The Selection and Evaluation of Library Bookstacks

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TO THE LIBRARIAN, architect, or purchasing agent charged for the first time with the selection of bookstacks for a library, the task looks simple enough. In fact, at a glance, the products of the several manufacturers are so similar in appearance that it is difficult to tell them apart. Closer examination, however, reveals variations that may be the difference between a satisfactory installation and one that fails to perform as intended. It is important therefore that the individual responsible for drafting specifications for a library bookstack installation knows the criteria of good stack design, be able to evaluate the differences in the products of the several manufacturers, and knows something of the ways by which the performance of a bookstack may be tested.

Although some form of shelving has been used for the storage of books since Biblical days, shelving design continues to evolve slowly. In earlier times, most library book shelves were of wood, a material used with very handsome effect in many modern libraries. By the middle of the last century, many commercial bookstack installations used cast-iron uprights or side panels, with wood shelves. Steel shelving first appeared toward the end of the century, and is still the preferred material. Other materials, such as aluminum, have been tried, but have not proved suitable for this purpose. Steel, of course, offers the advantages of strength, durability, fire resistance, and lower cost, as compared with wood.

Although the terms are somewhat loosely and interchangeably used, most manufacturers refer to their product as "library bookstack" rather than "library shelving" and for this reason the word bookstack will be used throughout this paper to refer to installations using steel. Wood units are usually, but not always, called shelving.

Two types of steel bookstack are used in library installations, neither

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of which is to be confused with the steel shelving sold for use in stock rooms and similar industrial purposes. The latter product is totally unsuited for library use, although the low cost sometimes makes it attractive to those not familiar with its deficiencies. Such shelving usually consists of four upright angle irons, to which the metal shelves are bolted. These units have no flexibility of shelf arrangement and are very crude versions of the more refined units to be discussed below. Unfortunately, an occasional librarian finds that his purchasing agent has been led to believe that this product is suitable for library use. Rarely, the need for cheap shelving for the storage of little-used materials may justify this product, but the librarian should be very careful to determine that such shelving will indeed meet his needs before accepting it.

Of the two types of steel bookstacks to be considered here, the first is variously referred to as case-type, panel-type, lock-shelf, or standard. Case-type is perhaps the name most frequently used and refers to a design having full backs, tops, and end panels slotted, usually for the full depth of the case, to receive the shelves. The shelves, which slide in and out of the slots in the side panels, are designed to lock in position when properly inserted. Most of the better known manufacturers of library bookstacks produce this style, as do other firms which do not normally supply libraries.

A few architects and librarians prefer case-type stacks because they believe the over-all design presents a neater and more finished appearance than the somewhat stripped-down effect of bracket-type bookstacks. Others prefer the more modern appearance of bracket-type stacks, as opposed to the rather box-like appearance of case-type stacks.[1] Case-type stacks are perhaps most frequently used in libraries where the collections run to long sets of uniform size, so that shifting of the collection can be kept to a minimum, e.g., law libraries. The same design is also used occasionally in rare book rooms, where the closed design offers some protection against dust. For the most part, however, the lack of flexibility and the higher cost, which for case-type may be from 10 to 30 per cent more than for bracket stack, usually leads to the selection of the latter. It is interesting to note that in the Library Technology Project (LTP) evaluation, five manufacturers reported that 90 per cent or more of their sales were of bracket stacks, one reported that 85 per cent of his sales were bracket stacks, and a seventh reported that bracket stacks accounted for 75 per cent of his sales as compared with case-type.[2]

In making a choice between case-type and bracket-type stack, adaptability for different needs is the most important consideration. Experienced librarians and manufacturers are in general agreement that the bracket stack is much the more flexible of the two styles. Case-type stacks are designed to accommodate shelves of only one depth in a given unit, i.e., an 8-inch section of case-type stack will accept only 8 inch shelves. In a bracket stack installation, on the other hand, there is, save for the fixed-base shelf, complete interchangeability of all widths of shelves in every section.

A major advantage of bracket stack is the ease with which a shelf, either partially or fully loaded with books, can be moved from one location to another. An entire shelf may be lifted from the uprights and carried to a new section of stack or it may be "walked" up or down the uprights by unhooking first one end and moving it to the new position, then unhooking and moving the other end. In a case-type installation, all books must first be removed from a given shelf, the shelf relocated, and the books shelved again.

Bracket stacks may also be rearranged more easily than case-type units, and require only one additional upright each time two sections are separated. Case-type stacks require two additional end panels when two sections are separated.

A further important advantage of bracket stacks lies in the availability of a variety of special shelves and other units. Magazine display shelves, pull-out reference shelves, inverted or flush-bracket shelves for shelving newspapers and large volumes, divided shelf units, carrels, book or typewriter lockers, coat rack units, and other features are available as standard items from most manufacturers of bracket stacks. A few such units, e.g., sloping display shelves, are available for case-type installations, usually on special order. Most of these features, however, do not lend themselves to use in this design.

There is some experience among librarians, unrecorded in the literature, to indicate that over a period of years, case-type stacks are more likely to suffer damage than a bracket installation. Careless placement of shelves may force the slotted portion of the end panels out of position, making shelves difficult to insert or remove thereafter. Designs in which the slots do not run the full depth of the shelf are less subject to such damage than those in which the slots extend the full depth. This is more likely to be a problem also, with the cheaper, case-type stacks in which relatively light gauges of metal are used.

