Uses of the General Services Administration performance test method for upholstered furniture in the engineering of upholstered furniture frames

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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 product and consumers with the information needed to evaluate it; 4) provide a means for quantifying historical 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.

Anwendung des GSA-Leistungstests für die Konstruktion von Polstermöbeln

Leistungstests können als beschleunigte Prüfverfahren im Sinne der Benutzer angesehen werden, ob die Eignung eines Produktes für die angestrebten Zwecke gewährleistet ist. Als Leistungsspektakeln stellen diese Tests wertvolle analytische Hilfsmittel dar, um viele Risiken und Schwächen ausschließen zu können, die bei der Entwicklung und Herstellung von Möbeln sowie beim Klassifizieren und Vertrieb auftreten könnten. Um eine akzeptierte Prüfmethoden zu entwickeln, sollten diese Methoden 1) unabhängig von geographischen Gegebenheiten sein; 2) möglichst viel Information für die Konstruktion liefern; 3) Daten für die Hersteller liefern, um damit die benötigte Information für die Vermarktung und die Kunden bereitzustellen; 4) eine Möglichkeit zur Quantifizierung der überliefernten Erfahrungswerte an die Hand geben und 5) eindeutige Bewertungskriterien für die Festigkeit der Möbel ermöglichen. Dieser Artikel diskutiert die grundlegenden Faktoren, die zu einer allgemeinen Akzeptanz der Methode führen können.

1 Introduction

The benefits of product performance standards and quality assurance programs which enable consumers to recognize and distinguish between quality differences, consider the trade-offs available, and weigh those trade-offs against income and personal preference have long been recognized by the international furniture industry (Eckelman 1979a; 1979b; Eckelman, Lee 1981). The Scandinavian countries, for example, along with other European countries have had quality assurance programs in operation for several years (Swedish Standards Association 1972; 1976) while Great Britain and other countries have developed extensive performance standards for furniture (British Standards Institution 1972). The other nations of Europe, especially West Germany, have been equally active (Winning 1981). Importantly, however, the European community as a whole, anticipating the emergence of the Common Market, has largely been willing to set aside regional differences and work through the International Standards Organization (ISO) to evolve common performance standards to serve the entire European community (International Organization for Standardization 1982). Given the size of the common market, it is anticipated that these standards will have a major impact on world trade in furniture.

In the East, Taiwan has also shown an interest in the development of performance standards for its products (Anonymous 1984) and standards for Japanese furniture have been established for many years. Australia has also become active in performance testing of furniture. Specifically, the Australian Furniture Research and Development Institute has established a performance testing laboratory for furniture and is developing accompanying performance tests, labels, and test certificates (Anonymous 1984).

In the United States, relatively few performance tests and quality assurance programs have been developed by the furniture industry as a whole although segments of the industry have been quite active. The office furniture industry, in particular, is clearly recognized as the champion of performance tests for its members’ products. The Business and Institutional Furniture Manufacturer’s Association (BIFMA), for example, developed a set of performance tests for office chairs in 1977 which was published and promulgated by the American National Standards Institute (ANSI) in 1985. In addition, BIFMA has developed a performance test method for lateral files (ANSI 1989a), a performance test method for desk products (ANSI 1989b) which include tests for tables, and finally a performance test method for lounge seating which includes upholstered furniture (ANSI 1983).

The American Library Association has also been active in developing performance tests for the products which its members use. In particular, a tentative standard for free standing library shelving was undertaken in 1966 (ANSI/ALA 1985). In addition, a test method was developed for evaluating library seating by Eckelman (1982). A subsequent study, whose purpose was to define acceptance levels for the tests developed in the previous study, was initiated in 1992. Similarly, the National Kitchen Cabinet Association developed a certification program (ANSI/NKCA 1985) for its members in 1970.

A few other attempts have been made by various groups to establish performance standards for furniture, but nothing substantive has come of these efforts.

