Product Requirements for Fabric Sofa Covers in Accordance with Customer Life Situation at Home

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In order to fully enjoy and appreciate this master thesis, for you- the reader- it is the best to find yourself in your living room. Sit in your IKEA sofa- when doing this; it is the best to firmly carry out the report in a yellow bag, hanging from your shoulder. Then make yourself really comfortable, open the first page and enjoy your reading…

And by the way, on the way reading, don’t forget to…
Acknowledgements

This project was only possible due to the common interests and collaboration of many people and institutions. First we would like to thank our university supervisor Jan Carlsson and programme director Håkan Torstensson for their support and our project leader Pikki Aziz for giving us the opportunity and endless support in order to carry out this study at IKEA of Sweden. We would also like to thank dedicated IKEA Test Lab and IKEA of Sweden co-workers for being there whenever we needed and helping us through this project.

Special thanks goes out to everyone who helped with our research out in the field and will never forget their efforts and the joy of sharing same vision and values.

Last but by no means least we would like to thank our families, friends and all other people for both motivating us and granting us with an experience of a lifetime that we will treasure always.
Background of Authors and Supervisors

Both authors of this master thesis are at the end of their studies in Masters of Science in Industrial Engineering, specialising in Applied Textile Management at Swedish School of Textiles, University of Borås. Besides specialising in Applied Textile Management, both authors have studied special courses within textile value chain related to supply chain management, consumer study and sustainable creative businessmanship.

In this research competencies within textile engineering and supply chain management are of great use as the research deals with issues related to consumer study and product development in textile value chain. Hence, background of authors is well in line with this study. The product and process oriented professional background of both authors also complements each other well for this research.

The supervisor at University of Borås is also chosen with consideration to the subject of the research. Jan Carlsson works as consultant at Swedish School of Textiles and he has a vast experience of industrial engineering in textile & apparel value chain. The project leader at IKEA, Pikki Aziz is responsible for global purchasing of upholstery fabrics for IKEA. In this way, any lack of knowledge among the authors is likely to be well complemented by the supervisors.
Abstract

In today’s world, people make demanding use of their upholstered furniture and hence unlike the formal sofas and parlour chairs of past that only saw use on “special” occasions; modern upholstery must now survive the rigours of everyday life. Taking its roots from previous studies, primary aim of this project was to review existing IKEA specifications related to upholstery fabrics for sofa covers; critically evaluating test methods and requirements mentioned in these specifications and investigating their alignment with feedback from customers. Secondary aim of this project was to implement new test methods reflecting actual customer life situation at home with special focus on customers with children and mature customers whose children moved out of house.

Having information available from a professional consumer study conducted in four different countries, four key parameters; durability, workmanship, colour fastness and comfort were concluded as customers’ perception of sofa cover quality forming the pillars of this study and main problems faced with fabric sofa covers were also classified.

Taking prestudy as backbones of this project, we have started with customer interviews conducted in IKEA stores in Sweden followed by reviewing existing sofa cover fabric test methods and requirements as discussed in detail throughout next chapters. Suppliers visit was performed for duration of one week visiting sofa cover and upholstery fabric suppliers and collecting invaluable data to reinforce project outcome. Robust collaborations are formed with textile test methods standardisation bodies, textile instrument manufacturers and dyestuff companies as well as with various IKEA functions to gather information and receive feedback on evaluation of logics behind test values and implementation of new test methods. In this parallel two new test methods were designed and implemented with a view to reflect actual customer usage at home which are described in detail under Chapter 8.
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1 Introduction & Background

In this chapter, the guidelines for this Master thesis will be described. A brief background of the company under study will be followed by more specific description of the problem with the main purpose and objectives of this thesis.

Industry Description

The last fifty years have seen a rapid evolution of the construction techniques used to manufacture upholstered furniture. Much of the advancement has been made possible by the introduction of new materials that have revolutionised the industry. Home furnishing retailers are always striving for customer friendly solutions to make life at home attractive. One of the smart solutions especially for customers having families with children is to make removable sofa covers that can be washed easily.