Differences in stability of the two types appear to be negligible. In

the LTP evaluation, four manufacturers reported no appreciable differences in the stability of bracket stacks versus case-type stacks.[2] One manufacturer stated that he believed bracket stacks should be more stable because the design is such that books are always shelved close to the center of gravity of the stack. Another manufacturer reported little difference in the stability of the two designs, if all refinements are added to the bracket stack. In the latter case, however, the only really important factor in stability is the end panels.

Aesthetics is, of course, a subjective matter. As indicated above, some architects and librarians like the appearance of the case-type design, although the majority seem to prefer the bracket stack. It should be remembered that metal or wood end panels can always be added to bracket stacks if a more finished appearance is desired.

Case-style stacks are manufactured by a large number of firms, only a few of which regularly supply the library trade. As a result, there is a wide range of quality and cost in the product. Since no performance standards for this design are available, the librarian who prefers the case-type stack is at a disadvantage. The best solution is to compare the products of the several manufacturers, noting such features as the design of the slots, the ease of inserting and removing shelves, the gauges of metal used, the presence of projecting screw heads or sharp edges that could damage books, the stability of the unit, and the ease of assembly. Evaluation from a catalog is difficult, if not impossible, and actual stack units should be examined either in the manufacturer's showroom or in a library installation.

Bookstacks of the bracket design were introduced by both Library Bureau and Art Metal just before the turn of the century. Today there are eight principal manufacturers of bracket-type stacks, and several others which produce this type but supply relatively small quantities to libraries.

The basic design of the bracket bookstack involves the use of vertical steel members (called uprights or columns) upon which the shelves are hung in cantilever fashion. If the uprights are supported at the base so that the unit will stand alone, the stack is called "freestanding." If the uprights support the loaded shelves but must be top-braced in order to remain standing, the stack is usually referred to as "non-freestanding." The latter is less expensive, but has the disadvantage of lacking a closed base and of being considerably less flexible. Freestanding units can be more easily re-arranged and moved from one location to another. Non-freestanding bracket stacks are usually con-

sidered less attractive than the closed-base, freestanding design. The latter, however, is a point the librarian will want to judge for himself, especially if cost is an important factor.

Bracket as well as case-type stacks are available in single-tier (one full-height unit, 7 feet-6 inches high), and in multi-tier. Multi-tier installations consist of two or more levels of stacks in which each level supports the weight of those above. In an earlier era, the spaces between vertical units were left open to allow the circulation of air around the books. These openings, however, promoted vertical drafts and considerably increased the hazards caused by fires. Today, air-conditioning largely obviates the need for this circulation of air around the books and, as a result, the great majority of libraries are constructed with continuous, solid floors, each of which is capable of supporting, independently, the full load imposed by the stacks and the book collection. Thus, most present-day stack installations are single-tier. Where multi-tier installations are made, floors are continuous to reduce the fire hazard, but are not self-supporting. Because multi-tier stacks constitute such a small part of current installations and because they present special engineering problems, they will not be discussed further in this paper.

In a bracket stack, of either free or non-freestanding design, the uprights or columns are square or rectangular in cross section and measure from 2 by 2 inches to 2 by 3 inches. They may be formed in a variety of ways, each of which is calculated to produce a rigid column capable of withstanding the stresses placed upon the unit when it is loaded with books. Most commonly, the upright consists of two pieces of steel formed in a hat-shaped cross section and welded together with the flanges on the outside and at right angles to the longitudinal axis of the stacks. Other designs have a single flange on the inside, or have the two halves of a "C" shaped column turned back to back and bolted together. Although each manufacturer claims superiority for his column design, independent studies are desirable to determine both actual library requirements and the degree to which the several existing column designs meet these requirements.

Each tubular upright contains two vertical rows of slots. At intervals, depending upon the manufacturer, these slots, which are on 1-inch centers, differ slightly in shape, to permit easy alignment of shelves. Laterally, the slots may vary from ½ to 1⅛ inches on centers. Adjustable shelves are hung from the uprights by means of hooks which engage the slots in the column.

The standard size of a single-faced section of bracket stack is 36 inches wide, by 7 feet-6 inches high, by 8, 10, or 12 inches deep. Two sections back to back, with the shelves on each side hung from the same pair of uprights, are referred to as a compartment, a double-faced section, or a bay. Most manufacturers will provide shorter or longer units on special order, and at least one manufacturer recently offered a standard 48-inch unit which will be discussed in more detail below. In addition to full-height (7 feet-6 inches) units, all manufacturers offer intermediate height (5 feet or 5 feet-6 inches) units, and standing height (3 feet-6 inches) units. The intermediate height is frequently used for installations in children's rooms or elementary school libraries, while the standing height units make convenient space dividers in open stack installations, or storage and work units in library work areas.

Rigidity in the longitudinal direction, i.e., in the long axis of the stack, is usually achieved by the use of steel cross braces. Under ordinary circumstances, sway braces are required only every fourth or fifth unit, although each manufacturer has his own recommendations. However, since the use of sway braces occasionally prevents large volumes from being pushed back on the shelves so that the spines line up with those of smaller books, some librarians object to them under any conditions. The alternative, for most manufacturers, is a very rigid design employing extra-heavy cross members in the base and some form of gusset or bracing at the top of each unit. Such designs are expensive, often adding as much as 10 per cent to the cost of a given job. Where gussets are employed, the shelving problem is alleviated only slightly, since the gussets themselves hamper the proper shelving of books. Whether the limited number of occasions when sway braces prevent an oversize volume from being shelved "through" is sufficient justification for the added cost of the specially reinforced design must be decided by the purchaser.

