Engineer’s Guide for Evaluating Furniture Quality and Improving Test Methods

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Introduction

Having to recall a product from the market is a costly and potentially brand damaging exercise that no company wants to face. It can bring litigation, shake consumer confidence in a product portfolio, and enables your competitors to step in with alternative products even your most loyal customers would consider switching to. Even more than that, it can damage share price and affect future investment in your organization.

Performance testing your products is an economical way to assure your furniture designs meet industry standards and quality from a structural durability, safety, and overall quality standpoint. It can help predict failures, improve durability, enhance safety, and identify unexpected problems before hitting the market.

Having your products tested for performance can provide you with a competitive advantage in the marketplace and allow you to:

- Gauge how well your products stack up against the competition so you can develop more competitive products.
- Make hard-hitting and qualified marketing claims, such as "the worlds quietest..."; "most efficient..."; "more durable..."
- Secure valuable endorsements from industry trade associations.
- Verify your internal test data.
- Prove to retailers that your product is “best in class”

This paper will give you information about how field failures can affect your products and discusses common product liability issues furniture manufacturers face. It will also provide you with unique tools to evaluate the quality of your products and help improve test methods, specifically with structural and flammability testing.

Field Failure Costs

Field failure costs are a result of product failure after the product has reached the consumer. The costs of field failures include, but are not limited to, customer returns or complaints, costs of recalls and warranty claims, and product liability costs.

Customer returns could result in additional costs and consequences that often go unmeasured. The most important being the potential loss of business, and reduced market share, not to mention increased freight costs for returned items.

Recalls and warranty claims lead to some less obvious consequences because of the additional costs required to maintain these claim systems. In most cases, the greater the number of warranty issues and recalls, the greater the costs associated with supporting the recall and warranty administration.

The most significant costs incurred due to field failures are those associated with product liability, due to the possibility of legal action and settlements.
Common Furniture Product Liability Issues

The spectrum of product liability costs loom over the furniture industry, especially in the consumer furniture market. Consumer Reports indicates that in an average year, 9 children, most of them under the age of 5, are killed when household furniture tips over. In addition, there are reportedly between 8000 and 10,000 injuries due to tipping furniture, with most of the injuries to children.

Another area of concern in the consumer market is furniture components made of glass. According to Consumer Reports, there are more than 15,000 visits to the emergency room every year from injuries caused by glass furniture. It is important to have the glass components of your furniture performance tested to ensure the safety and quality of your entire product.

Testing furniture for stability, and changing the design to enhance stability can reduce the potential for injuries due to tipping furniture. ASTM, ANSI BIFMA, GSA, EN, and other standards all provide options for stability testing for dressers, file cabinets, chests, seating, and other furniture products.

Pinch points and sharp edges can also cause injury. In addition to stability testing, it is important to perform a review of products pertaining to these issues, per the applicable portions of DD ENV 12520 Sec.4 Safety Requirements.

Flammability is perhaps one of the greatest contributors to product liability costs associated with furniture. N.I.S.T. reports that polyurethane foam in furniture is responsible for 30% of U.S. deaths from fires each year. This statistic comes from Anapolschwartz, a law firm specializing in lawsuits against furniture companies for fires caused by polyurethane foam. The firm claims to have settled one such case for $3.75 million.

The UK implemented flammability requirements in 1988 that require all upholstered furniture resist ignition by cigarettes or matches, and foams must be slow burning. Independent research studies determined that the effects of the regulations showed in the first 15 years, over 4000 lives were saved and 40,000 injuries were prevented.

