Performance testing of furniture. Part I. Underlying concepts

Abstract

Performance tests may be defined as accelerated-use tests that predict the ability of a product to fulfill its intended function. As indicators of performance, these tests are powerful analytical tools that can be used to eliminate many of the hazards and uncertainties associated with the development and production of furniture, as well as with its specification and buying. In order to develop universally accepted performance tests, test methods should be 1) independent of geographical range of application; 2) provide a maximum amount of engineering design information; 3) provide manufacturers with the information needed to market their products and consumers with the information needed to evaluate them; 4) provide a means of quantifying historical field experience; and 5) provide a means for quantifying the strength of furniture in an unequivocal manner. This paper discusses the basic factors underlying the performance test concept, especially those factors that are necessary in order to achieve universally accepted performance tests.

Performance tests may be defined as accelerated-use tests that predict the ability of a product to fulfill its intended function. The fundamental supposition underlying the performance test concept is that "consumer performance expectations" for products can be defined and measured. The necessary parallel supposition is that furniture does, in fact, possess unique inherent characteristics that can be identified and measured, and that these characteristics are reliable indicators of the furniture's ability to satisfy consumer expectations regardless of construction materials, design, or method of manufacture.

As indicators of performance, these tests are powerful analytical tools that can be used to eliminate many of the hazards and uncertainties associated with the development and production of furniture, as well as with its specification and buying. Demands for meaningful, well-designed performance tests have increased as both manufacturers and consumers have become aware of the potential value of the information the tests can provide.

In developing performance tests for furniture, the following procedure is typical: 1) observe how the furniture is used in service; 2) obtain reasonable estimates of the loads applied and their frequency of occurrence; and based on these observations 3) develop a test method that presumably simulates user service actions. Acceptance levels that are related to presumed service loads and the frequency of their occurrence are then formulated. Tests developed in this manner have been promulgated by both private and governmental organizations in numerous countries and have provided useful, reliable information concerning the performance of furniture.

Although these tests are valuable, typical furniture performance tests developed in this manner have several shortcomings. First, there has not been a unified development of tests. Each country, or group of countries, or an individual organization within a country has tended to develop its own set of tests, which may reflect unique local, regional, personal, organizational, and political perspectives. As a consequence, the results obtained from one set of tests may not be directly comparable with those obtained from another, unless the tests are first calibrated with respect to one another, a process that is both difficult and expensive and often yields ambiguous results.

Second, the tests have not been developed in such a way as to provide the maximum amount of useful information to the manufacturer; i.e., the tests do not provide information that can be readily incorporated into the engineering design of the furniture. This problem arises because performance tests have been developed.

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in order to circumvent the engineering design process, not augment it. Specifically, the developers of the tests have consciously sought to qualify fitness for use of furniture in a nontechnical manner without carrying out the technically complex engineering design process of identifying and quantifying the distribution and magnitudes of stress and strain in the construction.

Third, the tests often do not provide the information most useful to the manufacturer in marketing his product or to the consumer in purchasing it. Simply stated, although the tests may tell the manufacturer that his product is suited for a given end use, they ordinarily do not provide a means whereby he can meaningfully advertise and demonstrate the quality of his product in relation to its cost. That is, they do not provide a means whereby the manufacturer can clearly demonstrate the merits of his furniture in the marketplace. Similarly, the tests do not provide the consumer with information needed to make a comparison of quality versus cost among competing products. They do not tell the buyer/specifier or consumer how good one piece of furniture is compared to another. Of particular importance, the tests do not provide the information needed in life-cycle costing, which may justify the added cost of higher quality products that last longer.

The development of tests that eliminate these shortcomings and provide a maximum amount of useful information per unit cost requires a thorough understanding of the basic concepts that underlie performance testing. It is also necessary to have a clear understanding of how the test that is developed relates to the objectives to be achieved.

Furthermore, a departure from traditional parochial thinking and approaches is needed in order to develop what may be appropriately termed “universal” test methods, tests which provide uniform measures of the strength and durability of furniture in terms that have universal meaning, with an international range of application. Tests which, in effect, facilitate the free flow and orderly interchange of furniture in international markets.