A second solution to the sway brace problem has appeared recently with the development of a stack unit in which the uprights are welded to the top and bottom spreaders, to form a rectangular frame. This is an economical design that provides great rigidity in the longitudinal direction.

Lateral rigidity, as well as lateral stability, depends primarily upon the strength of the uprights and upon that of the base support system. Strength of the uprights is achieved by the design of the cross section in relation to the gauge of metal used. For the least deflection in the

lateral direction, the flanges in a two piece, welded upright are always at right angles to the longitudinal axis of the stacks. Where higher strength is required, an additional reinforcing strip of steel may be welded inside the column or bolted between the two halves of a non-welded column, or a heavier gauge of steel may be used.

Base support systems are of two general types. A few manufacturers offer both in order to meet a greater variety of specifications. In the more common design, the brackets at the ends of the bottom shelves are bolted to the uprights to form wings projecting at right angles to the longitudinal axis of the stack. In the second, and more rigid design, continuous support, from one side of the stack to the other, is provided either by a heavy duty member which wraps around and is bolted to the base of the column, or by a piece of heavy sheet steel which passes through the two halves of a non-welded upright. In some designs this may be the same as the reinforcing strip referred to above. In either case, these members provide a far more rigid support for the upright than the design in which the end brackets of the base shelves are simply bolted to the columns.

No independent engineering studies of column strength or of base support systems have been conducted. However, recent testing by the University of Illinois for its stack installation in the library of the new Chicago Circle campus suggests that the usual design, in which the base brackets are simply bolted to the uprights, may not have sufficient strength to support heavy eccentric loads, whereas designs utilizing heavy gauge members that wrap around the upright, or reinforcing members that pass through the upright, can sustain such loads.

In view of the lack of accepted performance standards for bracket stacks, the author would like to suggest that the Library Technology Project of the American Library Association consider this a matter for investigation. Such a study should include a determination of reasonable performance standards for bracket stacks, as well as mathematical and engineering evaluations of existing designs, to determine their performance in accordance with such standards.

Although library floors are designed to be level, in practice it is impossible to make them so. Variations of one quarter inch or more in a distance of 9 to 12 feet are not uncommon, and in distances of 18 to 21 feet, variations of three-eighths to one-half inch or more may occasionally be encountered. It is important therefore that library bookstacks be equipped with proper leveling devices. Shims, although frequently used, are unsuitable for several reasons and should not be

permitted. In the better designs, adjustable leveling clips or shoes are provided. These are usually covered with non-slip neoprene pads or sleeves. Such pads prevent damage to resilient tile flooring and decrease the tendency of stacks to "creep" when subjected to vibration.

The matter of stability in an installation of freestanding bookstacks is somewhat complicated. Every librarian has heard of occasional instances in which rows of bookstacks have been toppled, overturning others in succession, like dominoes. Under ordinary circumstances, a so-called freestanding stack is indeed freestanding. However, installations in those parts of the country subject to earthquake tremors may require special safety precautions. In California, the State Department of Public Works requires that freestanding stacks in the public schools be sufficiently stable to withstand a force equal to 20 per cent of the dead load of the books and the stacks.[3] Although not mandatory in other jurisdictions, many California libraries have included this requirement in their bookstack specifications. To provide an extra measure of safety, California law also requires that bookstacks in school libraries be able to withstand a force one and one-half times the overturning force.[3] Few freestanding stacks are able to meet the latter requirement without either anchoring or top bracing.

In cases where some fastening is required, floor anchoring is preferred because, in an earthquake, the bases of a stack installation can be displaced slightly, even if the tops are held in position by the top bracing.[4] Anchoring, however, is more expensive than top bracing and where earthquake tremors are not a problem the latter may be preferred.

Difficulties also arise when one tries to guard against vandalism. Many librarians consider this such a remote possibility that they take no further cognizance of the problem. Instances of deliberate overturning of stacks have occurred, however, and to be on the safe side some librarians, as well as some library consultants, prefer to fasten the stacks in one manner or the other. A few of the manufacturers take a less conservative view and state that their freestanding stack installations do not require any fastening. In California, some type of fastening is mandatory in elementary and high school libraries. Elsewhere, the librarian makes his own decision.

Where top-bracing is preferred to floor anchors, "U" shaped channels of at least 18-gauge steel and with at least a one-inch flange should be used. One such channel is usually installed for every three bays or compartments. Thus a group of ranges, each eight bays long, would

require three transverse channels. For the sake of appearance, channels are usually centered on the second upright from each end of the range, with other channels spaced at equal intervals along the remainder of the range, where possible. Transverse channels are located over the uprights, rather than in mid-section, to provide maximum rigidity.

Metal end panels are widely used with bracket stack installations to give a neater appearance and, through the use of color, to enhance the decor. Although normally fabricated of smooth-surfaced sheet metal, at least one manufacturer now offers a textured surface. Others offer end panels with chromium plated trim strips or wood inserts, or panels faced with fabric-backed plastics, leather, or textiles. Full, wood end panels, available in a variety of different grains, are unusually handsome, but may add from 50 to 100 per cent to the cost of each panel.

