

INTRODUCTION

The Joint Industry Polyurethane Foam Committee was established in 1987 under the auspices of the American Furniture Manufacturers Association. The JIPFC is a diverse group consisting of furniture manufacturers, polyurethane foam producers, foam fabricators, and raw material (chemical) suppliers. The primary function of the group is to provide a forum for establishing working relationships between the producers and suppliers of polyurethane foam cushions and upholstered furniture manufacturers. The original group that met in 1987 outlined many topics for discussion, with the primary topics as follows:

- Discuss the need for standards and guidelines and define major manufacturer/supplier problems and needs
- Discuss the procedures for setting standards and guidelines
- Set in motion the mechanics of committee formation and action
- Set the ground rules for committee meetings and procedures
- Canvass all interested parties to participate

One of the major findings of the first meeting was that a great deal of education was needed in both the furniture industry and in the foam industry regarding each others needs and limitations. As part of the ever-changing world of polyurethane foam technology and the trend setting stylishness of the upholstered furniture manufacturer, the Joint Industry Polyurethane Foam Committee is an ongoing, organized arena to help in the education and enlightenment of both furniture manufacturer and foam supplier. In light of the pace of innovation and the dynamics of technological changes and regulations, the committee meets twice annually and actively pursues new membership and new technical topics.

The Joint Industry Polyurethane Foam Committee maintains organization and fairness to both users and producers alike by establishing voluntary guidelines and standards, voted upon by all members. To avoid imbalance or bias, only one voting ballot per member company is allowed. An equal number of ballots from both producer and user companies are blindly chosen at random for counting. Negative ballots and criticisms are welcomed, with each negative ballot being brought before the committee for reconciliation. Although a 75% majority is necessary to pass any issue, the committee makes every effort to obtain unanimity on all issues. The standards and guidelines in this publication have been reached with almost 100% unanimity of the participants. The committee's balance of membership and balloting has provided a basis for the standards and guidelines to reflect a fair and acceptable "state of the art and state of the science" in both the furniture and polyurethane foam industries. However, it is necessary to point out that the standards, guidelines and practices presented herein are purely voluntary.

Finally, the Chairman would like to thank and commend every member of the Joint Industry Foam Standards Committee for their diligence and expertise in developing this set of voluntary standards and guidelines. These guidelines, which will serve as a valuable base of reference for both industries, have been reinforced by exhaustive research conducted by joint industry round robin testing. It should be noted that even the slightest deviation from any part of the testing procedures outlined in this publication will essentially nullify the accuracy of any results that are obtained by the user.

PARTICIPATING COMPANIES

Action Industries
Akzo Chemical
Albright and Wilson
Alexvale Furniture
American Furniture Manufacturers Association
Arco Chemical Company
Baker Furniture
BASF Corporation
Bench Craft, Inc.
Berkline Corporation
Bernhardt Furniture
Boling Company
Brookwood Furniture
Broyhill Furniture Industries
CR Laine Company
Carson's Inc.
Cellular Technology, Inc.
Century Furniture
Chromcraft
Clayton Marcus
Contour Foams
Corson Furniture Industries
Crest-Foam Corporation
Crest-Line Furniture
Cumulus Fibers
Detriot Testing Labs
Deville Furniture
Dow Chemical
Drexel Heritage Furnishings
E R Carpenter Company, Inc.
Ethan Allen, Inc.
Fairfield Chair Company
Fecken-Kirfel American
Flexible Foam
Flexsteel
Foam Fabricating, Inc.
Foamcraft
Foamex
Franklin Corporation
Future Foam, Inc.
General Foam Corporation
Great Lakes Chemical Corp.
Greene Brothers Furniture
Harden Furniture

Harold Kaye and Associates
Hickory Springs Manufacturing
Hugh Talley Company
Kay Lyn, Inc.
La-Z-Boy Chair Company
Lear Seigler
Leggett and Platt, Inc.
Marsh Armfield
MFPL, Mississippi State University
Milliken Chemicals
Mobay Chemical Corporation
Mohasco Upholstered Furniture
MPI, Inc.
NC Foam Industries
Norwalk Furniture
Olin Corporation
Olympic Products
Para-chem Southern, Inc
Pearson Company
Pennsylvania House
Polyurethane Foam Association
Prelude/Div of Cone Mills
Reeves/Curon Division
Rowe Furniture
Schnadig Corporation
Schweiger Industries
Sealy of MD and VA
Sheffield/Bristol
Simmons, USA
Sklar-Peppler, Inc.
Smith Brothers of Berne
Society of Plastics Ind.
Southwest Research Institute
Stanton Industries
Tech Aerofoam Products
Texaco Chemical Company
TPI
Trinity-American Corp.
Union Carbide Corp.
White Line Enterprises
Witco Chemical Corporation
Woodbridge Foam Fabricators
Vitafoam

Flexible Polyurethane Foam Standards and Guidelines Committee
Task Group Chairpersons and Company Affiliates *

Density Statements	Hugh Talley, Hugh Talley Company
Marking Guidelines	Danny Hall, Mohasco
IFD Interlab	Harold Kay, Harold Kay and Associates
CFD Temperature And Humidity Relationships	Frank Sasser, Olympic Products
One Inch Stroke IFD	Bill Ashe, BASF;Detroit Testing Lab Worth Jones, Olympic Products Company Jim Knight, Arco Chemical Company Jerry Pool, Vitafoam
Tapered Cushion IFD	Bill Ashe, BASF;Detroit Testing Labs Don Bentley, Berkline
Shredded Foam	Mike Smith, Schweiger Industries Hugh Talley, Hugh Talley Company
Fatigue-Hysteresis Relationships	Jerry Pool, Vitafoam Jim Knight, Arco Chemical Company
Dimensional Tolerances	Bob Krug, La-Z-Boy Chair Company Butch Ade, Schnadig Corporation
Vertical Adhesive Seams	Tom Buckingham, Norwalk Furniture Mark Masters, Para-Chem
Seating Foam	Handley Fincher, Drexel Heritage
Arm and Back Foam	Bob Dewitt, Pennsylvania House Mike Smith, Schweiger Industries
Upholstery Foam Performance	Kevin Brittian, Corson Furniture
Glossary	Handley Fincher, Drexel Heritage Audie Mitcham, Drexel Heritage
IFD Ranges of Various Foam Types	Bill Ashe, BASF;Detroit Testing Bob Mould, Berkline Roy Pask, BASF Corporation Ken Turnbow, Berkline

Commercial Foam Definitions

Handley Fincher, Drexel Heritage
Audie Mitcham, Drexel Heritage

**Receiving Acceptance
Procedures**

Worth Jones, Olympic Products

**Visual Condition of
Cushions & Pillow Wraps**

Worth Jones, Olympic Products

Writing Committee

Audie Mitcham, Drexel Heritage

The Joint Industry Polyurethane Foam Standards and Guidelines Committee would like to thank each of the chairpersons for their efforts and their affiliated companies for having the foresight to see the true benefit of committee work such as is included in this publication. The JIPFSGC would like to extend a special thanks to the following committee members for service above and beyond the call of duty:

Thanks to Bill Ashe of Detroit Testing Labs for his enthusiastic approach to the quest for knowledge about flexible polyurethane foams. Bill's revelations to the committee gave more insight into the field of flexible polyurethane foams and answered more questions than most committee members knew to ask.

Thanks to Jim McIntyre of the Polyurethane Foam Association for his guidance in the realm of legality.

* NOTE: Some individual company affiliations may have changed since Task Group work was completed.

MISSION STATEMENT

Joint Industry Foam/Furniture Committee

The mission of the Joint Industry Committee is to foster understanding between the upholstered furniture industry and manufacturers of flexible polyurethane foam. This mission is to be accomplished by jointly exploring the requirements of upholstery foam cushioning and the capability of the flexible polyurethane foam manufacturer to supply foam that will meet those requirements.

The joint industry, through a forum comprised of its members, shall identify, develop and continuously redefine test methods and/or guidelines for flexible polyurethane foam intended for use in upholstered furniture.

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Chapter 0.0 INTRODUCTION TO THE PHYSICAL PROPERTIES OF FLEXIBLE POLYURETHANE FOAMS FOR FURNITURE APPLICATIONS

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- 0.1 Selecting the best foam for the intended end-use is a difficult and complex process; selecting the best foam for the desired comfort is even more difficult and complex; and, finally, selecting a foam that will be durable in use is also a complex process.
- 0.2 One of the reasons for the difficulties and complexities is economics. The best foam for the intended use may be too expensive for things like margin requirements and other pricing and cost ramifications.
- 0.3 Far too often, the determination of best foam for a particular job will be based on subjective interpretation of test results--vis-a-vis-opinions; because some of the test methods and their accuracies and reproducibilities simply leave the circumstance open to subjective opinion. Testing of certain physical properties of foams also is not very reproducible from lab to lab or machine to machine. Errors of 10 to 30 percent can exist in certain test procedures, and many of these errors are the result of poor test-experiment planning or communication. For example, IFD interlab testing often leads to very wide differences in results; CD (compression deflection) testing often leads to wide differences in results; and flex fatigue testing also usually leads to very wide differences in test results.

NOTE:

Because of the potential wide differences in test results, it is imperative that furniture manufacturers work closely and continuously with their foam suppliers to correlate equipment, procedures, and test data. Supplier/furniture manufacturer IFD correlation is very possible and even very practical if everyone involved is diligent in continual attempts to correlate and communicate.

- 0.4 The subject of comfort is extremely subjective and open to opinion. As a result, putting numbers on entities associated with comfort becomes very difficult. It must be realized that comfort is related to a composite-of-factors in a piece of upholstered furniture. Some of these factors are:

-SEAT DEPTH

-SEAT HEIGHT

-SEAT PITCH

-SEAT CUSHION FOAM
USED

-TYPE AND AMOUNT OF
CUSHION WRAP USED

-SEAT-TO-BACK RATIO OFFIRMNESS

-DEPTH AND TYPE OF BACK

-KIDNEY ROLL SIZE (IF ANY)

-UNDER CONSTRUCTION
OF BACK

-UNDER CONSTRUCTION
OF SEAT

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|-----------------------------|--------------------------|
| -TYPE OF FABRIC USED | -SPRING TYPE AND SPACING |
| -CUSHION STUFFING RATIO | -SPRING CROWN HEIGHT |
| -SEAT-TO-BACK ANGLE (PITCH) | -USE OF HINGE-LINKS |

- 0.5 The key point is that the foam alone is not the only factor determining the comfort of a seat. As a matter of fact, the foam is not even the greatest factor in the determination of seating comfort. Many of these factors listed above contribute and/or detract as much as does the type of seat foam used.
- 0.6 There is also another term related to comfort which is generally misused and causes some confusion. That term is "support factor". A much more acceptable term for the ratio of the 65% IFD to the 25% IFD is "modulus" or "compression modulus".
- 0.7 Cushion or seat complaints from the field usually arrive with comments like: "this seat has collapsed", "it's too soft", "the foam in this cushion is too soft", "these cushions are too mushy", "or the foam in these cushions is too hard". One can't blame the customer or the dealer for such comments, because the customer or dealer is usually quoting what they feel is obvious. It is up to the furniture manufacturer to thoroughly investigate all of the potential causes of the complaints and to technically define those complaints. Then proper solutions can be derived.
- 0.8 The question of in-use durability is difficult and complex, but it is not impossible. There are many questions and differences of opinions as to which of the physical properties predict in-use performance. There are also many questions and differences of opinions as to how to test for the durability properties; but even with these questions and differences, there remains some good, common-sense, technically-based methodology for choosing good, durable foams.
- 0.9 More often than not, it is the lot-to-lot variation in a particular physical property that causes problems. For example, the absolute value of tensile strength above 8 p.s.i. bears little relationship to how a particular foam might perform in use or in the plant; but a lot-to-lot change in tensile strength of say 15-20% could be a harbinger for serious problems in the plant or in the field.
- 0.9.1 International environmental regulators have brought about the need to reformulate many polyurethane foam formulations. This reformulation has the potential to affect some of the physical properties of foams, such as hysteresis and flex fatigue. At this time, the total effects of the reformulation are not known.

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0.9.2 It is the hope of The Joint Industry Foam Standards And Guidelines Committee that this standards and guidelines publication will greatly assist the furniture manufacturer and foam manufacturer to make sensible, prudent, and technically sound selections of polyurethane foams for all furniture applications.

- 1.1. Density continues to be one of the most misunderstood properties of polyurethane foams. Some people mentally relate density to the firmness of foams, and that relationship is totally incorrect. Foams with an extremely wide range of hardness can be made at an extremely wide range of densities.

25% IFD (indentation load deflection, see chapter 4) is a measure of the hardness of foams; and for example, a 20 pound/50 in² IFD can be made at densities ranging from 1.0 PCF (pounds per cubic foot) to 10 PCF. The key is that density is in no way related to IFD.

- 1.2. The following chart demonstrates the commercial densities of flexible polyurethane foams used in furniture manufacturing in the United States:

CHART 1.2

GENERAL FOAM TYPE	COMMERCIAL DENSITY RANGE
CONVENTIONAL FOAMS	0.8 TO 2.5 PCF
FILLED CONVENTIONAL FOAMS	1.5 TO 5.0 PCF
HIGH RESILIENCY (HR) FOAMS	1.5 TO 6.0 PCF
COMBUSTION MODIFIED HR FOAMS	3.5 TO 10.0 PCF
MODIFIED HR FOAMS	1.5 TO 3.5 PCF
MELAMINE MODIFIED FOAMS ^a	1.5 TO 4.0 PCF
FOAMS FOR CALIFORNIA TB-117 ^b	1.3 TO 2.0 PCF

- a. Melamine modified flexible polyurethane foams can be made over a wide range depending on the flame retardancy requirements.
- b. California TB-117 foams can be made in a very wide variety of densities depending on the user's needs and requirements.

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- 1.3. Density is mass per unit volume. However, in the United States, density is expressed in pounds per cubic foot (PCF), and is calculated as follows:

$$\text{DENSITY} = \frac{\text{WEIGHT OF SAMPLE (pounds)}}{\text{LENGTH(ft)} \times \text{WIDTH(ft)} \times \text{HEIGHT(ft)}}$$

For example, suppose a typical cushion measures 24 inches x 24 inches x 4 inches, and weighs exactly 2 pounds. The density of the sample is calculated as follows:

first, since density is expressed in pounds per cubic foot, the dimensions must be converted from inches to feet: 24 inches divided by 12 inches per foot equals 2 feet, and 4 inches divided by 12 inches per foot equals 0.33 Feet. The sample was weighed in pounds. The density is calculated by then substituting the converted dimensions into the equation:

$$\frac{2 \text{ (pounds)}}{2 \text{ (ft)} \times 2 \text{ (ft)} \times 0.33 \text{ (ft)}} = \text{DENSITY}$$

$$\frac{2 \text{ (pounds)}}{1.32 \text{ (cubic feet)}} = \text{DENSITY}$$

$$1.52 \text{ (pounds per cubic foot)} = \text{DENSITY}$$

the density of the sample cushion is then 1.52 Pounds per cubic foot. If the sample is weighed in grams, the grams must be converted to pounds by dividing the weight, in grams, by 454 grams/pound. Then the density is calculated just as it was calculated above.

- 1.4. There are some guidelines in measuring and weighing samples for density computation:
- Always work with the largest possible sample, because normal weighing and measuring errors become smaller as sample size increases (to a point,) and weighing and measuring errors become larger as sample sizes get smaller.

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- b. For dimensional measurements, use the most accurate measuring equipment you can buy (a common yard-stick is seldom accurate enough, but a calibrated yard-stick IS ADEQUATE)
- c. In measuring dimensions, one must remember that flexible foams bend, contort, and stretch; thus, these factors must not be at all involved in foam dimension measurements.
- d. The formula used for measurement of foam densities is based on the fact that the foam is either perfectly square or rectangular in all cross-sections-regardless. If any cross-section is something other than perfectly square or rectangular, the density calculation will be incorrect to the degree that the particular cross-section is not rectangular or square. This is a common error in measuring for calculating density.
- e. Usually, the greatest errors in measuring occur in measuring the thickness of the density sample. One excellent way to measure sample thickness is with the indenter foot of an IFD measuring device (Reference ASTM D-3574 b₁).
- f. When weighing a sample for density calculation, a scale with adequate pan size to accommodate the sample size should be used. Don't ever try to balance the foam sample on a small pan or try to keep it from falling by stabilizing it with your hand. Secondly, never try to weigh in the extreme upper or lower end of the weighing range of the scale used because this is where most of the large weighing errors occur. The calibration accuracy of the scale should be checked, routinely, with known, calibrated weights. For the sake of accuracy, many laboratories weigh density samples on gram scales and convert the gram weights to pounds. This procedure is usually very acceptable, because many metric-system laboratory scales are very accurate.

1.5. DENSITY TOLERANCES

There are two basic ways of specifying density tolerances. One is to specify a minimum density. For example, one could specify a foam with a minimum density 1.8 PCF, and all densities for that foam under 1.8 PCF would be considered to be out of specification.

Secondly, one could specify a nominal density with a plus or minus tolerance. For example, one could specify a 1.8 PCF foam with a tolerance of plus or minus 0.1 PCF. This specification would normally be written as 1.8 +/- 0.1 PCF. Thus, all densities for that foam under 1.7 PCF and over 1.9 PCF would be out of specification.

The choice of how one should specify density tolerance is not necessarily dictated by technical considerations as much as economic considerations. One should remember that, in general, smaller tolerances mean higher prices.

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Thus, it is generally accepted that a minimum density specification is preferred. If plus or minus tolerances are used, the traditionally acceptable, commercial tolerances are a nominal density plus or minus 0.1 PCF.

