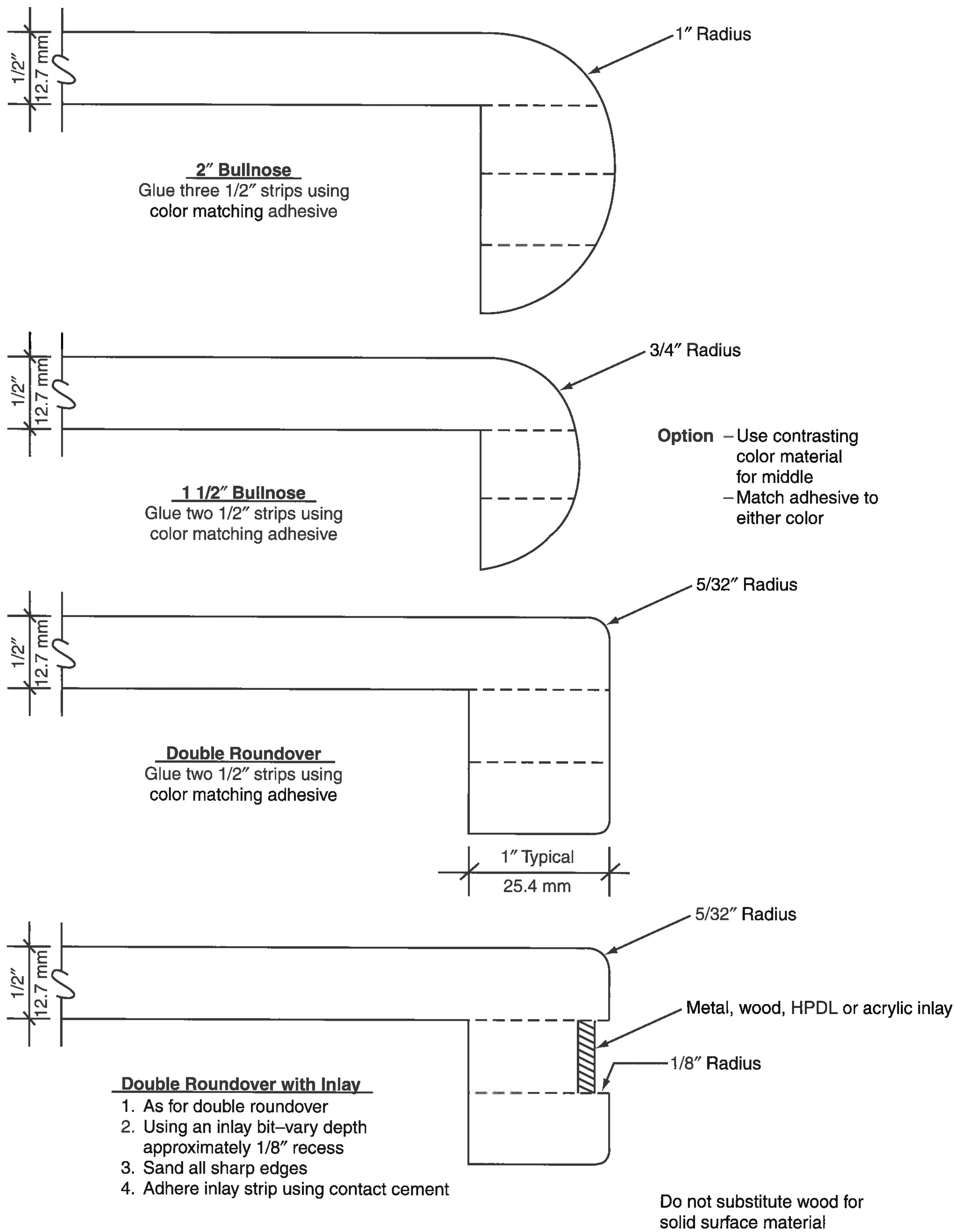


Figure 15-34. Decorative edge designs are created with different sizes and shapes of solid surface materials. Inlays enhance the appearance.

Figure 15-35. Plastic tops are cut and shaped with conventional woodworking tools. Use carbide tipped saw blades and router bits. (*DuPont*)

- **Air or electric sander (random orbital).** For better finishing.