Characteristics of good furniture performance tests

In developing performance tests, it is useful to first clearly define a number of inherent traits that are common to a successful performance test method. These characteristics can then be used to judge the merits of any specific performance test method.

1. A performance test method should be universal in its geographical range of application. It should not reflect the unique personal, organizational, or political bias of the country in which it is developed, nor should it reflect cultural differences. In short, it should be a standard that provides a universally accepted method for the evaluation and comparison of furniture.

2. The tests should be of such a nature that they provide the maximum amount of engineering design information concerning the furniture per unit cost. In effect, performance tests should evolve from the engineering design process and should provide direct feedback to it.

Conceptually, performance tests should be viewed as an aid to the engineering design process rather than as a means of circumventing it. The tests must provide a means of evaluating the key strength parameters of the furniture, provide for the elimination of over- as well as underdesign, and allow for the most efficient use of materials. Of particular importance, the tests should provide information concerning the true potential strength of the furniture, its ultimate strength and endurance. This information is vital to anyone concerned with the design, reliability, and safety aspects of the components, as well as the quality assurance of the final furniture product.

3. The tests should provide manufacturers with the information needed to market their products and consumers with the information needed to purchase them. Specifically, the tests should provide the means whereby manufacturers can clearly demonstrate the quality of their furniture to consumers. Similarly, the tests should provide the information needed for the consumer to make the comparison of quality versus cost. In particular, these tests should provide the information needed in life-cycle costing of furniture.

4. It is very important that the tests provide a means of quantifying experience, i.e., the tests must provide a means of quantifying the strength characteristics of furniture that fails in service, as well as the strength of furniture that is able to survive generations of use. Such tests provide a means of relating the inherent strength characteristics of the furniture to the expected life in any service environment.

5. The tests should provide a means for determining the key strength parameters of furniture in an unequivocal manner. The method should provide standard methods of test for evaluating the key specific strength properties of furniture so that a definitive database can be established and published, as is done for the important basic strength properties of wood.

Eventually, a performance test method that enjoys international acceptance must contain most of these points. Particularly in the import/export market, such tests provide the most unequivocal method for consumers to define and state their needs and for manufacturers to clearly demonstrate the ability of their furniture to satisfy those needs.

Basic concepts underlying specific individual performance tests

As previously stated, the fundamental hypothesis underlying the performance test concept is that the fitness for use of furniture can be evaluated in terms of user requirements, regardless of physical characteristics, design, or method of manufacture of the furniture. For this hypothesis to hold, two accompanying suppositions must hold. First, the supposition must hold that consumer performance expectations for furniture can be identified, defined, categorized, and most importantly, quantified. Second, the supposition must hold that furniture has certain inherent characteristics that can be identified, defined, and measured, and which are reliable indicators of its performance. Neither supposition, it should be noted, is necessarily universally true.
These suppositions provide the basis for the entire performance test concept. The first supposition mandates that the characteristics upon which a test is based and the performance expectations of the users must be closely correlated. It is essential, therefore, that those responsible for developing test methods have an adequate understanding of the way the furniture is used, so that the value structures and the expectations of the users are adequately addressed. A consequence of such an understanding is that the definition of performance in a test method should evolve naturally from an appreciation of what the end consumers will expect from a product, and how they will evaluate it.

The second supposition mandates that those parameters and characteristics of the furniture that are reliable indicators of its performance must be identified and defined, and then methods and tests can be developed to measure the degree to which they are present. Conversely, these suppositions dictate that noncritical characteristics should not be emphasized.

It also follows that the causative mechanisms operating in service should be duplicated in the test. Product failures that occur under natural service conditions presumably result from a variety of user and environmental inputs. Laboratory tests, at best, usually simulate only a few of these actions. Those actions included in the tests, therefore, should represent the most important of those operating in service. Otherwise, the results obtained will be a measure of the ability of the furniture to withstand the conditions imposed by the test itself, rather than a measure of resistance to conditions that exist in service. Of particular importance, the loads used in the tests, the stresses that result from them, the cyclic rate of loading, and the eventual mode of failure of the furniture in the tests should be similar to those that occur in service.

