THE GRAPHIC STANDARDS GUIDE TO ARCHITECTURAL FINISHES

Using MASTERSPEC® to Evaluate, Select, and Specify Materials

ARCOM

The American Institute of Architects

Editor

Elena M. S. Garrison, AIA, CCS, CSI

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PREFACE

The purpose of this book is to facilitate a more complete understanding of the issues relevant to evaluating, selecting, and specifying finish materials and to empower architects and designers to make informed choices for their projects.

When preparing drawings, architects refer to *Architectural Graphic Standards* for guidance. When selecting materials and products and when writing specifications, they turn to MASTERSPEC®, a product of the American Institute of Architects (AIA) published by ARCOM. By combining the invaluable resources of *Architectural Graphic Standards* and MASTERSPEC, this book efficiently assists an architect who is preparing a project's construction documents.

MASTERSPEC has long been the building construction industry standard for master specifications. Associated with each master specification section are supporting documents, which include a cover, evaluations, a drawing coordination checklist, and a specification coordination checklist. Evaluations in sections for finishes are the basis of this book.

A primary goal in producing this book is to make architects who are in early stages of the design process more aware of the information in MASTERSPEC evaluations, especially those architects who may not typically prepare specifications. Keeping this reference handy during the early design phases of a project will enable the project designer to ask suppliers and manufacturers educated questions, to make better initial product and system choices, and to successfully integrate these choices into the drawings and the specifications.

MASTERSPEC evaluations are the industry's only source of comprehensive information on product selection and specification. To produce them, ARCOM writers researched and integrated information from consensus standards, industry standards, model codes, industry organizations, manufacturers' product literature, and technical publications.

Evaluations were abridged for this book. Manufacturer listings and product tables were deleted because their data frequently change. This information, along with the master specification text and the coordination checklists, is available only in a complete MASTERSPEC section.

In keeping with *Architectural Graphic Standards* and MASTERSPEC, this book is organized according to the 1995 edition of *MasterFormat*™ published by the Construction Specifications Institute. The chapter numbers identify the *MasterFormat* divisions to which the content relates; chapter numbers and titles correspond to *MasterFormat* five-digit numbers and titles for specification sections.

As with any ambitious undertaking, this book is the product of collaboration. The staff at John Wiley & Sons, Inc. assembled this work; each participant can be proud of its eloquence. A special thanks to my counterpart at John Wiley & Sons, Inc., Julie Trelstad, Senior Editor, Architecture. Julie's vision and persistence were essential to making this book a reality; it is a pleasure to work with her and to count her as a friend.

For the graphic content of this book, we are indebted to the dedicated AIA members and other building construction experts who originally contributed the graphics to *Architectural Graphic Standards,* which now illustrate this work. The contributors' names appear on the acknowledgments pages at the back of this volume.

For the written content, we are indebted to the two AIA committees charged with guiding and reviewing the MASTERSPEC evaluations used in this book: the MASTERSPEC Architectural Review Committee (MARC) and the MASTERSPEC Interiors Review Committee (MIRC). Those who serve on these committees unselfishly volunteer their time to share experience and wisdom so that others might learn and benefit.

For completing the exacting task of associating the graphics from *Architectural Graphic Standards* with the text from MASTERSPEC and editing the annotations of the graphics, I am profoundly grateful to MARC members Philip W. Kabza, AIA, CCS, CSI; David Metzger, FAIA, CSI (current MARC chair); and E. Leo Scott, CDT, CSI, for sharing their time and wisdom.

Every ARCOM staff member helped prepare this book. To my fellow writers, your expertise and the vastness of our collective technical knowledge are astounding. To our editorial staff, thank you for your support, guidance, and unwavering dedication to clear, concise, correct use of the language. To our technical and production staff, thank you for working your magic on the documents to reformat them for this book. Finally, to Edward F. (Ted) Smith, D. Arch., FAIA, CSI, President of ARCOM, thank you for fostering ARCOM's culture of integrity and cooperation and encouraging all of us to find new ways to serve the building construction industry.

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FOREWORD

The American Institute of Architects (AIA) and ARCOM, publishers of the MASTERSPEC® master specification system for the AIA, are pleased to join with John Wiley & Sons, Inc. in presenting this publication for the building design and construction community. This book combines information from two of the AIA's most valuable resources, *Architectural Graphic Standards* and MASTERSPEC. Both support this nation's building design standards and represent the best architectural practice.

This book, for the first time, integrates graphic representations for finish materials from *Architectural Graphic Standards* with MASTERSPEC's technical information on evaluating, selecting, and specifying finish materials. Each page and each detail assist in the building design process, from product evaluation and selection through construction and evaluation of in-service use.

Every practicing architect is indebted to the founding authors of *Architectural Graphic Standards,* Charles George Ramsey, AIA, and Harold Reeve Sleeper, FAIA, for their creation of this indispensable work in 1932. We recognize the dedicated professionals who have contributed graphics to *Architectural Graphic Standards* to keep it current and vital through its ten editions.

In 1969, the AIA produced the first family of MASTERSPEC specification sections under the direction of John H. Schruben, FAIA. His efforts and the subsequent contributions of Roscoe Reeves, Jr., FAIA, CSI, who was the Director of Architectural Specifications for the AIA and now serves in this capacity for ARCOM, have made MASTERSPEC an essential tool of the profession. We must also acknowledge the immeasurable contributions of the professionals who have served on the MASTERSPEC Architectural Review Committee (MARC), MASTERSPEC Engineering Review Committee (MERC), and MASTERSPEC Interiors Review Committee (MIRC). Committee members give unselfishly and creatively to MASTERSPEC. The building design and construction industry benefits from their knowledge and expertise.

We would also like to express gratitude to those individuals who combined the information in *Architectural Graphic Standards* and MASTERSPEC to produce this volume. For ARCOM, Elena M.S. Garrison, AIA, CCS, CSI, coordinated the selection of MASTERSPEC text and the integration of *Architectural Graphic Standards* graphics. Members of MARC matched the graphics to the MASTERSPEC text. These committed professionals are Philip W. Kabza, AIA, CCS, CSI; David Metzger, FAIA, CSI, the current MARC chair; and E. Leo Scott, CDT, CSI.

To all of the people associated with this unique project, we offer the words of Eliel Saarinen, FAIA: "Always design a thing by considering it in its next larger context — a chair in a room, a room in a house, a house in an environment, an environment in a city plan." By combining two distinctly different and valuable resources, information from each will address its next larger context and will inform and empower professionals to do the same.

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CONTENTS

05511 **METAL STAIRS**

This chapter discusses *straight-run, steel-framed stairs with metal-pan, abrasive-coating-finished formed-metal, metal plate, and steel-bar grating treads. It includes preassembled metal stairs for commercial applications, industrial stairs, and steel-framed ornamental stairs. It also includes steel tube railings for preassembled metal stairs.*

This chapter does not discuss *alternating tread stairs, spiral stairs, or handrails and railings other than those made from steel tube.*

GENERAL COMMENTS

Steel-framed stairs information is covered in the National Association of Architectural Metal Manufacturers (NAAMM) publication NAAMM AMP 510, *Metal Stairs Manual.* NAAMM AMP 510 contains information on typical metal stair construction, as well as many photographs and drawings of more elaborate ornamental metal stairs. NAAMM AMP 510 also contains structural design information for metal-pan stairs, metal floor plate stairs, and metal railings. For structural design information for metal bar-grating stairs, see NAAMM MBG 531, *Metal Bar Grating Manual for Steel, Stainless Steel, and Aluminum Gratings and Stair Treads.* Refer to applicable building codes and accessibility standards to determine requirements for egress widths, structural performance, fire-resistance rating of enclosing walls, and accessibility by people with disabilities (fig. 1).

Metal stairs generally fall into one of three categories: preassembled metal stairs, industrial metal stairs, or ornamental metal stairs. Preassembled metal stairs, which usually have concrete-filled metal-pan treads, are used for commercial, institutional, light industrial, and multifamily residential occupancies (fig. 2). Industrial metal stairs are for more heavy-duty applications than preassembled metal stairs, and usually have steel floor plate or bar grating treads. Ornamental metal stairs are often of unique designs and are finished with highly decorative materials, such as marble, glass, ornamental metals, and so on.

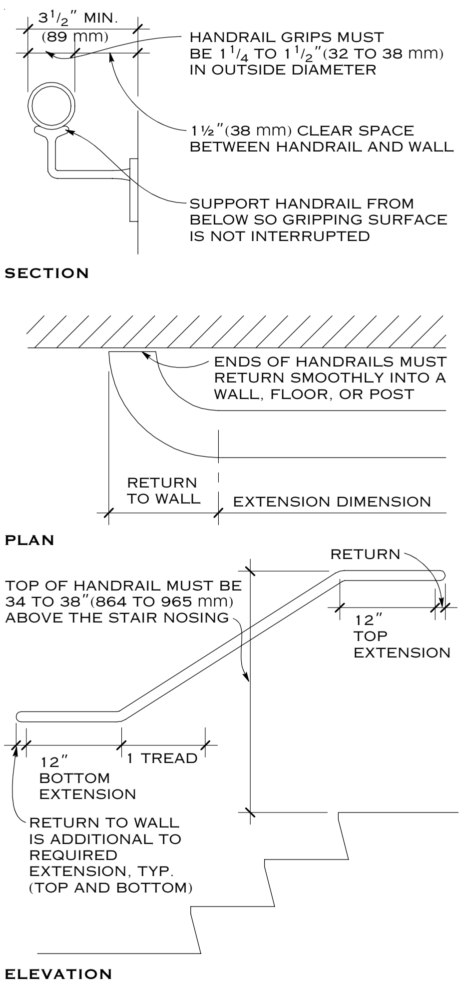


Figure 1. Typical accessibility requirements for steel tube handrail

PREASSEMBLED METAL STAIRS

Preassembled stairs offer faster erection, lower erection costs, and both improved and safer access to upper floors during construction (fig. 3). They are made by manufacturers that specialize in metal stairs and by local iron and steel fabricators. They are available either as multistory self-supporting units erected in advance of structural framing or as single-story or single-flight units installed as structural framing or wall and floor construction progresses. Consult manufacturers and local fabricators to determine limitations of these types of units if either is required or permitted as an option.

Preassembled metal stairs are usually specified with performance requirements so the manufacturer can design them based on its standard methods of construction. Performance criteria should always be accompanied by requirements for submitting structural calculations, and detailed shop drawings prepared by a qualified professional engineer who is legally authorized to practice in the jurisdiction where the project is located. In certain jurisdictions, however, authorities may require the engineer of record to prepare the drawings and calculations for fabrications supporting structural loads, or to approve them even when they are signed and sealed by another engineer legally authorized to practice in the jurisdiction where the project is located.