IKEA, one of the largest home furnishing companies was founded by Ingvar Kamprad in 1943 when he was 17 years old. He was selling matches, flower seeds, greeting cards, and later pens and ball-point pens. His idea of buying huge quantities at low price and selling them to many people turned IKEA into a great company. In 1948, furniture was introduced into IKEA range. The furniture was produced by local manufacturers in the forests close to Ingvar Kamprad's home. The concept was to produce functional, well designed furniture at prices so low that as many people as possible are able to afford them. In 1956, exploration of flat packing began when one of IKEA's first co-workers removed the legs of the LÖVET table so that it could well fit into a car and avoid damage during transit. After this discovery flat packs and self assembly became part of the concept. The idea sold very well and IKEA expanded quickly. In 1963, first IKEA store outside Sweden was built. Today, IKEA is located in more than 35 countries and has approximately 301 stores with more than 600 million visitors all over the world annually. Today, annual sales turnover is approximately 23 Billion EURO.
Background

The technological advances which have affected our lifestyles have also affected how we use upholstered furniture. As recently as several decades ago, upholstered seating was primarily used for formal occasions. People tended to treat their sofas with great care, as they were considered major purchases and were expected to last a lifetime. Children might have only been allowed on the sofa while under adult supervision, and eating, drinking, or roughhousing on the upholstery was rarely permitted.

The idea behind slip covers for sofa is to remove and clean those when they are dirty and put them again on the sofa to give a new look to your sofa. This idea is especially attractive for those customers who have children.

In today’s world, people live with and on their upholstery. People use their furniture today; they watch TV on it, eat and drink on it, lounge on it, sleep on it, and still expect it to look good after extensive usage. Children and family pets are now usually welcomed on the sofa. A sofa today might well receive more use in a year than a sofa of several generations ago did in a lifetime. Today, many of the sofas in the range are designed to stand up to the rigorous demands of everyday living, while maintaining their appearance.

Problem Description

The changing needs of customers for sofa makes it extremely important to have removable sofa covers on sofa in the living room that can be cleaned and washed over time. At the same time, it is also important for IKEA to know how long a particular fabric sofa cover should last with these changing ways of usage. This is done with the aid of various testing where fabric can be subjected to the kind of stress that corresponds to years of actual wear and tear.

This problem is not so easy to grasp. As IKEA is a global company and IKEA furniture is sold world wide, it is very hard to combine all kinds of usage and life styles globally into
one type of product. Customers use different ways of cleaning sofa fabric. Washing and drying procedures are different worldwide. Location of sofa in the living room also varies and is important too. In some countries, customers have pets in the living room. Kids play and jump on the sofa. Eating, drinking habits and way of socialising is also different from country to country and culture to culture. It is therefore, a challenge to set product requirements for all kinds of living styles at the same time.

**Purpose, Objective and Expected results**

This master thesis takes its grounds from a project description given by IKEA and this project directive has worked as basis when constructing the purpose and objectives of the thesis.

**Background of the IKEA project**

This project is a continuation of an already started project by IKEA. A professional consultant company was hired by IKEA to conduct a consumer study to understand customer requirements from IKEA fabric sofa covers. Based on those customer requirements, a project was launched in IKEA named “Great Quality Upholstery Covers (GQUC)”. In this project, different data were collected from customer complaint database as well to understand what kinds of problems customers have with fabric sofa covers.

The current project is to update product requirements for fabric sofa covers according to customer life situation at home based on this pre-study and GQUC project.

The project includes the following actions:

- Customer interviews in stores and home visits to understand the way they use fabric sofa covers in the living room,
- Review of existing quality of the furniture fabrics in IKEA range to monitor if it matches with customer requirements,
- Review of existing test methods applied on fabric range under study:
  - To evaluate if these methods secure customer requirements and simulate the way customers use the covers at home,
  - To find logics behind the test results to understand and communicate to the customer what these values mean in real life,
  - Develop new test methods if possible that can simulate customer life at home.
- To assess benchmark test methods followed by other industries with similar products,
- Competitors’ analysis to see what their fabrics with removable sofa covers are capable of and how they communicate to the customer
- Find out how IKEA can better communicate care and instructions while using fabric sofa covers to secure long life of sofa covers.

**Purpose**

Purpose of this master thesis is to see how IKEA can set all product requirements and establish test methods that can simulate every day customer life at home. The overall goal for IKEA after this research is to set everyday quality guarantee for fabric sofa covers.

**Expected Results**

The expected outcome of this project is to find some logical results based on test values that can help IKEA communicate to the customer about its fabrics. This will also lead to a solid future fabric strategy for IKEA to adopt for different sofa families.
Delimitations

This master thesis will mainly focus on fabric part of removable fabric sofa covers. Leather sofa and sofa bed is also out of scope. All the issues related to accessories, stitching and non-woven fabrics are not taken into account in this study. However all discussions related to these parts will serve as findings or future input.