Standard book shelves come in 8-inch, 10-inch, and 12-inch widths. Some manufacturers also offer a 9-inch shelf. It should be understood that the above figures are nominal widths and represent the distance from the front edge of the shelf to the center line of the stack. The actual widths of 8-, 10-, and 12-inch shelves are 7, 9, and 11 inches respectively. In almost all bracket stacks, the upright, between the inner edges of the shelves, is 2 inches thick, so that one inch is added to the actual widths of the shelves in calculating the usable depth of the section.

Since the wider the shelf, the higher the cost, no shelves should be wider than actually required. It is usually estimated that at least 80 per cent of the books in a comprehensive collection will fit on 8-inch shelves. Some bound periodicals of course require wider shelves, as do many medical, scientific, and art books. As a rule of thumb, it may be assumed that a normal installation will require 80 per cent 8-inch shelves, 15 per cent 10-inch shelves, and 5 per cent 12-inch shelves. Some special purpose shelves, e.g., sloping display shelves, have a nominal depth of 12 inches and should be used only in units with 12-inch bases.

Shelves of the several manufacturers vary from 35 to 35½ inches in usable length. It is easy to calculate that in a stack designed for 300,000 volumes at full capacity, one-half inch is the equivalent of 583 feet, in which could be stored an additional 4,500 volumes. On the other hand, since few libraries ever reach their absolute storage capacity, the additional space of the longer shelf design should not be given undue weight in writing specifications.

Within the last few years, one manufacturer has marketed a four-foot shelf for bracket stack installations. In theory, the longer shelf requires fewer uprights and in an installation of any size would result in substantial savings. It was assumed by the manufacturer that this shelf, as originally designed, would require no further reinforcement for all normal use. However, tests of the non-reinforced shelf, conducted by the University of California at Los Angeles, showed deflections of ¼ to ½ inch under loads of 62 pounds per square foot. Although this loading was made heavy for test purposes, it was, in actuality, only 1.1 pounds per square foot greater than the average load in many areas of the UCLA stacks.[5] The four-foot shelf is available with a reinforcing steel channel welded to the lower surface but this reduces the cost advantage. Some librarians who have considered the matter carefully, also believe that the four-foot shelf has a functional disadvantage in that it is difficult, in a stack aisle of standard width, for the eye to encompass a span of four feet. Thus, locating a given item may be more difficult on the longer shelf than on a standard three-foot shelf. For some purposes, the longer shelf, without reinforcing, may be quite satisfactory and could result in definite economies. However, the several factors involved should be considered carefully before adopting the four-foot length.

All standard book shelves are presently designed to withstand loads of 40 pounds per square foot with no permanent deflection, and with no temporary deflection in excess of 3/16 inch. While this standard is adequate for most library materials, bound copies of *Life,* for example, standing upright on a shelf, exert a load factor of 57 pounds to the square foot on a 12 inch shelf. Twelve-inch phonograph records produce a load factor of 49.5 pounds per square foot on a 12 inch shelf. Fortunately, most shelves are designed to withstand loads somewhat in excess of the 40-pound standard. This is not always the case, however, and there are recent installations in which the shelves sag to a degree noticeable to even the most casual observer. Strictly adhered to, the 40-pound standard is probably satisfactory in many situations, but the writer believes that a 60-pound per square foot standard, with an appropriate safety factor, is both desirable for the librarian and economically feasible for the manufacturer.

Although the U-bar shelf enjoyed considerable popularity some years back, such shelves are infrequent in present-day installations. They are still available, however, from at least one manufacturer. The split shelf, a fairly recent innovation, was designed to provide a more effi-

cient type of book support which slides in a track down the center of the shelf. In use, these supports always remain upright and attached to the shelf. There is an additional cost for this design and as yet it has not been widely used; only two manufacturers are known to have it in their lines.

Hinged-bracket shelves were more popular some years ago than currently. This design is still available, however, from several manufacturers, and some librarians prefer it to the slightly cheaper detachable-bracket shelf. In the hinged design, the brackets are permanently attached to the shelf and fold flat for easy storage. The detachable bracket, on the other hand, requires that the brackets be detached before the shelves are stored and re-affixed when the shelves are used. With the exception of one manufacturer who produces a bracket to fit either end of the shelf, brackets fit right or left ends of shelves only. There is little to choose between the two, except the greater convenience in storage of the hinged bracket type. Occasionally, one hears the objection that the hinged shelf is awkward to move, but this presents no problem if the proper technique is used.

A recent and very interesting innovation in shelving is known as Fold-a-shelf. Here the shelf and the end brackets are formed in one piece and the unit is slotted along the line at which the brackets would normally be attached to the shelf. In use, the brackets are simply folded upwards until they are in the vertical position. This design eliminates both hinges and loose end brackets and effects a saving over conventional shelves. If it is necessary to store the shelf, the ends are folded down to about 45 degrees, so that the units stack nicely. Although the metal eventually breaks from fatigue, it is good for at least 35 folds, if the end brackets are not bent downward more than 45 degrees.[6] In normal use, therefore, such shelves would last almost indefinitely. This design has gained acceptance on the West Coast where it was introduced.