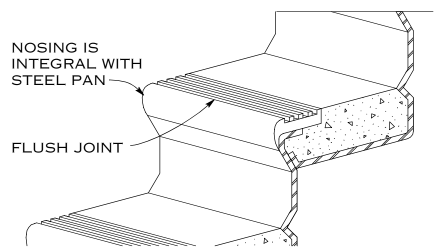


Figure 2. Preassembled stair with concrete-filled steel pan

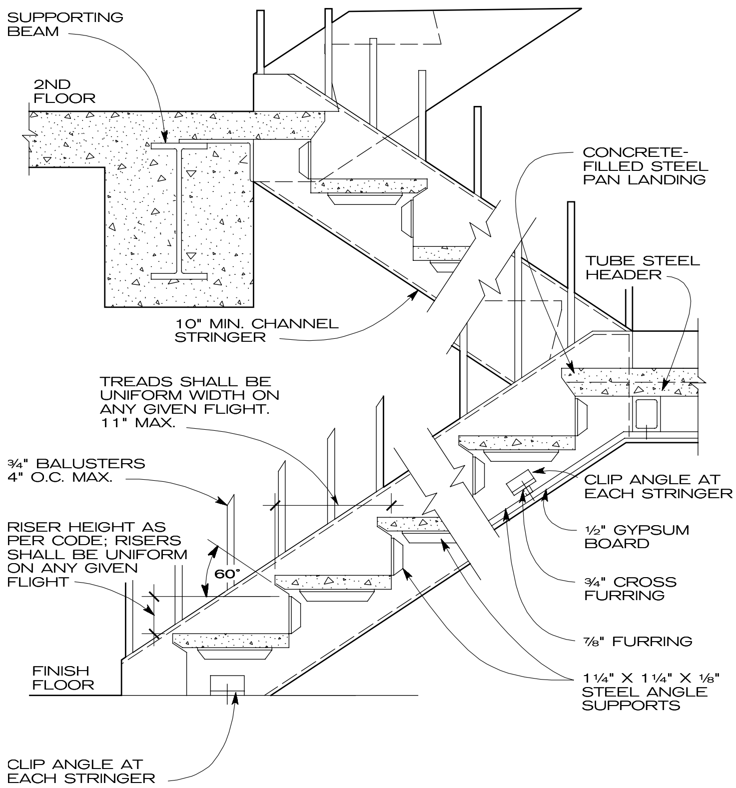


Figure 3. Preassembled metal stairs with pan-type stair construction

Precast concrete treads eliminate the inconvenience of pouring the treads on-site and offer smooth subtreads that are usable by workers without a temporary filler. Since the treads need not be installed until finishing operations are nearly complete, the treads are not vulnerable to job-site damage. Epoxy-filled treads are a lightweight alternative to prefilled concrete treads and have a more finished appearance.

Abrasive-coating-finished formed-metal stairs offer an economical alternative to metal-pan stairs. They require no finishing operations other than painting, but may not feel as solid under foot as metal-pan stairs. With this type of stair and with epoxy-filled metal-pan stairs, some protection is often required to prevent damage during construction.

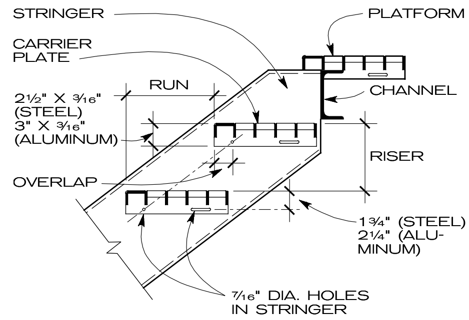


Figure 5. Industrial metal stairs

Steel tube railings are standard with most preassembled metal stair manufacturers. Where stairs are primarily utilitarian, and appearance is not critical, performance requirements, together with a general description of the desired railing configuration, are often sufficient, with few or no details on the drawings. Where appearance is more important, delete railing descriptions and show railings on the drawings together with notes for component dimensions, spacing, and so on (fig. 4).

INDUSTRIAL METAL STAIRS

Industrial stairs are usually fabricated by local iron and steel fabricators rather than by metal stair manufacturers (fig. 5). They are usually designed by the project's structural engineer and fully detailed on the drawings rather than being specified with performance requirements. Railings are usually made from steel pipe, bars, or structural shapes, and are also detailed on the drawings.

Steel floor plate treads have traditionally been used in the diamond pattern to provide some measure of slip resistance (fig. 6). Alternatives can be specified along with performance requirements for slip resistance. It should be noted, however, that no test method can totally predict slip resistance; foreign materials and lubricants can increase slipping, and no test adequately incorporates all directional forces involved in walking and all materials used for shoe soles. Other factors to consider in selecting slip-resistant surfacing are its profile, which can increase slip resistance by cutting through lubricants and foreign matter, and its durability.

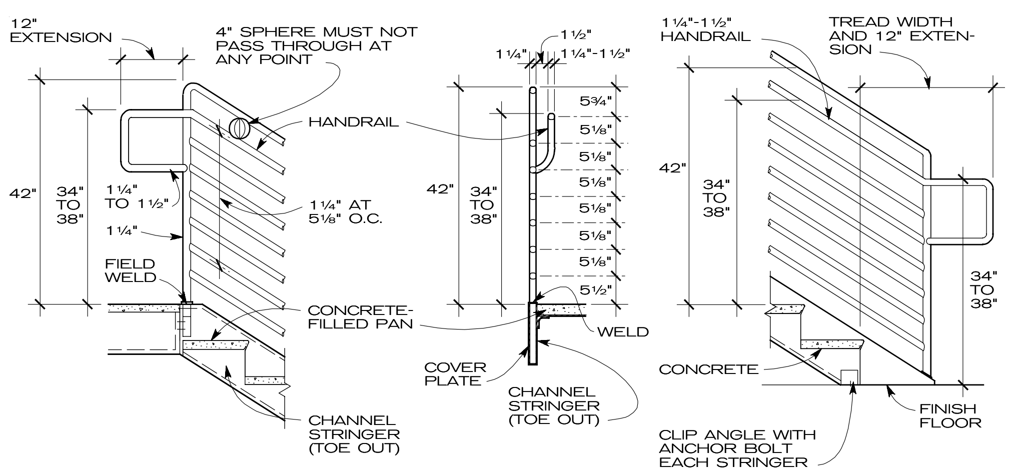


Figure 4. Steel tube railings

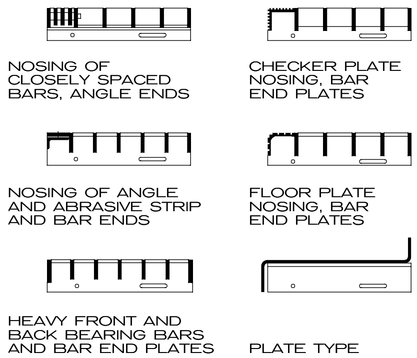


Figure 6. Steel floor plate treads

Metal bar gratings are specified by NAAMM standards and the NAAMM-recommended marking system.

ORNAMENTAL METAL STAIRS

Ornamental stairs are often designed with a steel supporting structure and finished with wood, stone, tile, ornamental metal, or another decorative finish. The supporting structure may be left exposed, and painted, or may be completely enclosed by finish materials. In either case, the steel supporting structure can be specified in Division 5, "Metals," with the finishes specified in Division 9, "Finishes." Ornamental metal stairs are usually fabricated by local ironworks, but may also be made by companies specializing in decorative and custom railings.

DESIGN AND DETAILING

Where appearance is important, it is necessary to provide adequate details and other graphic information on the drawings and not try to substitute written requirements that do not define complex relationships and details. Stairs and railings are perfect examples of building components where visual considerations, coupled with complex geometrical relationships, can involve a multitude of conditions. Only proper graphical development reveals all conditions and determines the appropriate specification and drawing requirements.

If appearance is important, the architect will probably not want to relinquish control of aesthetic details to the fabricator. Where appearance is not important, and the manufacturer's standard methods are acceptable, details can be kept to a minimum, and performance specifications with limited descriptive requirements can be used to ensure the most economical solution.

REFERENCES

Publication dates cited here were current at the time of this writing. Publications are revised periodically, and revisions may have occurred before this book was published.

National Association of Architectural Metal Manufacturers

NAAMM AMP 510-92: Metal Stairs Manual

NAAMM MBG 531-93: Metal Bar Grating Manual for Steel, Stainless Steel, and Aluminum Gratings and Stair Tread

06402 INTERIOR ARCHITECTURAL WOODWORK

This chapter discusses *fabricated wood products for use on the interior of the building. Architectural woodwork is distinguished from other forms of wood construction in that it is manufactured in a woodworking plant and complies with standards of quality for materials and workmanship. It includes items of woodwork permanently attached to the building and exposed to view. Architectural woodwork generally involves items custom-fabricated for an individual project, as opposed to mass-produced moldings or furniture. Woodwork can be specified to be shop- or field-finished.*

This chapter also discusses flush wood paneling for transparent finish; it is often considered woodwork. For stile and rail paneling, board paneling, flush paneling for opaque finish, and plastic laminate flush paneling refer to the Chapter 06420, Paneling.

This chapter does not discuss *wood doors, wood windows, manufactured casework of stock design, wood furniture, or wood pews or benches. Wood doors are included in Chapters 08211, Flush Wood Doors and 08212, Stile and Rail Wood Doors. Manufactured casework, wood furniture, and wood pews and benches should be specified in Division 12, "Furnishings." As mentioned above, finish carpentry is also not included, although no universal definition exists that states where woodwork ends and finish carpentry begins.*

ARCHITECTURAL WOODWORK STANDARDS

Woodworking Standards

Construction as described here is specified to comply with either the Architectural Woodwork Institute (AWI) or Woodwork Institute of California (WIC) standard. The location of the project determines, in part, which standard to reference. Except for projects located in California, Nevada, and Oregon, the standard to reference is the one published by AWI. For California, Nevada, or Oregon, either standard can be used.

Grade of Woodwork

For the most part, both woodworking standards were developed for designating quality by using three separate grades: Premium, Custom, and Economy. WIC, however, also includes Laboratory grade for casework. Although requirements for the same grade are not identical for different categories, the following criteria apply:

- **Premium** requires the highest grade of materials and workmanship recognized in either woodworking standard. Premium grade might be specified for woodwork throughout a building, but it should not be specified indiscriminately. Usually, Premium should be specified for selected areas or for items that have particular architectural significance.
- **Custom** is the predominant grade and requires a reasonable level of quality in both materials and workmanship. It is for typical commercial and institutional work.
- **Economy** is the lowest acceptable grade in both material and workmanship requirements, and is for work where price outweighs quality considerations.
- **Laboratory** is available with WIC-referenced casework, and is for items in chemistry or hard-acid areas that require additional protection. WIC also includes requirements for laboratory tops fabricated from several materials. See WIC's *Manual of Millwork* for explanations and choices for grade and other characteristics.

Substantial cost differences exist among the different grades, wood species, and finishes. Transparent-finished woodwork is more expensive than woodwork with an opaque finish, but the amount depends not only on the species and the cut of wood selected but also on the kind of transparent finish required.

Determination of quality grade should be based on a careful study of design role, function, location, and finish of each woodwork item. If this results in specifying several grades for the same job, the drawings or the specifications must indicate the locations and extent of each grade for a given category of woodwork. For most projects, woodwork will be of one grade, Custom. Premium and Custom grades differ primarily in appearance; where the appearance must be very high-quality, Premium grade is used. Custom and Economy grades may also differ in sturdiness, so the service life of the woodwork must be considered if Economy grade is chosen. Economy grade also does not have the appearance of Custom grade, so Economy should be used only where appearance is insignificant or at least not as significant as cost.