Pre-study used as input for this project was carried out in four markets: US, Poland, China and Germany whereas customer interviews conducted during this project were only possible in Swedish market and included Swedish respondents. Home visits could also not be arranged by IKEA of Sweden for customer interviews at home. However, all results were deducted taking global customer into consideration at all stages.

Target group

This master thesis is written mainly for people within IKEA who should provide IKEA with useful guidance on how to set fabric strategy for IKEA fabric sofa covers and how product requirements should be aligned with the customer requirements. The beneficiaries of this research will be product developers, engineers, sourcing developers and technicians for upholstery fabric.

Furthermore, this thesis is written with the assumption that the reader has at least the same level of knowledge as a student in his or her Master of Science education.
2 Previous Studies

In this chapter brief summary of global consumer behaviour study conducted will be given followed by customer interviews performed in three different IKEA stores in Sweden evaluating customer insights for key quality parameters identified as the outcome of global study.

Consumer Behaviour Pre-Study by United Minds

On behalf of IKEA of Sweden, United Minds conducted a consumer survey on four different markets. The aim was to obtain quantified results of the study that would serve as a base for product development & business strategy. A second aim was to use the results for internal communication of consumer insights throughout the company. In this regard 2000 consumers were interviewed in four countries.

This survey concluded the following results:

- There are four important aspects that customers consider the most important for fabric sofa quality which are; durability, colour fastness, workmanship, and comfort.
- The most common sofa problems according to respondents were worn out covers, stains and dirt & dust. Worn out covers are the worst of them.
- Purchase of sofa is triggered by both functional & emotional needs depending upon customer profile. Living room is considered the centre of the home and the sofa is the most important piece of furniture in the living room.
- When buying a new sofa, the most important factors for customers are price and quality.
- Customers think that quality of sofa should be guaranteed, no matter if it is longer or shorter.
- In all countries and all profiles, general IKEA customers and IKEA sofa owners, the quality expectations on IKEA are higher than average.
- Majority of customers try to remove the covers and wash them in case they are dirty. Most people wash them 2-3 times a year or more. But there is also large number of customers who clean the sofa cover with stain remover while cover is still on the sofa.
- There are considerable differences between countries in washing behaviour, washing temperature, time etc. This inevitably affects product demands in different markets. Users of washing liquid are more than that of washing powder in terms of washing agents used.
- Average temperature used for washing is 37 °C and average time of washing is 45 minutes.
- 62% of customers dry covers hanging outside. Only 18% follow care and instruction label. 27% use tumble dry for drying and 31% iron covers before putting them on sofa.
- In IKEA mature markets, those who recommend friends to shop for sofas at IKEA mention price and design as main reasons. In IKEA immature markets however, quality is the main reason for recommendations.

**Great Quality Upholstery Covers (GQUC) Project**

Based on the results of consumer behaviour study, GQUC project was launched by IKEA. The purpose behind this project was to set everyday quality guarantee (EQG) for slip covers. IKEA set direction to have as many machine washable covers as possible and position everyday quality. Another objective was to be able to tell the customer that IKEA has water washable covers.

During this project, a lot of tests were performed on IKEA slip covers to secure that the existing quality fulfils everyday quality guarantee. It was decided that 40 washes are corresponding to 10 years of use. As shrinkage requirements after one wash is maximum 3% for all fabrics which is fulfilled by all IKEA fabrics. But there was no test method at that time to simulate more than one time washing of covers during its use at home.
As far as dry cleanable fabrics were concerned, they fulfilled the requirements of 3% shrinkage even after 40 washes according to standard test method. But the problem with dry cleaning is that there are so many different methods of commercial dry cleaning world wide meaning that results of dry cleaning also differ a lot. At the same time, dry cleaning of covers is also a question mark from environmental aspect.

Similarly, there are many different washing methods and behaviours in the markets IKEA operates. There is always a big difference of both time and how the water is heated in the machine. Also, it was found out in the pre-study that many customers tumble dry covers after washing which is not recommended by IKEA so far.

Therefore, it was decided after this project that above question marks should be covered through further study. It was also decided that this study would decide how IKEA should act regarding washability of covers and fabrics.

- Does IKEA need new requirements and test methods to adapt to customer behaviour and expectations?
- How to tackle different washing behaviours in different markets IKEA is present?
- What is important for the customer regarding washability?
- How are detergents affecting washability?