Considerations in selecting a comprehensive test method

When specific individual performance tests are to be incorporated into a comprehensive test method, the concepts on which various test methods are based should be carefully examined and evaluated to ensure that the resulting method of test is consistent with the intended purpose and objectives of the group or organization the procedure serves. In general, two fundamental questions must be considered. The first deals with the “scope and range of application” of the proposed test method; the second deals with the manner in which “acceptable performance” is defined. Scope and range of application largely determine the type of quality assurance program into which the test method may be subsequently assimilated. The manner in which acceptable performance is defined will largely determine whether the test method is consumer-oriented or is intended primarily for the benefit of manufacturers.

In most cases, the question of range of application concerns itself with the functional uses of furniture, whether a single test method can be applied to a broad generic group of furniture, or whether specific individual tests are required for the individual items within that broad group. In the case of chairs, for example, it must be decided whether a single test method can be used for all types of chairs regardless of their end use, or, whether one type of test is needed for dining room chairs, another for office chairs, and yet another for school chairs. Furthermore, it must be decided whether such tests are valid for all people, regardless of their cultural differences (which could influence the way they use the furniture).

Test methods that utilize either range of application have both advantages and disadvantages. Test methods with a narrowly defined range of application are more easily defined and less subject to misinterpretation. Furthermore, there are fewer exceptions that are not covered in the method. The principal problem arises in the considerable number of individual methods of test required to cover all of the different sets of furniture within each category. Also, those involved in testing would have to be acquainted with and knowledgeable about the specific differences in all of the test methods. Questions also arise with respect to fairness when one set of requirements is specified for one type of chair, but other requirements (which may be more demanding) are specified for another type.

The principal advantage of standards with a broad range of application is simplicity of use. Only one standard is needed to cover all of the products within a given use category. The most serious disadvantage of a broad range method is that it may not treat individual differences in construction and use with sufficient thoroughness. Some furniture within a broad group type, for example, may have certain features that are important to its function and should be evaluated, but which may not be included in a broad range test method.

Perhaps the most controversial issue underlying the development of any performance test method, however, concerns the manner in which performance is defined and how acceptance levels are set. In general, the problem to be resolved is whether single-level (pass-fail) acceptance systems are to be used or multilevel graded test methods. Which of these two systems is used has more impact on the value and usefulness of the test method than any other factor that can be cited. In general, the differences between the two systems depend upon how the resulting data is to be used and its intended audience.

For the most part, single-point, pass-fail tests are used when the objective is to establish a base level of performance and safety for a product group as a whole rather than to distinguish between differences in performance among competing products within that group. Thus, pass-fail types of tests are almost universally preferred by trade associations that wish to establish base levels of performance for the products of their members, but cannot promote tests that would highlight the quality differences among the products.

Inherently, single-point acceptance levels must necessarily be minimum acceptable performance levels. Two reasons can be cited for this limitation. First, acceptable performance must be set at levels that will accommodate most of the members who belong to the organization responsible for development of the overall
test method. Second, and more important, if acceptance levels are set too high, they will become overly restrictive, act as impediments to product improvement and innovation, and tend to remove from the marketplace those products that may be perfectly satisfactory for many applications but cannot meet the requirements of the test method. In such cases, the test method is likely to be regarded as monopolistic in intent and a restraint to trade, and dealt with accordingly by governing bodies.

Unexpectedly, single-point acceptance test methods may also have the unwanted effect of lowering the quality of “high end” furniture in the marketplace. This follows because there is no mechanism built into the tests to demonstrate the inherent qualities of the furniture above the minimums. Thus, there is a negative incentive to “overbuild” furniture with performance characteristics above those required in the method of test.

Despite these shortcomings, single-point acceptance level tests are of considerable value to buyers and specifiers in that they provide a guaranteed base level of performance for all competing products that meet the standard. In this respect, they relieve the buyer/specifier of total responsibility and mitigate subsequent liability for the products purchased. They are also of value to manufacturers because they can be used as quality control tools to ensure that all products, and, in particular, new products, fulfill desired performance criteria.