1.6. SOME OTHER IMPORTANT FACETS OF DENSITY

One of the best uses of density measurements is quality control screening. Completely testing all foams received every day is not absolutely necessary; however, there are some key properties which should be tested on each shipment received. These properties can be indicative of changes which could cause serious in-use or in-plant problems. Density is one of these properties. For example, suppose one is buying a 1.6 plus or minus 0.1 PCF foam, and for the last two months the density has been checking from 1.50 PCF to 1.61 PCF. However, on today's shipment, the density measures 1.7 PCF.

Today's shipment is still within specification, but there is almost a six percent change over recently received shipments. At the very least, one should ask the vendor for all the physical property tests

made on this particular lot of foam, and then, one should review his concerns with the vendor's technical personnel. Because of the complexities of the chemistry of polyurethanes, there are many things that can happen during the manufacturing of foams. A 6% change in density may be meaningless, but it is always best to be cautious. In any good quality control process, the magnitude of relative changes should raise concerns.

1.7. MANAGEMENT OF DENSITY SPECIFICATIONS

Something should be suggested concerning the management of specification ranges and acceptance/rejection criteria. Look again at the 1.6 plus or minus 0.1 PCF foam. As before, suppose that one has been receiving a density range from 1.5 PCF to 1.61 PCF for the last two months. Now, suppose today's shipment measures 1.48 PCF! Do we reject the shipment?

The first thing that should be done is to recheck several other samples, and let's assume that some of them also measure 1.48 PCF; now, do we reject? Rejection isn't recommended unless some of the other physical properties--notably IFD--are out of specification. Why wasn't rejection recommended based on the 0.02 PCF out of density specification?

First of all, 0.02 PCF is just about the maximum precision to which density can be measured under the best of circumstances; so, those densities could well have been 1.50 rather than 1.48 PCF when one considers the error of measurement potential. It could be stated that we are giving 10 times the 0.02 PCF variance when we use a plus or minus 0.1 PCF tolerance on the nominal. That is true as far as it goes, but the error applies throughout the entire range on the

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nominal. One could view it this way; the plus or minus 0.1 PCF tolerance is related to how well the foam manufacturing process can be controlled and replicated from day-to-day, and the 0.02 PCF is the smallest error one can expect when weighing and measuring to calculate density. Secondly, perfectly harmless things can and do happen in the foaming process. Some of these happenings can affect density to the degree we have been discussing, and, if one part of a shipment is out of specification by 0.02 PCF, while every thing else in that shipment is in specification, there is a very high probability that it is safe to use that shipment of foam.

If the next several shipments, however, are out of specification by 0.02 PCF or more, one should then contact the vendor and suggest rejection if the density isn't shipped within the agreed upon range.

1.8. FOAM DENSITY VERSUS QUALITY/DURABILITY

The issue of foam density versus foam quality and durability is a very volatile and misunderstood issue. If quality is taken to mean performance to standard (specification), density has absolutely nothing to do with quality. If, for example, a 0.8 PCF foam is within the specifications originally agreed-upon by buyer and seller, the foam is within the expected quality standards and quality is not the issue.

It is very easy to understand the reason for the disparity between quality and durability and the resulting confusion; it is because quality and durability have typically and sometimes traditionally been used synonymously. Durability is described by that property or group of properties which describe or predict how a piece of foam will perform or fail to perform for a satisfactory period of time while in use. In certain well defined circumstances, using the properly applied, statistical theory of probability, it can be stated that density can affect durability directly. The major durability issue is in-use loss of load bearing characteristics or softening. This has classically and traditionally been called flex fatigue or just fatigue. Thus, a more accurate and acceptable statement concerning the effect of density on fatigue properties of polyurethane foams is: as densities of conventional, unfilled foams decrease, the tendency to fatigue soften increases.

Sorting out absolutes on the scale of available densities is very difficult; for example, the magnitude of how much a 1.4 PCF foam softens compared to a 1.6 PCF foam is not yet known, quantitatively.

An acceptable statement says only that the probability of in-use softening is greater with lower density foams. It is a virtual certainty that a 1.3 PCF density foam with a 32 IFD @ 25% will soften excessively in normal use as a seat cushion; conversely, it is virtually an equal certainty that a 1.8 PCF foam will soften less than the 1.3 PCF foam in the same in-use circumstances. The magnitude of the difference in softening between the two foams has not yet been quantitatively and statistically determined or proven.

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The statement that 1.8 PCF foams are always better than lower density foams is also an exaggeration of the true facts. Every manufacturer of foams will admit that it is just as easy to err when making a high density foam as it is when making a lower density foam. High density is not the total guarantor of good, in-use performing, durable foams. One must note the use of the words statistical probability and then understand that it is only probable that higher density foams will be more durable than low density foams. The magnitude of the degree of probability is not yet known, and, presently, only a statistical trend exists. The more accurate statement is then: it is highly probable that 1.8 PCF foams will soften less than foams of lower density.

It must be noted that the performance and durability statements made above only apply to conventional, unfilled foams. Separate performance and durability statements must be made on other foam types.

1.9. BALLOTED STATEMENT ON DENSITY VERSUS FATIGUE ON IN USE PERFORMANCE

The following statement was passed by committee ballot:

Years of experience, supported by considerable test data, have given strong indications that polyurethane foams with polymer densities of 1.8 PCF or higher perform better in seating applications than foams with lower polymer densities.

Chapter 2.0 TENSILE STRENGTH, TEAR STRENGTH, AND DELONGATION STANDARDS AND GUIDELINES

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2.1 Tensile Strength

2.1.1 Tensile strength is measured using the method specified in ASTM D3574. Generally, acceptable tensile strengths are above 8 p.s.i. depending to some extent on the final application of the flexible foam. There are some cases where lower tensile strength foams may be used, but it is generally advisable to use foams that have a tensile strength of at least 8 p.s.i.

2.1.2 Tensile strength alone should not necessarily be used to indicate potential foam problems or to accept or reject shipments of foam. The change in tensile strength from

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shipment to shipment or lot to lot is a better indicator of potential problems. For example, a particular grade of foam has been running at a tensile strength of 16 p.s.i. plus or minus 2.0 p.s.i. for three or four months, and suddenly, with the next shipment, the tensile strength drops to 8.5 psi. Then, the 7.5 p.s.i. drop in tensile strength should be cause for concern.

- 2.1.3 When significant changes occur (significant is defined as changes more than the original stated specification tolerances), the vendor should be alerted, and together, the remainder of the properties and test methods on the lot of foam in question should be rechecked.
- 2.1.4 If the changes are real and not due to testing errors, the testing equipment (yours and the vendors) should be recalibrated. Tensile changes of the order of magnitude mentioned do not occur unless something drastic has changed, and the changes will, in most cases show up in the other physical properties of the foam.
- 2.1.5 The key point is that the change in tensile strength from lot to lot is the most important factor. In the more than thirty years that polyurethane foams have been used in furniture, no one has yet defined the absolute values of tensile strength needed for each furniture application. Decisions have been made using much trial and error and the personal experience of the individuals testing the foams in furniture applications. However, it has been clearly observed that significant changes in tensile strength can be prime indicators of significant variations in other more important physical properties, such as density, IFD, compression set, and flex fatigue.
- 2.1.6 The most serious upholstery problem with low tensile strength is associated with handling of the foams within the upholstery plant and pulling and tugging of the foam during upholstery prepadding. Manual carrying, loading, and unloading foams within a manufacturing operation can lead to tensile breaking. The pulling and tugging associated with upholstering and stapling foams to the frames when they are used as underpadding can also produce tensile breakage with some low tensile foams.
- 2.1.7 When foams exhibit tensile breaks in actual, in-use circumstances, it is virtually given that the upholstered piece has been abused or that the original foam tensile and/or tear strength were exceptionally low in the beginning. Both conditions are relatively easily determined by careful testing and records management.
- 2.1.8 Most furniture manufacturers accept the tensile strength test results of their vendors rather than to routinely test for tensile strength themselves. However, the furniture manufacturers should have the equipment and the ability to perform tensile strength tests for random cross checks and their own R&D efforts.

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2.1.9 The major factors which may result in tensile strength testing errors include:

- 1--nick or burr in cutting die
- 2--poor measurement of cross-sectional area
- 3--irregular cutting of sample
- *4--excessively high jaw-separation speed
- *5--excessively low jaw-separation speed
- 6--improper reading or recording on force gauge
- 7--improperly calibrated force gauge
- 8--existing, unseen tears or cuts in sample
- 9--slippage of sample in jaws

*Since ASTM D-3574 permits a rather wide range on jaw-separation speeds, it is highly recommended that each furniture company should come to an agreement with their vendors on jaw-separation speeds to be used during testing.

2.2 Tear Strength

- 2.2.1 Tear strength is measured using the method specified in ASTM D-3574. Acceptable tear strengths begin at approximately 1.0 pounds per lineal inch (p.l.i.). As the tear strength progresses below 1.0 pounds per lineal inch, in-plant handling problems are virtually inevitable.
- 2.2.2 Rubber latex foams, which were in wide use in the furniture industry thirty years ago, had tear strengths which were mostly under 1.0 p.l.i.; and these rubber latex foams also presented some very serious in-plant handling tearing problems. Today, some of the more esoteric foams and highly filled foams can present the same in plant handling problems; thus, the furniture manufacturer must carefully evaluate all new foams for potential handling problems.
- 2.2.3 Tear strength is a greater problem than tensile strength in handling within the plant. Employees tend to get a fist full of foam when handling foam cushions, and this method of handling sometimes tears even the best of foams.

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- 2.2.4 Tear failures on foams in use are relatively infrequent and are mostly associated with shear forces such as squirming or shearing the cushion across the top of the front rail or shearing the top of an arm with the hands while getting out of a chair or sofa.
- 2.2.5 Often, foams are drilled or punched (including cushions) to receive button straps or twines, and tear failure around the drilled or punched holes are inevitable with foams exhibiting tear strengths significantly less than one pound per lineal inch, unless the foam is protected in some manner.
- 2.2.6 Shear forces during the shipment of upholstered goods can also create tear problems with some low tear strength foams. Many of these problems are simply but inappropriately blamed on the trucker. In many cases, a careful, thorough investigation may show that the foam tears were not the result of poor handling or loading/unloading but were the result of low tear strength.
- 2.2.7 Low tear strength can also be related to fatigue softening. As is the case with much of the furniture related polyurethane foam data, quantitative proof of the relationship between low tear strength and fatigue softening does not exist. However, there is enough trend type data to be concerned about the possible effects of low tear strength on fatigue softening.

The theory of what may happen during flexure lies with the fact that foams are made of billions of tiny gas bubbles (cells) which have very thin cell walls. The total tear strength (as is all of the other properties) is the sum of the strengths of adjacent cell walls. In the case of low tear strengths, each of the cell walls has low resistance to tearing, and in concentrated loading of shear forces or impact loading during sitting there may not be enough cell-wall strength to resist tearing. The cell wall tearing may occur on just a few cell walls, but with time and continued shear loading or impact loading, theoretically, enough cell walls could tear to affect the load bearing properties of the foam, resulting in softening. This type of softening is obviously irreversible.

- 2.2.8 Relative changes in tear strength can be indicators of potential problems. As was the case in tensile strength, shipment to shipment (or lot to lot) changes in tear strength can be indicators of many serious problems in foam formulation monitoring, changes within a run, or changes in the chemicals used. Tear strength should be monitored carefully.

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2.2.9 The major factors which may result in tear strength testing errors include:

- 1--nick in sample cutting die
- 2--poor sample cutting
- 3--undetected tears or voids in sample
- 4--incorrect sample dimensional measurement
- *5--excessively fast jaw separation speed
- *6--excessively slow jaw separation speed
- 7--incorrect reading of force gauge
- 8--slippage of sample in jaws
- 9--tear-out too quickly
- 10--improper calibration of force gauge

*Since the ASTM allows quite a wide range on jaw separation speed, it is highly recommended that furniture manufacturers should agree precisely with their vendors on an exact speed of jaw separation.

2.2.9.1 Most furniture manufacturers accept the tear strength tests results of their vendors. However, the furniture manufacturer should have both the equipment and the ability to test for tear strength for purposes of cross-checking and their own R&D efforts.

2.3 Elongation

2.3.1 The elongation (elongation at break) is measured using the method specified in ASTM D-3574. Elongations of under 100% have classically been suspect for potential problems; however, no single production problem or field problem has been statistically quantitatively associated with low elongation. Certain practitioners use the old adage, "if it doesn't stretch it'll break". This is certainly true to some extent, but as the adage relates to upholstered furniture in use and manufacturing foam performance, valid proof has yet to be produced.

2.3.2 It is not possible to judge the performance of any flexible polyurethane foam by using any single physical property alone, and elongation is no exception, but there are some good and acceptable "rules of thumb." Low elongation accompanied by low

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tensile strength and low tear strength is a definite cause for concern--particularly when evaluating new foam types for upholstery applications and when looking at lot to lot variations of foam physical properties.

- 2.3.3 As was the case in tensile and tear strength, the change in elongation from shipment to shipment or lot to lot is of more importance than the absolute value of the elongation. For example, if, for the past several weeks, shipments of a specific foam type have ranged from 130% to 150% elongation; and if today's shipment of the same foam is 105% elongation, a change of this order of magnitude is cause for concern; and it is almost a given that significant changes in tensile strength, tear strength, compression set, fatigue, or IFD will also be found.
- 2.3.4 Elongation by itself is a poor indicator of potential field or in-use problems, but changes in elongation and particularly those which occur along with changes in other physical properties should give rise to much concern and equivalent cross-checks and investigation for the facts.
- 2.3.5 Most furniture manufacturers accept the elongation test results of their vendors rather than to, routinely, test for elongation themselves; however, the furniture manufacturer should have both the equipment and the ability to test for elongation for purposes of routine cross-checks and their own R&D efforts.
- 2.3.6 The major factors which may result in elongation testing errors include:
- 1--improper benchmarking
 - 2--if the benchmark separation is measured visually, simple errors in reading the moving scale can be made (these are the most common errors)
 - 3--if the benchmark separation is measured visually and the elongation is relatively high (meaning large distance of separation of the benchmarks) eye angle errors called parallax errors can occur.
 - 4--Parallax errors can occur also in low elongation situations.
 - 5--If the benchmark separations are measured automatically by the testing equipment, slippage in the jaws can occur.
 - 6--In the automatic measurement circumstance, improper calibration of the test equipment causes errors.
 - 7--Excessively fast or slow jaw separation can cause errors.

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8--While running higher elongation samples, the bench-marks may fade or become difficult to read while being stretched.

9--Undetected tears or voids in elongation sample

Chapter 3.0 IDENTIFICATION AND MARKING OF FABRICATED COMPONENTS STANDARDS AND GUIDELINES

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3.1 Explanation of Need

The seemingly trivial details of marking cushions for identification can cause major quality problems for the furniture manufacturer. Details such as type of ink used, color of ink used, and location of marks determine whether or not the upholsterer will be able to mask over the identification marks with the cover fabric, particularly if the cover fabric is of a lightweight construction or a light color. Also, the serviceability of the construction in the field is affected relative to the cleanability of the cushion without causing bleeding of the marking ink onto the cover fabric. In an effort to diminish the frequency of these problems, the subsequent guidelines have been established by the Joint Industry Polyurethane Foam Standards and Guidelines Committee.

3.2 Solvent Fastness of Inks

All identifying markings on foams should be made using indelible ink which will resist bleeding when the cushions are sprayed with retail applied fabric treatments or wet with cleaning solutions.

3.3 Location of Identifying Markings

All identifying markings on foam should be made on the edge defined as the back of the pillow or cushion, when possible. Avoid front edge markings, which can telegraph through light color cover fabrics.

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3.4 Color of Identifying Mark

Marks should be made in colors agreed upon by the foam supplier and the upholstery manufacturer.

3.5 Types of Markings to Be Used

Information such as foam type, manufacturing dates, lot numbers, product numbers, etc. to be marked on cushion edges should be agreed upon by the foam supplier and the upholstery manufacturer.

3.6 Wrapping Materials

Wrapping materials for the transportation and handling of fabricated foam components should be agreed upon by the foam supplier and the furniture manufacturer.

Chapter 4.0 INDENTATION FORCE DEFLECTION (IFD) STANDARDS AND GUIDELINES

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4.1 To the furniture manufacturer and final user of a piece of furniture, one of the most important quality questions is related to the firmness of the seat cushions. The firmness of a polyurethane foam cushion is measured by a physical property called the indentation force deflection (IFD).

4.1.1 The history of describing firmness is very interesting. Prior to the advent of polyurethane foams, rubber latex foams were in wide use for furniture cushions. The term used to describe the firmness or softness of foam rubber was RMA, which stood for Rubber Manufacturers Association. RMA was measured only slightly different from the way IFD is measured today.

4.1.2 When polyurethane foams arrived on the scene, they weren't associated with the rubber industry, so the acronym "ILD" was developed. "ILD" stood for "indentation load deflection." During the drive for conversion to the metric system in the late seventies, the American Society of Testing and Materials decided that in all of their publications and test methods, the metric system would be used.

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Because the ASTM insisted on the use of the word "force" rather than "load," the term "IFD" came into common use--replacing "ILD." IFD stands for "Indentation Force Deflection and the actual test method is basically identical to the older ILD test.

4.2 It should be noted that the foam IFD is only one of the contributors to the comfort of a furniture seat cushion. There are many other contributors, and some of these have already been discussed.

4.2.1 In this publication, The Joint Industry Committee has purposely avoided using the word "comfort" directly associated with IFD or IFD properties. Suffice to say, IFD is a part of the comfort equation, but IFD is not always related directly to comfort. For example, one cannot say that a 25% IFD of 26 lbs/50 in² always produces comfort, while a 25% IFD of 40 lbs/50 in² does not produce a comfortable seat. Comfort is not directly related to the magnitude of the IFD number alone.

4.2.2 IFD is defined as the amount of force, in pounds, required to indent a fifty square inch, round indenter foot into a predefined foam specimen a certain percentage of the specimen's total thickness. IFD should always be specified as a number of pounds at a specific deflection percentage on a specific height foam sample, e.g., 25 pounds/50 in² at a 25% deflection on a four inch thick piece. Different IFD values will be obtained if a different percentage deflection is used or if the height of the test specimen is different.