**Customer Complaints**

IKEA is a company following customer focus approach. Feedback from customers is always considered and evaluated. Similarly, feedback from customers about fabric sofa covers was analysed during GQUC project. It is evident from the chart (see Figure 1) that colour fastness, durability and workmanship are critical factors when it comes to fabric quality. At the same time, this information also emphasises on process control to avoid problems like damage on fabrics and workmanship.
Customer Interviews

The profiles in focus for slip covers are customers having children at home and mature customers whose children have moved out. Therefore, it was important to have knowledge from customers about activities on sofa, washing and cleaning behaviours, preference of different materials and expectations from slip covers of IKEA sofa.

For this purpose, it was decided to visit customers in different IKEA stores and home visits to have a visual idea of life at home. But due to certain limitations, it was possible to interview customers in stores located in Sweden only.

Figure 1 – Customer complaints related to quality of sofa covers
Customers with Children

Majority of customers interviewed have children at home. Almost 70% of the customers have children with age group less than 16 years which means that sofa is one of the favourite places for children to play and jump. It is also noticeable that almost 50% of customers in Sweden have pets and customers like to welcome pets in the living room.

Since majority of the customers interviewed were with children at home, therefore 86% of them prefer to buy fabric sofa covers so that it can be washed and cleaned easily.

Average daily use

One of the important factors to notice is how long the daily use of sofa to decide its life span. Almost 75% of both customer profiles use sofa up to 5 hours a day. This is very critical in estimating wearing off of the fabric with the use.

Below figure (Figure 3) shows different activities being carried out during every day life in the living room. The activities like eating and drinking verify that fabric should have good colour fastness and stain repellence properties. Also, customers like to spend their time watching TV in the living room. Pets have become important part in the activities in certain cultures.
Main sofa in the living room is one of the most extensively used furniture. All these activities show that fabric used as upholstery cover should have good abrasion resistance to last long.

**Colour fastness to sunlight**

Location of sofa in the living room is another important factor. Although sofa in the living room is not directly exposed to the sunlight but it is mostly located near window. In some countries where sunlight is so intense, it may cause problems of colour change due to light passing through window panes over time. Most of the customers in Sweden feel change in colour due to sunlight after use of more than five years and they expect it not to change before that.

![Activities vs Customer Profiles](image-url)
Washing instructions

More than 70% of Swedish customers use care instructions before washing. But we can clearly identify the difference of behaviours of different customers worldwide when we see prestudy from different countries which show that only 18% of customers follow care and washing instruction label. It means that possible problems of damage to the fabrics are likely to occur if washing instructions are ignored. For example, it is recommended on the label not to tumble dry after washing whereas 27% of customers do that. Similarly, they can ignore the instructions of fastening zippers before washing and ironing instructions.

How customers clean sofa

It was crucial to know how customers clean their sofas most of the times. This chart (Figure 4) confirms the prestudy results as it says most of the customers use washing detergent or liquid for washing.

![Sofa cover cleaning habits vs customer profile](image)

**Figure 4** – Sofa cover cleaning behaviours
Sometimes customers try to clean normal spots of stain with damp fabric. In case they can not fix the problem, they remove the covers to wash.

**Shrinkage in fabric after washing**

Majority of customers do not think covers shrink after more than one time of washing. Majority of them feel noticeable change in dimensions after 10 washes.

**Fabric selection**

A vast majority of customers like cotton or mixture of cotton with polyester or other synthetic yarns. However, it was observed that customers hold limited knowledge about fabric materials and constructions. Most of them keep colour or texture as decisive factor when buying rather than construction or material contents.

**Life expectations**

Majority of IKEA customers expect IKEA sofa to last after 10 years but they do not really want or expect to last covers for the same period of time. They would rather like to change their covers before 10 years to give a new look to their sofa. Therefore, expectations from sofa covers are not the same as from complete sofa.

If we summarise the interview from customers, it is again clear that durability and colour fastness are the most critical parameters when we think of sofa cover quality. Customers do not consider shrinkage as a problem. They are more interested into colour and hand feel to see softness in the fabric rather than materials. They find comfort in contents of the foam in cushions more than fabric.
3 Current IKEA Furniture Fabric Strategy

In this chapter a brief overview of IKEA upholstery fabric range will be given followed by
the explanation of fabric selection process to complement our study by reviewing existing
fabric qualities to monitor where IKEA stands in terms of quality compliance in the eyes
of its customers and this effort is believed to serve as a self-assessment tool for IKEA
fabric strategy.