Interest in performance standards and quality assurance programs has also taken place in the United States at the federal level. The National Bureau of Standards, in particular, initiated an Experimental Technology Incentives Program (ETIP) whose
purpose was to find ways in which the government could work more effectively with industry in the development and transfer of science and technology to the private sector through the use of performance standards. Because of its long history of research and work in furniture engineering, the Furniture Research Center (FRC) at Purdue University was engaged by the federal government to develop performance tests for upholstered furniture which could be incorporated into performance specifications suitable for use by the federal government in its furniture procurement programs (General Service Administration 1981; 1989).

In the upholstered furniture program (with which we are concerned here), an orderly method was first developed for measuring the strength properties of the furniture in an unambiguous manner. Development of these tests was paramount to the success of the program since they made it possible to determine the levels of strength of furniture which was currently in production and being sold to the federal government. These tests, therefore, made it possible to obtain best estimates of the levels of strength which furniture manufacturers were building into their furniture and which, presumably, they felt were required for survival of such furniture in service. Ultimately, therefore, these tests provided a means whereby the collective experience and judgment of representative furniture manufacturers who participated in the program could be drawn upon, quantified, and incorporated into the test standard. The acceptance levels incorporated into the final federal specification, therefore, were based almost solely on furniture industry experience – as that experience is reflected in its construction practices.

Although these tests were developed to meet the specific needs of The General Services Administration (GSA), they have proven to be of equal, if not more, value to the manufacturers who use them to evaluate their furniture. By means of these tests, for example, manufacturers can methodically evaluate new designs and compare new constructions with old to see if desired levels of quality are being maintained. In addition, they can establish meaningful strength requirements for joints and sensibly material quality requirements for framing stock and other construction materials. The tests and data base developed during this study together with exhaustive subsequent testing, for example, have been used for such wide ranging purposes as evaluating new frame designs; evaluating new joint constructions and new fasteners such as metal toothed connector plates; evaluating new materials of construction such as softwood plywood, hardwood plywood, laminated veneer lumber, and oriented strand board; and for determining the number and type of defects which can be permitted in wood framing stock.

Finally, results of the study also provide the structural basis required for the development of quality assurance programs which are rapidly gaining acceptance among manufacturers. In this respect, these tests provide a marketing advantage to those manufacturers whose furniture has been approved for purchase by the federal government. Since the list of upholstered furniture which meets federal standards is public information, private, institutional, and state purchasing agents along with other agents such as architects who regularly specify or buy furniture in large quantities are also free to purchase from this selected pool of tested, proven furniture. Indirectly, therefore, the federal procurement program provides a quality assurance spin-off to the private consumer sector.

In this paper, the history of the conceptual thinking that went into development of these tests, a description of the tests, and specific product design data generated by the tests are presented.

2 Initial survey
At the outset of the program, it was agreed that, whenever possible, the tests developed should be consistent with those existing in other countries of the world and should reflect international thinking and experience. In particular, it was held important to avoid duplication, to foster the use of common test methods, and to promote the use of common standards. To fulfill that charge, bibliographies which contained the titles of some 2000 standards and specifications which in some way pertained to furniture were surveyed in order to identify those which were relevant to the study.

Approximately 250 of these standards representing 14 countries were identified and obtained for further examination. In addition, bibliographies of furniture and allied subjects were examined to locate and obtain papers of interest dealing with strength design, performance testing, and quality assurance. Finally, individuals and institutions concerned with the performance testing of furniture in France, Germany, Netherlands, Norway, Great Britain, Denmark, and Sweden as well as in the United States were visited in order to obtain first hand information concerning the test methods employed in those countries and to ensure that valuable sources of information had not been overlooked (Eckelman 1979a; 1979b).

The information gathered from these studies and visits indicated that world thinking concerning performance tests, performance specifications and standards, and quality assurance programs was rapidly evolving but was still in a state of flux. Overall, however, there was a general movement toward uniformity, particularly where this did not provide a market advantage for any specific country.