Structural Testing

Structural testing allows furniture manufacturers to evaluate products for static, dynamic, and fatigue strength properties, prior to releasing products for production. This allows for pre-production design changes, helping to reduce costly field failures, and recreate field failures that have already occurred to determine the root cause. The costs of field failures can be significant, therefore any reduction in these failures, achieved through performance testing, can increase your bottom line.
Innovative Structural Test Methods

Evaluating furniture for structural strength and durability is done by performing tests that are specified in a number of standards. In structural test standards, there are typically 3 different types of loading:

1. Static Loads
2. Fatigue Loads
3. Impacts

1. Static Loads

The load value is specified by the amount of time the load must be endured by the product, limits to the rate at which the load is applied, and evaluation criteria to determine compliance.

To achieve the specification requirements for this type of test on a vertical surface, the engineer typically loads the surface with a calibrated weight bag. This provides a high degree of reliability and repeatability. When tight tolerances exist for the rate of load application, a load cell is used to monitor the rate of load increase as the bag is lowered.

To achieve the specification requirements for loads that aren’t applied on a vertical surface, pneumatic, hydraulic, or electronic actuators are used to push or pull the part creating the load required, in the direction required. In these instances a load cell is typically used to monitor the load.

Analysis that can be done beyond testing the part with static load:

When the performance of a specific part or component is of particular interest to engineering, strain gauges can be applied to the part while performing the static load. Strain gauges are small resistive grids that can be applied to the part with a 2 part epoxy, and monitored electronically. The strain gauge is capable of detecting material movement on the micro scale; this can be thought of as “bending” that cannot be seen by the human eye.

The most valuable strain gauge configuration that can be used when performing static loads on furniture is the strain gauge rosette. This consists of 3 gauges at opposing angles. A common angle of opposition is 45 degrees between each of the three gauges, however there are other options.
The significance of the angle variation is that it provides the opportunity to calculate the maximum / minimum principal strains, and approximation of the strains about the entire 360 degree axis, through the strain transformation equation.

* Graph shows an example of the result of doing mathematical analysis on the values obtained by a strain gauge rosette.

The strain can also be used to calculate stress. Customers can then use these stress results to compare to FEA (Finite Element Analysis) results, and make educated decisions with regards to product performance expectations, and design change optimization.

2. Fatigue Loads

Typically, a load value is a specified number of cycles the load must be applied, cycle rate, and evaluation criteria to determine compliance.

To achieve the specification requirements for this type of test on a vertical surface, the engineer loads the surface with a calibrated weight bags, then uses a pneumatic or hydraulic cycler programmed to raise and lower the bags for the specified number of cycles, providing a high degree of reliability and repeatability. When tight tolerances exist for the rate of load application, a load cell is used to monitor the rate of load increase as the bag is raised and lowered.
To achieve the specification requirements for loads that must be applied horizontally or at non-vertical angles, pneumatic, hydraulic, or electronic actuators are used to push or pull the part creating the load required, in the direction required. PLC or Daq Card based controllers allow the testing engineer to then set the system for the number of cycles that must be performed, and the load to apply during each cycle. Proportional controllers can be used in these systems to create a closed loop load controlled process when tight tolerances are needed.

Improved Fatigue Test Performance through Intertek’s Control Algorithm

Clients often require a very high degree of accuracy when requesting cyclic testing. Often, loads in access of 200lbs must be accurately reproduced over and over again without being off by more the 2 lbs! This can be done easily when cycling very slowly, but it becomes very difficult when customers need to have the testing completed quickly.

Through the development of a complex control algorithm that goes beyond PID control, Intertek developed systems to meet these needs. The Intertek Cyclic durability servo controls that in the past utilized PID theory alone, now use an advanced control algorithm that improves upon the accuracy and speed capability of the servo system.

PID control loop theory:
PID stands for (proportional, integral, derivative).

The PID loop compares a measurement to the set point that the system is trying to reach, and then uses the difference “proportion” in the two to make a decision on how much the input should be increased to ensure a safe “landing” at the set point.
The “integral” and “derivative” are used as well because you can integrate, and derive the difference in the measurement and set point resulting in two additional tuning parameters for the PID loop.