Portable saber saws should *not* be used for cutting this material. The action of the saw can cause minute cracks that may enlarge in time.

Hand tools and supplies

Many hand tools are used for fabricating. Those commonly used are as follows:

- **Block plane.** Low angle (22°) with rounded corners.
- **1″ (25 mm) wood chisel with rounded corners.**
- **Clamps.** Used for working with wood. Refer to Chapter 33.
- **Straightedges.** Come in lengths of 30″, 96″, and 151″ (762 mm, 2438 mm, and 3835 mm).
- **Wood underlayment strips.**
- **Shim stock.** HPDL sample chips work well and do not compress.
- **Denatured alcohol.** Used to clean surfaces to be seamed or glued.
- **Micron film abrasive disks.** Micron sizes of 100, 60, and 40. Optionally, 30, 15 and 9 micron sizes.
- **3M ScotchBrite® #7447 pad.** Maroon color.
- **Putty knife.** Used to remove glue before it sets.
- **Razor blades.** Used to remove glue after it sets.

Manufacturers' accessories

Most solid surface material manufacturers have several accessories available. Aluminum conductive tape is used for cooktop appliance cutouts. This material dissipates the heat of the appliance to the air space below the countertop. Color matched joint adhesive for seaming and attaching edge build-ups. Color matched silicone sealant for caulking and securing countertop to cabinet bases. Inlay kits are also available.

The two types of adhesives that are used with solid surface material tops are mastic and joint adhesive. Mastic is applied to the underlayment to bond the solid surface material top. Color matched joint adhesive bonds sheets together and sheets to sinks of like, complementary, or contrasting color. Always buy joint adhesive that is made for the solid surface material being joined. Deck seams or joints should be located at least 3″ (76 mm) away from cooktops, built-in dishwashers, sinks or other cutouts, inside corners, and heavy work areas. This reduces the possibility of stress cracking.

Thermoforming

Thermoforming is the process of heating and bending materials. Solid surface materials can be used to bend sheets over a column, make unique table bases, or decorative edging. Thermoforming will change the color of solid surface materials slightly, so heat all the material to be used for the project to maintain perfect color match.

Fitting and setting solid surface material tops

Before fitting and setting solid surface material tops, the cabinetry must be checked and prepared. Once the solid surface material tops are fit and set, the work must be checked.

Preparing cabinets

Before installation, make sure that all base cabinetry is level and secured. Mount 1″ by 3″ (25 mm by 76 mm) underlayment lengthwise on the cabinetry. Again, be sure the underlayment is level. Shim if necessary and screw it to the base cabinets. For sink and appliance cutouts, install cross supports running from front to back. These cross supports are also to be installed under deck seams.

Cutting, routing, and sanding creates dust. Do as much of the fabrication as possible in the controlled environment of the shop. Do not prepare fixture cutouts in the shop. Wait and complete the cutouts with the material in place. Work on flat, well supported surfaces. Measure and lay out the size of the countertop and places where fixtures will be inserted. Full height backsplash should be installed against the wall before installation of the countertop. Cut all openings with a router. It is good practice to place heavy construction paper or cardboard on the cabinets and trace the outline on the paper.

Use a router to cut inside corners, leaving a minimum radius of 3/8″ (9 mm). Make sure to support the piece being cut so it will not fall. Use a router to cut openings for sinks, fixtures, and appliances. Ease edges with a 5/32″ (4 mm) round over bit. Lay out and cut backsplashes and built-up edges. Countertop and backsplash edges may then be shaped with a router. Select a carbide tipped router bit with the shape you wish.

Remove all saw or router marks with 120 grit to 180 grit silicon carbide wet-or-dry abrasive. A random orbital sander is recommended for this job. The surface should be ready for polishing after the solid surface material is bonded in place.

Inspecting the work

Position the top on the cabinet without adhesive. The top of the cabinet or wall mounted frame must be flat. The entire perimeter of the solid surface material top has to be supported near the edge. It cannot wobble on the frame. If it does, check and readjust the shims under the underlayment.