It is also necessary to report the entire sample size. Sample size, in addition to thickness, can drastically influence IFD readings. Flexible polyurethane foams can be made in a very wide range of IFD's. To get a good feeling of the potential uses of each of the various IFD ranges, the following chart should be of some assistance:

IFD @25% DEFLECTION END USE
(pounds/50 in² on 20 "x 20"x 4")

6--12 Bed pillows, thick back pillows

12-18 back pillows, upholstery padding, wraps

18-24 thin back pillows, tufting matrix, very thick seat cushions,wraps

24-30 average seat cushions, upholstery padding, tight seats, certain mattress types,quilting

30-36 firmer seat cushions, mattresses

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36-45 thin seat cushioning and firm mattresses

45 & up shock absorbing foams, packaging foams, carpet pads, and other uses requiring ultra-firm foams.

The above table should only be used as a beginning guideline. The actual IFD required is a function of many things, such as the design type, spring type used, and other parameters within the actual furniture construction.

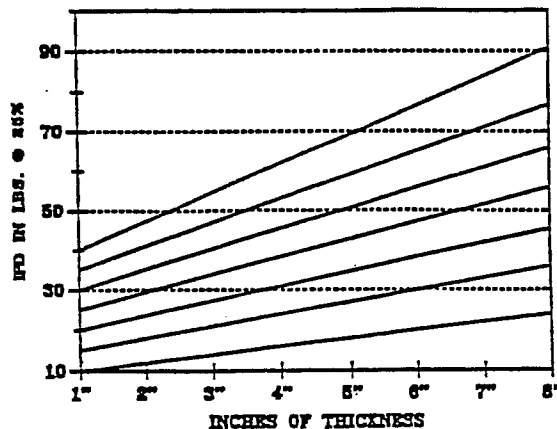
- 4.3 IFD varies significantly with foam thickness. On the exact same foam, the IFD increases as the thickness increases, as the following chart illustrates:

All samples are 20" x 20" x stated thickness.

Sample thickness (inches)	IFD at 25% deflection (lbs/50 in ²)
4-	28.0
5-	31.0
6-	34.5
7-	38.5
8-	43.0

IFD values in the above table were obtained from testing actual foam samples. These values should not be used as anything but a guide. The actual magnitude of the IFD versus thickness change must be determined for each foam type (see Figure 1). A simple "rule of thumb" on the degree of change is rarely accurate.

FIGURE 1
IFD CONVERSION CHART



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Notice in Figure 1 that the IFD increases with cushion thickness as you read from left to right. For example, if the IFD of a 2 inch thick cushion is 6.7 lbs/50 in², one could expect the IFD of that IDENTICAL foam, if it were 8 inches thick, to be approximately 16 lbs/50 in². However, the rate of IFD increase with increasing cushion thickness also varies with increasing IFD. Note in Figure 1 how the slope of the IFD-thickness line increases as the IFD increases, which shows that the foam thickness effect is essentially "compounded" at higher IFD levels. Please keep in mind that the values represented on this graph are approximate and are displayed here only for visualization of the concept.

- 4.3.1 The question arises, why does the 25% deflection IFD increase with sample thickness? The reason is that, as the thickness increases, the physical amount of deflection increases. For example, to obtain a 25% IFD on a 4" thick sample, the 50 in² deflector foot is indented into the foam one inch; and to obtain a 25% IFD on an 8" thick sample, the 50 in² deflector foot is indented into the foam 2". Obviously, even on exactly the same foam, the 8" sample IFD reading will be higher because the foam is being indented (deflected) much more. The following chart demonstrates the IFD/thickness concept more clearly:

Foam Sample Thickness (inches)	Amount Of Deflection (inches) Required For 25% IFD
4-	1.00
5-	1.25
6-	1.50
7-	1.75
8-	2.00

- 4.3.2 The key point to remember is that when measuring IFD's, the actual thicknesses and deflection values must be accurately measured. One can never assume that a 4" sample is exactly 4" and run the deflection accordingly.
- 4.3.3 In the ASTM test method, the original sample height is measured by using a one-pound load on the sample using the 50 in² indenter foot and the height measuring equipment on the IFD machine. This procedure is called "a one pound pre-load" and is done to attempt to cancel any small variations in height just under the indenter foot.
- 4.3.4 There are also significant problems in trying to cut flexible foams to exact dimensions, yet the IFD test requires very exacting dimensional measurements. This fact must be kept in mind when setting up any type of testing program for IFD. There are many

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potential errors inherent in the IFD test itself. It is of supreme importance that one accurately controls all of the dimensional, force, and time measurements specified in ASTM D 3574.

NOTE: For the sake of simplicity, from this point forward, it will be assumed that unless specifically stated otherwise, all IFD and IFD associated measurements were made on a minimum 20" x 20" x stated thickness samples, and that the indenter foot is always round and 50 in² in area. Thus, henceforth in this standards and guideline document, the IFD values will only be reported in lbs at the stated deflection; and the "per 50 in²" will be omitted.

4.4 Temperature and Humidity Effects on IFD

4.4.1 Little has been published in the public or industry domains regarding the quantitative effects of varying temperatures or humidities on the IFD properties of flexible polyurethane foams. There is, however, a great deal of inferential and observational information on IFD variation caused by varying temperature and humidity within the polyurethane industry itself.

4.4.2 There are two distinctly different--and often confused--effects of temperature and humidity on the IFD of flexible polyurethane foams:

- a. effect when pouring the foam
- b. effect when measuring actual IFD

4.4.3 The effects of temperature and humidity during the actual pouring of the flexible foams are called "summertime IFD regression." In the summertime, the IFD's of flexible foams regress or decrease on the average from their wintertime values. For example, let's say that a particular foam grade had been averaging a 25% IFD of 32 lbs during the months from October to June. From June through September, if the same foaming formulation were used, the average 25% IFD attained would be something significantly less than 32 lbs.

Although no significant research has shown the actual quantitative, numerical relationship between summertime temperatures and humidities and IFD, it is a well known fact that foamers must (and do) adjust their formulations to compensate for the differences. Lacking quantitative relationships, most of the formulation adjustments are empirical and experience related.

4.4.3.1 The key point about summertime IFD regression is that it is not reversible once the foam is made. In other words, once the foam is poured in a condition that produces IFD regression, the IFD amount lost is lost forever and is not recoverable.

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4.4.3.2 It is thought, however not quantitatively proved, that the summertime IFD regression is more a function of "absolute humidity" rather than "relative humidity."

4.4.3.3 See Appendix A3.0 for further explanation of humidity and temperature.

4.5 Another very significant source of variation of IFD is with testing equipment, i.e., from one piece of testing equipment to another. IFD is very difficult to reproduce even when using the same machine. When the additional element of different testing machines is added, the complexity increases, and the ability to reproduce test results decreases.

4.5.1 To investigate this variable, the following interlaboratory round robin was run:

4.5.2 Samples taken from the same bun location and cut to exactly the same thickness and lateral dimensions were sent to five testing laboratories who had the same testing machine models.

4.5.3 The labs involved were accurately temperature and humidity controlled. The samples were 15x15x4 inches and were all cut on the same piece of cutting equipment. Samples which did not measure 4.0" plus or minus 0.05" with the one pound preload were discarded. All samples were measured by the same person on the same piece of measuring equipment.

4.5.4 The testing labs were requested to condition all samples for a minimum of 36 (not 24) hours, and the preflex and indent speeds to be used were specifically defined. It was also asked that each lab should calibrate both preflex and indent speeds as well as to recalibrate the load cell (load measuring device). So, in this test, every known and controllable variable has been defined and calibrated. The results were as follows:

Lab Number	Sample 1 25% IFD lbs	Sample 2 25% IFD lbs	Sample 3 25% IFD lbs
1	28.0	27.0	28.5
2	27.5	26.0	26.5
3	27.0	27.0	28.0
4	28.5	27.5	27.5
5	28.0	26.0	27.0

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Even with all of the most careful controls, using the best available testing equipment, there remains some variability in the IFD results.

4.5.5 There are enough problems in the reproducibility of the IFD test to give rise to a question of the inherent accuracy of the test. Analysis of the data in 4.5.4, as well as other similar data, indicates that the reproducibility of the IFD measurements even under the best of circumstances is approximately plus or minus one pound. However, under normal testing and production circumstances, the variability is substantially greater.

4.5.6 Another source of IFD variation is from the foam manufacturing process itself, i.e. within a foam run and from run to run. The chemicals used to make foams vary from lot to lot; and the production pumps, temperature controls, and mixing equipment also have tolerances of variability.

A variety of processing variables can create variations in all of the foam's physical properties. Changes made by the foam chemists and engineers during a run of foam may create additional variations in the final physical properties of the foam.

4.5.7 Another source of variation in IFD is the variation from top to bottom and side to side within the manufactured buns. There is also potential IFD variation from front to back within a bun.

The following chart exemplifies the variations in IFD in a typical bun cross section. The horizontal lines represent 4" slices, and the vertical lines represent segmentation side to side into three 26" sections. A leveling cut of 2.5" was cut from the top of the bun; one inch thick side trim was removed from each side of the bun, and a bottom skin of 1.0" thickness was removed. The average density of the foam within the bun was 1.82 PCF. The 25% IFD's are noted in each 4" thick section:

25.0	25.5	24.5
25.5	26.0	25.0
26.5	27.0	27.0
27.0	28.0	28.5
28.5	28.0	27.0
29.5	29.0	29.0
29.5	29.5	28.5

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Note: The nearest 0.5 pound is reported as a matter of tradition only and does not reflect the precision of the test.

Note: The magnitude and position of the variation in the above example is only indicative of the bun that was actually tested. Other buns of the same foam type are likely to show more or less variation.

Examining the bun IFD data in the above chart indicates that there is a 4.5 pound maximum variation in IFD from top to bottom, and there is a 1.5 pound variation from side to side within this particular bun. There are several important things to note about the above bun IFD variation data:

- a.. Variances shown by this data are slightly better than average, in that, top-to-bottom IFD variances of 6.0 pounds (and even more in some cases) have been measured; and side to side differences of 2-4 pounds have also been measured.
- b.. It should be remembered that the above bun IFD data also contains the typical errors normally involved in measuring IFD.
- c.. The key point to remember is that the IFD will vary significantly. One should work with the vendors involved to develop reasonable IFD specifications.

4.5.8 Another significant source of IFD variation is variation with the size of the sample tested. For example, on the exact same piece of foam, the IFD on a 24" x 24" x 4" will be higher than on the same piece of foam cut 15" x 15" x 4". In this case, the furniture manufacturer is in a quandary. Because the ASTM standard test method for IFD permits the use of a 15" x 15" x 4" size sample, many foamers have established their background data bases on 15" x 15" samples.

Background and databases notwithstanding, it is much more accurate for the furniture manufacturer to calibrate seating comfort and the day-to-day replication of seating comfort using foam sample sizes that are closer to actual seat cushion sizes. Thus, it is recommended that the furniture manufacturer should specify IFD's based on a minimum sample size of 20" x 20"x purchased thickness. The following chart demonstrates typical variation of IFD with sample size:

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Sample Number	Sample Size (Inches)	25% IFD (lbs)
1	15 X 15	24.0
2	16 X 16	24.0
3	17 X 17	24.3
4	18 X 18	24.8
5	19 X 19	25.5
6	20 X 20	26.0
7	21 X 21	26.0
8	22 X 22	26.3
9	23 X 23	26.0
10	24 X 24	26.3
11	24 X 24	26.5
12	25 X 25	26.3
13	26 X 26	26.5
14	27 X 27	26.5
15	28 X 28	26.3
16	29 X 29	26.3
17	30 X 30	26.3

This chart demonstrates that most of the IFD variation occurred on sample sizes under 20" x 20". There was some variation from 21"x 21" to 30" x 30", but it was small compared to the variance under 20" x 20". The above data is the average of 10 replications.

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- 4.5.9 One may question the cause(s) of variation of IFD with sample size. The predominant reason for IFD variation with sample size is "edge effect." If one watches the edge of the round indenter foot while measuring IFD's, it is seen that all of that foam under the foot moves downward relatively uniformly, but the foam immediately adjacent to the compressed foam is stretched to varying degrees. The sample width-length, the elongation of the foam being tested, and the stiffness of the foam will impact the edge pull. The edge effect approaches a constant factor as the sample size is increased beyond 20" x 20".

4.6 The 65% IFD And Support Factor

To this point, only the 25% deflection IFD has been discussed because the 25% deflection value is usually the value used for specifying the foam grade. Because IFD is stated at a percentage of the thickness of the foam being tested and used, any percentage IFD could theoretically be used. For example, in Europe, instead of using the 25% IFD for day to day definition of foams, the 40% deflection IFD is used.

In the United States, the 65% IFD is commonly measured but is not typically used in specifying the foam. The 65% IFD value is used to calculate another foam property --support factor. The 65% IFD is the amount of force necessary to deflect the sample 65% of its original thickness after obtaining the 25% deflection value as directed in the IFD procedure.

- 4.6.1 The support factor of any foam is defined as the unitless value obtained when the 65% IFD is divided by the 25% IFD of the same piece of foam. For example, if a particular piece of foam has a 25% IFD of 30 lbs and a 65% IFD of 60 lbs, it has a support factor of 2.0. From a practical standpoint, support factor values run from 1.7 to 3.0.
- 4.6.2 Support factor provides an indication of support characteristics not correlated with any other foam property. It is very rare for foams under 1.4 PCF density to demonstrate support factor values over 1.8 to 1.9.
- 4.6.3 Support factor can be related to comfort of furniture. Higher support factor foams of the same 25% IFD will provide more load bearing at higher deflection values. It has also been claimed that with higher support factor values, softer foams may be used in cushions.

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5.1 Explanation of Need

This test method is intended to be a quick, simple quality control screening method for full size unwrapped cushions and slabs. The acceptable IFD ranges, as determined by the 1" Deflection Test Method, are to be specified by agreement between supplier and buyer. A one inch indentation deflection test is a useful tool as a "quick check" or screening method for approximating 25% IFD ranges on the fabrication or furniture factory floor. It can be used as a quick inspection for the correct grade of foam or to observe if a cushion meets an "at thickness" specification without cutting the cushion down to a 4" thickness.

5.2 Explanation of Method

5.2.1 For test specimens 3" to 4" in thickness:

Length and width of the test specimens are a minimum 24"x24". Using the indenter foot, measure the original height of the foam specimen using the one pound preload procedure in ASTM-D3574. Then preflex the test specimen 75% of its original thickness two (2) times. Before removing the test specimen from under the indenter foot, draw the diameter of the indenter foot on top of the test specimen using a felt tip marker. When circumscribing the indenter foot on the test specimen, be certain that the test specimen is not moved laterally in any direction from the exact location where it was preflexed with the indenter foot. The circumscribed circle will be used for exact relocation of the indenter foot after the required waiting period. After preflexing, a waiting period of 6.0 minutes plus or minus 1.0 minute is to be observed before performing the 1" deflection IFD.

The preflex indentation speed, the indenter foot, and the final indentation speeds are the same as specified in ASTM D-3574.

After the six minute waiting period, the test specimen height is again measured by using the one pound preload procedure in ASTM-D3574. The indenter foot is indented into the foam exactly 1.0" and after a sixty second plus or minus 3 second wait, the 1.0" indentation IFD is read from the force gauge.

5.2.2 For test specimens 4.0" to 6.5" in thickness:

On 4.0" to 6.5" thickness test specimens, the amount of deflection during preflexing shall be precisely 3.0". All other parts of the test are carried out as described above and in ASTM D-3574.

5.3 Limitation of Method

The 1" deflection IFD method is recommended for production screening and quality control on full size cushions only. The test method is designed to give a test value equal to the IFD on a

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4" thick piece of foam when the actual thickness is within the range listed in the test method.
In case of disagreement, the referee method is the IFD procedure in ASTM-3574 Test B₁.

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6.1 Measurement Options

Seat or back foam cut into tapered shapes is measured for IFD by option A or B below, depending on the available equipment.

6.1.1 Option A: Swivel Indentor

A free, mobile, universal swivel on the indenter foot provides the simplest set up for tapered foam IFD measurements. The indentory foot with a universal swivel is brought in contact with the tapered side of the foam sample and the standard IFD protocol (ASTM D-3574) is carried out. (See Figure 1). Note: The operator should determine that the thin edge of the linear taper has sufficient depth to measure a 65% deflection. If not, only report the 25% deflection result.