Once a PID loop has been setup, each of its three outputs; the proportional difference, integral of the proportional difference, and derivative of the proportional difference are each multiplied by a gain. By adjusting the gain for each of these, the user can improve the ability of the loop to control the “system”.

In the case of furniture testing, the “system” is a servo controlled load application device. (a piece of equipment programmed to apply the same load to a piece of furniture over and over again). This process is usually performed by using a linear actuator to create movement, a proportional controller to adjust the amount of load, and a load cell to provide the measurement feedback.

The problem that arises with PID control of these furniture test systems is that even when you fine tune the loop, you may still see some overshoot if you’re trying to go very fast.

Intertek has solved this problem by modifying the loop to “memorize” the proportional settings it took to achieve the load in previous iterations of the loop.

Each time the loop executes, the system autonomously “learns” from the previous iteration creating a system where accuracy and precision are increased each cycle, or until the set point specified tolerance is achieved. The system is constantly tuning itself through fine adjustments to accommodate for material fluctuations such as firmness and permanent set.

This results in a system that is capable of running at very high speeds without making a mistake.
The enhanced response characteristics of Intertek’s Furniture Test Equip Control Algorithm

Analysis that can be done beyond just testing the part for fatigue:

When additional analysis of a product is of interest to engineering, linear transducers can be applied to the part while performing the fatigue load. Linear transducers come in a variety of different sizes and tolerances. They are devices that can measure displacement and are monitored electronically. The most valuable use of the linear transducer is in fatigue testing.

A data acquisition system with a linear transducer can do more than just measure the displacement of the product under load for one cycle. With proper programming, the system can be set up to record the maximum displacement caused by each cycle during a fatigue test. The values recorded can then be used to plot change in displacement over time for the fatigue test.

This data and the relationships that can be derived from it, can be a valuable tool for engineering to evaluate the performance of their product over time. (Not only for strength, but for performance deterioration that may cause discomfort, and changes to ergonomic properties as well)

*Graph shows an example of the result of doing mathematical analysis on the values obtained by a linear transducer during a fatigue test.
Additional Analysis that can be done to Improve the Fatigue Test Procedures through Statistical Process Control (SPC):

For further control of the fatigue test when tolerances for the load application are tight, Statistical Process Control (SPC) can be applied. SPC can be applied to both a process measurement and outcome measurement taken from the fatigue test. The measurements can then be used with SPC to identify out of control conditions and help make trouble shooting decisions if out of control conditions are found.

The accuracy of the load application is the process measurement to which SPC can be applied. The number of cycles endured by each identical sample submitted by the client is the outcome measurement to which SPC can be applied.

The method that can be used to measure the process is data acquisition recordings of the load application throughout each test. A data acquisition system can be programmed to log the max load recorded by the load cell, each cycle. The method to measure outcome can be manually recording the average number of cycles achieved by each sample set.

Two different SPC charts can then be created using the process measurement recordings. Both can use upper and lower limits 10% tighter than the load tolerance specified by the customer or test specification. The first chart will be a chart of the max load applied during each cycle of the test. The second chart will be an Xbar chart of the average max load applied throughout the entire test for each sample.

Outcome measurements (cycles endured by each sample) can be SPC charted without limits. (It is the client’s responsibility to determine what endurance ranges they consider
acceptable for the product) The outcome SPC chart will be a chart of the number of cycles achieve by each sample.

Example of an SPC chart:

*See the flow chart below for an explanation of how the charts will relate back to the fatigue test process.

SPC Chart 1: Process chart for maximum load applied during each cycle
SPC Chart 2: Process xbar chart for average load applied during each cycle of each test
SPC Chart 3: Outcome chart for cycles endured by each sample
3. Impacts

A load value is the height from which to drop the load, construction of the load device, and evaluation criteria to determine compliance.

To achieve the specification requirements for this type of test, the engineer uses a hoist to raise the calibrated loading device or bag above the surface to be impacted. The height is then checked with a gauge or calibrated rule. A quick release or equivalent is used to release the load so that it free falls the specified distance and impacts the test surface.