It was concluded, however, that none of the tests or systems in use was entirely satisfactory for the purposes of the program. It was evident that many of the tests had not emerged from the engineering sector and thus were not based on an understanding of engineering design. In fact, many had been written to circumvent the need for knowledge of the engineering design process in making purchasing decisions. Thus, even though the tests provided the information needed to evaluate the quality of the furniture, in many cases they did not provide the information needed by manufacturers to engineer their product. Specifically, such tests would not be expected to produce the type of information needed for product development and improvement. This violated a basic premise of the project; namely, that the tests developed should provide information of equal value to the manufacturer and the consumer since this would eventually result in an improvement of the quality of furniture offered to the federal government. The value of the information obtained from the foreign literature and from visits to furniture institutes and other furniture research centers cannot be over-stated, however, since it provided the background experience and historical perspective which led to the development of truly meaningful test procedures and sound test objectives.

3 Basic concepts
The development of performance tests for upholstered furniture presupposes that such furniture possesses certain inherent characteristics which can be identified and measured which are reliable indicators of its ability to satisfy user performance expectations (Brenner 1973; Eckelman 1983a). To the extent that fundamental product performance indicators can be identified and evaluated which are closely related to the expectations of the users, these tests serve a useful purpose. To the extent that they deal with non-performance charac-
teristics, they are meaningless and even misleading (Ferguson 1972).

In addition, it is desirable that tests be of such a nature that they can be incorporated into performance standards which are based on graded rather than single point or pass/fail acceptance criteria since a pass/fail system does not provide a method of rating the performance capabilities of those products which satisfy the basic standard (Peterson 1973). Furthermore, pass/fail systems eventually tend to exclude products of lower quality/lower price from the marketplace which do not meet the standard but which may be quite satisfactory for many users.

Finally, it follows that tests which are developed should evolve naturally from an understanding of the way furniture is used and from an appreciation of the corresponding responses induced in the furniture (Dillon 1973; Eckelman 1988a; 1988b). Specifically, the tests should be of such a nature that the stresses induced by them and the resulting mode of failure of the frame are similar to those which occur in service. It is all too easy for laboratory tests to superficially simulate service conditions without duplicating the causative mechanisms operating in service. The results obtained with such tests tend to be related to the specific test employed rather than to the conditions which exist in service. Perfect correlation between the effects induced by the tests and those induced by service conditions is seldom attainable. It is necessary, therefore, that the relationship of the stresses induced by the test to those which occur under service conditions be fully understood so that results of the tests can be meaningfully interpreted.

4 Development of tests

In developing the tests needed to evaluate the performance characteristics of upholstered furniture, it is necessary to take into consideration the types of loads which can be used in these tests (Eckelman 1978). Numerous types of loadings may be used in evaluating furniture performance, but perhaps two of the most commonly used are static loads and simple fatigue loads. Static loads are ordinarily used either to determine the ultimate strength of a frame or to qualify the frame in a pass/fail type of test. Fatigue tests are carried out to determine the resistance of the frame to repeated applications of low level loads such as might occur in service. These tests may be carried out at a given load level for an indefinite number of cycles until the furniture fails, or they may be continued for only a specified number of cycles which presumably qualifies the furniture for a given use.

Static loads do not appear well-suited for evaluating the performance characteristics of furniture frames because most service failures appear to be fatigue related and it would be necessary to establish relationships between the static strength of the frames and their fatigue strength. Constant load amplitude fatigue tests also do not appear well suited for evaluating performance characteristics. In a simple fatigue test, the structure is gradually weakened as the test progresses until it reaches a point where it can no longer carry the load applied and it fails.

It can often be seen during the course of such tests that a frame or component would fail if the load were increased even the slightest amount, yet the frame may continue to carry load for thousands of additional cycles. In practice, furniture is gradually weakened during the course of its life through normal use until at some point in time, it is subjected to an overload which it can no longer carry and it fails. This concept is similar to what has been described as a “first crossing” theory of failure in aerospace engineering (Yao 1976). In general, this theory hypothesizes that a structure gradually weakens under the repeated application of normal loads during its life. In addition to normal loads, however, it is also subjected to chance overloads. Initially, while it still has a high degree of strength, it will be able to resist these overloads. As its strength continues to diminish, however, a time is reached when the magnitude of one of these overloads will exceed the resistance of the structure and it will fail.