A Monumental grade does not exist in either woodworking standard, but some architects feel there should be such a grade. This belief is apparently shared by some woodworkers who, like architects, feel that the current requirements for Premium grade allow the woodworker too many options in the choice of materials and construction and do not represent the highest level of quality attainable by woodworkers. Several methods are available that try to obtain a higher level of quality than that produced by specifying Premium grade. One such method is the prequalification of woodworkers before bidding, which may be based on work previously completed. Although this is no guarantee that they will continue to perform at the same level, past performance is often an indicator of future performance. Thoroughly research the woodworking firms selected if this procedure is used. Verify that they have not had significant changes in personnel, large increases in workload, or financial difficulties since earning their good reputation.

Another method that attempts to raise the level of quality is the mockup. The problem with this method is that the woodworker may build a mockup that is no better than Premium grade. Still, a mockup does give the owner and the architect a sample of what they are getting before the job is complete, and it does provide a standard for enforcing a level of quality. Mockups can also be required before bidding to identify qualified woodworking firms. A woodworker could also be hired to build the mockup before the bidding, and the bidding could then be based on the premise that the contract work would match the mockup, but most projects do not have the time or budget to allow this procedure.

A third method for raising quality is to increase requirements, eliminate options, tighten tolerances, and so on. This method works for some aspects of woodworking but, unless directly related to results, may unduly restrict the woodworker without ensuring higher quality. This method does not work where expected results cannot be quantified, such as the appearance of the finish, the matching of veneer and solid stock, and so on; nevertheless, it is the basis of the distinction between the various grades established by the woodworking standards.

For interior transparent-finished woodwork, flush doors, matched paneling, and cabinets are often the most important work from a visual standpoint. When this is the case, frames, trim, and ornamental items should match these items. However, there is usually no way to achieve a perfect match between veneered items, plywood, and solid-lumber items. Logs with the best grain character are selected for veneer slicing, leaving less-distinguished logs for sawing into lumber. The direction of the cut for sawing lumber is also not the same from one piece to the next, nor necessarily the same as for slicing, even though specified to be the same. For example, rift sawing and cutting cover a range of cutting methods and grain angles. The architect is usually forced to accept a reasonably good color match and a similar grain character. A high-quality woodworker can provide near-perfect matching, but such matching is impossible, or nearly so, to specify. For work where only perfect matching is acceptable, a mockup should be a must, or samples should be used to define a minimum level of match.

Moisture and associated shrinkage problems must be recognized as serious considerations for achieving successful woodwork. Both woodworking standards include requirements for optimum moisture content of the wood (based on the relative humidity range). Because AWI covers a broad area, it has divided the United States and Canada into four geographical regions. Refer to the AWI standard for these locations and the corresponding requirements, and confirm that the humidity levels given correspond to local conditions before specifying a moisture content range. If they do not, consult the project's mechanical engineer and woodworkers familiar with conditions in the project area, and insert specific requirements into the specification.

Remember that for the woodwork to be at its best, humidity must be controlled within specific limits after installation. In some parts of the United States, this means that humidification will be needed in the winter, or joints will open up and tolerances will be lost. It is pointless to specify furniture-quality woodwork, then not provide the humidification necessary for maintaining that quality. Excessive indoor humidity during cold weather can result in condensation within exterior walls, so exterior walls must be designed to control the transmission of vapor produced by humidification or humidification based on an analysis of vapor-transmission characteristics of exterior walls.

VENEER SPECIES SELECTION

Numerous options are available for specifying veneer species, but a lack of knowledge about wood veneers and the available options can result in unpleasant surprises when the finished woodwork arrives. See Table 1 for an overview of general characteristics of common veneer species.

Natural birch is often specified without either the architect or the owner fully realizing that this means the veneers may contain both heartwood and sapwood, which may vary considerably in color. Birch sapwood is an off-white to light-yellow color; heartwood may be a creamy tan or a reddish brown and may be much darker than sapwood. The distribution of heartwood is not controlled by any standards, so it may appear as stripes in flat-sliced veneers or as blotches in rotary-cut veneers. The pattern can be irregular, regardless of the cut, and the appearance can be gaudy. If natural birch is specified, woodwork cannot be rejected because of the irregular variations in color that are likely to occur. Staining can reduce the contrast but will not eliminate it entirely. Shading (a term for selectively staining the sapwood to try to match the heartwood) can also be specified to reduce the contrast, but its cost may not be justifiable. This contrast in appearance can be eliminated by specifying white birch (all sapwood) or red birch (all heartwood) rather than natural birch.

White and red maple, and white and brown ash similarly distinguish sapwood from heartwood, although white and brown ash distinguish the sapwood of one species group from the heartwood of another species group. Ash is an underutilized species that provides veneers of fine appearance at a modest price. White ash is a very light-colored, open-grained wood that can be used with a clear finish for a blond effect or can be stained. If the blond effect is desired, specify a type of clear finish (such as lacquer) that is water-white; the slightest bit of yellow in the finish will show up on a wood as light in color as white ash. Brown ash shows more variation in color than white ash and is often used for paneling, where a more figured appearance is desired.

Oak veneers usually contain little sapwood, and heartwood is not as easily distinguished from sapwood as it is in birch. For these reasons, oak is not usually specified as all heartwood or all sapwood. The difference between white and red oak is one of species, not cut. White oak is light tan to grayish brown in color, while red oak is pinkish tan to red-brown or brown. Red-oak veneers are also less expensive than white oak. Plain-sliced red-oak veneers are less expensive than plain-sliced white birch, and are a good choice for inexpensive, good-quality woodwork. Oak veneers, besides being plain sliced, are frequently quartered or rift cut for a straight-grain appearance. Since quarter cutting and rift cutting require larger logs, the veneers are more expensive and usually narrower. Rift-cut oak is similar to quartered oak, but the amount and size of ray fleck, which some people find objectionable and which does not take stain well, are less for rift-cut veneers than for quartered veneers. If unsure which cut is desired, look at finished samples to see the grain pattern and the effect that ray fleck has on the appearance of the veneer; consider having the client review the samples for concurrence.

VENEER CUT

Veneers may be rotary cut, rift cut (usually applies only to oak), plain sliced (also called flat sliced), quarter sliced, or half-round sliced (fig. 1). Rotary cutting minimizes waste but results in a grain pattern that does not resemble any cut of lumber and is often very irregular. Plain slicing and half-round cutting can produce pleasing grain patterns, with the ring width increasing from the center to the edge and with a "cathedral grain" effect produced by the natural taper of the log. Quarter slicing and rift slicing (cutting) produce a straight grain and more evenly spaced rings than plain slicing or half-round cutting. Half-round cutting, which is not illustrated, involves reversing a half-log flitch on a lathe (placing the saw cut made at the middle of the log on the outside and the bark side of the log near the center of the lathe) and usually offsetting the flitch away from the center of the lathe to increase the radius of the cut. This process allows a lathe to be used instead of a slicer and produces leaves that are similar to those produced by flat slicing but slightly wider due to the curvature of the cut. Refer to Table 2 for common face veneer patterns.

VENEER MATCHING

Book matching readily comes to mind when discussing veneer matching: laying out the leaves like an open book so pairs of adjacent leaves are nearly mirror images (fig. 2). From one pair of veneer leaves to the next,

Table 1

GENERAL CHARACTERISTICS OF WOOD VENEER SPECIES

SPECIES		WIDTH TO (IN.)	LENGTH (FT)	FLITCH SIZE	COST[1]	AVAILABILITY
Mahogany	Plain sliced Honduras mahogany	18	12	Large	Moderate	Good
	Quartered Honduras mahogany	12	12	Large	High	Moderate
	Plain sliced African mahogany	18	12	Large	Moderate	Moderate
	Quartered African mahogany	12	12	Large	High	Good
Ash	Plain sliced American white ash	12	10	Medium	Moderate	Good
	Quartered American white ash	8	12	Small	High	Good
	Quartered or plain sliced European ash	6, 10	10	Medium	High	Limited
Anegre	Quartered or plain sliced anegre	6, 12	12	Large	High	Good
Avodire	Quartered avodire	10	10	Large	High	Limited
Cherry	Plain sliced American cherry	12	11	Medium	Moderate	Good
	Quartered American cherry	4	10	Very small	High	Moderate
Birch	Rotary cut birch (natural)	48	10	Large	Low	Good
	Rotary cut birch (select red or white)	36	10	Medium	Moderate	Moderate
	Plain sliced birch (natural)	10	10	Small	Moderate	Limited
	Plain sliced birch (select red or white)	5	10	Small	High	Limited
Butternut	Plain sliced butternut	12	10	Medium	High	Limited
Makore	Quartered or plain sliced makore	6, 12	12	Large	High	Good
Maple	Pl. sl. (half round) American maple	12	10	Medium	Moderate	Good[2]
	Rotary bird's-eye maple	20	10	Medium	Very high	Good
Oak	Plain sliced English brown oak	12	10	Medium	Very high	Limited
	Quartered English brown oak	10	10	Medium	Very high	Limited
	Plain sliced American red oak	16	12	Large	Moderate	Good
	Quartered American red oak	8	10	Small	Moderate	Good
	Rift sliced American red oak	10	10	Medium	Moderate	Good
	Comb grain rift American red oak	8	10	Small	Very high	Limited
	Plain sliced American white oak	16	12	Medium	Moderate	Good
	Quartered American white oak	8	10	Small	Moderate	Good
	Rift sliced American white oak	8	10	Medium	High	Good
	Comb grain rift American white oak	8	10	Small	Very high	Limited
Hickory or Pecan	Plain sliced American hickory or pecan	12	10	Small	Moderate	Good
Sapele	Quartered or plain sliced sapele	6, 12	12	Large	High	Good
Sycamore	Plain sliced English sycamore	10	10	Medium	Very high	Limited
	Quartered English sycamore	6	10	Medium	Very high	Limited
Teak	Plain sliced teak	16	12	Large	Very high	Limited[3]
	Quartered teak	12	12	Medium	Very high	Limited[3]
Walnut	Plain sliced American walnut	12	12	Medium	Moderate	Good
	Quarter sliced American walnut	6	10	Very small	High	Rare

[1]Cost reflects raw veneer costs weighted for waste or yield characteristics and degree of labor difficulty.

[2]Seasonal factors may affect availability.

[3]Availability of blond teak is very rare.

NOTE

When quartered or plain sliced are listed on the same line, the width dimensions are listed with quartered first and plain sliced second.