Fabric Categorisation and Strategy

Although there are various ways of categorising upholstery fabrics, Table 1 provides a
simplified summary of the IKEA range upholstery fabrics and this classification adopts a
combination of various aspects related to fabric characteristics e.g. dyeing technique,
yarn contents etc.

<table>
<thead>
<tr>
<th>Fabric Type</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piece Dyed</td>
<td>Both woven and knitted</td>
</tr>
<tr>
<td>Yarn Dyed</td>
<td>Both woven and knitted</td>
</tr>
<tr>
<td>Effect fabrics</td>
<td>Chenille, slub, polyester mixtures</td>
</tr>
<tr>
<td>Prints</td>
<td>Mainly on 100% cotton cloth</td>
</tr>
<tr>
<td>Wool and wool mixtures</td>
<td>100% Wool, Wool/Nylon mixtures</td>
</tr>
</tbody>
</table>

Table 1 - Summary of IKEA range upholstery fabrics
Above categorisation includes fabrics used in sofas, arm chairs, office chairs, cushions and chair pads. If we are to discuss solely sofa covers, which is the main focus of this project, each fabric is assigned to a certain sofa family (e.g. Ektorp, Karlstad, Kivik etc.) and these fabrics are regarded as “DNA Fabrics” whereas rest are regarded as “Key Range Fabrics” and can be used in different sofa families simultaneously.

**Fabric Selection**

In order to better understand where IKEA is currently standing with regards to upholstery fabrics quality and to project and quantify the level of compliance with test requirements, we have decided to select a number of sofa cover fabrics with the intention to represent and cover the diversity of current IKEA range upholstery fabrics. These fabrics were then applied a number of finely selected tests to receive a reliable input which is believed to form the backbones of this project.

As a result of deep discussions and brainstorming with cover technicians, fabric team and project leader; fabrics represented in Table 2 were chosen with the belief to cover current range fabrics for IKEA sofa covers. Since these fabrics were employed throughout project a table including detailed information for these fabrics can be seen in Appendix A.

<table>
<thead>
<tr>
<th>Fabric name</th>
<th>Fabric content</th>
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</thead>
<tbody>
<tr>
<td>Fabric A</td>
<td>100% Cotton</td>
</tr>
<tr>
<td>Fabric B</td>
<td>100% Cotton</td>
</tr>
<tr>
<td>Fabric C</td>
<td>PC, viscose, linen blend</td>
</tr>
<tr>
<td>Fabric D</td>
<td>100% Cotton</td>
</tr>
<tr>
<td>Fabric E</td>
<td>Polycotton</td>
</tr>
<tr>
<td>Fabric F</td>
<td>Polycotton</td>
</tr>
<tr>
<td>Fabric G</td>
<td>PC, viscose, linen blend</td>
</tr>
<tr>
<td>Fabric H</td>
<td>Polycotton</td>
</tr>
</tbody>
</table>

Table 2 – Selected fabrics
During selection process following criteria were taken into consideration;

- fabrics that represent specific sofa families,
- dyeing and/or finishing methods of fabrics,
- weave effect and weight,
- yarn type and count,
- dry cleanability and machine washability of selected fabrics,
- and finally sales/purchase volume of specific fabric.
4 Review of Existing Test Methods

In this chapter upholstery fabric specifications outlining test methods and requirement levels will be introduced and contents of these specifications will be described.

Reviewing existing test methods and related specifications that are applied for IKEA range upholstery fabrics was one of the major parts of this project and this effort is believed to help us determine which test methods currently IKEA follows and whether these test methods and requirement levels are aligned with customer everyday life situation at home.

There are two specifications that are related to upholstery fabrics, namely; PRF-0025 and TM-0007 of which the former describing the requirements of upholstery fabrics specifically and the latter outlining test methods applicable for all textile materials in IKEA range.

PRF-0025

This specification is solely dedicated to furniture fabrics and outlines product requirements in following successive sections;

- General requirements
- Requirements for furniture fabrics
- Additional requirements for Children’s IKEA
- Documentation

Before ordering tests for our selected fabrics, critical evaluation of PRF-0025 was made in order to absorb the background into specification and better suggest ideas on how to implement new test methods and/or review the values of existing test requirements. In
In this context, various test methods and their corresponding values were evaluated in line with following requirement classification:

- Mechanical properties
- Chemical properties
- Colour properties

**Mechanical properties** included tensile and tear strength tests, resistance to abrasion, pilling and seam slippage, and dimensional change after washing and dry cleaning tests.