It would be difficult to simulate the “first crossing” concept exactly in furniture testing both because appropriate load models have not been developed and also because it would be somewhat difficult to introduce loads of random magnitude at random intervals into the loading sequence. A reasonable alternative to this, however, is to increase the load level by a fixed increment each time a specified number of load cycles has been completed. This testing procedure obviously involves an interaction between load cycles and load levels. The principal value of this procedure is that it permits furniture to be evaluated on a graded basis with respect to its combined load carrying capacity and fatigue resistance. Because of this advantage, the increasing-load/fatigue type test concept appears best suited for use in furniture performance tests.

5 Common test factors

Although independent tests were developed to evaluate each of the performance characteristics of interest, certain features were common to all the tests. A rate of loading of 20 cycles per minute is used in each test. Previous experience indicated that this was about the maximum cyclic rate which could be used with a practical air delivery system and still allow a desired load level to be reached and held for a defined time under a variety of conditions. In addition, all of the tests are carried out for 25,000 cycles at a given load level before proceeding to the next. Again, experience in testing other furniture indicated that this was a reasonable number of cycles to carry out at each load level. In addition, from a practical point of view, at a rate of 20 cycles per minute, 25,000 cycles can be completed in slightly less than 24 hours so that a new test cycle can be started each day. Finally, tests are continued until the frame or its components suffer disabling damage. Loosening of a joint is not considered a failure as long as the members jointed together continue to function as intended.

6 Descriptions of specific tests

6.1 Seat load test for upholstered sofas

Procedure: The cyclic vertical seat load test for sofas consists of subjecting the seat of the sofa to the “sitting action” of three identical load heads, Figure 1. These loads are applied at the center and at points 1/6th the length of the open face of the sofa from each end.

Testing of the sofa is begun with 100 pounds applied to the rear load position of the load head and with 50 pounds applied to the front position, Figure 1. The dead weight of the load frame and the load head at the front and rear points are added to that of the loads applied by the air cylinders to obtain the total test loads. Front and rear loads are applied simultaneously. Rear loadings are increased in increments of 25 pounds and front loadings in increments of 12.5 pounds after 25,000 cycles have been completed at each preceding load level. After a load of 275 pounds is reached on the rear and 137.5 pounds on the front load positions, however, the load is not increased further since the expected load capacity of the seat system would be
exceeded. Beyond this point, therefore, the test becomes a fatigue test at constant load level. The sofa is carefully re-examined for damage each time an additional 25,000 cycles has been completed.

Tests are continued until some type of seat foundation failure such as breakage of a spring occurs, until some type of frame failure occurs, or until a desired level of performance has been achieved.

6.2 Backrest foundation test for upholstered sofas

Procedure: The test consists of applying three loads to the backrest of the sofa in a front to back direction, Figure 2. These loads are applied at the center and at points 1/6th the length of the open face of the sofa from each end. Point of contact of the center of the load heads with the backrest surface is 9 inches above the point of intersection of the backrest with the seat surface. The line of action of the load frame is inclined downward at an angle of 12.5 degrees with the horizontal. The action of these forces is resisted by a 1-inch diameter crossbar which is placed crossways behind the rear legs of the sofa. This crossbar prevents the sofa from sliding backwards when the front to back forces are applied to the backrest.

The test is begun at the 50 pound load level. Loads are increased in increments of 12.5 pounds after 25,000 cycles have been completed at each preceding load level. Testing is continued until some type of physical failure occurs in the backrest foundation system, such as a broken spring, or until a desired level of performance has been achieved.