Analysis that can be done beyond testing the part with impacts:
When additional analysis of a product is of interest to engineering, piezoelectric load cells can be placed underneath the part while performing the impact test. Piezoelectric load cells are devices that can measure impacts, monitored electronically, and they are capable of operation at very high sample rates. The most valuable use of the piezoelectric load cell is in determining the maximum impact strength of products.

With proper programming, the system can be set-up to record the maximum impact caused by dropping the load device or bag. The values recorded can then be used to plot change in impact force over time for the impact test.

By increasing the impact height to a height that will knowingly damage the product, the engineer can analyze the maximum impact force achieved by the product. This data, and the relationships that can be derived from it, can be a valuable tool for engineering to evaluate the performance of their product when impacted.

**Flammability**

Flammability testing is utilized by manufacturers to ensure that they are creating a product that will not cause, or contribute to the generation of potentially deadly fires.

**Innovative Flammability Test Methods**
Evaluating furniture for flammability is done by performing tests that are specified in a number of standards.

In flammability test standards, there are typically 3 different types of measurements, but many different types of flame sources.

Measurements include:

1. Flame Spread
2. Rate of Heat Release
3. Mass Loss

Some examples of flame sources include; smoldering sources, open flames, and cigarettes. Flammability standards specify the required flame source for the test, and the measurement technique or techniques with their max allowable values. Other requirements are often included for the HVAC system that must be operated while performing the test.
Conclusion

With the recent surge to develop new, and in many cases, long-distance relationships with suppliers, there is a necessity for performance testing in the furniture industry. This is due to the need to insure that new parts sourced from new suppliers meet the specifications of the previously used parts. This comparison can be made by furniture testing through structural and flammability testing.

The field failures that could result from a lack of testing can be potentially very costly. Again, recalls and warranty claims lead to less obvious consequences because of the additional costs required to maintain these claim systems. The most significant costs incurred due to field failures are those associated with product liability because of the possibility of legal action and settlements. Protect your product from liabilities with the proper furniture performance testing.

At Intertek, we believe that the testing and certification process doesn’t have to be burdensome to manufacturers and distributors. We use technology and engineering expertise to streamline the testing process and help get products to market faster.

Below are some examples of how Intertek simplifies the testing process for our clients.

1. Clients have a strong desire to watch their testing, but the current economy has resulted in a strong push to reduce travel expenses.

Intertek’s furniture flammability and durability labs have added IP cameras. This allows the client to log on from a PC to watch their test. The camera can move to look at areas of concern, zoom in, and even look at a screen that reports the test results live if they desire.

2. With the increase in storage space available on servers, it is now possible for customers to store the DVDs of their burns. This streamlines visits from regulating agencies because you no longer have to fumble through a file of DVDs.

Intertek has developed a way to provide the file contents of the DVD on the actual DVD itself. The client can insert the DVD into their PC, and move the files onto their server (PC must have a DVD drive).

3. There has been an increased desire from mattress manufacturers to be able to test a variety of sizes and shapes.

To facilitate this need, Intertek has added an open calorimeter to its furniture flammability lab. Mattresses and furniture of all shapes and sizes can be tested under this hood. Testing in this manner is not subjected to some of the measurement criteria required when performing the testing in the flammability room.
4. Clients have the need for more updates, and the duration of some cyclic durability
tests can stretch out for as long as 7 days.

Intertek has developed software that allows our cyclic test equipment to send the
customer update emails at any frequency they desire.

5. Clients need faster report turn around time more than ever before.

Intertek’s furniture lab has streamlined its report distribution process resulting in an
improvement of more that 3 days in some cases. The goal of the lab is to provide the
final report in **24hrs or less** from the test completion date.

**For more information about Intertek's services for furniture performance testing:**

Call: 1-800-WORLDLAB  
Email: icenter@intertek.com or visit: www.intertek.com