**Chemical properties** included formaldehyde presence and pH-value tests and,

**Colour properties** included colour fastness to light, to rubbing, to washing and dry cleaning, to water spotting, to perspiration and to water.

For the purpose of our project flammability and Children’s IKEA requirements specific to certain retail markets were excluded and not further investigated.

**TM-0007**

This specification is designed to outline all test methods related to IKEA range textile materials although some of the test methods issued can be applicable to non-textile materials and all test methods in this specification are based on national (regional) and international standards. Some test methods are designed in-house after detailed research and international equivalents might not exist.

TM-0007 includes all test methods currently applicable to IKEA upholstery fabrics, defines test methods clearly and correct assessment of these test methods. TM-0007 provided us with the information on upholstery fabrics test methods (international and in-house) and stands over PRF-0025 giving detailed information on performing of test methods mentioned and does not include product specific requirements.
5 Suppliers Visit

*In this chapter outcomes of the two upholstery fabric and a sofa cover suppliers visit will be given and conclusions of the visit will be drawn at the end of chapter.*

The four key quality parameters; durability, workmanship, comfort and colour fastness formed the pillars of our project and this combined with the most common problems with sofa covers as outlined in pre study, the need to obtain feedback from cover and fabric suppliers were believed to complement this project and hence one week on-site visit to IKEA’s sofa cover and upholstery fabric suppliers were made and our independent and parameter related observations will be explained throughout this chapter.

Before starting our discussion, we would hereby like to acknowledge that the names of the suppliers will not be disclosed due to confidentiality purposes though suppliers will be recalled by ‘stitching supplier’ for sofa cover manufacturer and the two fabric suppliers as ‘Fabric Supplier 1’ and ‘Fabric Supplier 2’.

Processes undertaken during production stage are believed to have an overall effect on end product quality, that is fabric sofa covers in this case and feedback received from suppliers are believed to serve a vital function for our project purposes. In this regard various aspects of our main tasks were noted beforehand and the key points of supplier visit agenda are described as below;

- Observation of each step involved in sofa cover production and its relative influence on key quality parameters, especially with a focus on durability and workmanship.

- Observation of stages involved in upholstery fabrics manufacturing and their negative/positive contribution(s) to key quality parameters, with a special focus on durability, comfort and colour fastness.
• Getting feedback from fabric suppliers on industry practices and discussing feasibility of various chemical/mechanical applications on upholstery fabrics to improve durability, colour fastness and comfort properties of these fabrics.

• Discussing upholstery fabric test methods and exchanging knowledge with an IKEA approved external lab in supplier country.

During this suppliers visit many points related to our key quality parameters and test methods were forwarded to IKEA suppliers and in following section you can find a summary of discussions taken with external IKEA test lab and various suppliers. Findings and conclusive points of this visit are summarised at the end of this chapter which served as helpful roadmap for the project.

**Stitching Supplier**

Processes involved in sofa covers production in IKEA stitching supplier are monitored from fabric arrival in warehouse to packaging and following remarks are made which relates directly to our key quality parameters;

• Mechanical laying of fabric plies were employed,

• Fabric plies were piled too high leading to extensive fabric tension,

• No flagging and splice marks made,

• Relaxation of fabric plies is missing due to heavy production schedule,

• Fabric elongation/shrinkage regarded as a problem resulting in ill fitting templates,
• Colour shade variation between lots and/or fabric rolls is a problem which might lead to colour variations in sofa covers.

**Workshop in IKEA Approved Lab**

A one day long workshop was carried out with assistant lab manager to discuss various test methods applied on upholstery fabrics evaluating the requirement levels and discussing possible test methods and requirement levels applicable to upholstery fabrics. Highlighted remarks of this workshop are as follows:

• A standard lotion test method does not exist but can be attempted by identifying the main ingredients of a hand lotion especially by following an international brand,

• According to assistant manager, although a saliva test is currently required from baby garments, it might be irrelevant and costly in case of upholstery fabrics,

• Sock board idea currently applied on socks testing might be suitable to evaluate and scale the fitting of sofa covers on sofa however representation and modelling of frames could be difficult and hence not feasible,

• Colour fastness to water value was commented as low,

• Resistance to abrasion value of 15,000 cycles was commented as low and comparative examples were given by this test lab’s international guideline where the value of abrasion for shirting fabric was issued as 20,000 cycles,

• Stiffness test which is applied usually on denim fabrics to evaluate the softness was observed with the intention to find a suitable test method of judging comfort in upholstery fabrics,
- Determination of the elasticity in woven fabrics (ISO EN 14704-1) test method simulation was observed on a lycra fabric and applicability of this test method for IKEA upholstery fabrics was discussed,

- Feedback on ISO EN 14465:2004, an international document outlining the specifications and test methods for upholstery fabrics was received to be further investigated after suppliers visit.