Inspect the final layout. There should be 1/8″ (3 mm) of clearance between the edge of the solid surface material top and any wall. Allow 1/8″ (3 mm) for each 10′ (3 m) for expansion. Allow 1/16″ (1 mm) between sheets where a joint is necessary. After positioning the solid surface material top, mark the underside for placement.

Remove the solid surface material top and smooth the edges to be seamed using a straight edge, 3 hp router with a ½″ (12 mm) bit, and clean the edges. Wipe all the joints with alcohol and let them dry.

Attaching tops

To attach the top, apply small amounts of mastic to the top of the underlayment. Do so on the edges and cross supports. Lay the solid surface material on the underlayment and position it according to the marks you made earlier. Gently clamp the top to the underlayment, if necessary, to position the sheet. If multiple sheets are used, leave 1/8″ (3 mm) between them. Use hot-melt glue to temporarily attach clamping blocks 2″ (50 mm) on either side of the seams.

Now bond the sheets, backsplashes, and edges together. Use the color matched joint adhesive supplied by the solid surface material manufacturer. Place separation paper underneath the seam area. As a substitute, use clear packing tape or wax paper. Between sheets, apply enough adhesive to fill the joint half full. Remove any previous clamps. Then, push the sheets together until adhesive is squeezed from the joint. Using sliding bar clamps, gently snug the seam together. Leave the bead that is squeezed out on the surface undisturbed. Remove the excess only after the adhesive has completely cured.

Allow the assembly to set for about one hour. Press into a hidden joint with your fingernail. You should not be able to penetrate the adhesive. Reclamp the sheets to the frame to maintain their positions. Then, apply adhesive to the back of the top where the backsplash will set. Also apply mastic to the wall. Clamp the backsplash in place. The edges are bonded with joint adhesive.

Mounting blocks should be installed under the front edge of openings for installing dishwashers. Use a compatible adhesive to adhere wood blocks for attaching under-mount sinks. Never use screws in solid surface materials.

Final finishing

Once the solid surface material top is fitted and set it must be finished. Final finishing includes abrading and polishing.

Abrading

Belt sanding, such as smoothing a seam, will remove the finish in the surrounding area. Using a 100 grit aluminum oxide open coat abrasive belt, sand and blend an area at least 12″ (305 mm) on each side of the seam. Continue with 100 micron film-backed disks using a random orbit portable sander. Feather out the original belt sanded area an additional 8″ to 10″ (203 mm to 254 mm). Clean the entire surface and inspect to make sure the entire area has been blended, if not, sand and inspect again. Then, abrade with 60 micron and repeat with 40 micron to eliminate scratches. For a desirable matte finish, buff the entire surface with the ScotchBrite® #7447 pad. Minute scratches from daily use will not be apparent. For visible minor scratches buff the areas with the #7447 pad.

Polishing

Polishing tops to the desired gloss level—from high-gloss to matte. The shinier the surface, the more work is required. For a high-gloss finish, continue to abrade using 30, 15, and finally 9 micron film disks. Then, using the 3M Buffing Pad #05701 (White) and the 3M Buffing Pad #05705 (Yellow), polish using 3M Superduty Heavy Cutting Paste #05957, 3M Superduty #15455, and 3M Final Glaze #15488, successively. Instead of the 3M polishing compounds, Countercut Compound #1, Countercut Compound #2, and Countercut Compound #3 can be used successively.

Alternative compounds are available from automotive paint distributors. Regardless of your choice of compound, follow the manufacturer's instructions.

Selecting Ceramic Tile

Ceramic tile is sold in a variety of colors, shapes, and glaze textures. Some tile is smooth and becomes slick when wet. Other types have a textured, nonslip surface. The colors and shapes are selected to suit the design of the cabinet or room.

Tile is available as individual pieces, mats, and mosaics. Individual tiles typically are square, rectangular, or other shapes. A mat is a 12" by 12" square of equally spaced small tiles bonded to a fiber mesh. Mosaics are pictures created with tile. These also are bonded to a fiber mesh.

Installing Tile

Tiles are most likely installed after the cabinet is assembled and finished. Tile may be applied on tabletops, countertops, and as wainscoting (partial wall covering). The process of tiling includes preparing the surface, laying out the pattern, applying the adhesive, setting full tile, cutting and setting partial tile, grouting, sealing, and drilling and attaching fixtures.