The number of hooks used on shelf brackets may occasionally be a matter of importance. Such hooks, formed at the top of the bracket, engage the slots in the upright and support most of the weight of the books on the shelves. Lugs at the bottom of the bracket also fit into the slots of the upright, but serve only to keep the shelf from being moved sideways; they support no weight. Two hooks, if properly designed, are entirely adequate to support all possible loads. Three hooks, as furnished by some manufacturers, may tend to bind in the slots and make it difficult to shift shelves quickly and easily if hooks and slots

are not properly sized and aligned. Sample shelves of three hook design should be carefully checked for proper clearances.

The normal capacity of a standard 90-inch stack is seven shelves—the fixed base shelf plus six adjustable shelves. For convenience and flexibility, uprights should have slots all the way to the top. With a 4-inch base, this permits separation of the shelves approximately 12½ inches on centers, thus providing a clear filing space between shelves of 11¾ inches.

A variety of other types of shelves are available from the manufacturers, although these may not always be shown in their hand-out literature. Among the more common special-purpose designs are sloping display shelves for periodicals, flush bracket shelves for the storage of oversize volumes and newspapers, pull-out reference shelves, divided shelves for pamphlets, phonograph records, and similar items, book storage lockers, coat racks and umbrella stands, and desk units. Such units add greatly to the flexibility and convenience of the bracket stack installation. One new unit, which has not yet found its way into the catalogs, is a sloping newspaper display and storage shelf designed for the University of Notre Dame Library and used again in the Chicago Circle library of the University of Illinois. This special shelf, which eliminates the need for the traditional newspaper stick, holds the newspaper in a nearly vertical position under a plexiglas cover which lifts to permit access. Although users can leave newspapers in a state of disarray that is impossible with the traditional stick, experience at Notre Dame indicates that it requires little more staff time to straighten an issue and replace it behind its cover than to place the paper on the traditional stick.[7] The advantages of the new shelf are the ease with which a given title may be located, the convenience of access, and the ease of reading.

Although canopy tops are available for bracket stack installations, they are infrequently used in air-conditioned buildings. Such tops add appreciably to the cost and serve no useful purpose except to protect books from dust in areas that are not air-conditioned. They may occasionally be selected for aesthetic reasons, but against this must be balanced the fact that they prevent utilizing the full height of the stacks.

Bookstack accessories include such small but important items as book supports, range indicators, end-label holders, and shelf-label holders. Designs vary with the manufacturer. Choice of style, where available, rests with the purchaser, but there are some useful guidelines.

For general use, the wire-type book support is probably least satisfactory, although it is the most economical. The principal objection to this support is that it damages books carelessly shelved, by "knifing" into the pages. Plate-type supports are of two kinds. The first, and most common type, consists of a piece of sheet metal with a portion cut out and turned under to form a base. Although more expensive, this design is no better than the wire support and is to be avoided for the same reasons. A second design is frequently called the "findable" or "non-losable" support. In this type, the two sides are formed at right angles to the main body of the support to produce a surface ½ to ¾ inch in width. This eliminates the danger of "knifing" and makes it easy to locate the support when books are shelved on either side of the support. However, unless this type of support is provided with the proper non-skid surface on the base it will slide out of position when books are moved, and may scratch the surface of the shelf. For best results, the synthetic corks are superior to rubber-type materials as a non-skid surface. Application of these materials by pressure sensitive adhesives is unsatisfactory, and one of the solvent activated adhesives should be specified instead.

A third type of book support clips to the box edge at the front of the shelf, along which it slides as on a track. Usually known as a hook-type support, it also has a flange at right angles to the edge of the shelf to eliminate knifing the pages of books. This type of support should also be ordered with non-skid bottom.

Range finders are "V"-shaped holders for 3 by 5 inch cards. Normally placed in the center of the end panel and close to the top, they identify a range at some distance and simplify the task of giving directions to users of open stack collections. Architects and designers occasionally object to these devices because they consider them unsightly, but the convenience they afford the library user compensates for any lack of aesthetic quality. Sometimes made in aluminum, range finders are better specified in steel.

One card holder is usually furnished for each end panel of a single-faced range, and two for a double-faced range. Although some manufacturers offer double holders for a double end panel, this design is less satisfactory than two single holders.

Even such small items as snap-on label holders can be unsatisfactory if not properly designed. Ordinarily these holders are used on periodical shelves to indicate the location of unbound issues. They should be designed of light weight metal with a high degree of spring, and

it should be possible to remove them and relocate them quickly and easily, and without damage to the finish. Despite such obvious requirements, some manufacturers make these holders of fairly heavy-gauge steel with little or no spring. Better type holders are made of special aluminum alloys with sufficient spring to keep them in position but still permit easy adjustment.

A thorough knowledge of the several elements of good stack design is requisite for the development of proper specifications, but such knowledge alone does not guarantee a satisfactory installation. As with so many other products used in libraries, the development of specifications has been left largely to the manufacturers. Performance standards and specifications prepared by librarians to meet library needs do not exist. In consequence, nearly every specification for steel stacks is copied, in whole or in part, from specifications prepared by the several manufacturers for their own products. The result is often called a "nuts and bolts" specification. That is to say, the materials and methods of manufacture are specified, rather than the performance of the product. To date, the manufacturers concerned have shown little interest in developing performance standards for bookstacks.

Thus, if such specifications are to be developed, it appears that the work must be undertaken by an organization such as the Library Technology Project of the American Library Association. In fact, determination of the basic performance requirements of steel bookstacks, sponsorship of the required engineering tests, and the technical evaluation of existing designs are better conducted by an independent body. It is to be hoped that LTP will consider this a project that it might profitably undertake.