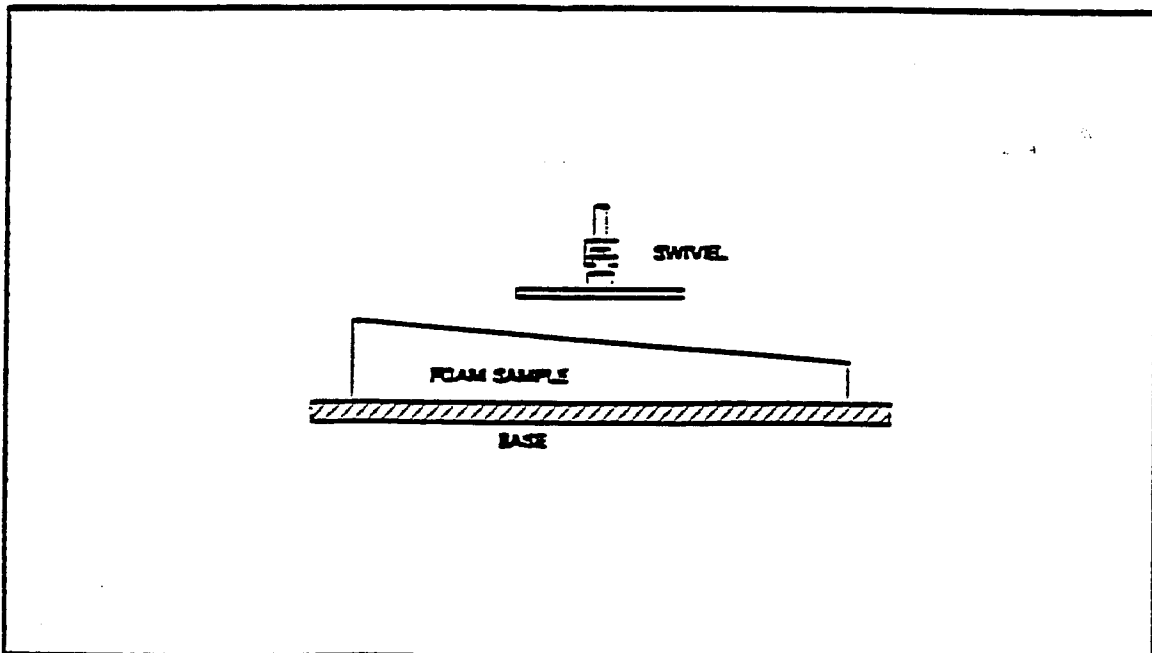


Figure 1: SWIVEL INDENTOR FOOT

Chapter 6.0 TAPERED CUSHION IFD STANDARDS AND GUIDELINES

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6.1.2 Option B: Fixed indenter or Ball and Socket Indenter

This procedure requires an adjustable inclined plane and a light weight carpenter's level. The indenter foot is rigidly mounted so as to prevent any angular movement. In the test, the base on the inclined plane is secured under the geometric center of the indentory foot. Use a piano hinge or equivalent to attach the adjustable 1" thick plywood incline member to the base plate. Laboratory jacks, adjustable turnbuckles or adjustable screws can be used to elevate or depress the 1" thick plywood inclining plane. Use a retainer strip if needed to keep the test sample in position. (See Figure 2 for details).

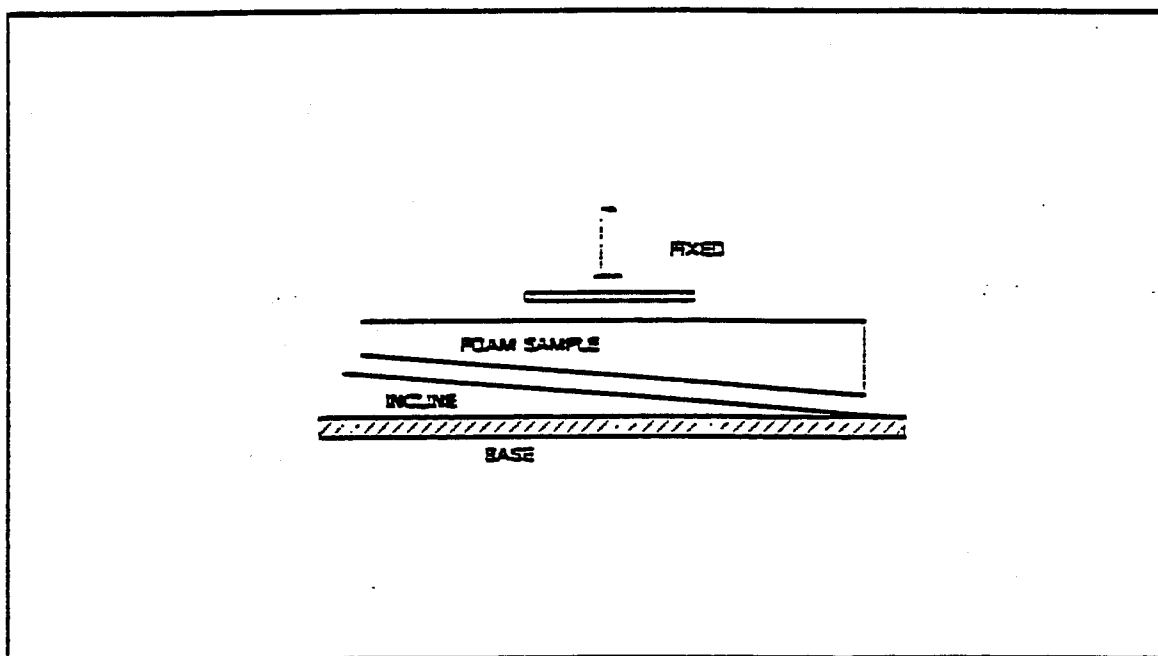


Figure 2-RIGID INDENTOR FOOT

6.2 Procedure

6.2.1 Option A

Use the standard method for IFD measurement following ASTM D-3574.

6.2.2 Option B

Center the incline device base plate under the indenter foot. Place the sample on top of the adjustable top plate and use the jacks or adjustable screws to level the sample. Fix final position of the sample with the carpenter's level. Check that the sample is centered under the indenter foot ready for the test. Determine the IFD according to ASTM D-3574.

Chapter 7.0 TESTING OF CUSHIONS CONSTRUCTED WITH CONVOLUTED FOAM STANDARDS AND GUIDELINES

Joint Industry Foam Standards and Guidelines
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7.1 Scope

The intent of creating convoluted foam is to alter the immediate surface feel of the foam, almost invariably to soften the initial touch of the cushion. This softened touch is accomplished by decreasing the initial contact area of the foam surface by using a contoured surface. The initial load bearing of the foam is only on the uppermost crowns of the contoured surface, creating a soft, cushy feel. The usefulness of convoluted foam to the furniture industry manifests itself as a wrapping material used around foam block cores in seat, back, or pillow constructions.

7.2 Recommendations

It is the recommendation of this committee that testing of cushions that have been wrapped with convoluted foam not be done with the wrapping in place. In order to achieve reliable test data on thickness, density, or IFD measurements, the convoluted foam wrapping material should be removed and the tests performed only on the foam core. Knowledge of the performance data of the convoluted foam wrapping material is best obtained from the foam stock before it is convoluted.

Chapter 8.0 SHREDDED FOAM STANDARDS AND GUIDELINES

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8.1 Statement Concerning Shredded Foam

Typically, shredded foam consists of or is a combination of many foam types, densities, IFD's, and sometimes even colors. Shredded foam ingredients are byproducts of various foaming/fabrication processes. Quality control of diverse foam types that are converted to a shredded composite is beyond the scope of practicability; thus, performance specifications for such shredded foam products should, out of necessity, be much less stringent than those of non-shredded foam.

Inclusion of skins from foam buns is a standard practice of the shredded foam business, therefore, the need to exclude skins is a matter to be resolved by vendor and user.

Users of shredded foam should be aware of its tendency to settle and compact, thus reducing the foam's filling capacity. Product design should incorporate a tolerance for this variable.

Chapter 9.0

FLEX FATIGUE OR IN-USE SOFTENING STANDARDS AND GUIDELINES

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9.1 Introduction:

The fatigue properties of flexible polyurethane foams have long been a major source of controversy. Questions relating to the causes of fatigue, the relationship of fatigue to other physical properties, the ramifications of measuring errors, and the correct test method have been debated for years with little quantitative results.

For example, ASTM D3574 lists the following acceptable test methods for fatigue softening:

- a---static force loss at constant deflection
- b---dynamic fatigue test by the roller shear at constant force
- c---dynamic fatigue test by constant force pounding

A plethora of other, non-ASTM tests abound in the industry for fatigue measurements on foam:

- a---Squirming Irma (several versions)
- b---Bouncing Betty (several versions)
- c---Rotary Shear
- d---cushion on springs (simulating actual furniture construction)
- e---The Fire-House test
- f---The Rest-Home test
- g---the college dorm test
- h---the lobby test
- i---the tractor test
- j---fatigue of CFD size specimens

9.2 The constant load, roller shear test--at this point in time--seems to correlate well with in-use testing and performance. In 1982 and 1986, two papers were presented to the Annual Technical/Marketing Conferences of the Society of the Plastics Industry:

- a. Fatigue testing of flexible foams by Dr. Herman Stone, proceedings of the SPI 27th Annual Technical/Marketing Conference--1982
- b. SPI study--Flexible Foam In-Use Fatigue Testing for Chairs by J.E. Knight, proceeding of the SPI 30th Annual Technical/Marketing Conference--1986

Note: Excerpts from the above papers are used by permission from both authors.

The research work and conclusions published in these two papers is and will be the beginning core for quantitatively relating laboratory fatigue testing to actual in-use softening or fatigue.

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9.3 Following are the observations and conclusions from the 1982 paper:

- a. Density measurement agreements between laboratories were good though some laboratories reported significant deviations from the average value. This was important because of the correlation determined between foam density and dynamic fatigue properties.
- b. IFD determination--there was poor agreement between laboratories in determining initial IFD values. The 4" IFD measurements show better agreement than the 2" samples.
- c. IFD losses in fatigue testing occur very rapidly regardless of the fatigue protocol used.
- d. The percent loss after 1000 cycles may be used as a rapid indicator of quality. The losses after 1000 cycles were lower on 4" samples than on 2" samples.
- e. Fatigue tests on 2" samples were more severe than on 4" samples.
- f. There is a general effect of density which becomes more pronounced at the low end of the density range (1.2 PCF or less).
- g. HR foam performs well but not better than an unfilled conventional foam of equal density (one data set reported in the study).
- h. Filled foam did not perform as well as HR foam or conventional foam. Its performance was close to its unfilled density.

9.4 Following are the observations and conclusions from the 1986 paper:

- 9.4.1 In the 1982 work, some suggestions were made for future research, and many of these suggestions were incorporated in the 1986 research work. The 1986 work contained some very interesting ground rules and commentary:
- 9.4.2 The correlation between laboratory dynamic fatigue and the field evaluations of foams was of primary interest. For this reason the number of foams chosen as the subject of the study was restricted. Four commercially available foams were selected for study.
 - a. 1.0 PCF--30 lb IFD conventional
 - b. 1.5 PCF--30 lb IFD conventional

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c. 2.0 PCF--30 lb IFD conventional

d. 2.5 PCF--30 lb IFD HR

9.4.3 None of the foams selected for study contained any inorganic fillers or fire retardants.

9.4.4 In the 1986 paper, the following observations and conclusions were offered:

a. Density--results from participating laboratories show excellent agreement, much better than was reported in earlier studies. The uniformity of test samples may have accounted for the improvement.

b. The 90% compression sets generally showed good agreement between laboratories with only an occasional outlying result. As would be expected of the conventional foams tested, the 1.0 PCF was much higher in compression set.

c. Tensile--the standard deviation shown between laboratories was generally good for the tensile property. The variation for tensile between the highest and lowest reported results from a foam grade was about 20%.

d. Elongation--the variation shown between laboratories for the elongation was not as good as for tensile. The high and low variation was greater than 30% with greater dispersion.

e. Tear--the standard deviation for the tear property was good. The dispersion was better than for tensile and elongation.

f. IFD--the variation between IFD values reported was no better than what would be expected if ASTM procedures were followed. The 25% IFD showed about the same variation as the 65% IFD. The sample density did not appear to influence variation. The accuracy in IFD was better in this study than others and may be attributed to sample uniformity. The accuracy in the compression modulus data reflects the limitations of the IFD test method.

g. Roller shear dynamic fatigue--

1--after 1000 cycles the variation in IFD between laboratories was about the same as the initial IFD. The percent loss was significant.

2--After 20,000 cycles the variation in all IFD's showed significant increase.

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3--The lower the foam density, the greater the percent loss (more fatigue).

4--Allowing the foam to rest 24 hours after flexing showed the foam recovered some of the IFD loss.

5--All test foam showed very little height loss.

6--The percent loss at 40% and 65% IFD was not as great as the percent loss at 25% on all test foams.

7--The variation between laboratories showed that the percent loss in all foam grades calculated at 25%, 40%, and 65% IFD was inordinately large. The reasons for the large variations are not clear. It may be a:) humidity since most roller shear apparatus are not in humidity controlled atmospheres, b:) due to inaccuracies of the IFD measurement or c:) difference between the roller shear equipment between laboratories.

9.4.5 Observations on the in-use testing were:

Cushion height used in the test chairs was selected to be 4". This was done to provide a more direct correlation between laboratory dynamic fatigue data and field evaluation data. While the use frequency or severity of use of the test chairs may vary from one test site to another, averaging the data still provides good correlation information.

9.5 The following observations are offered for the reported data. (From the research paper--1986)

- a. One very surprising finding was the height loss observed in the 1.0 PCF density foam. In the other test densities, height loss was very low and close to that observed in the roller shear fatigue test. With the 1.0 PCF foam, height loss approached 10.0%.
- b. The percent loss in IFD was very rapid at all indentations. Approximately 75-90% of the IFD loss was seen in the first 30 days.
- c. As expected, the lower the foam density, the greater the loss in IFD. The percent loss in IFD is much greater for foam densities below 1.5 PCF.
- d. The average percent loss after 180 days for a particular foam grade was very close to the average percent loss in IFD for that grade as determined by the roller shear procedure.

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- e. The variation in the percent losses were not as great as the variation observed between laboratories with the roller shear procedure.

9.6 Summary, conclusions, and commentary on the test results and observations from both research papers is as follows:

- 9.6.1 It is becoming more and more statistically evident that low density foams cannot be expected to perform as well as higher density foams from the standpoint of fatigue or loss in IFD with flexure from any source.
- 9.6.2 Thinner foams simply take a greater beating than thicker foams, and seats should be designed accordingly, or foams should be chosen accordingly.
- 9.6.3 More research should be performed on the reproducibility and accuracy of IFD measurement.
- 9.6.4 The roller shear test may adequately correlate with in-use fatigue losses.
- 9.6.5 More work yet is required on the roller shear fatigue test; as the results from lab-to-lab are not yet statistically dependable.
 - 9.6.5.1 Because of their ultimate importance, excerpts of this research were reproduced here in their entirety (with only numbering changes to accommodate this publication.) This research is and will be the core information source for the ultimate solution to fatigue problems, and, thus, may soon allow the furniture industry to design seats and constructions without the total subjectivity which presently exists.
 - 9.6.5.2 Many fatigue or softening complaints may be caused by the furniture manufacturers and their sales and marketing philosophy. Generally, the sales, marketing, and merchandising personnel perceive that upholstered furniture must have a soft, showroom feel in order to interest the buyers. In order to obtain that soft, showroom feel, IFD's are sometimes lowered. This lowering of the IFD may cause as much as 30-75% of the field softening complaints. First, a lower IFD deflects more under the same load than a higher IFD foam, and it is the amount of deflection which causes fatigue softening.
 - 9.6.5.3 Another very important point to consider is that even well made, good quality flexible polyurethane seat-cushion grade foams will lose 4-6 pounds of the 25% IFD (4" THICK), with time in actual use. If the original IFD were 26 lbs @ 25% and the fatigued 25% IFD were 19-21 lbs, the 19 to 21 pound values would not be adequate to prevent an average weight person from feeling the springs and/or the under construction of the sofa. The customer complaint is likely to be "that cushion has become too soft." Complaints of this nature were most likely caused by

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incorrectly choosing the lower end of the acceptable IFD range. Conversely, in this case, had the lower end of the IFD range been selected to be 28 lbs at 25% deflection, the foam would fatigue soften to 22-23 lbs at 25% and would just barely (but acceptably) keep the average weight person from feeling the springs and under construction. Thus, manufacturers whose 4" 25% IFD specifications are 25-26 pounds minimum are walking on the edge of potential field complaints at all times--particularly in the summer when IFD's regress because of higher temperatures and humidity.

9.6.5.4 High density (3-3.5PCF) HR type foams which fatigue no more than 3 pounds in the same in-use period may be used to minimize field problems with fatigue.

9.6.5.5 With HR type foams and their high compression moduli, there is a temptation to use softer foams. Caution should be exercised in using softer or lower IFD foams because they do deflect more under the same load, and deflection is the cause of fatigue. Thus, while lower IFD foams are indeed softer to the feel, they may exhibit more fatigue because of their greater in-use deflection.

9.7 Edge set at the edges of cushions:

9.7.1 The mass of the foam in the very edges of perfectly rectangular (non-radiused or buffed) cushions and the degree of compression at the cushion edge leads to a very interesting type of fatigue failure called "cushion-edge-set" or just "edge set." When the foam core is stuffed in the cushion casing, the volume of the foam used is always substantially more than the volume of the cavity of the cushion casing or jacket. The foam is then, after stuffing into the cushion jacket, always under a constant, static load equal to the volume stuffing ratio differences.

9.7.2 Since the edges of the foam are in first contact with the cushion jacket, and since much of the static load or force is transmitted into the foam through the now-compressed edges, the edges see the brunt of the compressive, static load. As was mentioned earlier, the edges do not contain much mass and, thus, are not very resistant to compression; so the edges deflect a great deal under the compressive forces caused by simply stuffing the foam core in the cushion jacket. This compression on the edges is further compounded by the act of normal sitting on the cushion. Regardless of the beginning quality of foam or foam type used, some edge set will be found. Most of the edge set is usually not recoverable when the compressive forces are removed from the edges of the cushion.

9.7.3 Edge set can contribute to fabric movement on the foam core and thus, lead to cushion jacket rotation and/or wrinkles in the fabric which, in turn, can lead to excessive fabric wear.

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- 9.7.4 To minimize edge-set, a radius can be cut or buffed on the edge of the cushions. Another way to minimize edge-set is to wrap the cushion with polyester fiber.
- 9.8 Other fatigue considerations: while not published, statistically planned laboratory results are available. It is becoming generally accepted that the hysteresis measurement can be a good indicator of fatigue for all types of flexible polyurethane foams. The theory, in this case, states that if the 25% return hysteresis loss is, for example 30%, the actual in-use fatigue will be very close to 30%. More testing and research is required, but obviously if hysteresis is in fact correlatable with fatigue, much expensive and time consuming testing will be obviated.
- 9.9 Criteria for fatigue losses:
- 9.9.1 Even though the research into the in-use fatigue losses of flexible polyurethane foams has produced some viable trend data, the state of the accuracy and reproducibility of the measurement of IFD is still inadequate enough that specific, quantitative criteria for IFD losses in fatigue and in-use testing cannot--and should not--be proposed. Some guidelines, however, can be suggested for use until more reliable and quantitative data is available.
- 9.9.2 For 4" thick seating grade foams tested using any of the test methods in ASTM D3574, the fatigue loss in the 25% IFD should be no more than 6 lbs. The percentage loss values on typical 4" seating IFD's are found in chart 9.9.2.