Multipoint or graded performance tests are preferred when the intent of the test method is to distinguish between differences in performance among similar competing products. Multipoint tests are of most value, therefore, to those concerned with specifying and buying furniture, the consumers, since these tests provide the information needed to make meaningful cost versus performance decisions. Increasingly, however, they are being used by manufacturers who desire a means of demonstrating the high inherent qualities and superior performance of their products relative to other similar products. This phenomenon is not limited to manufacturers of any single quality level because the intent of the manufacturers is usually to demonstrate 1) the fitness of their furniture for a particular application; and 2) its excellent quality versus cost ratio.

Graded performance tests are also an invaluable engineering tool in new product development and quality control. They allow manufacturers to evaluate the strength of furniture currently being produced and thereby develop a standard of quality by which new designs may be judged. Thus, they permit product engineers to create new cost-effective designs whose performance lives up to the established quality image of the company. Subsequently, they may be used as quality control tools to ensure that desired levels of performance are maintained in production. They also provide great product design and engineering flexibility. They help manufacturers arrive at optimum design solutions by evaluating the performance of products that have had one material substituted for another, had the joints or adhesives changed, or had some construction details changed. Most important, perhaps, these tests provide the manufacturer with the tools needed to evaluate and change successive designs until an end product is developed whose performance lies within a range of preselected values.

Within the context of either single-point or multipoint tests, the specific procedure used to determine whether or not the furniture satisfies the requirements should not allow ambiguous interpretations. In general, acceptance or nonacceptance with regard to structural considerations is usually stated in terms of deflection or resistance to breakage. Test procedures that are based on readily measured deflections or breakage of a part usually provide the least ambiguous results. Test procedures that define failure in terms such as “excessive deflection” or “loss of serviceability” are subject to considerable subjective interpretation and should be avoided. In general, when strength is the primary consideration in the test, the equipment required, the complexity of the test method, and the interpretation of the test results are all simplified if acceptance or nonacceptance is based on catastrophic failure.

Other factors that must be considered in the development of a performance test method include such practical matters as whether or not the document defining the test method should be self-contained or whether it should in effect be synthesized through references to other test methods. Again, both types of instruments have advantages and disadvantages. Self-contained methods of test are desirable in that all the information needed to carry out the test is contained in the one document. From a practical point of view, such documents may become bulky in size and inconvenient to use. When methods of test are not self-contained, however, and include requirements that are specified and described in other documents, potential users may not have access to the documents referenced. Furthermore, many of the documents referenced will likely become outdated or changed with time, so that the method of test must necessarily be updated regularly to reflect such changes.

Careful consideration must also be given to the resources and in-house capabilities of the intended end users. If the test method is intended for widespread use by individual furniture manufacturers, small as well as large, then the tests should be relatively simple to carry out and require relatively inexpensive, reliable equipment that is easily maintained and can be readily calibrated. Test methods that require complex sophisticated equipment and highly trained technicians for their use and maintenance are best suited for independent laboratory or research center use. Care must always be exercised in setting up test methods to ensure that they do not reflect the specific laboratory capabilities of those developing the test, rather than the actual needs of the test itself. Otherwise, the test method may require the use of excessively specialized and expensive equipment, which may limit its use to the few laboratories that are equipped to carry it out. As a general rule, therefore, the test procedures developed and the equipment required to carry out the tests should be consistent with the mean technical capability of the groups to be served.

The method of reporting test results should be con-
sistent with the manner in which the information is to be used. When test results are to be used by the manufacturers themselves, standard detailed laboratory reports are obviously appropriate. When the information is to be used by consumers, however, every effort should be made to ensure that the results are presented in a way that will enable the ultimate buyer to make meaningful purchasing decisions. Only information dealing with truly important performance characteristics should be presented, and it should be stated concisely. Presentation of nonessential performance data should be avoided, but detailed product test results should be available to those who desire them. For the nontechnical buyer, results and acceptance levels should be presented in simple terms that relate to perceived needs.

Concluding statement

In this paper, which is the first of a two-part series, the basic concepts that must necessarily underlie a universal performance test method have been discussed. Part II will discuss the concepts of a universal performance test method and the load models on which it is based, along with a number of individual performance tests for specific pieces of furniture.