Despite the fact that carefully evaluated performance specifications are not yet available, there are tests that can be applied by the librarian, architect, or purchasing agent as a means of determining the performance of steel stacks. These tests are set forth in Appendix I.

We have not mentioned, thus far, the finishing of steel stacks. As with other elements of stack performance, finishes vary widely in quality and, unless specified in terms of performance, may not provide the durability, resistance to scratching, and other qualities desirable in a stack installation. Fortunately, performance specifications for steel finishes were developed by the LTP a few years ago and have been successfully used in some recent installations. These specifications, which deserve to be more widely known and used, are reproduced in Appendix II.

Wood has been used for library shelving since time immemorial. With the advent of sheet metal stacks, however, wood began to be used less frequently. Today, although still a popular material, wood is rarely used in large installations. There are exceptions, of course, and custom wood shelving is not infrequently found in rare book rooms, in browsing rooms, and in other areas of the library where shelving made of fine cabinet woods is used to enhance the decor.

Aside from these rather specialized uses, wood shelving today appears to be restricted mainly to installations in school and small public libraries. Despite its higher cost (wood shelving may run from twenty to thirty per cent more than steel) and its lack of flexibility, librarians justify their use of wood on the basis of its added "warmth," and on the fact that it is "less noisy."

As with steel, wood shelving may be obtained in both single- and double-faced units. Standard high shelving is 82 inches in wood instead of 90 inches, as in steel. Intermediate height shelving is 60 inches high, and counter height shelving is 42 inches high. These measurements will vary slightly from manufacturer to manufacturer. Shelf depths also parallel those used for steel shelving with 8-, 10-, and 12-inch shelves the accepted standards. In this instance, however, the depths given are actual rather than nominal. Again, as with steel units, the standard width module is 36 inches on centers.

As in case-type steel shelving, wood shelving may be purchased with backs, although this adds appreciably to the cost. If backs are not specified, full-height, double-faced shelving requires sway braces to provide longitudinal stability. Because of its lower height, wood shelving is not ordinarily anchored to the floor, nor is it top-braced as in the case of steel shelving.

Fixed bottom shelves may be flat (standard) or tilted at a ten degree angle. Some librarians prefer the latter design because it is easier to read titles on the bottom shelves. Against this advantage, however, must be weighed the tendency of books to slide to the back of the shelf, where they are often more difficult to see than if stored on a flat shelf. The cork or composition strips employed to overcome this difficulty usually are ineffective, especially under conditions where passing traffic sets up vibrations that affect the furniture in the building.

Both particle board and plywood shelves are used in the cheaper grades of wood shelving, but are subject to warping under sustained loads. The best shelving specifies solid hardwood (northern yellow

birch or hard rock white maple) 13/16 inches thick. Such shelves are "built-up" by edge-gluing a number of strips together.

Wood shelving is usually adjustable on one inch centers. A common method of providing for such adjustment uses vertical rows of holes drilled near the front and back edges of the end panels. Threaded brass pins inserted in the holes support the shelves, which are grooved at the ends so that the shelves drop over and cover the pins. This method is entirely satisfactory under ordinary circumstances, although school students have been known to replace the metal pins with wood pins or matches, which break when the shelf is loaded beyond a certain limit. Other methods of shelf support include the use of small metal hooks which fit into holes in the end brackets and at the same time project under the shelf to provide support. More expensive, but probably the most satisfactory if properly installed, are long metal standards which are set into grooves extending the full height of the end panels near the front and back edges. The shelves are supported on small metal angles which fit into slots in the standards. This system, which permits adjustments on one-half inch centers is virtually foolproof. It is available from most manufacturers at the option of the purchaser.

Although less varied than the line of accessory shelves available with bracket-type steel stacks, several special shelf types may be obtained. Among these are sloping display shelves for periodicals, newspaper holder racks, and divided shelves. Wood shelving is intermediate between case-type and bracket stacks in the ease of moving shelves loaded with books. In many cases, the position of a shelf may be adjusted without removing the books. In other instances, such adjustment is difficult if not impossible.

Wood shelving is similar to case-type, steel shelving in flexibility. In most cases a first unit consists of two end panels with appropriate shelves, base unit, and top. If additional sections are added, they are inserted between the original end panels. If a range is separated into two parts, two additional end panels are required to complete the modification.

Finishes used on wood bookstacks are the same as those used on other wood furniture. In general, the conversion varnishes (catalytic varnishes) are superior to the lacquer finishes. Tests of the conversion varnishes show that there are differences among different brands. Thus the only method by which quality can be assured is to subject representative samples to performance tests. Appendix I following the

article, "The Materials and Construction of Library Furniture," lists tests by means of which the performance of both the finishes and the glues used in fabricating the shelving may be evaluated. These tests have been successfully used in many library furniture installations, but should be more widely known and used in specifications for wood furniture.

References

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3. Gallichotte, V. H. (W. R. Ames Co.) Letters dated Nov. 12 and Dec. 7, 1964.
4. *Ibid.*, Letter dated Nov. 12, 1964.
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APPENDIX I

Performance Tests for Bracket-Type Steel Bookstacks

Although in theory it should be considerably easier to develop complete performance specifications for steel bookstacks than for wood furniture, such specifications are not now available. Before they can be made available, engineering studies of bookstack requirements and complete evaluations of existing designs are required. In the absence of such specifications, the following tests may prove helpful.