Note: the use of two integers and a decimal fraction in some of the following data does not imply that the data is to be taken as accurate to three significant figures. There are presently no data available which factually indicates the number of significant figures in an IFD test or a percentage using IFD as the basis of the percentage.

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CHART 9.9.2

25% IFD on 4" thick cushion	%IFD loss if actual loss is no more than 6.0 Lbs
24	25
25	24
26	23.1
27	22.2
28	21.4
29	20.1
30	20
31	19
32	18.7
33	18.2
34	17.6
35	17.1
36	16.7

Chapter 10.0

STANDARDS AND GUIDELINES FOR DIMENSIONAL TOLERANCES OF POLYURETHANE FOAM

Joint Industry Foam Standards and Guidelines

Published: 5/94

10.1 Preparation of samples

Prior to measuring length, width and height of various purchased foams units, the furniture/foam industry has agreed that the following is a reasonable preparatory step: All foam compressed in any manner during shipping shall be removed from its compressed state and allowed to recover undisturbed for 24 hours prior to any measurement for acceptance and/or billing purposes.

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STANDARDS AND GUIDELINES FOR DIMENSIONAL TOLERANCES OF POLYURETHANE FOAM

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10.2 Tolerance Guidelines

10.2.1 Foam units

- A. Whole, untrimmed buns
 - Width: overall width minus 1"
 - Thickness: Cut line at top containing no skin to bottom of bun, less 3/4" allowance for trimming bottom skin
 - Length: Ordered length, plus 1"
- B. Top trimmed buns
 - Purchased height, plus 1/2", minus 0"
- C. Slab Goods(Thickness 1" or greater)
 - Length: Purchased length, plus 1/2", minus 0"
 - Width: Purchased width, plus 1/4", minus 0"
 - Thickness: Purchased thickness, plus or minus 1/16
- D. Unconvoluted Roll Goods (1/2" to 1")
 - Length: plus or minus 1/2 %
 - Width: plus 1/4", minus 0"
 - Thickness: plus or minus 1/16"
- E. Convoluted Foam
 - Length: Purchased length, plus 1", minus 0"
 - Width: plus 1/4", minus 0"
 - Thickness: Base between pinnacles, plus or minus 1/8"
 - Pinnacle thickness above base, plus or minus 1/8"
 - Combined pinnacle and base thickness, plus or minus 1/8"
 - Set nested pinnacle to pinnacle, plus or minus 1/8"

10.2.2 Fabricated Cushions

Cushion units including convoluted wrap, garnetted polyester, resinated polyester, and other constructions are to meet furniture manufacturer's specifications as agreed by user and supplier.

Note: All wrapping materials should be stripped from the cushion unit before measuring.

Chapter 11.0

VERTICAL ADHESIVE SEAMS STANDARDS AND GUIDELINES

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Definition - A vertical seam is a seam parallel to the same planes of the vertical edges of the seat cushion. For the purpose of this publication, a seat cushion shall be defined as the primary foam core excluding ears, tees and flares. It has been found that gluing together two pieces of foam with similar densities and IFD's is an acceptable method for constructing cushions for the upholstered furniture industry.

The adhesive seam task group conducted a sitting test at the May 1991 meeting of the Joint Industry Polyurethane Foam Standards and Guidelines Committee. A panel of committee members sat on cushions with front to back glue seams joining foam pieces with two different IFD's. The purpose of the sitting panel was to determine what IFD difference was discernable by the average person when sitting. The following cushion types (constructions) were used in the sitting test:

KEY: F = CUSHION WITH FIBER WRAP
NF = CUSHION WITH NO FIBER WRAP

CUSHION ID	WRAP/NOWRAP	LOW IFD	HIGH IFD	IFD DIFFERENCE
A	F2	32	33.8	1.8
B	NF2	32	33.8	1.8
C	F1	31.5	35.5	4
D	NF1	31.5	35.5	4
E	F3	27	36.5	9.5
F	NF3	27	36.5	9.5

Participants were asked to sit and evaluate each cushion as follows:

- 1 -- No variation in feel;
- 2 -- Slight variation in feel;
- 3 -- Large variation in feel

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The results were as follows:

WRAP/ NO WRAP	CUSHION ID	NO VARIATION	SLIGHT VARIATION	LARGE VARIATION
F	A	27 (96.4%)	1 (3.6%)	0
NF	B	16 (57.1%)	12 (42.9%)	0
F	C	15 (53.6%)	10 (35.7%)	3 (10.7%)
NF	D	15 (53.6%)	8 (28.6%)	5 (17.9%)
F	E	8 (28.6%)	15 (53.6%)	5 (17.9%)
F	F	7 (25%)	11 (39.3%)	10 (35.7%)

Joint Foam Industry Guideline - The following recommendations are to be used to make satisfactory glue seams:

- Maximum of one vertical seam, from front to back, per cushion.
- For seat cushions, do not exceed 4 pounds IFD variation between the two glued pieces of foam.
- The adhesive should be applied according to the adhesive manufacturer's instructions and recommendations by foam type, e.g., conventional, filled, HR, etc.

Chapter 12.0 SEATING FOAM PERFORMANCE STANDARDS AND GUIDELINES

Joint Industry Foam Standards and Guidelines
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12.1 Hysteresis Loss (25%)

The method for determining the values from which the 25% deflection hysteresis is measured and calculated shall be in accordance with ASTM D-3574 Test C.

12.1.1 The 25% deflection hysteresis loss for unfilled conventional foams with densities of 2.5 pounds per cubic foot (pcf) or higher and "high resiliency foams" (as defined by ASTM) with densities of 2.5 pcf or higher shall not exceed 20%.

12.1.2 The 25% deflection hysteresis loss for all other foams having polymer densities of 1.8 pcf up to 2.49 pcf shall not be greater than 25%.

12.2 Compression Set: Before Humid Aging

Compression sets shall be determined in accordance with the methodology set forth in ASTM D-3574, except the constant sample deflection for all samples shall be 75% of the original sample height. Compression set calculations shall be done in accordance with ASTM D-3574 Section 42.1.1.

12.2.1 A limit of 10% maximum compression set shall apply to the following foam types:

Unfilled conventional foams, 1.8 pcf and higher
Filled conventional foams, 1.8 pcf minimum polymer density

12.2.2 A limit of 20% maximum compression set shall apply to the following types:

High Resiliency (by ASTM definition) type foams
Melamine type foams

12.3 Compression Set : After Humid Aging

Humid Aging shall be performed according to ASTM D-3574, procedure J.1; and compression set shall be performed according to ASTM D-3574 except all samples shall be deflected 75% of the original sample height. Compression set calculations shall be done in accordance with ASTM D-3574 Section 42.1.1.

12.3.1 A 10% maximum compression set, after humid aging, shall apply to the following foam types:

Unfilled conventional foams, 1.8 pcf and above
Filled conventional foams, 1.8 pcf minimum polymer density

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12.3.2 A 30% maximum compression set, after humid aging, shall apply to the following foam types:

High Resiliency (by ASTM definition) foams
Melamine type foams

Chapter 13.0

ARM AND BACK FOAM PERFORMANCE STANDARDS AND GUIDELINES

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13.1 Introduction

Foam backs and arms add comfort and impart design freedom, beauty and style to upholstered furniture. The "best" foam for a furniture manufacturer's application may be based on many factors - styling requirements, "feel" of the back or arm and economics. Upholstered furniture backs and arms are usually made of foam or fiber or a combination of the two. While the seat is the support portion of the furniture and is usually judged on a strict durability criteria, backs, and to a lesser extent, arms, are the cushioning comfort components of furniture, with resiliency a less significant factor than seat foams.

This section is meant to give practical guidelines and ranges on back and arm foams in the daily manufacturing environment. Testing was carried out in an accurate and scientific manner. Test material was obtained from various foam suppliers out of daily production runs, so as to simulate the foam that is seen daily in the furniture manufacturing plant. While these are working guidelines for the industry in general, manufacturer and supplier relationships can supersede any of these guidelines if so agreed upon. Also, it should be noted that laboratory to laboratory variations can be present and must be resolved between testing facilities if a dispute should arise.

As a result of environmental legislation, low density back foams may have changes in physical properties in the future or could be eliminated altogether. A move to higher density, soft foams could happen as environmental concerns continue.

13.2 Test Methodology

The back foam committee was comprised of furniture manufacturers and suppliers and utilized up to six laboratory facilities. All tests performed on the back foams tested followed the guidelines of ASTM 3574, except for the dynamic fatigue test. Following is a list of

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the foam types tested and analyzed by the committee:

Density	IFD	Type
1.0	10	Back
1.1	15	Back
1.5	15	Back
1.5	33	Arm
1.8	18	Back
1.5	23	Back
2.5	15	Back (melamine)

13.2.1 Test Samples

Foam test samples were cut from production runs of foam. A total of six samples were cut, top, middle, bottom, left and right. Samples were taken 8" from the top skin, 8" from the bottom skin, a minimum of 4" from the bun sides, and 4" from the forward and rear skin. Samples size was 30" x 24" and was divided into pieces for IFD/Hysteresis testing, CFD, Humid Aging and Compression Set testing.

13.3 Density

In common foam terminology, nominal density names of foam refer to the top end of a density grade range. Upon laboratory testing of the foam samples, the following recommendations can be made concerning density:

The range on all back and arm foams up to a 2 pound density should be minus 0.1 pound, plus 0.0. Filled foams such as melamines may sometimes be expressed as minimum densities.

13.4 IFD Ranges

IFD testing data on back and arm foam leads to the following conclusions: There are natural IFD spreads within a bun of foam. The middle of a bun, where it is hotter, produces the firmest foam within the block. The top, where it cools the quickest, is normally the softest. IFD ranges shipped to the furniture manufacturer should fall within +/- three pounds, unless density sorting arrangements have been made between the manufacturer and supplier. Although the ASTM IFD testing procedure is a precise machine test, there can be subtle differences between test machinery and laboratory test procedures that can show up as much as a 10% variation in IFD readings between labs.

Because of the sample size of 24"x24"x4", IFD ranges obtained in this round robin testing were higher than the standard foam industry grading procedures using a 15"x15"x4" sample size. For example, a foam grade of 1115 would test 1121 on the larger sample. However, all

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test results within the particular sample size showed the proper ranges of IFD correlation. It should also be noted that a larger piece of foam also produces a higher modulus value.

13.5 CFD versus IFD

Both IFD and CFD are compression force of deflection tests. The correlation shown between the two types of testing was that a grade of foam measuring firm on IFD would have a range of firmness on the CFD apparatus.

13.6 Hysteresis

Test results show that most higher density foams have better hysteresis than lower density foam.

13.7 Fatigue

Many fatigue tests are available for testing purposes. This committee chose the constant force deflection flex fatigue test. The apparatus must be capable of deflecting the test specimens 75% of their original thickness with minimum distortion at a rate of 30 cycles/minute (+/- 5). Many labs did not have the capacity to test at cycles more than 30 cycles per minute, thus 50 cycles/ minute was not used. Sample size for CFD testing was 4"x4"x3". The initial thickness and 50% CFD values were determined using ASTM D-3574 Test C. After 100,000 cycles of flexing at 75% deflection, the specimens were removed and allowed to equilibrate for 30 minutes. The thickness and the 50% CFD value was measured for a second time. The change between the initial and final values was calculated to obtain the fatigue factor.

Test results from the CFD dynamic fatigue tests showed that back foams should perform well in all categories of density for back and arm foam requirements. However, no actual full scale furniture tests were run to correlate actual performance to the laboratory fatigue tests. [Higher density foams will have better fatigue properties and durability over the lower density foams, but the cost effectiveness of higher performance foams is often a major consideration of furniture manufacturers.]

13.8 Compression Set

Good consistency between laboratories. Compression set of less than 10% are acceptable for conventional back foams. HR and melamine foams will perform well with compression sets of up to 25%.

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14.1 Introduction

The foam/furniture flammability issue is so complex and important that attempting to cover the issues and problems thoroughly in a guidelines publication is ill advised. Therefore, only a sketch of the flammability issues and regulations will be presented in this publication. Through UFAC, PFA, and SPI, the joint industries have much information, details, and sourcing regarding the flammability issues; so if more complete and detailed information is required, it is suggested that one of these associations should be contacted. The major issues and regulations will be covered in the following sections.

14.2 UFAC

The voluntary UFAC (Upholstered Furniture Action Council) program involves all residential upholstered furniture sold in the United States with the exception of furniture sold in the state of California and some other areas where there are other specific regulations. The state of California has its own residential furniture flammability specifications which, contrary to the UFAC program, are not voluntary.

- 14.2.1 The UFAC program is a voluntary program which became completely instituted in 1978. The UFAC program involves everyone in the upholstered furniture loop, i.e., the raw material suppliers to the furniture industry, the furniture manufacturers, and furniture retailers. To date, the UFAC program is shown to be successful by virtue of significant decreases in fire incidence and fire deaths since the inception of the UFAC program.
- 14.2.2 In the UFAC program, UFAC has developed an extensive series of test methods, furniture construction criteria, and procedures which assist manufacturers in complying with the UFAC program. The UFAC tests are cigarette smoldering protocols (as opposed to open flame protocols) since from the very beginning, cigarettes were shown to be the major cause of upholstery fires.
- 14.2.3 In the UFAC protocol, applicable raw materials are tested using lighted cigarettes. Outer fabrics are classified by the use of lighted cigarettes, and then UFAC furniture construction criteria are used to assemble upholstered furniture which is resistant to ignition by lighted cigarettes.
- 14.2.4 UFAC has also developed cross-checks, i.e., verification procedures that include an annual sampling of all of the participant's raw materials for a compliance cross-check in an independent laboratory selected by UFAC. UFAC also has a technical committee laboratory alliance which meets routinely to investigate new technology and/or new flammability requirements.

14.3 NFPA 260

NFPA 260 is the National Fire Protection Association's (NFPA) version of the UFAC test

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protocol and criteria. NFPA 260 differs only in language and publication form from the UFAC test methodology.

14.4 California Technical Bulletin 116

California Technical Bulletin 116 is a voluntary cigarette test for full scale pieces of upholstered furniture which are manufactured for residential use in the state of California.

14.5 California Technical Bulletin 117

California Technical Bulletin 117, a mandatory standard, is both an open flame test and a smoldering cigarette test for the component materials used to make residential upholstered furniture which is to be sold in the state of California. In this test, each upholstery component except the covering fabric is time exposed to either an open flame or a smoldering cigarette in a defined test chamber, and the propagation of the open flame or the cigarette char length is measured to a specific specification criteria contained in Technical Bulletin 117. All upholstered furniture components except frames must comply with this test procedure and criteria.

14.6 California Technical Bulletin 133

California Technical Bulletin 133 is a very severe open flame test, mandatory for furniture sold in what is called "public occupancies" in the state of California. It should be noted that several other states have adopted California Technical Bulletin 133 for the same occupancies in their states. In the California Technical Bulletin 133 (TB-133) test protocol, a full scale piece of furniture or a mock up is placed in a specially designed room where the furniture or mock up is exposed to an approximate 16 kw open flame for eighty seconds. The temperature at the 4 foot level and at the ceiling are monitored constantly. The mass loss of the test furniture is monitored continuously, and the carbon monoxide concentration in the test room is monitored continuously. Smoke opacity in the room is also monitored continuously. TB-133 lists criteria for each function measured. Another way to test for passing TB-133 is the use of oxygen consumption (depletion) calorimetry. In oxygen consumption calorimetry, the oxygen consumed by the burning furniture is monitored continuously, and the peak heat release and total heat release are calculated from the amount of oxygen consumed by the burning furniture. There are specific criteria for peak heat release and total heat release. It should be said here that the TB-133 test for upholstered furniture was designed specifically for upholstered furniture used in public occupancies, and this test is definitely not applicable to upholstered furniture used in residential occupancies. It should also be noted that TB-133 is the most severe fire test in the world for upholstered furniture.

14.7 The Boston Fire Department Test and Requirements

The Boston Fire Department Tests and Requirements (The Boston Fire Code) was developed solely for public occupancy furniture sold in the city of Boston. While the Boston Fire Code

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is an open flame test and officially requires test methodology that differs from the TB-133 tests and criteria, Boston officials have stated in public forum that they will accept the results of TB-133 if the TB-133 data is submitted to the Boston Fire Department.

14.8 NFPA 264, The Cone Calorimeter

The Cone Calorimeter is a bench scale apparatus used to measure peak heat release and total heat release of small size furniture components and composites. The Cone Calorimeter measures these heat values based on oxygen depletion during burning, so it is an oxygen consumption calorimeter. In the Cone Calorimeter, other apparatus are available to measure mass loss, smoke opacity, carbon monoxide, and other gases when required. Thus far, the Cone Calorimeter has been a useful research tool for the measurement of the heat properties of materials and composites. Some of the data from the Cone Calorimeter can be used in computer modeling of fires.

14.9 ASTM, Underwriters Labs, The European Community

14.9.1 ASTM

ASTM has published equivalents to the UFAC cigarette test methods. Like the NFPA 260, the ASTM method is exactly the same as the UFAC methodology--only differing in publishing style and language form.

ASTM has published a form of California TB-133 as ASTM E-1537. This test method also contains some other approaches to full-scale oxygen consumption calorimetry which could eventually lead to some economies of scale in testing.