6.3 Backrest frame test for sofas

Procedure: The test consists of applying three loads to the top rail of the sofa in a front to back direction, Figure 3. These loads are applied at the center and at points 1/6th the length of the open face of the sofa from each end. Angle of inclination of the load frames is 12.5 degrees. The action of these forces is resisted by a 1-inch diameter crossbar which is placed crossways behind the rear legs of the sofa. This crossbar prevents the sofa from sliding backwards when the front to back forces are applied to the backrest.

The test is begun at the 75 pound load level. Loads are increased in increments of 25 pounds after 25,000 cycles have been completed at each preceding load level. Testing is continued until the frame suffers disabling damage or until a desired level of performance has been achieved.

6.4 Horizontal side thrust arm load test for sofas

Procedure: The test consists of subjecting one arm of the sofa to a horizontal force in an outward direction, Figure 4. This force is applied to the inside surface of an arm at a point as near as possible to the intersection of the stump with the arm. This force is resisted by a 1-inch diameter crossbar which is placed across the end of the sofa. This crossbar prevents the legs of the sofa from sliding endways.
Tests are started at the 50 pound load level; loads are increased in increments of 25 pounds after 25,000 cycles have been completed at each preceding load level. The test is continued until the arm suffers disabling damage or until a desired level of performance is reached. If, by chance, a leg should break during the test a substitute leg may be clamped to the sofa frame and the test continued.

6.5 Front to back load test for legs

Procedure: The test method consists of applying a horizontal load to one stomp of a sofa in a front to back direction, Figure 5 (or, two loads of the same magnitude may be used, one applied at each end of the sofa as shown in the figure). This load is applied at one end of the sofa – preferably, near one of the front rail to side rail joints. Line of action of the load is parallel to the floor and perpendicular to the longitudinal axis of the front rail.

The action of this force is resisted by a 1-inch diameter crossbar which is placed crossways behind the rear legs of the sofa. This bar prevents the sofa from sliding backwards when front to back forces are applied to the front of the sofa; simultaneously, it applies the desired floor reaction forces to the legs.

Testing is begun at the 150 pound load level. Loads are increased in increments of 50 pounds after 25,000 cycles have been completed at each preceding load level. Testing is continued until the sofa frame or leg suffers disabling damage.

6.6 Horizontal side thrust load test on legs

Procedure: The test method consists of applying a side thrust load to one end of a sofa in an inward direction which is resisted by the legs at the opposite end, Figure 6. Usually, the load can be applied to a side rail. It should be applied in a direction parallel to the floor and perpendicular to the longitudinal axis of the side rail at a point on the side rail midway between the front and back legs. The sofa is prevented from sliding endways by means of 1-inch diameter crossbar which butts up against the legs at the other end of the sofa. This crossbar applies floor reaction forces to the legs in the inward direction so that the desired loading of the legs is achieved.

The test is begun at the 200 pound load level. Loads are increased in increments of 50 pounds after 25,000 cycles have been completed at each of the previous load levels. Testing is continued until a leg or the frame suffers disabling damage or until a desired level of performance has been achieved.

7 Product design data generated by tests

A discussion of the information generated by each of the tests is given below. In general, this discussion is directed toward manufacturers rather than consumers.

7.1 Vertical load test on seats

This test is particularly effective in uncovering defects in construction since several of the critical parts of the frame are highly stressed by the seat loads. As a result, if any component fails, the entire frame soon fails.

Failure of the front or rear rails occurs primarily because the rails are too small, but rails also fail when they contain too much cross grain or when included knots are too large or too numerous. In this respect, knots on the bottom edges of the rail are particularly damaging. Failures frequently originate around the dowel holes for the stretchers and then propagate through the remaining cross section of the rail. The front rail to front post joints also frequently fail during this test, both in the vertical and also in the front to back direction. Many of these joints lack the glue blocks needed to resist the front to back forces imposed on them by sinuousoidal type seat springs, or, the glue blocks are improperly positioned to resist the forces. Vertical failures tend to occur when dowels are located too near the top edge of the rail.