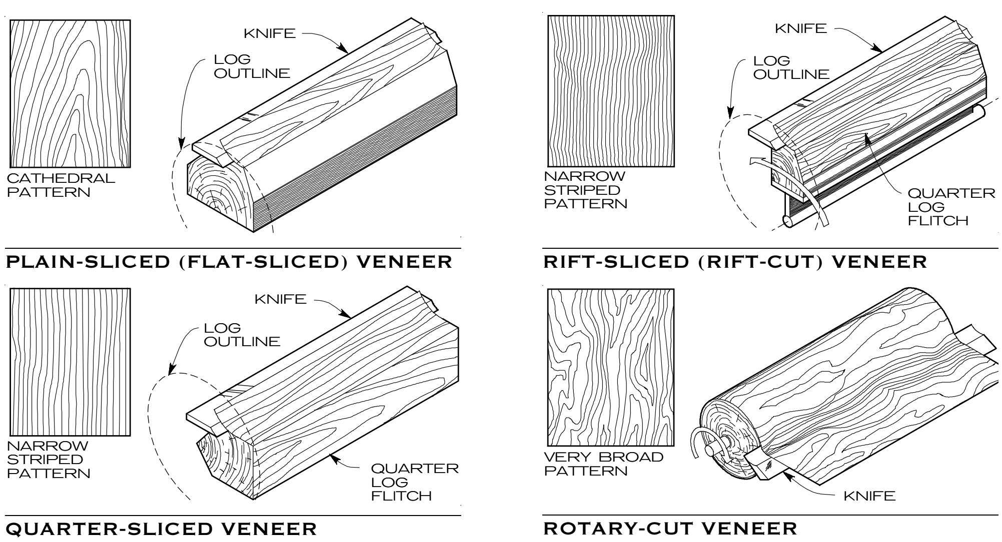


Figure 1. Veneer cuts

Table 2

COMMON FACE VENEER PATTERNS OF SELECTED COMMERCIAL SPECIES

PRIMARY COMMERCIAL HARDWOOD SPECIES	FACE VENEER PATTERNS[1]			
	PLAIN SLICED (FLAT CUT)	QUARTER CUT	RIFT CUT AND COMB GRAIN	ROTARY CUT
Ash	Yes	Yes	—	Yes
Birch	Yes	—	—	Yes
Cherry	Yes	Yes	—	Yes
Hickory	Yes	—	—	Yes
Lauan	—	Yes	—	Yes
Mahogany (African)	Yes	Yes	—	Yes
Mahogany (Honduras)	Yes	Yes	—	Yes
Maple	Yes	Yes	—	Yes
Meranti	—	Yes	—	Yes
Oak (red)	Yes	Yes	Yes	Yes
Oak (white)	Yes	Yes	Yes	Yes
Pecan	Yes	—	—	Yes
Walnut (black)	Yes	Yes	—	Yes
Yellow poplar	Yes	—	—	Yes
Typical methods of cutting[2]	Plain slicing or half-round on rotary lathe	Quarter slicing	Offset quarter on rotary lathe	Rotary lathe

[1] The headings above refer to the face veneer pattern, not to the method of cutting. Face veneer patterns other than those listed are obtainable by special order.

[2] The method of cutting for a given face veneer pattern shall be at mill option unless otherwise specified by the buyer in an explicit manner to avoid the possibility of misunderstanding. For example, plain-sliced veneer cut on a vertical slicer or plain-sliced veneer cut on a half-round rotary lathe could be specified.

some matching is lost in the progression through the log, but the effect can still be stunning. When looking at a pair of book-matched veneers, the inside surface of one and the outside surface of the other is shown. This view causes some differences in color and sheen between the two leaves, which is called *barber poling.* For this reason, it is preferable to use slip matching with straight-grain veneers, such as quarter sliced or rift cut, or with fairly symmetrical plain-sliced veneers. Sanding and stain color can also affect the appearance of barber poling.

Running match requires all veneer leaves to be from the same flitch and in sequence, which means that they must be either book or slip matched. The width of the running-matched leaves can vary, and the piece trimmed from one edge of the panel can be used to start the next panel. Balance matching also requires a book or slip match and that all veneer leaves be the same width, which results in some trimming waste and an increase in cost. Center-balance matching requires an even number of veneer leaves, all the same width and from the same flitch, which further increases the waste and cost over running or balance match. For maximum economy, random matching, which is really no matching, can be specified so the woodworker can make the most efficient use of the veneer log—veneer leaves can even be from different logs. Random matching can use any number of leaves from any number of flitches with no regard for color or grain; it is used only in Economy grade woodwork.

FIRE-RETARDANT TREATMENT

Usually, small amounts of architectural woodwork (10 percent of the wall surface) are permitted for most occupancies and spaces without regard to flame spread. However, for many applications where woodwork

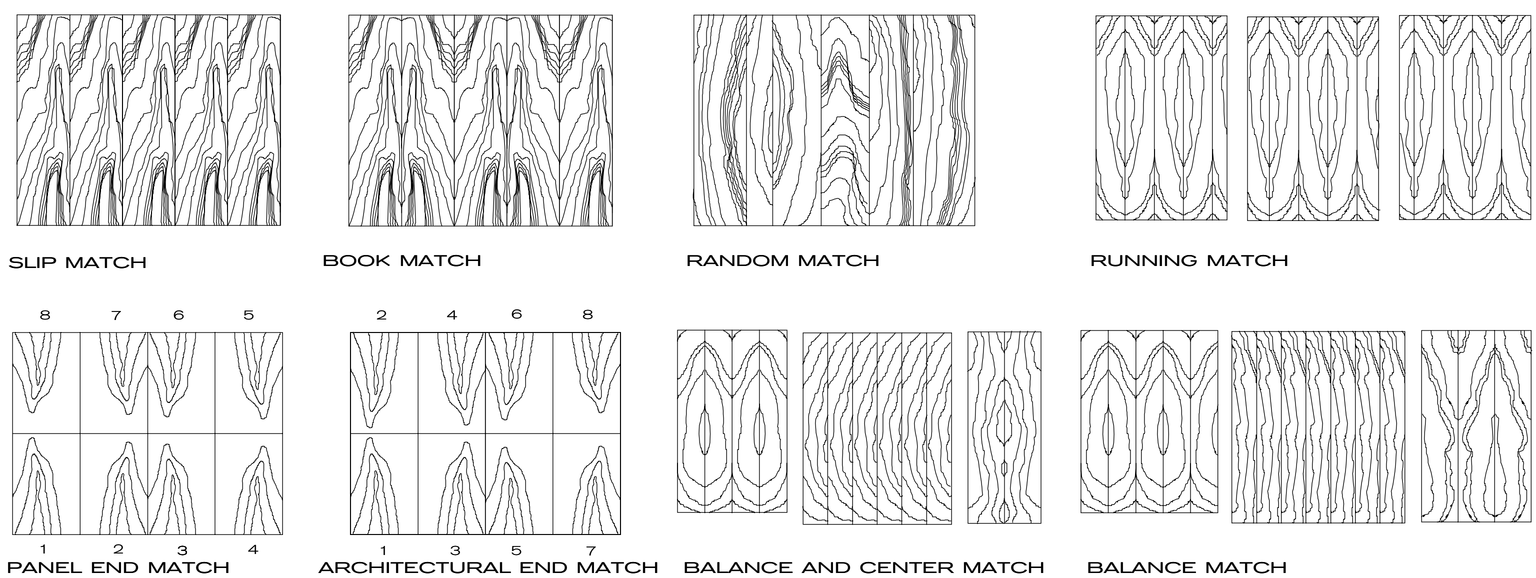


Figure 2. Veneer match types

(of any type) is extensive, flame-spread considerations may require treatment of all or part of the woodwork. Using fire-retardant wood limits choices for materials, thicknesses, treatments, and finishes, particularly transparent finishes.

Specifying fire-retardant treatment of architectural woodwork is complicated because American Wood-Preservers' Association (AWPA) treatment standards (AWPA C20 for lumber, AWPA C27 for plywood) are intended for structural materials used as exceptions to requirements for noncombustible materials. These standards are not intended for use where limits on flame spread of finishes and trim are the goal. Code requirements differ for wood used as a structural element or backing of finish and that exposed as finish or trim. To qualify as fire retardant for structural and backing uses, a material must have a flame-spread index of 25 or less when the test period is extended to 30 minutes, with no evidence of significant progressive combustion. To qualify as finish and trim, materials need only be subjected to a 10-minute test period; flame-spread requirements will depend on the code in effect, size and height of building, use group of building (business, assembly, residential, etc.), location and function of room or space where finish and trim occur, and whether a fire-suppression system is provided. For typical locations where fire-retardant-treated woodwork is specified, most codes require a flame-spread index of either 25 or less or 75 or less.

Fire-retardant-treated lumber is only available in a limited number of species for two reasons. First, penetration of the fire-retardant chemicals varies according to species, requiring each one to be tested individually; and second, testing costs limit available species to those for which a substantial market exists. There even exist certain untreatable species: those for which retention of chemicals is inadequate to achieve the desired test results or which require incising the lumber, a process unsuitable for woodwork. Where woodwork is to be milled after treatment, only western red cedar, red oak, or yellow poplar can be used, and only licensed plants can do the milling. For this reason, it is better to mill the woodwork before treating and to take extra precautions to ensure that the treatment process does not stain or mar the exposed surfaces of the woodwork.

Fire-retardant formulations, commonly used to treat architectural woodwork, are organic-resin type, low-hygroscopic type, and nonpressure-treatment type. The organic-resin formulation qualifies as an exterior type in AWPA C20 (lumber) or AWPA C27 (plywood). An exterior type in these standards produces treated lumber that shows no increase in flame spread when subjected to a standard rain test, ASTM D 2898, Method A. In the treatment of architectural woodwork, particularly hardwoods, this type is often favored because it is unaffected by exposure to moisture or high humidity and, depending on the wood species and product source, can be milled after treatment. Being able to mill woods after treatment allows for the removal of surface imperfections, such as raised grain and sticker marks, caused by the treatment process. Light sanding will also remove raised grain and surface stains.

The low-hygroscopic formulation is referred to as Interior Type A in AWPA standards. It was developed to overcome the problems that often resulted from using the older formulation, now removed from AWPA standards. Though both formulations are water-soluble, the older, conventional type often developed unsightly surface blooming when exposed to moisture and high humidity. The newer, low-hygroscopic type eliminates surface residues and is less expensive than the organic-resin type. Wood treated with the low-hygroscopic formulation cannot be milled after treatment. Always verify availability of a given species before specifying that it be treated.

A nonpressure-treatment process should be less harmful to the woodwork and less expensive to apply. Since the process does not take long, does not require heat or pressure, and does not require kiln drying, there is less tendency for the wood to warp or mark, and staining is slight. This treatment is listed by Intertek Testing Services (ITS) for both Class A and Class B finishes for some species of wood and presumably could be applied to wood products supplied by the woodworker to the treatment shop.

Regardless of which formulation is used, all have a darkening effect, particularly in light-colored wood species. Compare treated and untreated samples before deciding which species and finish to use, particularly where matching treated and untreated wood is expected.

Wood-veneered panel products with fire-retardant properties usually consist of treated cores with untreated face veneers. Consequently, the appearance of these panels does not pose the same problems as fire-retardant-treated lumber. Selection of untreated face veneers is limited to those species and thicknesses whose surface-burning characteristics comply with code or other requirements. Where the face veneer is $\frac{1}{28}$-inch (0.9-mm) thick or less and does not pose a greater fire hazard than paper, its surface-burning characteristics are generally not regulated by the model codes, provided the veneer is applied directly to substrates that are either noncombustible or of fire-retardant wood that complies with code requirements.

Fire-retardant particleboard and fire-retardant medium-density fiberboard, as well as pressure-treated plywood, have superior qualities as substrates for veneers and plastic laminates. The physical properties of fire-retardant particleboard are not, however, the same as for nonfire-retardant particleboard.