Preparing the surface

A surface to be tiled should be flat. Sand the surface to remove ragged edges and splinters. These might prevent the tile from lying flush.

Apply a primer or sealer to the surface. A sealer prevents moisture in the tile adhesive from entering the wood or drywall surface. Brush or roll on the primer or sealer recommended by the mastic manufacturer.

Laying out the tile pattern

Pattern layout typically follows one of two methods. One is symmetrical layout. The other is a one edge layout.

Symmetrical layout

A symmetrical layout begins at a center point. Tile is laid from the center outward. See **Figure 15-36.** Mark the layout with centerlines for the width and length of the area to be tiled. Use a pencil or chalk line.

One edge layout

A one edge layout begins at one edge of the surface. For a countertop, the edge is the front corner of the counter. Tile is laid from the front edge beginning in the center of the counter. Continue toward the counter ends and back. See **Figure 15-37.**

A one edge layout is also used to install wainscoting. ***Wainscoting*** is a wall tiled partway from the floor toward the ceiling. The starting edge may be the floor or the top edge of the wainscoting. The height of the wainscoting typically is determined by the number of tile to be laid and the spacing between tile. This avoids having to cut tile at the top or bottom. With an accurate layout, you may need to cut tile only where they meet at an inside corner.

Applying the adhesive

Tile mastic is a slow-drying adhesive. It can be applied to a large area without fear of the adhesive setting up too quickly. Spread the mastic at room temperature with a notched trowel. See **Figure 15-38.**

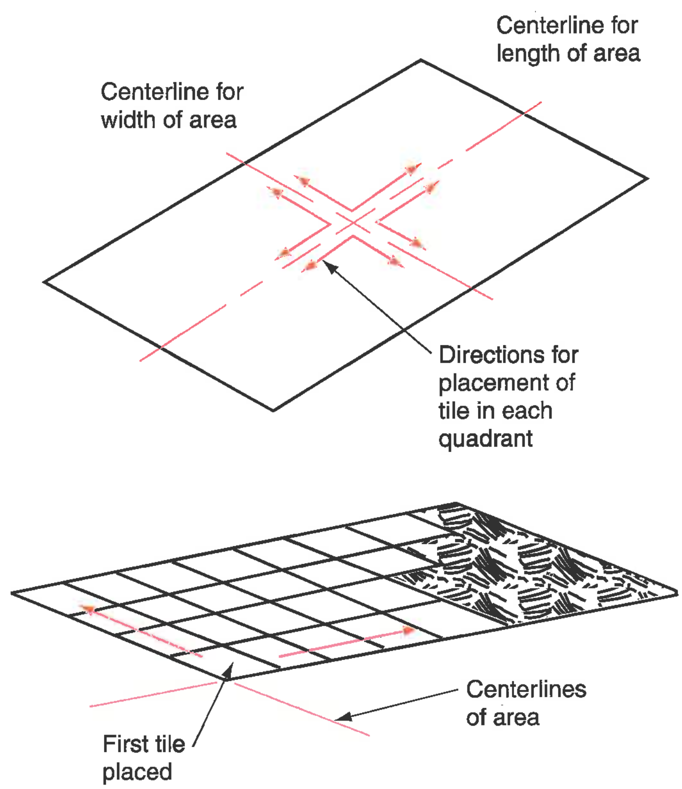


Figure 15-36. A symmetrical tile layout begins at the center of the area to be tiled. Then lay the tile toward the wall along the centerlines.