Perhaps the greatest value of this test, however, lies in its ability to evaluate the durability of spring systems. The difference in performance characteristics of springs from different suppliers cannot be overstated – some springs will simply not pass the lightest GSA test requirements. Furthermore, this test will quickly determine when springs are improperly installed.

Failure of the stretchers usually occurs when they are inherently too small in size, or they are too widely spaced (i.e., too few are used so that they are highly stressed), or they have serious defects in them. A common cause of stretcher system failure is inadequate reinforcement of the stretcher to front rail joints – usually, the glue blocks are either too small in size or they are poorly glued. Lack of reinforcement at this point may cause the end of the stretcher to split out, or, the dowels themselves may break off. Caster stretchers regularly fail at the front rail joint if not reinforced.

Occasionally, this test may cause legs to collapse. This usually occurs only with hollow plastic legs. More commonly, leg blocks and corner leg rails collapse owing to poor attachment to the front and side or back and side rails.

In general, therefore, this test is effective both in detecting inherently poor construction systems and also in detecting the products of poor assembly practice.
7.2 Cyclic front to back load test on backrests
This test is effective in evaluating the durability of backrest foundations as well as weaknesses in the frame system as a whole. The test is particularly useful in evaluating spring systems in backrests, both with respect to the durability of the springs themselves and with respect to their method of mounting – this test has repeatedly shown that the method of mounting, i.e., the type of clip used, etc., has a very significant effect on the life of springs.

The test has also proven effective in determining the durability along with the weaknesses of other backrest foundation systems; tearing of the fabrics by staples is a common problem. Loosening of staples which occurs in some composites is also detected.

7.3 Cyclic front to back load test on top rails
In general, back systems fail in this test because: a) the top rail breaks, b) the side frame or frames collapse, c) the back post pulls loose from the rear of the arm and side slat, d) the back post splits, e) the top rail to back post joints fail, or f) the top of the back post splits or breaks off. The variety of ways in which this test is able to cause failure indicates that it is effective in evaluating individual differences in performance strength properties. Of particular importance, it is able not only to detect problems owing to the use of members of inadequate size or members with too many or too large defects, but it is particularly effective in detecting inherent weaknesses in common construction systems along with weaknesses associated with poor assembly practices such as poor gluing techniques.

7.4 Cyclic side thrust load tests on arms
When the stump is attached to the front rail, the stump to front rail joints will ordinarily fail in this test although the stump may also split if it is glued up from several pieces and the glue bonds are inadequate. Those constructions with wide front rails are usually relatively strong since the dowels in the joints may be widely spaced (Eckelman 1978). The strongest stump to front rail connections, however, are those in which the joint is reinforced on the back side with a plywood gusset which is of the same width as the rail.

In those frames in which the stump is attached to the side rail (T-front construction), failure occurs most often in the stump to side rail joint. Some stumps also split lengthwise with this construction, but the second most common cause of collapse is failure of the side rail to front rail joint. In general, it should be recognized here that this type of joint is inherently weaker than those constructions in which the front rail frames into the stump itself.

Overall, this test is effective in determining differences in the resistance of various arm constructions to side thrust forces. From a manufacturing perspective, it is particularly useful because it is effective in discovering poor assembly practices. Inadequate gluing of the dowels in front rail to stump joints, for example, is commonly disclosed by this test.

7.5 Cyclic front to back load test on legs
In those constructions where legs are attached to leg stretchers by means of anchor bolts and T-nuts, this test discloses significant differences in the performance of legs of high versus low quality. The test is also effective in detecting differences in strength in those constructions where the legs are glued and screwed to the inside surface of the side rails – legs which are haphazardly glued in place generally perform poorly compared to those which are properly glued and screwed in place. Differences in leg to metal plate construction are also readily apparent. The most obvious weakness with this construction occurs when the leg plates are not properly secured to the underside of the frame; either too few screws are used or the screws are too short. With other leg constructions, poor or sloppy construction practices also quickly become apparent. In particular, weaknesses which arise from inadequate gluing and haphazard attachment of glue blocks tend to cause early failure. Finally, the test is also effective in evaluating the strength of the legs in frames in which the leg is an integral part of the frame. This test necessarily evaluates the racking strength of the side frame, but it also evaluates the bending strength of the leg itself along with its splitting strength. Splitting of the leg is the most common type of failure when the leg fractures rather than the frame, but the test is needed in order to evaluate those constructions in which the leg is joined to the back post by means of a finger-joint to form one continuous member.