Although both fire-retardant particleboard and fiberboard have a flame-spread index less than 25, neither meets model code requirements for fire-retardant-treated wood and, therefore, they do not qualify as substrates for the exception to flame-spread requirements discussed in the previous paragraph. They have to be tested for flame spread as a veneered panel to be acceptable to the model codes. Surface-burning characteristics of wood are related to their densities, and this is the way veneered, treated panel products are classified in Underwriter Laboratories' (UL's) *Building Materials Directory.* Because surface-burning characteristics increase in direct relation to density, wood for veneers has to be within certain density limits for the required flame-spread index.

FORMALDEHYDE EMISSION LEVELS OF PANEL PRODUCTS

Formaldehyde is a natural component of wood products, but some wood glues, and wood products made with them, contain significantly higher amounts of this chemical than does wood alone. Limits on formaldehyde emissions from wood panel products are now included in the standards in which these materials are specified. For particleboard, the maximum emission level is the same as that required in the Housing and Urban Development (HUD) regulation 24 CFR, Section 3280.308, which controls formaldehyde emissions for particleboard and plywood for manufactured housing. For medium-density fiberboard, which is not regulated by HUD, the emission level is the same but the loading ratio is lower, since fiberboard is intended as a component of cabinets and furniture, not as a material for constructing manufactured housing. It should be understood that HUD regulations apply to manufactured housing, not to applications such as those discussed here.

Particleboard made with phenol-formaldehyde, which emits far less formaldehyde, is available by designating "exterior glue" at an increase in cost of about 30 percent. Medium-density fiberboard made without the addition of formaldehyde is also available. Hardboard uses much less resin than medium-density fiberboard, and phenolic resins rather than urea-formaldehyde, so it does not emit a significant amount of formaldehyde.

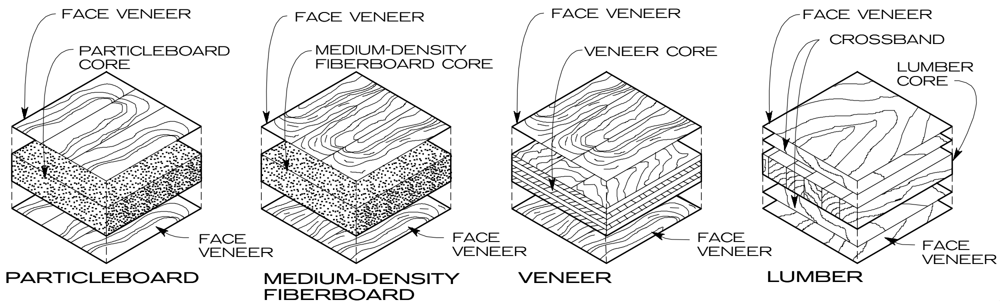


Figure 3. Hardwood plywood core types

Hardwood plywood is also covered by HUD regulations and by HPVA HP-1, published by the Hardwood Plywood & Veneer Association (HPVA). For plywood wall paneling, formaldehyde emission is limited to two-thirds of that allowed for particleboard but is measured at a higher loading ratio (fig. 3). Limits for industrial panels (unfinished multi-ply products with decorative face veneers and various cores) and reconstituted-wood wall panels (panel products made with strands, wafers, particles, or fibers of wood) are the same as for particleboard. According to the American Plywood Association (APA), softwood plywood is not involved because it is made with phenolic glues, which emit far less formaldehyde.

The Occupational Safety and Health Administration's (OSHA's) rules limit formaldehyde emissions of panel products in the workplace. OSHA attempted to require labeling of each formaldehyde-containing product as a potential cancer hazard; although the attempt was not accepted by the Office of Management and Budget, it may be in the future. The Environmental Protection Agency (EPA) is still in the process of investigating the safety of formaldehyde and could decide to implement rules governing the use of products containing this chemical.

Other regulations by federal agencies, including the EPA, the Consumer Products Safety Commission, and OSHA, may be enacted in the future. Moreover, local regulations that are more stringent than those specified in the voluntary standards may be in effect. For more information on formaldehyde emissions of wood products, see the American Institute of Architects (AIA) *Environmental Resource Guide Subscription*, especially the chapters on particleboard and plywood.

FACTORY FINISHING

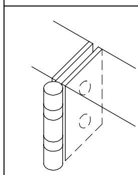
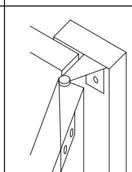
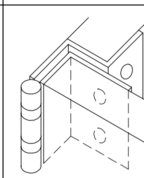
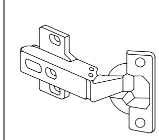
Prefinishing interior woodwork in the plant or finishing shop is generally limited to items for which a minimum of handling, cutting, fitting, and adjusting is needed during installation, such as cabinets, doors, paneling, and other woodwork near these items. According to AWI, factory finishing is usually chosen for high-quality work where superior appearance and performance of the finish are desired. Factory finishing may also be used to minimize fieldwork, to comply with OSHA regulations, or to reduce volatile organic compound (VOC) emissions. For Economy-grade work, shop-applied finishes that cost less than field-applied finishes are available, and may be used, especially when they are standard with the finishing shop and quantities are too small for efficient jobsite painting. Field finishing is advantageous when woodwork requires extensive fitting at the project site.

Shop finishing or priming serves to seal the woodwork against moisture absorption and helps prevent dirt and foreign substances from penetrating the wood and staining it. Shop priming also makes it easier to clean the woodwork before final finishing. If woodwork is primed or finished in the shop, it should also be backprimed to seal concealed surfaces against moisture penetration during periods of high humidity. Although this does not completely prevent fluctuations in moisture content and the attendant swelling and shrinking, it will delay or lessen this effect; and the more complete and less permeable the seal, the more it will moderate swelling and shrinking. AWI only requires backpriming for factory-finished moldings, factory-finished paneling, and Premium-grade factory-finished cabinets. WIC requires backpriming surfaces that abut walls, ceilings, and so on, on all shop-finished woodwork, but only for Premium or Custom grade. For the little that it costs, backpriming should be specified for all woodwork, regardless of where it is finished.

CABINET HARDWARE

Cabinet hardware can be specified in several ways (Table 3, figs. 4, 5). A schedule listing each cabinet and the items of hardware required for it can be prepared. Specifiers can refer to Builders Hardware Manufacturers Association (BHMA) numbers and standards or use specific manufacturers' names and product designations. For those desiring to list manufacturers' names and product designations, WIC's Manual of Millwork, Supplement No. 1 to Sections 14 and 15, contains a list of products that they consider acceptable.

Table 3
HARDWARE HINGES

	BUTT	PIVOT	WRAPAROUND	EUROPEAN STYLE
HINGE TYPE				
Applications	Conventional flush with face frame	Reveal overlay, flush overlay	Conventional reveal overlay	Conventional flush without face frame, reveal overlay, flush overlay
Strength	High	Moderate	Very high	High moderate
Concealed when closed	No	Semi	No	Yes
Requires mortising	Yes	Usually	Occasionally	Yes
Cost of hinge	Low	Low	Moderate	High moderate
Ease of installation	Moderate	Moderate	Easy	Very easy
Adjusted easily after installation	No	No	No	Yes
Remarks	Door requires hardwood edge	Door requires hardwood edge	Exposed knuckle and hinge body	Specify degree of opening; no catch required on self-closing styles

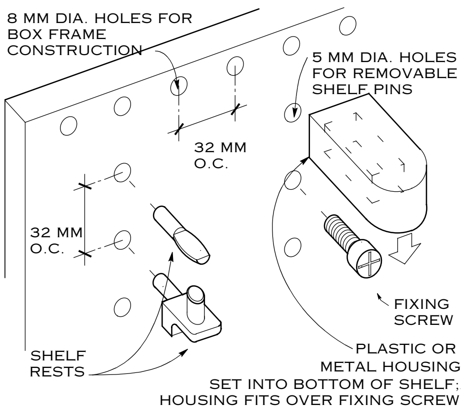


Figure 4. 32 mm box frame system

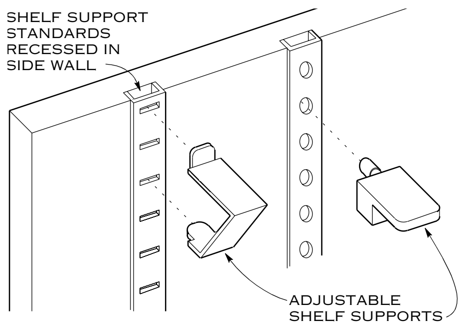


Figure 5. Shelf standards and supports

Because of the quality of work involved in architectural woodwork, it is advisable to specify that cabinet hardware be furnished and installed by the cabinet fabricator to ensure a single point of responsibility. This requirement minimizes problems with coordination and delivery and with potential damage to finish and materials if hardware is supplied and installed in the field by others. Pivot hinges, if used, should be installed in the field because of their tendency to shift during the setting and fitting of cabinets.

Specifying finishes for hardware may be a problem where casework involves products from different manufacturers, such as exposed hinges from one and pulls from another. This is especially true if finishes for both are expected to match but are classified in Category B or C per BHMA A156.18. Category B finishes are not identical when applied to different alloys and forms of base material and when supplied by different manufacturers. Category C finishes are nonuniform by nature (such as a blackened, brushed brass) and vary greatly when supplied by different manufacturers. If uniform appearance is important, specify that hardware with these types of finishes be supplied by the same manufacturer.

ENVIRONMENTAL CONSIDERATIONS

Architectural woodwork is produced primarily from renewable resources (wood and wood products), although glues, plastic laminates, and finishes used in woodwork are, at least in part, made from petroleum and coal-tar products. For this reason, and because the amount of nonrenewable resources consumed by the woodworking industry is small compared to our consumption of these resources as a whole, there is no need to dwell on this aspect of woodwork's environmental impact. Instead, the effects of timber harvesting should be looked at more closely.

Architectural woodwork uses many varieties of both hardwood and softwood, as well as wood products derived from both. The consumption of many species encourages the timber industry to produce a variety of species, which leads away from the monoculture of the tree farm and promotes biological diversity. The large logs used for face-veneer production require a longer growth period to produce the timber necessary, which leads away from even-age stands and promotes biological diversity. Because hardwood species reseed a forest if allowed to, and need shade to become established, hardwood production does not rely on clear-cutting as does softwood production. For these reasons, the hardwood forest supports a wider variety of wildlife than the pine plantation, even though the tree farm supports more deer and rabbits with its abundance of young trees and undergrowth. In specifying architectural woodwork, give some thought to using seldom-used or unusual veneer species to promote diversity, in both buildings and the forest.

Tropical species, on the other hand, are not generally being replanted as they are harvested. Much tropical timber is harvested simply to get it out of the way so the land can be used for agriculture. Selection of veneer species does little to stop the clearing of land for farming, but the careful use of tropical hardwoods may encourage conservation and the replanting of some species. Conscience must also guide selecting tropical veneers to ensure the speed of the extinction process is not increased for some exotic species. Under the Convention on International Trade in Endangered Species (CITES), plants and animals are listed as being in danger of extinction (Category I) or requiring controls to avoid being threatened with extinction (Category II). Unfortunately, it is sometimes difficult to identify the lumber or veneer of these species since the wood may be sold under a name that includes similar, nonthreatened species or those that are not even remotely related and come from a different continent. Most species listed are, however, traded under a name unique to them, so verify that an endangered species is not involved when using any woods named.