These tests are designed to evaluate the actual strength of the uprights; the lateral stability of the bookstack as measured by the strength of the base support system; longitudinal stability as measured by the strength of the sway braces, welding, or other reinforcing designed to provide rigidity in the longitudinal direction; and the strength of the shelves. In a weak or unstable unit, the eccentric loading of so much weight could cause the unit to topple sideways. Care should be exercised, therefore, in conducting these tests. A properly designed and erected bookstack, on the other hand, can withstand all such loading and still be so stable that it can be lightly rocked from side to side without danger.

These tests may be included in bookstack specifications under the heading: On Site Testing. They can be conducted in many cases by the owner, or they can be performed for the owner by an independent

engineering laboratory. In addition to ordinary mechanic's tools, a platform scale for weighing the materials used to load the shelves, a spring scale reading 100 pounds or more for measuring longitudinal stability, and sufficient weight, in the form of steel or iron scraps or small ingots of pig iron or lead, to load all shelves as indicated, are required. Most cities have foundries or iron works where such weights may be obtained for temporary use. It is recommended that each bidder be permitted to observe the testing of his product. All samples for testing purposes should, of course, be delivered before bids are opened, but the tests should be conducted after such opening.

Although the following tests have been used successfully by a few institutions, most recently by the University of Illinois at Chicago Circle, it is to be hoped that they will be replaced by more comprehensive specifications resulting from sound engineering studies.

Samples for testing and evaluation should consist of one range of two, double-faced sections with 20-inch bases, complete with fixed base shelves and 24, 10-inch adjustable shelves. Sway braces, if included in the specifications, should be required with the sample. End panels are desirable for purposes of general evaluation, but should not be installed while the tests are being conducted.

If possible, samples should be erected on a concrete floor rather than a resilient tile floor. In any case, all neoprene pads should be removed so that direct contact between the base of the stack and the floor is achieved.

On Site Testing

1. When the sample bookstack has been properly installed and leveled by the bidder, it shall be tested by loading first the shelves in one complete section from the top down. One hundred seventy-five pounds shall be added to the topmost shelf, adjusted to the highest position in the section, after which one hundred seventy-five pounds (uniformly distributed over the shelf) shall be added progressively to each lower shelf until the section is completely loaded with one hundred seventy-five pounds on each of six adjustable shelves and on the base shelf. The first measurements of deflection shall be made at this time. The same procedure shall then be followed on the section opposite that first tested, and the deflection measured again. Any deflection of the upright from a straight line[1] in excess of ⅜ inch, shall be considered a failure and shall result in disqualification of the bidder. Further, any deflection of the upright from the vertical[2] in excess of

⅜ inch shall also be considered a failure and shall likewise result in the disqualification of the bidder.

2. The sample bookstack shall be further tested by applying a 100 pound force, horizontal and parallel to the long axis of the range, against the uprights at a point 48 inches above the floor. This test may be conducted with or without adjustable shelves, but one hundred seventy-five pounds shall be added to each of the four base shelves before testing. Any temporary deflection from the vertical in excess of ⅜ inch and any permanent deflection exceeding 1/16 inch[3] shall be considered failure and shall result in disqualification of the bidder.

3. At least five adjustable shelves shall be tested, after placing them in position in the sample range and loading them with the equivalent of 50 pounds per square foot. Any temporary deflection of the shelf in excess of 3/16 inch, and any permanent deflection of any of the five shelves,[4] shall be considered failure and cause for disqualification of the bidder.

Notes

1. Such deflection is best measured by stretching a chalk line along the loaded side of the upright from extreme top to extreme bottom edges and measuring the maximum deviation from a straight line. Ordinarily, such deviations will occur somewhere between 12 and 30 inches above the floor line.

2. Prior to loading the stack, a plumb line should be suspended from the top of the column so that the bob, which must swing freely, is at rest not more than two inches above floor level and in the exact center of the column. (The center line should be marked on the column as a reference point.) Deflection of the column from the vertical is measured by the distance the bob swings from the mark on the center of the column.

3. As in note 2 above, a plumb line should be suspended from the top of the column so that the bob swings freely and rests over an established mark on the floor. The necessary force may be exerted by a spring scale hooked to the upright at the proper height and pulled to the 100 pound mark by two men, or by a lever with one end fixed to the floor.

4. A nominal 10-inch shelf (actual depth 9 inches), 35.5 inches long, contains 2.2 square feet. Thus a loading factor of 50 pounds per square foot requires a shelf load of 110 pounds for testing purposes. Shelves should be loaded with the narrow edges of all weights at right angles to the length of the shelf, to avoid the "bridging" effect. Measurement may be made with a stretched chalk line or, preferably, with a metal straight edge. If desired, the sample may also include five nominal 8-inch shelves (actual depth 7 inches) which contain 1.7 square feet and require a shelf load of 85 pounds to develop a load factor of 50 pounds per square foot.

APPENDIX II

Performance Tests for Finishes on Steel Bookstacks

In steel bookstacks, as in the case of wood furniture, it is easier to test the finish than to test other elements of performance. The following tests for finishes on steel bookstacks were developed for the Library Technology Project a few years ago. They have been used successfully in a few instances, but deserve wider dissemination. In slightly modified form, they are included here by permission of the LTP.