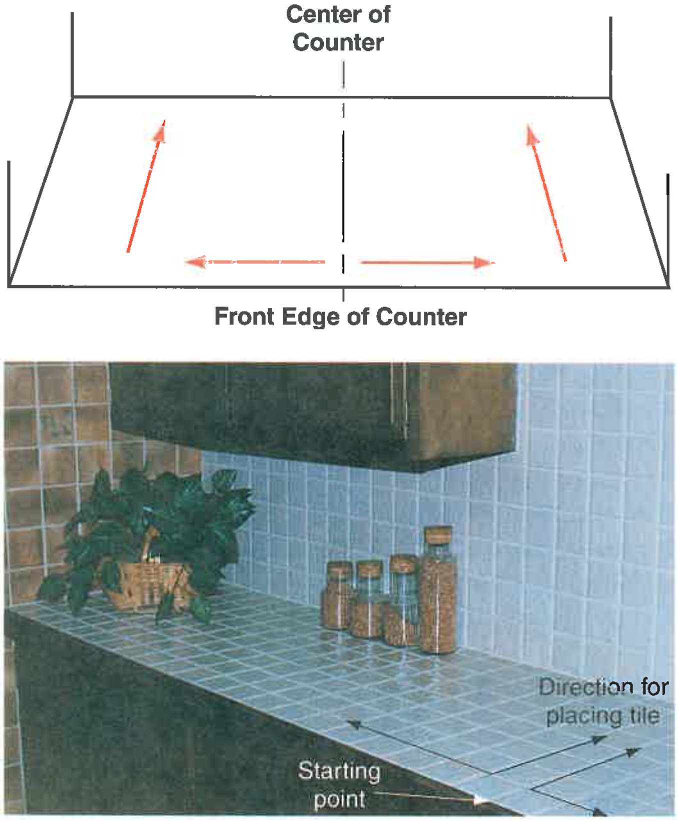


Figure 15-37. A one edge tile layout begins at the front edge. This type of layout is common for countertops.

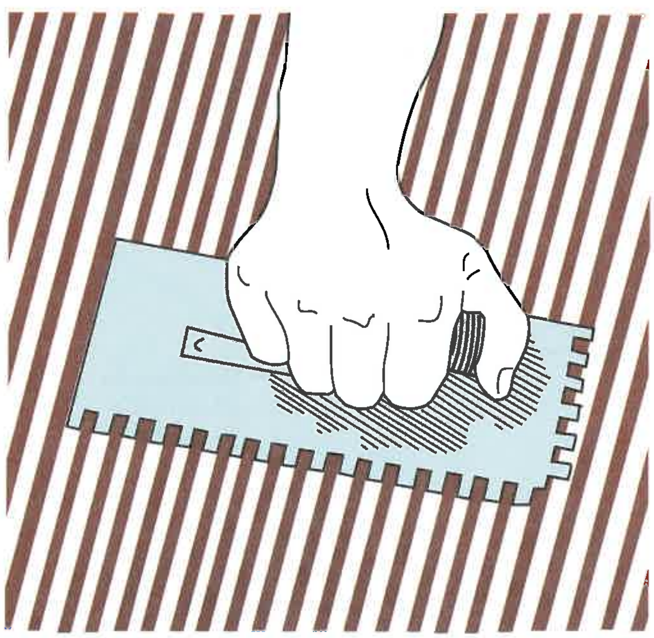


Figure 15-38. A notched trowel spreads mastic evenly.

Setting full tile

Full tiles are easy to set. (Setting is another term for positioning.) Start from the layout lines. The lines should be visible through the mastic. Set full tile as follows:

1. Place the first tile against the layout line.
2. Twist it slightly as you align it. This creates a better bond between the tile and mastic. (Do not slide the tile. Sliding removes the mastic.)
3. Remove any adhesive on the tile surface.
4. Space the individual tiles using edge tabs on the tile. (The tabs should touch each other.)

Setting partial tile

Partial tile is cut and set in areas where full tile will no longer fit. There are several methods to cut tile. One is to fracture the tile with a tile cutter or tile nippers. The other is to saw the tile with a carbide blade.

Tile cutter

Use a tile cutter for straight line fracturing. The break may be made parallel or diagonal to the edge depending on your layout. Score the tile with the cutter wheel. See **Figure 15-39**. Then, locate the