Brazilian rosewood (also called *jacaranda* or *palisander*), alerce (South American redwood), and the monkey puzzle tree (sometimes sold along with similar species under the name parana pine) are listed as Category I species along with several lesser-known woods not generally in demand for woodwork. Afrormosia (kokrodua, African teak), Caribbean mahogany (Cuban mahogany), Mexican mahogany (Pacific coast mahogany), lignum vitae, Brazilian padauk (macawood, cristobol, granadillo), and red sandalwood (redsanders) are listed as Category II species. Honduras mahogany (big leaf mahogany) is listed as a Category III species for Costa Rica, but it is unrestricted if it is from other countries.

Category I species cannot be harvested and require special permits to ship unless they are plantation grown, but existing stocks (veneers and logs) are available and are excepted from CITES regulations. Categories II and III species can be harvested, but they are regulated by a permit system. That system requires an export permit issued by the exporting country certifying that the wood was legally obtained and that its export will not be detrimental to the survival of the species. Generally speaking, management of Categories II and III species should restrict harvest to a sustainable level that may force prices up and redirect demand toward other species. It should be noted that there are species with names similar to those listed that are not restricted, such as African mahogany, East Indian rosewood (and many other varieties of rosewood), African padauk, Andaman padauk, Burmese padauk, and true sandalwood. For more information on this subject, see the AIA's *Environmental Resource Guide Subscription: TOPIC.I-6005, Tropical Woods.* For a complete list of scientific and common names of species listed by CITES, see 50 CFR, Section 23.23, which can be viewed at and downloaded from www.access.gpo.gov/nara/cfr/cfr-retrieve.html#page1.

Sustainable forestry is the ultimate answer to preventing the extinction of timber species and the ecosystems that include them. To this end, the Forest Partnership has compiled a database of wood species, called *Woods of the World,* with information about their technical properties and sustainability, as well as color pictures of the wood.

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06420 **PANELING**

This chapter discusses *custom-manufactured paneling, which includes board paneling, flush wood paneling, laminate-clad paneling, and stile and rail paneling.*

This chapter does not discuss *stock-manufactured wood paneling and plywood sidings used as interior paneling.*

WOOD-PANELING CHARACTERISTICS

This discussion covers custom-fabricated paneling that may involve complex drawing and specification requirements. Choices that seem minor may have significant effects on appearance and cost. Chapter 06402, Interior Architectural Woodwork, has additional information about paneling materials, finishing, and construction.

Standards

Commercial and product standards for stock paneling are inadequate for custom-paneling materials, and do not cover custom-millwork fabrication. Standards developed by the Architectural Woodwork Institute (AWI) and the Woodwork Institute of California (WIC) are widely recognized. They are the basis for the custom-fabricated paneling. The location of the project determines, in part, which standard to reference. Except for projects located in California, Nevada, and Oregon, the standard to reference is the one published by AWI. For California, Nevada, or Oregon, either standard can be used.

BOARD PANELING

Board paneling is included with other types of woodwork in referenced woodworking standards. In the AWI standards, it is included as part of “Standing and Running Trim”; in the WIC standards, it can be found as part of “Miscellaneous Interior Millwork.” Because board paneling can take so many forms, and can even be combined with plywood panels, it is difficult to develop universal specification requirements. One example requirement is for fabricating individual boards, which assumes that random-length pieces are unacceptable; otherwise, require end-matched (machined) boards that can be of random length. Additional requirements could be included, such as color and grain matching, in adjoining boards. Usually, requirements for the assembly of boards into panel units assume that details showing backing materials and attachment methods are on the drawings.

FLUSH WOOD PANELING

Premanufactured sets of sequence-matched panels are produced and warehoused by some major panel product manufacturers. These sets can be seen at selected locations, usually at the shop or in large metropolitan areas. Panel construction and the quality of the face veneers and matching are similar to those commonly used in custom-fabricated paneling, but stock sets do not offer the same unlimited possibilities in custom fabrication. Stock sets are generally less expensive than custom-fabricated panels, and their greatest advantage is availability. Long delays in fabrication are avoided, and stock sets can be seen and judged as a finished product.

As stock items, premanufactured sets are produced in standard sizes, not in exact custom sizes. Although sequence-matched from one flitch or similar flitches, they cannot be matched to other elements, such as doors and casework. The number of panels in a set is limited, moreover, to the size of the log from which the flitch was cut. Usually, smaller logs are used for stock panels. If they can conveniently be inspected by the architect (and possibly the owner), premanufactured sets offer a good solution under the following conditions:

- Wall areas fall within the limits of available panel sets (in total area and height).
- Blueprint match with doors, cabinets, and so on, is not required.
- Some sacrifice of sequence is acceptable at corners.
- Elaborate or extensive fabrication of flush joints, exposed edges, and exterior corners is not required.

If these limitations are unacceptable, specify custom panels. Do not assume that acceptable premanufactured sets are available; investigate the available range and be prepared to accept one of several comparable sets, unless preselected choices can be reserved until the contractor can purchase them.

Shop finishing of premanufactured sets is recommended. Unfinished panels are subject to moisture pickup and damage by soiling and handling.

Flush Paneling Standards

AWI standards have more extensive requirements for flush paneling than WIC standards. For sophisticated veneer selection and matching, additional requirements must be added to both standards. WIC standards tend to treat this type of paneling as plywood that can be bought from existing stock, rather than as an item requiring extensive fabrication. AWI standards include an elaborate, separate chapter titled “Wood Paneling.” WIC standards, by contrast, consider paneling as one item in a catchall section titled “Miscellaneous Interior Millwork,” and most of the requirements cover stile and rail paneling, with no particular fabrication requirements for flush paneling.

Flush Wood Paneling for Opaque Finish

Custom-fabricated, flush wood paneling usually involves fine hardwood veneers that are finished with a transparent coating. However, fine quality opaque finishes can be specified. Quality depends on the level of fabrication required for joints, exterior corners, and so on. The selection of face species is minor, the main criterion being good paint-holding qualities with resistance to feathering and indentation.

Flush Wood Paneling for Transparent Finish

Custom fabrication of panels for transparent finish involves the most expensive and complex selections in the entire paneling field; hence, it is usually specified only for the most important areas.

Special, uniform-size sequence or blueprint matching is available under AWI standards only in Premium grade. WIC standards include data on sequence matching only as general information, not as specific requirements. Although fabrication requirements derived from AWI standards are feasible only with the thicker panels required under AWI Premium grade, they are equally applicable under WIC standards as long as ¾-inch- (19-mm-) thick paneling is specified.

STILE AND RAIL PANELING

This type of paneling is usually custom-fabricated to exact sizes and profiles and is detailed on the drawings, but it is also available with prefabricated panels made to standard sizes (fig. 1). The basic unit frame consists of solid-wood stiles and rails with infills of relatively small panels.

Panels may be raised or flat and set in simple or elaborately profiled frames. Panel material may be limited to panel products (AWI Premium grade) or solid lumber, in either single-width boards or glued-for-width panels (AWI Custom grade), or it may be laminated or veneered (all WIC grades). The material may not be critical if the paneling is to be painted, but if a transparent finish is required, and the selected species has a strong figure, it may greatly affect appearance.

Both AWI and WIC standards set minimum grades for solid wood and plywood components. Fabrication requirements also differ in AWI and WIC standards. Review the standards to ensure that the grade and other requirements specified will give the quality desired.

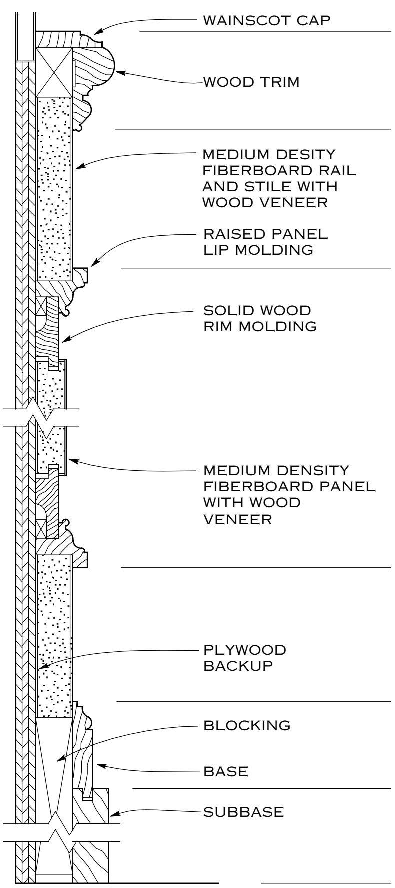


Figure 1. Section-wainscot stile and rail paneling

HARDWOOD FACE VENEERS

Several factors, including species and cut, quality, and types of matching, affect the selection of face veneers for paneling. Selecting stock paneling is a simple matter. If ordinary, prefinished paneling is required, the choice is made after examining representative samples. Flitch-matched stock sets can be examined in the warehouse, where the entire set can be seen.

A less-direct approach for selecting stock paneling involves naming the species and cut and specifying a minimum quality of veneer, based on HPVA HP-1, developed by the Hardwood Plywood & Veneer Association (HPVA). This approach ensures nothing more than submitting panels of the specified species and cut with minimum defects. Book or slip matching of the individual leaves of veneer can also be specified for stock paneling to produce a match of grain or color between adjoining leaves of veneer (fig. 2). The arrangement of veneer leaves on the panel face involves another level of matching, based on the size and number of pieces. However, only the most common match, called running match, is usually available on stock panels. Running match does not restrict the size or number of leaves, and if one leaf is not completely used on a panel face, the surplus starts the next panel. This arrangement results in the least waste, thus is the most economical. Although running match would seem to provide a continuous sequence match, the result is not the same: adjoining pieces may be from different flitches (from different logs), or imperfections may require cutting out and discarding portions or entire pieces of veneer, thus interrupting the sequence.

Sequence matching requires high-quality veneers cut from one log or flitch. The flitch must contain enough veneer not only for the area of paneling but for the trimming required to eliminate defects and still maintain an exact match of grain and color. If the arrangement on the panel face is balance or center-balance matched, as well as book or slip matched, more waste is involved. Custom fabrication of panels to exact sizes to fit a given space also affects sequence matching. This overall sizing can involve uniform spacing of veneer leaves in a given stretch, and placement of remainders at corners and at openings (over and at jambs of doors, windows, etc.). Blueprint match requires specified matches to be continuous on the faces of other wood elements, such as doors and casework. Sophisticated matching arrangements may have a veneer waste factor as high as 4:1; that is, only one-fourth of the flitch may be usable. If the area of the available flitches is inadequate, a similar second flitch cut from another log must be selected, and the joint between the two flitches (which never match) must be located in a corner or other interruption of the paneling.

Vertical and horizontal matching may be required. This may be as simple as matching a transom panel with a door to achieve a continuous vertical grain and color effect, or it may be more complex. Rows of panels separated by a chair rail, picture mold, or reveal may require continuous matching (vertically adjacent veneers are a continuation of the same leaf) or end matching (vertically adjacent veneers are from the same flitch but reversed end for end to produce a vertical book matching, or mirror image). If the paneling is more than 10 feet (3 m) in height, veneer selection is limited to flitches from larger logs, and the cost increases. Flitches up to 16-feet (5-m) long may be available, but heights above 12 feet (3.7 m) usually require vertical matching in addition to the other matches. This creates the effect of two parallel horizontal rows of sequence-matched paneling, all from one flitch or similar flitches.