7.6 Cyclic side thrust load test on legs
Most of the comments made in the previous section concerning the front to back load test for legs apply to this test also. In general, differences in strength are readily detected by the test, and it provides a valid method, therefore, of discovering weak inadequate constructions.

8 General observations concerning the test method
Tests carried out on hundreds of sofas indicate that the six tests included in the method evaluate the most important strength characteristics of the furniture and are equally effective in discovering weaknesses and hidden defects.

Experience with the cyclic, stepped load model has been favorable and provides considerable support for its continued use. It provides a maximum amount of information about the performance characteristics of the furniture up to and including the point of failure in a reasonable amount of time and is of obvious value in ranking furniture in graded performance rating systems. Furthermore, this concept of testing is not limited to upholstered furniture, but is equally useful in evaluating almost all other types of furniture. Development of the cyclic stepped load model continues to be one of the most important benefits derived from this program.

9 Manufacturers’ experience with the test method
Use of the tests to evaluate furniture produced for sale to the federal government indicates that the tests are able to effectively distinguish between levels of strength and durability and to detect points of weakness. Of particular interest, the tests have often disclosed areas of weakness in the furniture which were unknown to the manufacturer. In general, manufacturers have welcomed this information since it allows them to make the changes needed to eliminate potential problems and thereby increase the durability and reliability of their products.

Ordinarily, such changes have not resulted in an increase in cost in the furniture since improvements usually come about from proper use of materials and improved design of joints rather than from the use of additional materials.

10 Performance acceptance levels
Although the intent of this paper was to discuss the value of the GSA performance test method for product engineering
Table 1. Summary of performance acceptance levels

<table>
<thead>
<tr>
<th>Test</th>
<th>Light-service</th>
<th>Medium-service</th>
<th>Heavy-service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat load foundation test</td>
<td>200/100</td>
<td>250/125</td>
<td>275/137.5</td>
</tr>
<tr>
<td>Backrest Foundation test</td>
<td>112.5</td>
<td>125</td>
<td>150</td>
</tr>
<tr>
<td>Backrest frame test</td>
<td>75</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Sidethrust load test on arms-outward</td>
<td>75</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>Back leg test</td>
<td>150</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>Sidethrust load test on legs</td>
<td>200</td>
<td>250</td>
<td>350</td>
</tr>
</tbody>
</table>

Table 2. Summary of initial load levels and increments

<table>
<thead>
<tr>
<th>Test</th>
<th>Initial Load Per Cylinder</th>
<th>Load Increments Per Cylinder</th>
<th>Number of Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat load foundation test</td>
<td>100/50</td>
<td>25/12.5</td>
<td>3</td>
</tr>
<tr>
<td>Backrest foundation test</td>
<td>50</td>
<td>12.5</td>
<td>3</td>
</tr>
<tr>
<td>Backrest frame test</td>
<td>75</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Sidethrust load test on arms-outward</td>
<td>50</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Back leg Test</td>
<td>150</td>
<td>50</td>
<td>1 or 2*</td>
</tr>
<tr>
<td>Sidethrust load test on legs</td>
<td>200</td>
<td>50</td>
<td>1</td>
</tr>
</tbody>
</table>

* This test may be run with a load applied at only one end of the sofa, or identical loads may be applied at each end.

purposes, the acceptance levels used by the GSA may be of interest to some readers. Acceptance levels for light, medium, and heavy service, accordingly, are given in Table 1. Initial load levels and load increments are summarized in Table 2. It should be noted that the acceptance levels are not meant to be associated with length of service but rather with anticipated severity of service.

11 References


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