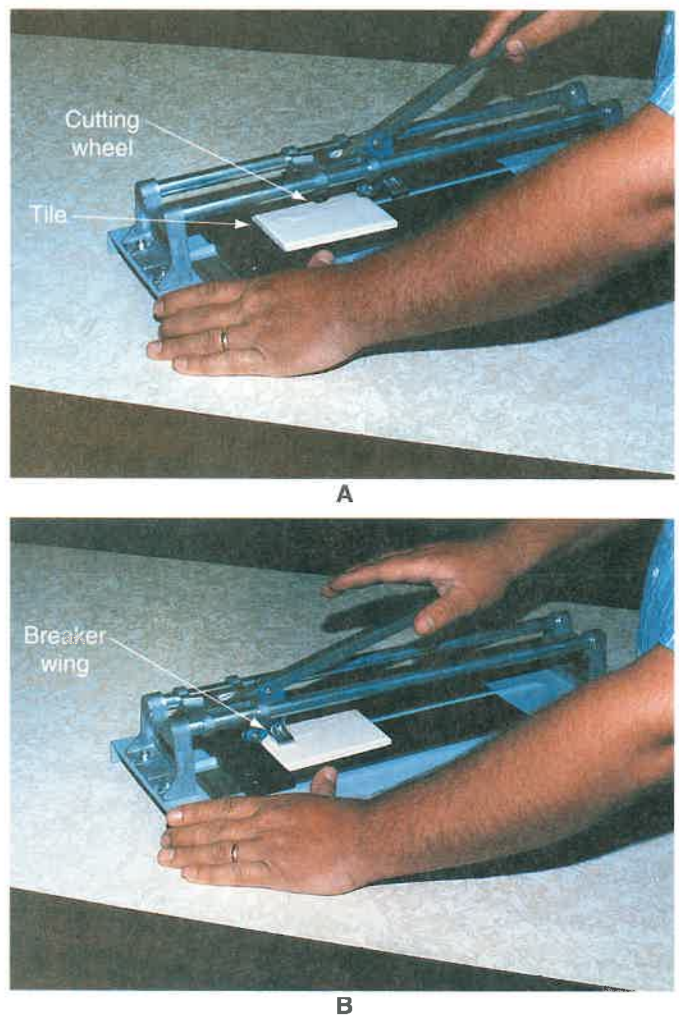


Figure 15-39. A tile cutter scores and breaks tile easily. A—Place marked tile in cutter. Pull the handle toward you to score the tile. B—Locate the breaker wing over the tile and push the handle down to fracture the workpiece.

breaking wing over the tile. Press the cutter handle downward. The breaking wing fractures the tile.

Tile nippers

Tile nippers remove small pieces of tile. They work best for irregular shaped breaks. First, mark the desired shape of the tile with a crayon. Chip away at the tile by squeezing the nippers, then giving a slight downward pressure. See **Figure 15-40**. Remove small pieces until you reach the crayon line.

Carbide blade

Carbide edged blades are available for saber saws and hacksaws. See **Figure 15-41.** Mark the tile with a crayon and saw just inside the line. A hacksaw works well for irregular shapes. A saber saw can be used to make holes for pipes or fixtures.

Set partial tile as you would full tile. Once the partial tile is set, clean all tiles with tile cleaner. Allow the tile mastic to set for 18 hours to 24 hours. Then apply grout.

Grouting

Grout is a form of cement applied in the space between tile. It covers the space between and over the tile tabs. Mix grout by adding water to the dry grout powder. The mixture should be about the consistency of toothpaste. Allow the grout to set for a few minutes. Then, mix it again to assure an even texture.