In practice, these tests should be included in the specifications as a means of determining the qualifications of the several bidders. The tests should be conducted by an independent laboratory qualified to conduct tests on paints and related products.

As in the case of samples for testing the finish on wood, the samples required here should be submitted not later than the opening of bids and the award, other elements of the bids being equal, should be made on the basis of the satisfactory performance of the samples under testing.

Performance Tests for Finishes on Steel Bookstacks

1. **Manufacturer's Obligations**—Failure of the finish on the test samples in any portion of the following tests shall be cause for disqualification of the bid. Further, the owner reserves the right to conduct such tests, on a random basis, on stack components delivered to the job. Failure of such components to meet these specifications may result in an order to stop fabrication until the condition is corrected. The cost of such random testing will be borne by the owner, except in the event of failure of the finish to meet the specifications, in which case the charges will be assessed to the manufacturer.

2. **Samples Required**—Prior to the opening of bids on this contract, bidders shall furnish to the owner twelve, 4-inch by 6-inch and two, 4-inch by 4-inch panels of 20-gauge cold rolled steel for testing purposes. These panels shall have been prepared by running them through a production line similar in all respects to the procedures to be used in finishing the bookstacks to be supplied on the contract, including cleaning and rustproofing, followed by a finish coat as close as practicable to the color to be furnished on this contract. The test panels shall be fully representative of the quality of paint finish for the entire installation.

3. **Testing Agency**—All tests will be made by a testing engineer,

laboratory, or agency selected by the owner, and in accordance with applicable standard methods of the American Society for Testing Materials (ASTM), or by the procedures described herein.

4. Tests—The following tests shall be conducted on the test panels.

(a) *Film thickness.* Thickness of enamel shall be measured by a General Electric film thickness gauge or equivalent (See ASTM Method D1005-21 and ASTM 1400-58). Measurements of less than 1.5 mil. thickness shall be considered a failure and cause for disqualification of the bidder.

(b) *Gloss.* Gloss shall be not less than 50 nor more than 70 as determined on a 60 degree gloss meter (See ASTM Method D523-53T).

(c) *Bend test (adhesion).* Two specimens prepared as outlined above shall be bent 180 degrees over a ¼ inch diameter mandrel, one parallel to and one transverse to the grain of the steel, as follows: place the coated side uppermost on a mandrel at a point equidistant from the edges of the panel and bend the panel double in approximately one second. Cracks occurring at either end and extending no more than ¼ inch shall be disregarded.

(d) *Print Resistance.* Panels prepared as previously described shall be subjected to the following tests:

Cold print—A piece of 2 inch x 2 inch cheesecloth shall be placed on the finished panel. A five pound metal weight shall be placed on the cloth. The contact surface of the weight shall be a smooth surface and one square inch in area. The weight shall remain unmoved in the position for 24 hours at 75 degrees F.

Hot print—The same procedure shall be used for the hot print test as used for the cold print, except that the weight shall be two pounds instead of five pounds, and the temperature during the pressure shall be 110 degrees F. instead of 75 degrees F. Immediately after removal of the weights the exposed area shall be rubbed with a soft cloth and examined. Any printing discernible after rubbing shall be considered a failure.

(e) *Impact test (adhesion and flaking).* Two specimens shall be prepared as described above. One specimen shall be placed over a 1¼ inch diameter opening. A ball of 530 gram weight shall be dropped 10.5 inches on the section of the panel over

the opening. The test shall be repeated on the other specimen on the reverse side. Cracks, hairline cracks, or chipping of the impact area shall be considered a failure of the test and cause for disqualification.

(f) *Abrasion resistance (Taber).* Two, 4-inch by 4-inch panels shall be prepared as described above. The film thickness, which shall be measured at four places equidistant from the center of each panel, shall not vary more than 0.2 mils. After weighing each panel, place one panel on the platform of the Taber Abrader using a CS10 wheel and two, 1,000-gram weights. Subject the panel to 1,000 cycles, cleaning the panel by brushing every 100 cycles. Repeat with the second panel. Loss in excess of .650 grams per 1,000 cycles (average of two results) shall be considered a failure and cause for rejection and disqualification.

(g) *Salt spray.* This test shall be run in accordance with ASTM Method B287-57T, using panels prepared as previously specified. After fifty hours of salt spray, specimens showing any evidence of discoloration or scratched areas showing lifting or rusting more than ⅛ inch outside of the scribe lines shall be considered failure and cause for disqualification.

(h) *Acid and chemical resistance to cleaning chemicals, etc.* Five wells ½ inch in diameter and ½ inch deep shall be formed on the face of test specimens with modeling clay. Into each of four individual wells, one of the following shall be poured: alcohol (95 per cent), mineral or vegetable oil, acetic acid (10 per cent), and undiluted household ammonia. At the end of fifteen minutes, a 10 per cent lye solution shall be poured into the fifth well. At the end of thirty minutes from the time the first four solutions were poured into the wells, the five wells shall be removed and the test panel rinsed thoroughly and wiped dry. Evidence of discoloration, softening, or blemish of the finished surface shall be considered failure and cause for disqualification.

(i) *Cigarette burns.* A well-lighted cigarette shall be laid on the finished panel and allowed to remain in one position for 1½ minutes. After removing the cigarette, the test panel shall be rinsed with water only and wiped dry. Any evidence of stain or blemish on the finish shall be considered failure and cause for disqualification.