**Fabric Suppliers 1 & 2**

The aim of IKEA upholstery fabric suppliers visit was to observe production methods currently followed; the relationship/influence of various production techniques on fabric durability, comfort and colour fastness properties and to forward key quality parameters related questions and concerns to fabric suppliers and collaborate with them to hear their reflections and feedback on fabric quality improvement/development. In this context a brief summary of main concerns and points discussed with both suppliers will be given as follows;

- Oil/stain/water repellent finishes are strongly believed to be the only way to fully tackle with stains and will enhance abrasion properties. Previous attempts on stain repellent finish application was considered effective however due to presence of fluorocarbons (C6 and C8 chemistry residuals) these initiations were disbanned,

- The perception and boundaries of durability must be better explained since there are various non-fabric components which might lead to poor durability of ‘sofa covers’ (e.g. weak zippers or velcro),

- Open-end and ring spinning processes were observed; ring spun cotton was noted to offer enhanced fabric surface which translates into better abrasion and pilling results,
• Yarn and fibre dyeing processes were observed; although fibre dyeing is not favourable environmentally, a more union dyeing is achieved compared to yarn dyeing and shade variation problem is less likely to occur,

• Anti-pilling and silicon finishes increase abrasion resistance of fabrics although excessive silicon might create slippery fabric surface that might lead to discomfort during sitting on sofa,

• Resin finishes deteriorate fabric tear and abrasion properties,

• Anti static finishes can be used for dirt and dust. But question is formaldehyde and resins which are hazardous,

• Durable fabric levels can be achieved only by employing right fibre content and weave construction if we are to stay away from suspicious chemical finishes,

• Although sanforising secures fabric shrinkage an optimum level has to be achieved since too low or too high sanforising might lead to unfavourable fabric properties (i.e. too slippery or harsh surface),

• IKEA requirement of less than 25% synthetic fibre content poses challenges on the way to achieve desired durability and comfort properties from upholstery fabrics,

• Fabric rolls’ continuous exposure to different temperature/humidity conditions throughout their travel from fabric supplier to stitching supplier might stand as the primary reason for fabric shrinkage/elongation,

• Brushing and silicium finishes are 2 possible solutions (mechanical and chemical options respectively) to fabric comfort offering anti-slippery surface effect on fabrics.
Various aspects of techniques and methods involved in fabric sofa covers production were observed and discussed with suppliers; keeping in mind each stage’s correspondent effect on end product quality. With the feedback received from suppliers and workshop performed with IKEA external lab, further tasks to carry out were outlined and conclusive remarks of suppliers visit will be found as follows;

- Stretch/Elongation test (ISO EN 14704-1) can be applied to 8 fabrics chosen for our project but detailed discussion must be carried out on test parameters (e.g. load selection, pre-tension etc.)

- In terms of stain repellence properties, Clariant’s Nano Sphere technology shall be investigated further and dyestuff companies shall be contacted to get more information on stain/oil repellent, anti static and anti-slippery finishes,

- Review ISO EN 14465:2004 document outlining the test methods and specifications for upholstery fabrics,

- A test method representing the effect of lotions on fabric surface and colour fastness properties shall be investigated,

- Requirement level for colour fastness to water shall be reviewed,

- Test requirements should be according to different fabric characteristics and hence an approach to set different requirement levels for different fabric types shall be considered rather than simply adopting one fit for all approach.
6 Fabric Tests

In this chapter background into fabric tests ordering will be given clearly outlining the arguments elaborated during tests selection process and results of these tests will be presented accompanied by brief explanation of each test method applied.

After careful evaluation of upholstery fabric test methods (PRF-0025) and requirement levels, the next step was to order tests on our eight selected fabrics. We had previous data from past including different fabrics being applied various test methods and after detailed discussions with fabric team and related functions in IKEA, following tests were decided to be conducted. (see Table 3).