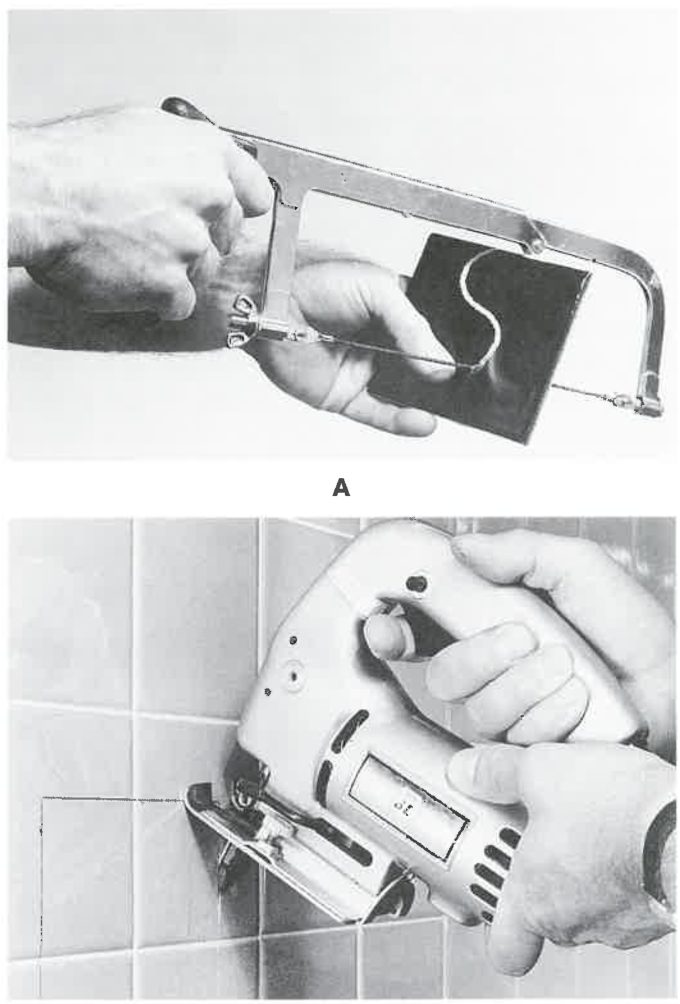
Grout paste has a short pot life. ***Pot life*** is the time grout or other adhesives can be applied. Mix only the amount that you can spread in 10 minutes. Apply grout with a grout float. This tool is a felt covered block. Use it to press the grout into the space between tiles. Then wipe away excess grout with the float held at a 45° angle to the tile lines.

Allow the grout to set for 15 minutes to 20 minutes. Then clean all residue from the tile faces and grouted spaces with a damp sponge. Rinse the grout out of the sponge frequently. Allow the grout to dry for three to four hours. Then wipe the tile and tile lines lightly with a rough cloth, such as burlap. Remove any remaining dry grout with tile cleaner. Allow the grout to dry for 48 hours before sealing the surface.

Sealing tile

Sealer protects the tiled surface. It is usually a silicone based liquid. Sealer is applied in two ways. If the tile is unglazed, spread sealer over both tile and grout lines. If the tile is glazed, apply sealer only to the grout lines. Use a small artist's paintbrush to prevent getting sealer on the tile.

Figure 15-40. Tile nippers chip off bits of tile for irregular shapes.



A

B

Figure 15-41. Sawing tile. A—Cut curves with a carbide blade hacksaw. B—Cut holes in tile with a saber saw. (*Remington Arms Co.*)

Drilling tile

Tile can be drilled to mount fixtures, such as towel bars or soap dishes. Use a carbide tipped glass drill. Select the bit size for the diameter of anchors used with the mounting screws. Drill slowly to prevent chipping the tile.

Slate Tile

Slate is an alternative to ceramic tile for floors and counter or table surfaces. Slate is a rock that breaks naturally in parallel layers. It may be black, gray, red, or green. It is generally fractured into ¼″ and ½″ (6 mm and 12 mm) thicknesses. Sometimes the slabs of slate are irregular shapes. They may be cut into squares or rectangles with an abrasive saw. See **Figure 15-42**. The shapes may be random or all one size. Sawed slate edges are not often finished (smooth). Plan to cover them with some kind of edging or molding. Check with your tile distributor for available slate sizes, color, and finishes.

Installing slate tile

Slate tile is installed much like ceramic tile. First, lay out the tile to form a desired pattern. Leave about 3/8″ (9 mm) between pieces. The pattern may be random or based on colors or sizes. Partial slate tile is cut with a carbide edged blade.

Lay the pieces aside in the order you want to use them. With a notched trowel, spread mastic on the surface to be slated. Position the pieces as you laid them out originally. Allow the mastic to set at least 24 hours. Press grout into the space between pieces. After the grout has dried, seal the slate surface.