It is also possible to alternate pieces of veneer in sequence from one end of the wall to the other so the figure created by the grain is largest, or highest, at the center of a wall, and diminishes or tapers toward both ends. However, as veneer strips alternate from the centerline of the wall, a slight

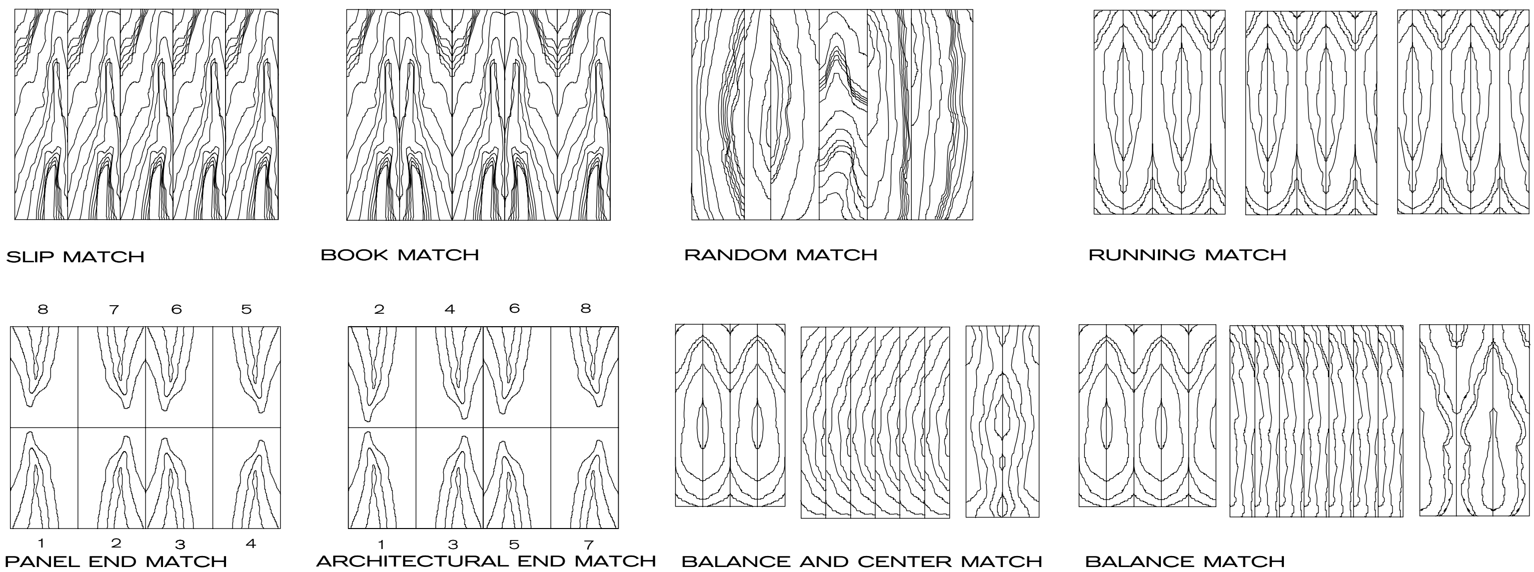
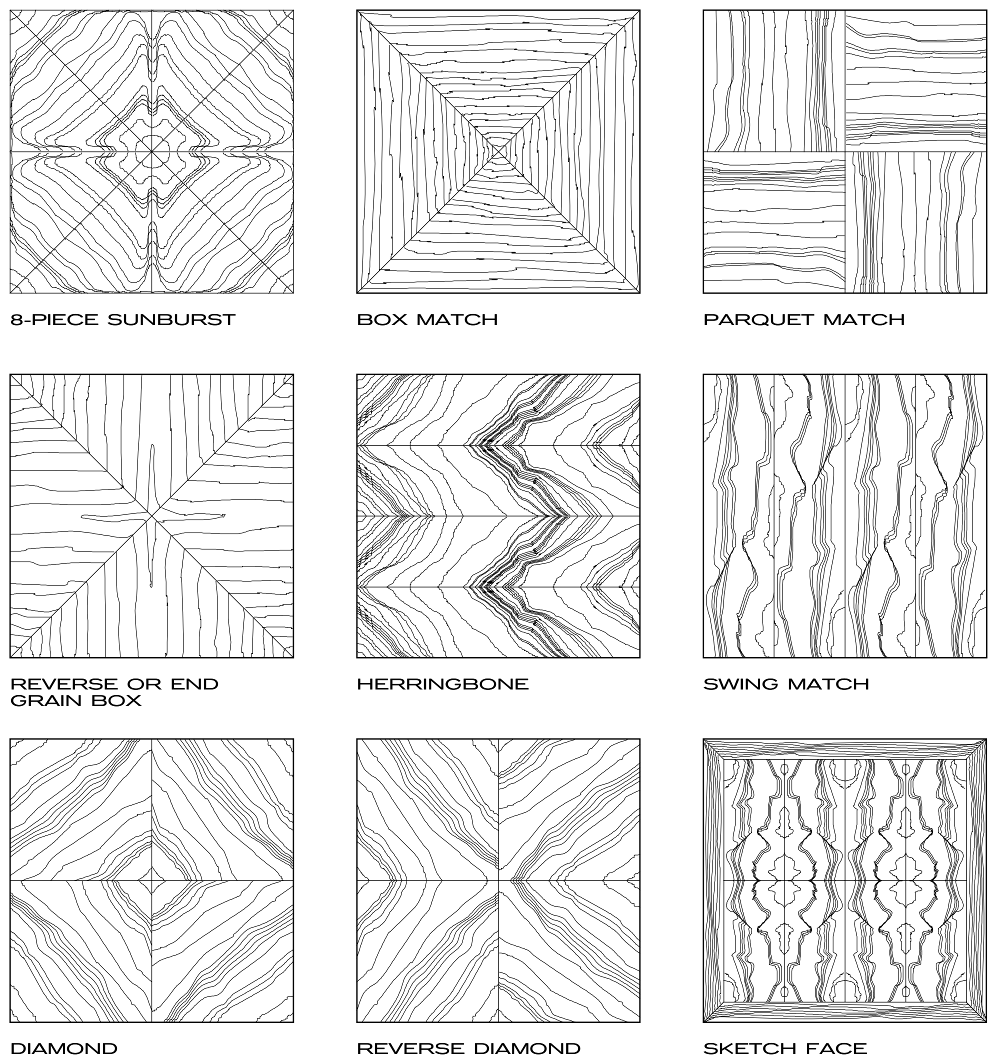


Figure 2. Veneer match types



NOTE

During specification, use both names and illustrations to define the desired effect, as names vary by region for these matching techniques.

Figure 3. Special wood veneer matching options

slippage or mismatch of veneer-figure occurs. Other special matching includes patterns that form figures based on the orientation of the wood grain. Examples are box, diamond, and sketch-face matching (fig. 3).

The almost limitless combinations of species, cuts, and matching possible in custom fabrication of flush wood paneling, and the high cost and visual importance of such work, have led to the practice of the architect's preselecting veneer flitches. This is the only possible way to pick flitches with a particular color and figure range. Nature does not grow uniform trees, and selection based on the most carefully written description may not have the desired effect. Natural variation also dictates inspecting the entire flitch, not just a few representative samples, if unexpected and unacceptable color and grain surprises are to be avoided.

If flitches are preselected and reserved, the number and source of flitches must be indicated. Actual yield of a given flitch is difficult to estimate, and the estimates of the flitch supplier and the panel fabricator frequently differ. If flitches are selected by the architect from flitch samples submitted after bidding, a price allowance is mandatory to control selection. Price allowances must be realistic and must anticipate the selection of additional flitches for adequate yield. For sources of veneers, view the *Wood & Wood Products* Red Book Online Web site, given at the end of this chapter.

LAMINATE-CLAD PANELING

High-pressure decorative laminates are available in many colors, patterns, and finishes. Each manufacturer offers products that differ in one or more of these characteristics from those of competitors. Certain finishes can be specified in nonproprietary terms by referencing the surface-finish designations implemented by the National Electrical Manufacturers Association (NEMA) in NEMA LD 3, which are measured in terms of gloss level. However, textured finishes that cannot be characterized by any available standard test have to be described in proprietary or semiproprietary terms.

Laminate thickness can be specified by referencing NEMA LD 3 grade designations. To specify manufacturers' products that do not comply exactly with NEMA requirements, describe those qualities that are different. Heavily textured laminates may not meet NEMA performance requirements for wear resistance because of resulting variability in thickness of the surface sheet. Before specifying heavily textured laminates, obtain test data that indicate actual performance from manufacturers.

Custom colors and textures are available only as a negotiated product with a particular manufacturer. Custom colors are not feasible in small quantities, and some colors may not be feasible at all. Custom patterns are even more restricted and costly.

Surface-burning characteristics of plastic-laminate paneling are determined by testing an assembly of face laminate, adhesives, core material, and backing-grade laminate. Using a fire-rated laminate is generally not enough to achieve low flame-spread indexes without also using a certain type of adhesive and a core material with fire-retardant properties. No requirements for surface-burning characteristics or test methods are included in NEMA LD 3 for fire-rated plastic laminates. These requirements must be inserted in the project specification to fit the project.

Door matching is easier with wood-grain-patterned, plastic-laminate paneling than with wood veneers. The door manufacturer can use the same manufactured sheet as the paneling fabricator, ensuring that flush doors match the paneling. This is much simpler and less risky than having two fabricators share a sequence-matched wood flitch.

Adhesive type and performance, with the exception of fire-retardant qualities, are covered in the referenced woodworking quality standards. However, for special applications, it may be necessary to specify the adhesive. Otherwise, adhesive selection should be the fabricator's responsibility.

FIRE-RETARDANT PANELING

Treated wood products are significantly more expensive than untreated products. Some formulations used in fire-retardant treatment make cutting and fastening more difficult and affect the appearance. Chapter 06402, Interior Architectural Woodwork, contains a more comprehensive commentary on fire-retardant-treated materials.

For guidance on face-veneer selection, consult AWI literature and the literature of various panel manufacturers. The densities of available species are listed according to surface-burning characteristics (flame-spread and smoke-developed indexes).

Consult governing codes and local authorities having jurisdiction to verify acceptance of panels with treated cores.

FORMALDEHYDE EMISSION LEVELS OF PANEL PRODUCTS

Chapter 06402, Interior Architectural Woodwork, contains information on formaldehyde emissions from panel products.

SHOP FINISHING

Chapter 06402, Interior Architectural Woodwork, contains information on shop finishing of paneling.

ENVIRONMENTAL CONSIDERATIONS

Chapter 06402, Interior Architectural Woodwork, contains information on environmental considerations relating to paneling.

REFERENCES

Publication dates cited here were current at the time of this writing. Publications are revised periodically, and revisions may have occurred before this book was published.

Architectural Woodwork Institute

Architectural Woodwork Quality Standards, 7th ed., version 1.0, 1997.

Hardwood Plywood & Veneer Association

HPVA HP-1-1994: Hardwood and Decorative Plywood

National Electrical Manufacturers Association

NEMA LD 3-95: High-Pressure Decorative Laminates

Woodwork Institute of California

Manual of Millwork, 1995.