14.9.2 Underwriters Labs (UL-1056)

UL has published a full scale test method for upholstered furniture. In many respects, the UL method is similar to TB-133 as it utilizes oxygen consumption calorimetry. To date, the significant difference between the UL method and TB-133 is the ignition source. UL continues to use a wooden crib as the ignition source for their testing.

14.9.3 The United Kingdom

The most significant happening in Europe related to the furniture/flammability issues has been the banning of the use of conventional, flexible polyurethane foams in the manufacture of upholstered furniture for sale in The United Kingdom. In the process of banning the conventional foams in favor of combustion modified foams, the U.K. adopted the British Standards Institute 5852 standard in phases, and at this writing all phases are in full effect.

This entire issue in the U.K. has caused much confusion and turmoil, and the true value of the banning and imposed standards are both in question.

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14.9.4 The European Common Market Countries (EC)

During the process of defining criteria for cross border trading within the EC, a group of technical personnel from each country involved was appointed to study the flammability issues and make recommendations to the ruling body of the EC. This technical group studied the issues carefully and decided that the open flame issues were too complex to include in an immediate EC standard. At this writing, their estimate of the time necessary to develop an open flame standard was three or more years. As a result, the EC technical community decided on a cigarette smoldering test only, and at this time, two tests are under consideration by the EC technical group: the BSI 5852 test and the UFAC tests and construction criteria. In the European community, the UFAC program will be called EUFAC.

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AFMA - American Furniture Manufacturers' Association. A voluntary organization of furniture manufacturers dedicated to fostering the growth and development of the furniture industry and improving the effectiveness and efficiency of furniture manufacturers. AFMA was formed from the merger of the National Association of Furniture Manufacturers and the Southern Furniture Manufacturers Association.

ANSI - American National Standards Institute. An organization that verifies that standards developed by other organizations have met the requirements for due process before approval as an American National Standard. The use of American National Standards is voluntary.

ASTM - American Society For Testing and Materials. An organization devoted to the establishment of standard methods and procedures for testing materials.

Acoustical Flexible Polyurethane Foam - Foam designed to attenuate, or dampen vibrations or sound waves.

Air Flow - A measure of the ease with which air will pass through a foam sample. (Test Method ASTM D3574)

Aliphatic - Class of organic chemical compounds containing carbon, having an open chain molecular structure.

Anti-Oxidants - Materials which when added to a flexible polyurethane foam formulation improve the resistance of the foam to oxidative type reactions, such as scorch.

Anti-Static Flexible Polyurethane Foam - Foam that has been impregnated with electrically conductive materials to prevent static electricity buildup or promote static dissipation. It is used primarily in packaging applications, such as electronic components.

Aromatic - Class of organic chemical compounds characterized by having a benzene, or six membered, ring molecular structure. Toluene diisocyanate is an aromatic organic compound.

Auxiliary Blowing Agents - Compounds used to produce gases to expand, or blow, flexible polyurethane foam during production. Most auxiliary blowing agents are low temperature boiling solvents, such as chlorofluorocarbons, methylene chloride, methyl chloroform, acetone, hydrochlorofluorocarbons, and isopentane.

BIFMA - Business and Institutional Furniture Manufacturers' Association. An association of manufacturers of business or institutional furniture dedicated to the development of voluntary product safety and performance standards and test methods.

Back Foam - Flexible polyurethane foam used for other than seat cushioning, usually of a lower density than seating foam.

Ball Rebound - A test procedure used to measure the surface resiliency of flexible polyurethane foam. The test involves dropping a steel ball of known mass from a predetermined height onto a foam sample. The rebound height attained by the steel ball, expressed as a percentage of the original drop height, is the ball rebound resiliency value. (Test Method ASTM D3574)

Barrier Material - A barrier placed between a cover fabric and filling materials to slow heat transfer and flame spread to the filling material.

Blocks - A cut-off segment of the continuously produced flexible polyurethane foam being made by the slabstock technique. In some cases this block would have top, bottom, and side skins intact and have cut surfaces only on the ends. In other cases, the skins may be removed by in-line trimmers, leaving a smooth rectangular block.

Blowing - The process by which flexible polyurethane is foamed during production. The majority of blowing is accomplished in polyurethanes by adding water to the polyol/toluene diisocyanate reaction. Water reacts with the toluene diisocyanate to produce carbon dioxide gas bubbles that expand the polyurethane as it polymerizes. Auxiliary blowing agents are high volatility liquids that, when added to the polymerizing liquid, tend to boil and produce large quantities of gas. The gas produces bubbles as the polymerization takes place, expanding the liquid resin before it solidifies. Common auxiliary blowing agents include CFC's and methylene chloride.

Board Foot - Unit of measurement in the flexible polyurethane foam industry equal to a square foot of material one inch in thickness.

Boardy - Flexible polyurethane foam with a stiff or rigid feel, generally indicated by high 25% IFD values.

Bolster - A loose pillow, flexible polyurethane foam and/or fiber filled, that is not attached to the upholstery frame.

Bonded Foam - Flexible polyurethane foam crumbs or shredded flexible polyurethane foam that has been rebonded to form a salable product.

Boston Chair Test - Boston Fire Department test method to measure performance of flexible polyurethane foam padding materials when exposed to a fairly severe flaming ignition source. This test is a full scale composite test. Ignition source is four double sheets of newspaper crumpled inside a paper grocery bag.

Boston Foam - Flexible polyurethane foam filling or padding material that will meet the requirements of the Boston Fire Department chair test.

Bottom Out - The lack of support by a flexible polyurethane foam under full load. This term is very subjective, as a foam may bottom out with a heavy person, and be very comfortable to a lighter-weight individual.

Breathability - See air flow.

British Standard BS-7176 - British standard specification for resistance to ignition of upholstered furniture when tested according to BS-5852. This standard sets the specifications for ignition source resistance levels for low, medium, and high risk occupancies.

British Test BS-5852 - British Standards Institute test method for the ignitability of upholstered composites by open flame or smouldering cigarette sources. BS-5852 is a small scale composite test of material combinations. Open flame ignition sources range from a match equivalent butane flame up to a nominal 126 gram wooden crib. Additionally, a smouldering cigarette is used as an ignition source.

Buffed - Flexible polyurethane foam pieces that have been shaped or contoured by removal of foam using abrasive or "buffing" methods.

Bun - See block. Generally, buns are longer than blocks, approximately equal to or greater than 60 feet in length.

CFC-Free Foam - Flexible polyurethane foams that have been made without the use of chlorofluorocarbons as auxiliary blowing agents.

California 117 Foam - Flexible polyurethane foam filling material or padding that will meet the requirements of the California Bureau of Home Furnishings' Technical Bulletin No. 117.

California Technical Bulletin 116 -California Bureau of Home Furnishings test method for cigarette ignition resistance of residential upholstered furniture. This is a small scale composite test.

California Technical Bulletin 117 -California Bureau of Home Furnishings test method and requirements for open flame and cigarette resistant materials used in residential upholstered furniture construction. Cal-117 is a small scale component test. Ignition source is either an open flame gas burner as specified by Federal Test Method Standard No. 191, Method 5903.2 or smouldering cigarettes meeting the cigarette specification of DOC FF4-72.

California Technical Bulletin 133 -California Bureau of Home Furnishings test method and requirements for open flame resistance of seating furniture for use in public occupancies in seating areas of ten or more seats. Cal-133 is a full scale composite test in which physical design and construction material combinations can affect the test outcome. Ignition source is five double sheets of newspaper or a specially designed gas burner as specified in the test method.

Carbon Dioxide Blown Foam -Flexible polyurethane foam in which all the gas for expanding the foam is carbon dioxide generated by the chemical reaction between water and the isocyanate material.

Catalyst - A chemical that changes the rate of reaction of a chemical process, but is not consumed or produced during the reaction.

Cell - The cavity remaining in the structure of flexible polyurethane foam surrounded by polymer membranes or the polymer skeleton after blowing is complete.

Cell Count - The number of cells per linear inch or centimeter, expressed as pores per inch or pores per centimeter.

Cell Size - The average diameter of the cells in the final flexible polyurethane foam product, often measured in micron units.

Chlorofluorocarbon (CFC) - Chemical compounds that are chlorine and fluorine substituted alkane hydrocarbons. CFC's are commonly used as auxiliary blowing agents for foams, refrigerants, aerosol propellants, and cleaning agents.

Clickability - The ability of a flexible polyurethane foam to recover from the pinching effects of die-cutting.

Cold-Cure Foam - See high resiliency foam.

Combustion Modified Foam - Flexible polyurethane foams manufactured by using additives containing fire suppressants such as chlorine, bromine, phosphorus, antimony oxide, or some combination thereof, with or without hydrated alumina or melamine.

Combustion Modified High Resilience Foam (CMHR) - High resilience flexible polyurethane foams that have been modified for better flammability behavior by the addition of various flame retardants.

Compression Force Deflection (CFD) - The determination of the resistance to compression of a flexible polyurethane foam sample when the entire surface area of the sample is compressed. Test method is described in ASTM D3574.

Compression Rate - See Support Factor.

Compression Set - A permanent partial loss of initial height of a flexible polyurethane foam sample after compression due to a bending or collapse of the cell lattice structure within the foam sample. Large percentages of compression set will cause a flexible polyurethane foam cushion to quickly lose its original appearance with use, leaving its surface depressed or "hollowed out".

Cone Calorimeter - Small, "bench-scale" calorimeter characterized by its inverted cone shape used to determine heat and smoke release rates for various materials when exposed to radiant heat. This is a small scale component test piece of equipment.

Constant Deflection Compression Set - Test used to determine the amount of foam recovery from a static or fixed compression. Test method is described in ASTM D3574.

Conventional Flexible Polyurethane Foam - Polyether type polyurethane foams made by the basic manufacturing process with no additives.

Conventional California or FR Foam - Conventional flexible polyurethane foams to which fire retardants have been added.

Convuluted - A fabrication process in which flexible polyurethane foam is cut while compressed non-uniformly to produce a surface with a multicontoured texture. This texture gives the foam a different surface feel, or apparent softness.

DOT MVSS-302 - Department of Transportation Motor Vehicles Safety Standard in which the test sample is ignited in a horizontal position by a calibrated gas flame for 15 seconds. Burn length, time and speed are determined and sample is classified by the outcome. This is a small scale component test developed for automotive interior materials.

Deflect - To compress, usually by a specified amount or percentage.

Densified - A material that has been made more dense by permanently compressing a unit mass into a smaller volume.

Density - The mass of a substance divided by its volume. In the United States, density is accepted as the weight of a substance divided by its volume. Foam density is often expressed as pounds per cubic foot or kilograms per cubic meter. (Test Method ASTM D3574).

Dish - Description of what occurs when a weight is placed on the center of a cushion and the corners of the cushion rise up in response.

Double Tee - See Tee.

Durometer - An instrument used to measure hardness of elastic materials. Durometer is also used to reference a scale of hardness; ie, a low durometer implies a soft material.

Dynamic Flex Fatigue - See Fatigue.

Ear Job - See Tee.

Ears - See Tee.

Elastomer - Polymers which resist and recover from deformation produced by force, similar in behavior to natural rubber.

Elephant Skin - Surface creasing effect due to lateral resistance of a stiff, thick flexible polyurethane foam when compressed parallel to its face.

Elongation - The percent that a specially shaped sample will stretch from its original length before breaking. (Test Method ASTM D3574).

Environmentally Safe - Flexible polyurethane foam processed with no auxiliary blowing agents.

Exotherm - The heat released as a by product of some chemical reactions. Flexible polyurethane foam producing reactions are exothermic.

FIRA - Furniture Industry Research Association - A voluntary British organization of interested parties involved in flammability research, creating methods of testing and establishing specifications for flammability performance of upholstered furniture.

Fatigue - A tendency to soften under cyclic stresses. Fatigue of foam samples can be measured by cyclicly compressing and relaxing a flexible polyurethane foam sample and measuring its change in IFD.

Feel - See Hand.

Felted - Flexible polyurethane foam that has been densified by heat and compression for use as a vibration dampening or shock absorbing material.

Filled Flexible Polyurethane Foam - Flexible polyurethane foams that have inorganic materials, such as marble dust, barium sulfate, graded sand or clay added to the foam during polymerization to increase foam density. These inorganic fillers are not chemically bonded into the foam polymer. They are instead mechanically trapped within the molecular structure of the polymer. Substantial amounts of filler may increase the foam's support factor, but may be detrimental to resiliency, strength, or durability.

Filler - The inorganic materials added to foam to increase foam density.

Finger Nail - A quick, general test for boardiness or stiff surface feel flexible polyurethane foam. A finger nail pressed into a foam sample that leaves a definite impression that does not quickly recover indicates a boardy foam.

Fire Retardants - A material that, when added to flexible polyurethane foam, will cause the foam to be more difficult to ignite or burn less rapidly or lose less weight during a fire than without that material.

Flat Top - A block or bun of flexible polyurethane foam that is essentially flat on the top surface when poured, as opposed to having an arched top when allowed to free rise.

Flex Fatigue - See Fatigue.

Flexible PUF - Flexible polyurethane foam.

Graft or Polymer Polyol - Polymers with active hydroxyl groups that have other organic groups or polymers "grafted" to the polyol molecule. These grafted organic compounds serve to reinforce the strength or modify other properties of the flexible polyurethane product.

Guide Factor - $GF = 25\% \text{ IFD divided by density determined after one minute rest.}$

Guts - Flexible polyurethane foam that has adequate support under load and does not "bottom out" is said to have "guts".

HCFC's - Non-fully halogenated chlorofluorocarbons that are used as substitutes for CFC's in foam blowing. Theoretically, HCFC's have a lower ozone-depletion potential to the environment than do "hard" fully halogenated CFC's.

Hand - Hand is the feel of the surface of flexible polyurethane foam when rubbed lightly. Stiff or hard feel is poor hand. Good hand is described as a springy, velvet feel.

Hardness Index - Synonym for the 50% IFD value. Some furniture designs are for a maximum 50% indentation while some are for only a 20% indentation, ie., chairs versus bar stools.

High Resilience (HR) Foam - Flexible polyurethane foam that has a very rapid recovery from extreme compression and a fairly linear increase in resistance to compression per unit of penetration. (See ASTM D-3770).

Hook - A wedge shaped foam extension on cushion units used to make cushions conform to the shape of a back.

Humid Aging - An accelerated aging test under conditions of high humidity and temperature. ASTM D3574 describes the test method.

Hydrolytic Degradation - The degradation of flexible polyurethane foam by hydrolysis or disassociation by water under conditions of constant exposure. The humid aging test method was developed to attempt to measure the effects of hydrolytic degradation.

Hydrophilic - An affinity for water.

Hydrophobic - A repellency for water.

Hysteresis - The ability of a flexible polyurethane foam to return to its original support characteristics after it is compressed. $\text{Hysteresis} = (25\% \text{ IFD initial} - 25\% \text{ IFD after compressing } 65\% \text{ of initial height}) / 25\% \text{ IFD initial} \times 100$.

IAFF - International Association of Fire Fighters.

Indentation Force Deflection (IFD) - A measure of the load bearing capacity of flexible polyurethane foam. IFD is generally measured as the force (in pounds) required to compress a 50 square inch circular indenter foot into a four inch thick sample no smaller than 24 inches square, to a stated percentage of the sample's initial height. Common IFD values are generated at 25 and 65 percent of initial height. Reference Test Method ASTM D3574.

Indentation Load Deflection (ILD) - See Indentation Force Deflection.

Indentation Modulus - IM = $(40\% \text{ IFD} - 20\% \text{ IFD}) / 20\% \text{ IFD}$. The force required to produce an additional 1% indentation between the limits of 20% IFD and 40% IFD determined without the one minute rest. The slope of this line represents the resistance of the cell struts to post buckling. The slope of the linear portion of the stress-strain curve is defined as the indentation modulus.

Indentation Residual Deflection Force (IRDF) - A test method used with seating foam to determine how thick the padding is under the average person. The amount of deflection is determined by measuring the thickness of the pad under fixed force of 4.5 Newtons, 110 N, and 220 N on a 323 square centimeter circular indenter foot.

Initial Hardness Factor - IHF = $25\% \text{ IFD} / 5\% \text{ IFD}$ determined without the one minute rest. This ratio defines the surface feel of a flexible foam. Soft surface foam will have a high IHF value, while stiff or boardy surface foams will have a low IHF value.

Initial Softness Ratio - See Initial Hardness Factor.

Interior Density - The density of a foam sample at its center. Generally, a foam will form a density gradient, with the highest density being at the outer, or skin surface, and the lowest density being at the core of the foam sample.

JIPFSC - Joint Industry Polyurethane Foam Standards Committee. A voluntary standards organization formed under the auspices of the American Furniture Manufacturers Association, dedicated to the development of flexible polyurethane foam standards, guidelines, test methods, classifications, and definitions for the furniture industry.

L - See Tee.

Lamination - A fabrication process bonding two foam types, or a foam and another substrate, using an adhesive.

Latex Foam - A latex rubber foam product not related to flexible polyurethane foams.

Life Safety Code - A collection of specifications and test methods relating to fire safety in buildings and structures compiled by the National Fire Protection Association.

Loop Splitter - A mechanical splitter which allows continuous slitting of long buns of foam.

MDI - An abbreviation for 4,4-diphenylmethane diisocyanate, it is often mixed with toluene diisocyanate in the production of molded flexible polyurethane foam cushions.

Maxfoam - A foam manufacturing process utilizing a trough and fall plate system for efficient foam manufacturing. See Varimax.

Melamine Foam - Flexible polyurethane foam incorporating melamine powder as a filler primarily as a fire retardant.

Methylene Chloride - A non-flammable, low-boiling chlorinated hydrocarbon solvent used as an auxiliary blowing agent in flexible polyurethane foam production.

Modulus - See Support Factor.