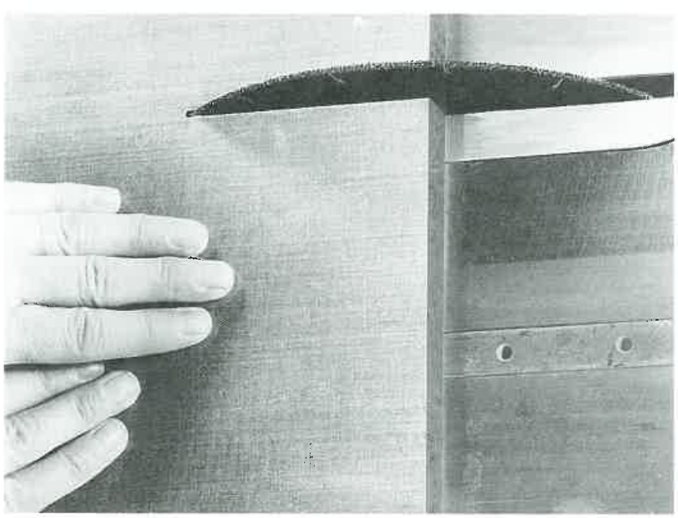


Figure 15-42. Cut slate with an abrasive blade. Guard is removed to show operation. (*Remington Arms Co.*)

Think Safety—Act Safely

Many health and safety problems are associated with the materials discussed in this chapter. Use the following precautions:

- Wear eye protection.
- Wear leather-palm gloves while working with glass, plastic and ceramic products.
- Wear a respirator and rubber gloves while working with fiberglass.
- Work with lead and fiberglass in a well ventilated area.
- Lead is toxic. Keep your hands away from your face and mouth when handling it.
- Be aware of allergies to certain substances.

Summary

Glass, plastic, and ceramics are functional and decorative materials. Glass windows and ceramic tile have been used for thousands of years. Molded glass has been formed into knobs and pulls in the past two hundred years. During the past century, plastic has replaced many glass and ceramic products. Plastic typically is stronger, more flexible, and less apt to break. Plastic also can be formed or bonded into complete furniture pieces.

Glass is available in many forms. Flat glass is the most common glass form for cabinetry. Glass may be clear, decorative, tinted, or mirrored. It may also be tempered to increase its strength. Leaded glass panels are made with decorative glass pieces and lead came. The came is soldered around the edges of the glass. Colored glass is used to make stained glass panels.

Plastics may replace other materials. Clear sheet plastic might replace glass. Molded plastic can replace wood components. Plastics are either thermoset or thermoplastics. Thermoset plastic products are permanently shaped during manufacture. Thermoplastics may be heated and reshaped. Tile may cover floors, cabinet tops, and table surfaces. Ceramic tile is made of baked clay. Tiles are bonded to the surface with mastic. Spaces between tile are filled with grout. Slate, a form of rock, is applied like ceramic tile. Slate size may be random or all one dimension.

Two methods for cutting glass, plastics, and ceramic are fracturing and sawing. Fracturing involves scoring the material and breaking it along the score line. When sawing glass or ceramics, use a carbide tipped blade. Certain plastics also require a carbide blade.

Test Your Knowledge

Do not write in this text. Answer the following questions on a separate sheet of paper.

1. Two forms of glass, plastic, and ceramics are _____ and _____.
2. Mats, rolls, and rovings are forms of _____.
3. During manufacture, glass may be toughened by _____.
   a. annealing
   b. curing
   c. quenching
   d. tempering
4. List the three types of flat glass.
5. What is the difference between "sheet glass" and a sheet of glass?
6. The two steps to cut glass are _____ and _____.
7. Describe the four types of decorative glass.
8. List the three methods to fracture glass.
9. Leaded panels are held together with _____ and _____.
10. Explain the steps to assemble leaded glass panels.
11. Describe the two classifications of plastics.
12. Which classification of plastic is suitable for forming? List three formable plastics.
13. Fiberglass is a mixture of glass fibers and _____.
14. Explain the difference between cement and solvent bonding.
15. Ceramic tile can be cut with _____ blades that are available for saber saws and hacksaws
16. Ceramic tiles are spaced by _____.
17. Describe two methods of laying out tile. Which is appropriate for a tabletop?
18. _____ is a form of cement that covers the space between and over the tile tabs.
19. The time period for which grout or other adhesives can be applied is called the _____.
20. List three of the health and safety precautions discussed in this chapter.

Cabinets use glass doors and shelves to permit display of china and crystal collectibles.