WEB SITES

Architectural Woodwork Institute: www.awinet.org

Forest Partnership, Inc.: www.forestworld.com

SmartWood: www.smartwood.org

Wood & Wood Products Red Book Online: www.podi.com/redbook

Woodworking at Woodweb: www.woodweb.com

World Timber Network: www.transport.com/~lege/wtn2.html

08110 **STEEL DOORS AND FRAMES**

This chapter discusses *standard steel doors and frames fabricated to comply with ANSI A250.8 and with established Steel Door Institute standards.*

This chapter does not discuss *custom hollow-metal work specified in Division 5, "Metals."*

GENERAL COMMENTS

The Steel Door Institute (SDI) publishes the basic reference standard for steel doors and frames, SDI 100, *Recommended Specifications for Standard Steel Doors and Frames*, which was recently updated, approved as an ANSI standard, and redesignated ANSI A250.8. First published in 1980 as a guide, it was recognized as an American National Standard in 1985. Although revised and improved, the general scope of the document has not changed. In this discussion, the standard will henceforth be referred to as ANSI A250.8.

It is useful to acquire a copy of the latest version of ANSI A250.8 before specifying steel doors and frames. The *SDI Fact File* is also useful; contact SDI to order a copy. Obtain catalogs from door and frame manufacturers whose products will be specified.

The line between standard and custom hollow-metal work has blurred over time. Most hollow-metal door and frame manufacturers can also now produce products traditionally considered custom.

PRODUCT CHARACTERISTICS

Door Models

Full-flush doors do not have visible seams on their faces (fig. 1). Seamless and stile and rail doors do not have visible seams on their surfaces or along their vertical edges. Doors are available with louvers or with openings for glass with stops (figs. 2, 3) furnished; they can be fabricated as Dutch doors and in many other designs, as illustrated in SDI 108. Six different methods of internal construction are listed in ANSI A250.8.

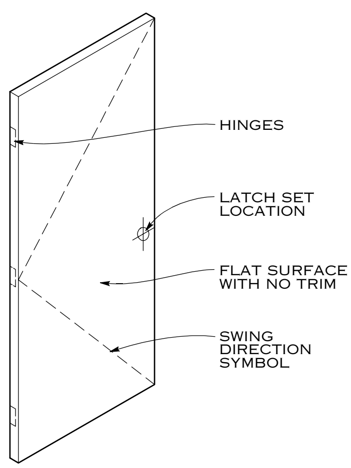


Figure 1. Typical flush door sizes and characteristics

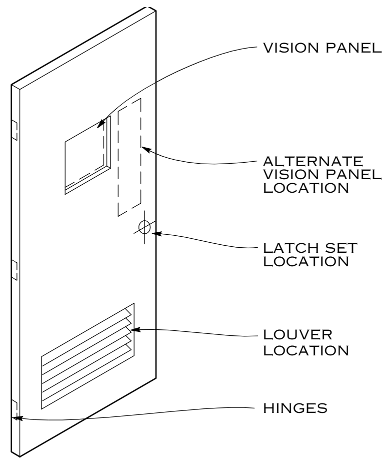


Figure 2. Vision or louvered door

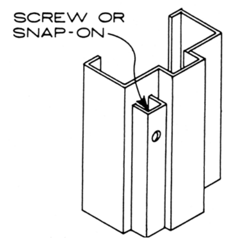


Figure 3. Removable glazing bead

Frames are available as either welded construction or knock-down units. Welded set-up frames may have mitered or butted corners with welded and finished frame faces. (Continuous welded corners are not needed or recommended.) Knock-down units have mechanical joints between the header and jambs for field assembly (fig. 4). Drywall slip-on frames are designed for installation after gypsum board partitions are erected (fig. 5). Drywall frame corners may have mitered or butt joints, and may be designed to be screwed together, snap-locked, or slip-fitted, but they cannot be welded. Several common wall conditions with various frames and anchors are indicated in SDI 111A.

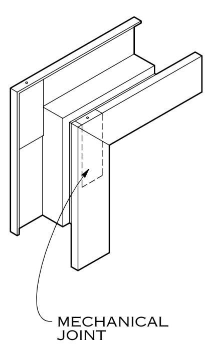


Figure 4. Knock-down frame

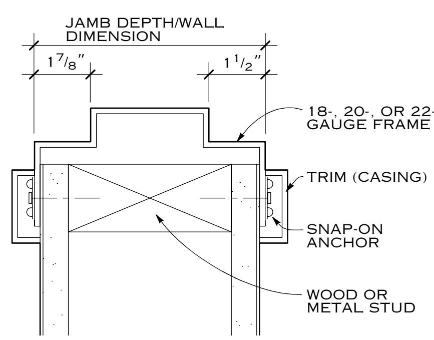


Figure 5. Drywall slip-on frame

PRODUCT SELECTION CONSIDERATIONS

Metal Thickness

The hollow-metal industry continues to use the term gage to indicate sheet metal thickness although, according to the ASTM standard specifications for these products, sheet metals are only produced in decimal or fractional thicknesses. ASTM A 480/A 480M, *Specification for General Requirements for Flat-Rolled Stainless Steel and Heat-Resisting Steel Plate, Sheet, and Strip,* includes the following statement in Section 4, Ordering Information: "Thickness shall be ordered to decimal or fractional thickness. The use of the gage number is discouraged as being an archaic term of limited usefulness not having a general agreement on meaning." ANSI A250.8 includes not only the gage numbers but the equivalent minimum thicknesses of uncoated steel sheet in both IP and SI units, and the same figures for metallic-coated steel sheet thicknesses, whether the coating is applied by the hot-dip or electrolytic process. The standard explains that the gage numbers and equivalent minimum thicknesses were derived from figures published by Underwriters Laboratories (UL) in its *General Reference Guide No. 1 for Field Representatives,* which was not meant for public use but to enable inspectors to verify the metal thickness of a door skin by using a micrometer.

Uncoated and Metallic-Coated Steel Sheet Thicknesses

ASTM A 568/A 568M, which contains the general requirements for hot- and cold-rolled uncoated steel sheet, allows purchasers to specify minimum or nominal thickness. If minimum thickness is specified, the standard over- and under-thickness tolerances listed in ASTM A 568/A 568M tables are applied only as over-thickness tolerances, and are doubled. This method of applying tolerances can also be invoked for hot-dip metallic-coated steel sheet, but only if it is specified by minimum base metal thickness. Otherwise, over- and under-thickness tolerances in ASTM A 924/A 924M are applied to the total thickness, including both base metal and coating.

Level And Model Table

This table relates the thickness of the steel-face sheet to the door thickness and the SDI Level and Model. If warranted by conditions, specify exterior doors from metallic-coated, galvanized or galvannealed steel sheet.

Table 1
MINIMUM STEEL SHEET THICKNESSES FOR DOOR FACES

SDI Level	SDI Model Designation	MSG No.	Minimum Face Sheet Thickness	Door Thickness
1	Model 1: Full Flush	20	0.032″ (0.8 mm)	1⅜″ (34.9 mm)
1	Model 2: Seamless	20	0.032″ (0.8 mm)	1⅜″ (34.9 mm)
1	Model 1: Full Flush	20	0.032″ (0.8 mm)	1¾″ (44.4 mm)
1	Model 2: Seamless	20	0.032″ (0.8 mm)	1¾″ (44.4 mm)
2	Model 1: Full Flush	18	0.042″ (1.0 mm)	1¾″ (44.4 mm)
2	Model 2: Seamless	18	0.042″ (1.0 mm)	1¾″ (44.4 mm)
3	Model 1: Full Flush	16	0.053″ (1.3 mm)	1¾″ (44.4 mm)
3	Model 2: Seamless	16	0.053″ (1.3 mm)	1¾″ (44.4 mm)
3	Model 3: Stile and Rail	16	0.053″ (1.3 mm)[1]	1¾″ (44.4 mm)
4	Model 1: Full Flush	14	0.067″ (1.7 mm)	1¾″ (44.4 mm)
4	Model 2: Seamless	14	0.067″ (1.7 mm)	1¾″ (44.4 mm)

Note
[1]Center panels of stile and rail doors are 0.042 inch (1.0 mm) thick.
Key
Level 1 Standard-Duty Level C according to ANSI A250.4
Level 2 Heavy-Duty Level B according to ANSI A250.4
Level 3 Extra-Heavy-Duty Level A according to ANSI A250.4
Level 4 Maximum-Duty Level A according to ANSI A250.4

Metal Thickness Equivalent Table

This table lists some popular sheet-metal gage equivalents in IP and SI thicknesses.

Table 2
SDI GAGE EQUIVALENT IN INCHES AND MILLIMETERS

Uncoated Steel Sheet												
MSG	7	8	10	12	14	16	18	20	22	24	26	28
INCH	0.167	0.152	0.123	0.093	0.067	0.053	0.042	0.032	0.026	0.020	0.016	0.013
MM	4.2	3.8	3.1	2.3	1.6	1.3	1.0	0.8	0.5	0.5	0.4	0.3

Steel Sheet

Both hot- and cold-rolled steel sheet are commonly used to fabricate doors, frames, and accessories. Door faces should always be made of cold-rolled steel sheet because its surface is smoother than hot-rolled steel, and it is easier to form, weld, and paint. Frames may be made of hot- or cold-rolled steel, but the surface appearance of hot-rolled steel is generally inferior.

Metallic-coated steel sheet is used for improved corrosion resistance. A metallic coating may be applied by either the hot-dip or electrolytic process. For metallic coatings applied by the hot-dip process, the term *galvanized* refers only to steel that has been zinc-coated; the term *galvannealed* refers only to steel that has been zinc-iron-alloy-coated. The latter type of coating is imprecisely referred to in ANSI A250.8 as the alloyed type of hot-dip zinc coating. Electrolytically coated sheets have a thinner zinc coating than the sheets coated by the hot-dip process. ANSI A250.8 includes electrolytically deposited zinc coating for anchors and accessories only, not for door faces or frames. For exterior locations, galvannealed steel sheet provides better corrosion resistance, especially if the atmosphere is corrosive, and has better paint-holding qualities than galvanized steel sheet. ANSI A250.8 establishes a minimum coating weight of A40 (Z120); if a heavier coating is required, verify its availability with manufacturers.

Fabrication

Steel doors can be constructed with internal steel stiffeners placed between two face sheets or with face sheets laminated to several core materials such as impregnated paper honeycomb, plastic foam, or structural mineral blocking (figs. 6-10). The steel-stiffened core construction has been used for many years; it produces a strong, long-lasting door.

Thermal and Acoustical Doors

Thermal and acoustical properties of doors can be improved by packing spaces between steel stiffeners with insulating material. The best possible

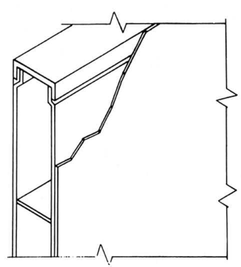


Figure 6. Flush door closer reinforcement

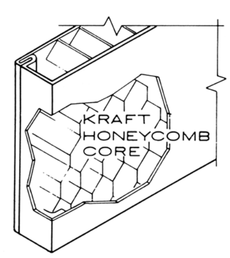


Figure 7. Flush door core