Modulus Irregularity Factor - $MIF = 2 * 20\%IFD - 40\%IFD$. The MIF is the extrapolated intercept of the stress axis, or y axis, of the linear portion of the stress-strain curve. If the MIF is zero, the indentation modulus is essentially constant, and the stress-strain curve is linear and passes through the origin. If the indentation modulus varies at low levels of strain before reaching a constant value at above approximately 10 per strain, the MIF will either be a positive or negative value. The degree of deviation of the MIF from zero describes the shape of the lower end of the stress-strain curve, and thus the performance of cushioning for some seating applications.

Modulus of Compression (MOC) - See Support Factor.

Molded Foam - A cellular foam product having the shape of the mold cavity in which it was produced.

NFPA - National Fire Protection Association.

NFPA 260 - National Fire Protection Association test method for determining resistance to cigarette ignition for materials used in upholstered furniture. This test is a small scale composite test. Ignition source is a smoldering cigarette.

NIST - National Institute for Standards and Technology, formerly the National Bureau of Standards.

OSU Calorimeter - Calorimeter developed at Ohio State University for determination of heat and visible smoke release rates for various materials when exposed to different levels of radiant heat. The test method for using the OSU calorimeter is published under ASTM E-906, and is a small scale component test.

Organotin Catalysts - A family of organic tin compounds used as catalysts in flexible polyurethane foam production that have a specific influence on the rate of the gelation reaction. Members include stannous octoate, dibutyltin dilaurate, dibutyltin diacetate, and dibutyltin diethyl hexoate.

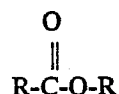
PFA - Polyurethane Foam Association. A trade association of the manufacturers of flexible polyurethane foam and their suppliers of goods and services.

Permeability - The rate at which a liquid or gas can penetrate into or through a flexible polyurethane foam. Usually associated with airflow, a measure of the openness of the foam.

Pieced - Flexible polyurethane foam that has been glued together from two or more smaller pieces. Commonly seen in cushioning to create special shapes or use up small pieces produced during fabrication.

Plasticizer - Chemical additives in a flexible polyurethane foam formulation that generally serve to increase the flexibility of the foam structure.

Polyester - A family of organic polymers characterized by the presence of ester groups



within the molecule. Polyesters can be prepared to have reactive hydroxyl groups and thus can be used as a polyol in the preparation of urethane foam. Esters are more susceptible to hydrolysis than are ethers.

Polyether - A family of organic polymers characterized by the presence of ether groups



within the molecule. Polyethers can be prepared to have reactive hydroxyl groups and thus can be used as a polyol in the preparation of polyurethane foam. Ethers are less susceptible to hydrolysis than esters.

Polymeric Foam - See High Resilience Foam.

Polyol - A chemical compound having more than one reactive hydroxyl group within the molecule. Polyol usually refers to a glycerine based product with three reactive hydroxyl groups.

Polypropylene Glycol - A propylene based diol having two reactive hydroxyl groups per propylene unit.

Polyurethane Fillers - See Fillers.

Pores Per Inch (ppi) - Unit for expressing cell count of a foam.

Porosity - The presence of numerous small cavities within a material. See Air Flow.

Pounding Fatigue - Accelerated fatigue aging of flexible polyurethane foam by cyclicly compressing samples to a specified percentage of their original height and releasing for a specified number of repetitions.

Preflex - The practice of compressing a flexible polyurethane foam sample once or twice to a predetermined thickness before determining IFD.

PUF - Polyurethane Foam.

Rate of Heat Release (RHR) - The quantity of energy released in a given amount of time from a burning sample, used in flammability studies. Units include BTU/hour, calories per second, joules per second, or watts. Values are determined by calorimetry, including cone calorimetry or the Ohio State University furniture calorimeter.

Rebonding - The process of adhering flexible polyurethane foam crumbs or shredded foam back together again to make a salable product. Rebonded foam is often used for carpet padding.

Recovery - The return to original dimension and properties of a flexible polyurethane foam sample after a deforming force is removed.

Reinforced Foam - See Filled Foam.

Resiliency - The ability of a surface to spring back to its original shape after being deformed and released. The resiliency of flexible polyurethane foam is measured using the ball rebound test.

Reticulated Foam - Flexible polyurethane foams characterized by a three-dimensional skeletal structure with few or no membranes between strands. Reticulated foams are generally used as filters, acoustical panels, and for controlled liquid delivery.

Roller Shear - Procedure that fatigues a flexible polyurethane foam specimen dynamically at a constant force, deflecting the material both horizontally and vertically. See ASTM D-3574.

Roll Goods - Flexible polyurethane foam that has been peeled or slit from a foam "log" and rolled onto a core for handling purposes. Rolled foam sheets are commonly used for large area padding, such as carpet padding.

SPI - Society of the Plastics Industry. A national organization of companies and individuals in the plastics industry that is oriented toward developing industry standards and test methods.

Scorch - Discoloration in center of foam buns due to oxidation of the polymer during manufacture.

Seam - The splice line formed by two or more separate pieces of flexible polyurethane foam that have been bonded together.

Seat Foam - Flexible polyurethane foam used for seat cushions.

Section Density - Density of a flexible polyurethane foam taken from the cross section of a bun with top and bottom skins intact.

Shiners - Light reflected from intact cell walls, noticeable on the cut surfaces of flexible polyurethane foam. A large number of shiners, or shiny spots, indicates a foam with many closed cells.

Shredded Foam - Flexible polyurethane foam that has been mechanically torn into small pieces or crumbs, for the purpose of creating a loose filling material.

Silicone Foam - Organosilicon polymers that are expanded or blown during the polymerization of silicone rubber.

Silicone Surfactant - Complex organosilicon compounds that exhibit surface active properties when used in polyurethane foam formulations. These compounds add stability to the liquid foaming mixture so that collapse of bubbles is retarded and flowability is increased.

Skin - The higher density outer surface of the flexible polyurethane foam slab, resulting from surface cooling during polymerization.

Skive - Concave curved back edge of a cushion.

Slab Stock - Flexible polyurethane foam made by the continuous pouring of mixed liquids onto a conveyor, creating a continuous loaf of foam.

Splits - Horizontal tears or rips in the side of the flexible polyurethane foam block, either intermittent or continuous along the side of the slab, commonly caused by excessive speed of the blowing reaction or too steep an angle of rise.

Static Fatigue - The loss in load bearing properties of a flexible polyurethane foam sample under constant compression of 75% for 17 hours at room temperature. See Test Method ASTM D-3574.

Static Force Loss - See Static Fatigue.

Support Factor - Support Factor = 65%IFD/25%IFD determined after one minute of rest or recovery. When based on 25% IFD values, the support factor indicates the 65% IFD values that will be attained by the foam. Seating foams with low support factor are more likely to bottom out under load.

TDI - An abbreviation for toluene diisocyanate, TDI is one of the two primary reactants involved in the production of flexible polyurethane foams.

Tear Strength - The ability of a piece of flexible polyurethane foam to resist propagation of a cut made in the sample. Reference ASTM D-3574.

Tee - Horizontal extension on the front edge of cushion that extends in front of arms or stumps of chair or sofa frames.

Tensile Strength - The pounds per square inch of force required to stretch a material to the breaking point. Reference ASTM D-3574.

Tight Foam - Flexible polyurethane foam with many closed cells, resulting in low air flow measurements.

UFAC - Upholstered Furniture Action Council. A voluntary furniture industry association organized to conduct research into more cigarette resistant upholstered furniture.

UL - Underwriters Laboratories. An independent, non-profit organization testing for public safety. UL is chartered to establish, maintain, and operate laboratories for the examination and testing of devices, systems, and materials to determine their relation to hazards to life and property.

UL-94 HBF - Underwriters Laboratories test method in which the test sample is ignited for one minute with a calibrated gas flame. Sample is classified by burn time, length, and glowing combustion time after the flame is removed. This is a small scale component test.

UL-94 HFI - Test method similar to UL-94 HBF, with the additional requirement that no flaming drippings are allowed which would ignite cotton placed below the test specimen.

UL-1056 - Underwriters Laboratories test method for the ability of upholstered furniture to resist rapid heat release when subjected to a flaming ignition source. UL-1056 is a full scale composite test in which physical design and material combinations may affect the test outcome. Ignition source is a nominal 340 gram wood crib.

Urea - Urea is a by product of the water-toluene diisocyanate reaction during flexible polyurethane foam production. The urea forms short length polymer cross links between the long polyurethane chains, which adds firmness to the foam.

Urethane - A colorless, crystalline substance used primarily in medicines, pesticides, and fungicides. Urethane is not used in the production of urethane polymers or foams. The urethanes of the plastics industry are so named because the repeating units of their structures resemble the chemical urethane.

Varimax - A foam manufacturing process utilizing Maxfoam technology with the addition of moveable sidewalls for greater processing flexibility.

Vertifoam - A foam manufacturing process utilizing Maxfoam principles where the direction of foaming is vertical.

Voids - The presence of numerous small cavities within a material.

Water Blown Foam - Flexible polyurethane foam in which the gas for expansion is carbon dioxide generated by the reaction between water and an isocyanate material. All flexible polyurethane foam is waterblown, although auxiliary blowing agents are often used to obtain special physical properties.

Wedge - See Hook.

APPENDICES

A1.0 TASK GROUP ON ACCEPTABLE IFD RANGES

Joint Industry Foam Standards and Guidelines

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A1.0 Task Group on Acceptable IFD Ranges

- A1.1 Flexible polyurethane foam for use as furniture cushions is produced in a continuous process where huge slabs of foam often eight feet wide, four feet high, and several hundred feet long are poured. The hardness of this foam is affected by a number of variables, including TDI index, polyol temperature, cell size, air flow, and density. These processing variables limit control of foam hardness levels to roughly ± 10 percent.
- A1.2 The Joint Industry Polyurethane Foam Standards and Guidelines Committee recommends a ± 3 lb. spread on a nominal 30 lb. IFD foam to be acceptable ($\pm 10\%$ on firmer grades of foam).
- A1.3 The committee recognizes that some furniture manufacturers require tighter control of IFD levels in their cushions. In these cases, foam cushions of the desired hardness level shall be supplied on an individual basis by agreement between the foam supplier and the manufacturer through selective cutting and grading.
- A1.4 The measurement of IFD in foam cushions is affected by a number of variables. Some factors which may affect the IFD value measured include temperature, humidity, state of foam cure, equipment differences, and test procedure differences. The committee therefore recommends that for refereeing purposes the procedure described in ASTM D-3574 test B₁ be strictly followed.

A2.0 EFFECT OF COVER FABRICS ON CUSHION FIRMNESS

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A2.0 Effect of Cover Fabrics on Cushion Firmness

- A2.1 Many of the sources of complaints on firmness or softness of cushions are associated with something other than variations of foam IFD. One of the single largest and most significant sources of problems of this type is upholstery fabrics.
- A2.1.1 Fabrics affect firmness - but the exact magnitude of the effects is not known. The following table demonstrates quantitatively, the effect of this group of upholstery fabrics on final cushion IFD. Data in the table was derived as follows:

A2.0

EFFECT OF COVER FABRICS ON CUSHION FIRMNESS

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- A2.1.2 24" x 24" x 4" thick foams with IFD's measuring 26 pounds, 27 pounds, or values between 26 and 27 pounds only were used in the test. (All IFD measurements were made in a conditioned lab by the same technician). Foam cushion cores were 24" x 24" x 4", and the foam was wrapped with 1.1 Oz/square yard, resinated polyester fiber with 1.5" measurable loft. All polyester fiber came from the same roll and was allowed to relax under zero load (uncompressed) for 36 hours prior to cushion wrapping. Two inches of the entire horizontal periphery of the foam cushion cores were sprayed with adhesive to prevent rolling or moving of the polyester while the cushion jacket was being stuffed with the core plus polyester wrap.

Each upholstery fabric used in the experiment was cut and sewn as follows:

top and bottom panels-----24" x 24" (then sewn with 0.5" seam allowance)

boxing strip -----4.5" Wide (then sewn with 0.5" seam allowance)

(the experimental cushions were boxed, non-welted, zippered cushions)

- A2.1.3 A standard pile fabric was chosen based on general softness-pliability; ease of sewing without wrinkles, puckers, etc; and breatheability. All other fabrics were compared to the standard.

After the cushion jackets were cut, sewn, and stuffed, a type of IFD was run as follows: the finished height of the cushions was measured in the exact center of the cushion by using a one pound pre-load. The cushions were then flexed twice to 75% of their total, original measured height using the indenter foot and a vertical speed of 1.0 inch per minute. The cushions were allowed to rest for 10 minutes plus or minus 5 minutes before further testing. After the rest period, the finished cushion height was measured with a one-pound pre-load, and the indenter foot was indented into the cushion exactly 1.25" at a vertical speed of 2.0"/minute. After one minute, the force required to accomplish the deflection was read in pounds and recorded. Data thus generated is as follows:

The Effect Of Upholstery Fabrics On Cushion IFD

Fabric Description	1.25" IFD (in pounds)
--Standard Velvet	31.5
--Sliver Knit (14% Elongation)	29.0
--8.4 Oz/yd ² Cotton Print (warp satin)	32.0
--Raschel Knit Velvet (Mayer Type)	32.0

A2.0 EFFECT OF COVER FABRICS ON CUSHION FIRMNESS

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--Tufted Velvet	30.0
--Woven, Textured Flat (With Air Textured, Spun, Chenille, and Monofilament Yarns)	45.0
--Weft Insertion Knit (With Spun, Boucle', Air Textured, and Chenille Yarns)	43.5
--Printed Flock	41.5
--Flat Jacquard (double cloth tied-down construction)	49.5
--Flat Woven (with large diameter spun yarns adjacent to very small diameter spun yarns and then latex backcoated to accommodate the large degree of heterogeneity in yarn sizes)	54.5
--Vinyl Fabric (with breather strip sewn on one side of cushion)	50.5

Note: With the exception of the printed cotton and the vinyl fabric, all fabrics were backcoated.

Fabric construction and yarn type alone are not totally responsible for the increase in finished-cushion, equivalent IFD. Latex backcoating applied and/or selected improperly can even spoil the softness and suppleness of the standard fabric. Suffice to say, however, fabrics do contribute significantly to the firmness-softness of seat cushions; and complaints should be thoroughly reviewed before core foams are deemed to be at fault.

A3.0 TEMPERATURE AND HUMIDITY EFFECTS ON IFD

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- A3.1 "Relative humidity" is defined as the amount of moisture vapor in the air "relative" to the amount of moisture vapor the air will hold at a specific temperature. For example, a relative humidity reported as 80% at 75 degrees F means that the air contains, at that specific temperature, 80% of the moisture that the air could contain. Another way to look at relative

A3.0 TEMPERATURE AND HUMIDITY EFFECTS ON IFD

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humidity in the above example is that 20% more moisture could be added to the air at that temperature. If 20% more moisture were added to the air at 75 degrees F, the air would then be completely saturated, and the relative humidity would be 100%. Relative humidity is always reported as a percentage value.

A3.2 "Absolute humidity" is the quantitative amount of moisture in the air regardless of the temperature. Absolute humidity is usually reported in grains of moisture per cubic foot (or cubic meter) of air. Typical absolute humidity values in the wintertime are 10 to 30 grains of moisture vapor per cubic foot, while typical values for the summertime are 120 to 140 grains per cubic foot.

A3.3 The other effect of temperature and humidity is related to the temperature and humidity during the actual measurement of the IFD. The effects of temperature and humidity during the measurement of IFD are generally reversible. For example, the following scenarios are actual measurements on actual pieces of foam:

SCENARIO I

25% IFD of a piece of foam in a laboratory conditioned to 70 degrees F and 50% relative humidity	32 lbs
--	--------

25% IFD of the same piece of foam when placed in the plant a week later at 90 degrees F and 88% relative humidity	26 lbs
---	--------

25% IFD of the same piece of foam when placed back into the conditioned laboratory a week later	32 lbs
---	--------

SCENARIO II

25% IFD of a piece of foam in a laboratory conditioned to 70 degrees F and 50% relative humidity	32 lbs
--	--------

25% IFD of the same piece of foam in the plant warehouse a week later at 32 degrees F and 40% relative humidity	39 lbs
---	--------

25% IFD of the same piece of foam one week later placed back in the conditioned laboratory @ 70 degrees F and 50% relative humidity	32 lbs
---	--------

A3.0 TEMPERATURE AND HUMIDITY EFFECTS ON IFD

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A3.4 It is easily seen that the IFD changes due to temperature/humidity are reversible and are directly related to the temperature and humidity. Furthermore, with the technology available today, the magnitude of the actual change in IFD is not quantitatively predictable.

3.4.1 There is a very good reason that the quantitative relationship between IFD and temperature/humidity is not yet predictable. It is fairly certain that the chemical structure of the foam has much to do with the temperature/humidity related IFD changes. Because the temperature/humidity IFD relationship varies with different foam types, development of a universal temperature/humidity IFD relationship statement is impractical.

A3.5 As the IFD increases, the effects of both relationships of temperature and humidity also increases. For example, the effects of both summertime regression and changes only due to measurement temperature/humidity are much more significant on a 36 IFD foam than on a 15 IFD foam. The reason for this is probably due to the magnitude of the IFD number. For example, if the IFD change is 20% on both foam types, 20% of a 36 pound IFD is 7.2 pounds while the same 20% change of a 15 IFD foam is only 3 pounds.

A3.6 Thus, temperature and humidity must be considered carefully and thoroughly in the day to day management of IFD specifications by both the foam manufacturer and the furniture manufacturer.

A3.7 The question arises, with the variations caused by temperature and humidity, how can one devise an acceptance testing procedure and not have to maintain huge inventories awaiting test results from controlled temperature and humidity laboratories?

A3.7.1 Day-to-day acceptance of foams, tested in non-controlled temperature and humidity conditions, can be accomplished by working closely with one's vendors. Some general knowledge about IFD variation with temperature and humidity is necessary.

A3.7.2 It is generally recognized that the key point to remember is that the IFD/temperature/humidity relationship is an inverse relationship; that is, as the temperature/humidity increases, the IFD decreases.

A4.0 INTERLABORATORY STUDY OF IFD

Joint Industry Foam Standards and Guidelines

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A4.0 Interlaboratory Study of IFD Measurement Precision and Bias.

A4.0

INTERLABORATORY STUDY OF IFD

Joint Industry Foam Standards and Guidelines

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A4.1 Scope

The purpose for conducting an interlaboratory study of IFD measurement is engendered by the necessity to establish acceptance range guidelines for IFD of flexible polyurethane foam for use by both the foam manufacturer and the furniture manufacturer. The test method under scrutiny is ASTM D 3574-86 Test B1 "Standard Methods of Testing Flexible Cellular Materials--Slab, Bonded, and Molded Urethane Foams".

A4.2 Procedure and Sampling

The basic outline for conducting an interlaboratory study to determine the reliability of a test method is outlined in ASTM E 691-87 "Standard Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method".

In preparing the interlaboratory study, nineteen laboratories were chosen to conduct measurements of weight, height, 25% IFD, 65% IFD, and 25% Return IFD on flexible polyurethane foam samples. These five measurements are the fundamentals on which other parameters are calculated, i.e., density, modulus of compression, hysteresis, etc. In addition, a calibration spring was circulated among all participating laboratories to collect height and 25% compression values for comparative reference.

The flexible polyurethane foam samples were supplied by two manufacturers, each to provide a nominal 1.8 lb/ft³ density, 30 lb IFD conventional grade foam. The foam pieces were cut horizontally from the center of the foam bun and serially numbered for location identification. All foam samples were cut a nominal 24 inches square by 4 inches in thickness. Foam samples were crushed 90% of their original thickness twenty-five cycles by the use of rollers. The samples were kept segregated by supplier, thus yielding two sample sets.

A4.3 Sample screening

All foam samples were sent to a centralized screening laboratory to test for uniformity of 25% IFD measurements within the sample sets, allowing the opportunity to remove any outlying specimens from the test.

Great care was taken in establishing the interlaboratory study procedures to provide each laboratory with foam samples that were in equal condition. Previous studies circulated a great number of foam specimens from laboratory to laboratory, compounding the foam fatigue element each step along the way. In this study, each laboratory received its own set of specimens with each specimen having been subjected to exactly the same crushing and screening steps, i.e., the fatigue element was exactly the same for each specimen and therefore was eliminated as a variable.

A4.0

INTERLABORATORY STUDY OF IFD

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A.4.4. Data

The reported data required from each laboratory included specimen weight, height, 25% IFD, 65% IFD, 25% return IFD for three specimens from each of two sample sets. The test method used was ASTM D 3574-86 Test B1 with the prefix rate set at 10 inches per minute. Test machine type and capacity, and laboratory temperature and relative humidity readings were also reported.

A4.5 Statistical Analysis

The data returned from the nineteen laboratories was analyzed according to the consistency statistic procedures as outlined in ASTM E 691 to determine repeatability and reproducibility limits at the 95% acceptance level. Precision and bias statements were prepared by following the procedures outlined in ASTM E 177-90a "Standard Practice for Use of the Terms Precision and Bias in ASTM Test Methods". The data was also analyzed using the Kolmogorov-Smirnov test to compare distributions between sample sets and distributions between the screening lab data (used as a population distribution since there are no known true values) and the interlaboratory data.

A4.6 Conclusions

The consistency analysis results show that there was relatively consistent performance between laboratories. There was, however, some imbalance within some of the laboratories. The consistency analysis points toward equipment or measurement scale deficiencies as a possible explanation for intralaboratory inconsistencies. The following tables summarize the precision statements in terms of 95% repeatability and reproducibility limits of IFD measurement for the foam sample sets A and B from the interlaboratory study. These limits demonstrate just how closely one could expect to reproduce the test values observed in this study within a single laboratory (repeatability) or among several laboratories (reproducibility).

SET A	25% IFD	65% IFD	25% RETURN IFD
Average test value (lbs)	29.9	65.8	24.5
95% Repeatability limits (lbs)	1.26	5.66	1.60
95% Reproducibility limits (lbs)	2.21	7.14	2.16

A4.0

INTERLABORATORY STUDY OF IFD

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SET B	25% IFD	65% IFD	25% RETURN IFD
Average test value (lbs)	32.7	66.9	24.4
95% Repeatability limits (lbs)	2.32	4.68	2.27
95% Reproducibility limits (lbs)	3.70	7.39	6.36

Using the screening laboratory values as reference values, the bias statements are:

- the ILS 25% IFD means for sets A and B were approximately 3% lower.
- the ILS 65% IFD mean for set A was approximately 0.2% higher.
- the ILS 65% IFD mean for set B was approximately 1% lower.
- the ILS 25% Return IFD means for sets A and B were approximately 0.4% higher.

The comparison of distributions (Kolmogorov-Smirnov test) of the interlaboratory study shows a significant difference between data sets A and B and the screening laboratory (population) data at an alpha level of 0.05, particularly on height and 25% IFD measurement (see table below).

KOMOGOROV-SMIRNOV TEST
COMPARISON OF DISTRIBUTIONS

DISTRIBUTIONS COMPARED	HEIGHT	WEIGHT	p- values		
	HEIGHT	WEIGHT	25% IFD	65% IFD	25% R-IFD
ILS vs SCREEN SETS A & B	0.0007	0.6634	0.0001	0.2115	0.0021
ILS SET A vs ILS SET B	0.0001	0.0001	0.0001	0.0001	0.0033
ILS vs SCREEN SET A	0.0036	0.3442	0.0001	0.4761	0.0386
ILS vs SCREEN SET B	0.0126	0.4761	0.0001	0.0126	0.1031

If p-VALUE < 0.05, THEN DIFFERENCE IS SIGNIFICANT @ ALPHA OF 0.05

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One explanation for this significant difference is the degree of error associated with measuring foam height using a one pound preload. The survey of equipment used by the participating laboratories reveals that the load cells used have capacities ranging from 150 to 1000 lbs.

The sensitivity of the various load cells in the extreme low end of their range is very suspect to error. The 30 pound force generated by compressing the foam samples to 25% of original height in the 25% IFD measurement is also very near the lower extremity of most of the load cell ranges.

The conclusions drawn and the precision and bias statements presented in this interlaboratory study are only valid for 1.8 lb/ft³ density, nominal 30 lb IFD conventional flexible polyurethane foam. Extrapolation to other foam densities, IFD's, or types is highly speculative. One could expect to see similarities in inter- and intra- laboratory performance when testing different foam populations, however, the precision and bias statements will take on different values than those presented in this interlaboratory study.

One must remember that the purpose of this study was to determine the reliability of the test method. Many of the variables that are encountered in routine IFD measurement have been controlled or eliminated within this interlaboratory study. Therefore, the data collected in this study reflects only the "good end" of the data spectrum. In actual practice, IFD measurements are victim to variables such as height measurement error, preflex speed variances, recovery time differences, flex rate differences, and numerous on-site "shortcuts" in following test methodology. Also, the physical properties of the flexible polyurethane foam that is routinely purchased in the industry are much more random than the controlled sampling obtained for this study. However, the +3 lb IFD acceptance range currently in practice is satisfactory and practical in this random foam supply.

DETERMINING CHARACTERISTICS

AND PERFORMANCE PROPERTIES

OF

UPHOLSTERY FIBER BATTINGS

STANDARD TEST METHODS FOR DETERMINING CHARACTERISTICS AND PERFORMANCE PROPERTIES OF UPHOLSTERY FIBER BATTINGS

Joint Industry Foam Standards and Guidelines
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1.0 STANDARD TEST METHOD FOR WEIGHT PER UNIT AREA OF UPHOLSTERY FIBER BATTINGS

1.1 Scope

1.1.1 These test methods cover the measurement of fiber battings to determine actual weight per unit area for comparison as to how they have been represented.

1.2 Definitions

1.2.1 Weight, Noun. - As used with fiber battings, weight per unit area.

Fiber batting weight per unit area is expressed ultimately in ounces per square foot for large unit measurements. Also, weight per unit area for small sample sizes is determined in grams per square centimeter but should be converted to ounces per square foot.

1.3 Summary of Method

1.3.1 Fiber batting weight is calculated from the weight of a given sample and its length and width expressed as square footage.

1.4 Apparatus

1.4.1 A certified scale with enough capacity and sensitivity to weigh full batting rolls within an accuracy of plus or minus 0.1 percent of their gross weight in ounces.

1.4.2 A certified scale with enough capacity and sensitivity to weigh small sample units, 232 square centimeters (6" x 6"), to within an accuracy of plus or minus 0.1 percent of their gross weight in grams.

1.4.3 Measuring scales

1.4.3.1 One inch ruler

1.4.3.2 Centimeter ruler

1.4.4 Sample cutting die or template (12" x 12" x 3/4" deep).

1.4.5 Mechanical press for die cutting test specimens, if required.

1.4.6 Anvil panel for die cutting batting.

1.5 Test Room Conditions

- 1.5.1 Test sample preparation and testing should be conducted in a standard atmosphere of 70 plus or minus three degrees F and 50-65 percent relative humidity.

1.6 Sampling and Specimens

- 1.6.1 Large scale sample would be a typical full roll of batting as received. Test two rolls.
- 1.6.2 Small scale samples 12.0" x 12.0" are taken in an equally spaced diagonal direction across and along width of the roll. Take three test specimens spaced at least 12" apart.

1.7 Procedure: Option A- Large Scale Test

- 1.7.1 Weigh batting roll as received on an ounce scale to the nearest 1/4 ounce. Deduct the weight of shipping wrapper, if any.
- 1.7.2 Unroll batting and measure to nearest 1/4" the length at median location of the roll.
- 1.7.3 Measure to nearest 1/4" at five width locations, equally distributed along roll. Average the five measurements.
- 1.7.4 Calculate area to square foot unit.
- 1.7.5 Calculate weight per unit area by the following formula:

$$\frac{\text{Total ounces for roll}}{\text{Total square foot area of roll}}$$

1.8 Procedure: Option B-Small Scale Test

- 1.8.1 Weigh each of the three samples cut from a roll of batting on scales having capacity to weigh to the nearest one hundredth (0.01) of a gram.
- 1.8.2 When exact area of die is known, calculate weight per unit area by the following formula:

$$\frac{\text{Grams} / 28.35}{\text{Sample area inches}^2 / 144} = \frac{\text{Ounces}}{\text{Square foot}}$$

1.9 Reporting

- 1.9.1 Weight per unit area for both large and small scale tests should be reported in ounce(s)/square foot. In cases of dispute in the small scale test only, repeat the small scale test at both ends and the middle of the roll.

2.0 STANDARD METHOD FOR MEASURING THICKNESS OF UPHOLSTERY FIBER BATTING

2.1 Joint Industry Foam Standards Committee Method:

Reference Document - JIFSC Test Method for "Static Fatigue" of Polyester Fiber Batting.

Section 5: Subparagraphs 5.1 - 5.4

Section 8: Subparagraphs 8.1 - 8.7

2.2 Referee Method:

Reference Document - ASTM D 1777 Standard Method For Measuring Thickness Of Textile Materials.

3.0 STANDARD TEST METHOD FOR COMPRESSION SET (STATIC LOAD) OF TYPICAL UPHOLSTERY FIBER BATTING

3.1 Scope

3.1.1 This test method is designed to be a uniform procedure to determine the resilient qualities of upholstery fiber battings following an extended static compression time period.

3.2 Applicable Document

3.2.1 ASTM Standard D 123 Terminology relating to textiles

3.3 Summary of Method

3.3.1 Testing for compression set is achieved by using a long term typical seating static load to produce cold flow of fibers, thus, a reduced height of the batting from its original height.

3.4 Uses and Significance

3.4.1 This method is useful to predict the maintenance and performance of battings in cushioning applications so appearance and acceptability of the upholstery product will not be compromised.

3.5 Apparatus

3.5.1 Steel rule die or template, 6" x 6" x 3/4" deep, batting specimen cutter.

3.5.2 Aluminum plates, 6" x 6" x 0.025", weighing 2 grams per square inch, with geometric center of plate marked.

3.5.3 Preflex plate, 6" x 6", weighing one pound.

3.5.4 One inch range micrometer, 0.001" divisions, mounted on suspension lever to extend over 6" x 6" specimen.

3.5.5 Square steel weights, 6-1/2" x 6-1/2", having a total weight of 54 pounds for each test specimen.

3.5.6 Mechanical press for die cutting test specimen.

3.5.7 Anvil panel for die cutting batting.

3.6 Sampling, Selection, and Specimens

- 3.6.1 Using a fiber batting roll containing 2 or more linear yards, die cut three 6" x 6" samples in a diagonal direction across and along the roll with at least 12 linear inches between each sample. Cut enough sample at each of the three locations to create a stack height of at least 4" or more for greater accuracy.
- 3.7 Conditioning
- 3.7.1 No special conditioning is required for any batting or fiber types.
- 3.8 Procedure
- 3.8.1 Place specimen #1 on a flat surface for measuring height.
- 3.8.2 Using the one pound 6" x 6" reflex plate, depress the batting with the one pound load twice in rapid succession and remove.
- 3.8.3 Very gently place the 6" x 6" x 0.025" aluminum plate on the fiber batting sample.
- 3.8.4 Bring the lever mounted micrometer over the geometric center of the aluminum plate and lower the micrometer to faintly touch the aluminum plate surface.
- 3.8.5 Note and record height of batting and 0.025" aluminum plate.
- 3.8.6 Deduct the 0.025" plate thickness for the net batting height.
- 3.8.7 Remove the 0.025" aluminum plate from the batting.
- 3.8.8 Load the 54 pound, 6-1/2" x 6-1/2" weights onto the fiber batting sample.
- 3.8.9 Repeat the procedure above for batting sample #2 and #3.
- 3.8.10 Allow the 6" x 6" samples to stay under compression for a period of 14 days.
- 3.8.11 After 14 days under compression, remove all weights and allow a 30 minute and 24 hour recovery.
- 3.8.12 After each recovery period, repeat height measurements outlined in 3.8.3 through 3.8.6 above.
- 3.8.13 Calculate and record the compression set results using the following formula:
- $$\frac{\text{original height} - \text{final height}}{\text{original height}} \times 100$$
- $$= \% \text{ set}$$
- 4.0 STANDARD TEST METHOD FOR COMPRESSION SET (DYNAMIC FLEXING) OF TYPICAL UPHOLSTERY FIBER BATTINGS
- 4.1 Scope
- 4.1.1 This test measures the ability of polyester and other fiber upholstery battings to rebound and resist taking a set in height after being flexed at a constant rate.

4.2 Applicable Document

4.2.1 ASTM Standard D 123 Terminology Relating to Textiles.

4.3 Summary of Test

4.3.1 Compression set in this test is produced by the dynamic flexing of a batting specimen at a constant rate to a predetermined percent of original height. This induces cold flow, entanglement, and fatigue of fibers while confined in a typical upholstery ticking.

4.4 Uses and Significance

4.4.1 Utilizing this test can provide a substantial indicator as to the long term performance of battings in cushioning applications so appearance and acceptability of the upholstery product will not be compromised.

4.5 Apparatus

4.5.1 Indention Force Deflection (IFD) machine used to test firmness of flexible polyurethane foam or equivalent.

4.5.2 Bearing plate (15" x 15") to cover entire surface of 14" x 14" test specimen. Thickness of bearing plate varies with material used, e.g., 3/4" plywood or 1/4" aluminum has sufficient stiffness to distribute load of the 50 square inch foot of the IFD machine.

4.5.3 Flexing machine having capacity to compress entire 14" x 14" sample up to 85% of its original height at a rate of 35 plus or minus 5 cycles per minute.

4.5.4 Top loading gram weighing scale.

4.6 Test Specimens

4.6.1 Create three 14" x 14" tickings with a 4" boxing, using 1.5 ounces per square yard breathable woven or non-woven sheeting, leaving one edge open for filling purposes. Weigh the sewn ticking in grams before inserting fiber. Cut batting approximately 15" x 15" and stack layers until the weight of the fiber equals 500 grams. Blown fiber should also equal 500 grams. Insert fiber in sewn ticking and close the open edge.

4.7 Conditioning

4.7.1 No special humidity conditioning is required except for nylon fibers.

4.7.2 When pillow/cushion specimens are prepared and packaged before testing, remove the packing constraints, separate specimens and let recover 24 hours before beginning tests.

4.8 Procedure

4.8.1 Raise pressure foot of IFD machine or equivalent and center specimen under 50 square inch pressure foot.

4.8.2 Bring foot in contact with test pillow/cushion with two pounds pre-load and note height and record as original thickness.

- 4.8.3 Raise pressure foot so 15" x 15" bearing plate can be centered atop pillow/cushion.
- 4.8.4 Compress entire specimen with 120 pounds.
- 4.8.5 Note and record compressed height, deducting thickness of bearing plate.
- 4.8.6 Calculate percent entire pillow/cushion compressed with 120 pounds.
- 4.8.7 Place specimen in dynamic flexing machine pre-set to flex the pillow/cushion to the same level as the 120 pounds.
- 4.8.8 Flex the specimen 50M cycles, non-stop, at a rate of 35 plus or minus 5 cycles per minute.
- 4.8.9 When cycling is complete, remove from machine, let rest for 30 minutes before taking the first of three measurements for height recovery.
- 4.8.10 Following recovery periods of 30 minutes and 24 hours, place the tested pillow/cushion under pressure foot of IFD machine or equivalent with a two pound pre-load and record heights.
- 4.8.11 Calculate loss of original height and record.
- 4.8.12 Reapply 15" x 15" bearing plate atop test specimens and check each for height with 120 pound load. Deduct thickness of bearing plate and record new pillow/cushion height.
- 4.8.13 Calculate additional loss in height as a result of dynamic flexing and record.
- 4.8.14 Test a total of three pillow/cushion samples for each fiber being evaluated.