<table>
<thead>
<tr>
<th>TEST NAME</th>
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<tbody>
<tr>
<td>Determination of weight</td>
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<tr>
<td>Dimensional change after washing and drying (warp/weft)</td>
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<tr>
<td>Dimensional change after dry cleaning</td>
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<tr>
<td>Tensile Strength (warp/weft)</td>
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<td>Tear Strength (warp/weft)</td>
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<tr>
<td>Resistance to Seam slippage (warp/weft)</td>
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<td>Colour fastness to Light</td>
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<tr>
<td>CF to Rubbing Dry (st/cc)</td>
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<tr>
<td>CF to Rubbing Shampoo (cc)</td>
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<tr>
<td>CF to Rubbing Perchloroethylene (cc)</td>
</tr>
<tr>
<td>Colour fastness to Washing (st/cc)</td>
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<tr>
<td>Colour fastness to Dry cleaning (cc)</td>
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<td>Colour fastness to Perspiration (st/cc)</td>
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<td>Colour fastness to Water (st/cc)</td>
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<tr>
<td>Colour fastness to Waterspotting (sur/edge)</td>
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<tr>
<td>Resistance to pilling at 2000c</td>
</tr>
<tr>
<td>Resistance to Abrasion (cc, thread breakage)</td>
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</table>

Table 3 - Performed Tests
As a result of supplier visit; bearing in mind points discussed at suppliers and IKEA approved external lab in Istanbul, combined with the views of fabric team members and other related functions in IOS test methods to be applied on our selected fabrics were finalised and throughout this process following points influenced and shaped the test selection;

- Existing test methods as outlined in PRF-0025 were matched with their correspondent key quality parameter and this played a vital role in identifying relative importance of each test method. (e.g. resistance to seam slippage is attributed to workmanship parameter whereas resistance to abrasion test corresponds with durability parameter)

- Some previously conducted test methods were concluded as of secondary importance when considered within our project scope and thus eliminated (e.g. Formaldehyde, determination of yarn count and threads per cm)

- Certain test methods required in Chinese and British markets were also considered irrelevant and hence not included in tests list (e.g. flammability tests, tinorganic and APEO)

- Cross-staining of colours in multi colour fabrics, especially in prints, were identified as a potential area of focus in colour fastness to rubbing, washing and resistance to abrasion (change in colour sub-part) tests since cross staining of colour combinations on fabric pattern previously was not observed and this point was requested from test performing labs as an additional data on our test ordering.

- Although colour fastness to saliva was considered at first hand as an alternative test method necessary to be applied on upholstery fabrics due to children’s continuous interaction with sofas at home, later it was decided to be dropped from our tests list due to moderate irrelevance of test method.
Another test method, although does not exist currently, that aroused after discussions were ‘lotion test’ which is intended to assess colour fastness property of upholstery fabrics upon exposure to hand lotions. Details on this test will be given further in ‘Proposed Tests’ chapter.

Considering above summarized arguments and project scope, test methods outlined in Table 3 above were ordered and detailed discussion regarding test results will be given in next chapter.

**Test results evaluation**

After receiving test results from external and internal test labs a detailed study of test results were made. Before commenting on test results for our 8 fabrics a brief explanation of test method applied will be given followed by conclusions of the relevant test results.

**Determination of weight**

In this test method average fabric weight in grams per square metre is measured. This test is carried out in order to ensure weight informed by fabric manufacturer matches with actual production lots weight. No discrepancy was observed in our test results related to fabric weight.

**Dimensional Change after Washing**

The aim of this test method is to measure fabric shrinkage/extension after washing and drying and after ironing. Dimensional change in fabric specimen for both directions (warp and weft) are calculated and reported as ±% values.
According to test results only in Fabric A, that is 100% Cotton, warp shrinkage before ironing was observed to be beyond acceptable limit whereas other fabrics were within requirement levels.

**Dimensional Change after Dry cleaning**

The aim of this test method is to measure fabric shrinkage/extension after dry cleaning procedure as outlined in standardised test method. Dimensional change in fabric specimen for both directions (warp and weft) are calculated and reported as ±% values.

According to test results Fabric E warp shrinkage and Fabric H warp/weft shrinkage values were observed to be slightly over the requirement limits.

- For 100% Cotton fabrics, dry cleaning shrinkage results were observed to be less than washing shrinkage results which proves that dry cleaning process is more suitable for 100% cotton fabrics from shrinkage perspective.

**Resistance to Seam Slippage**

The aim of this test method is to determine the seam slippage on fabric samples for both directions (war/weft), result of which gives indication on how easily/difficult the seam formed on fabric will slip upon force exertion.

According to test results only Fabric E was observed to fail and perform over acceptable limit and this result can be attributed to this fabric’s open weave structure which facilitates seam slippage. All other fabric samples were observed to perform considerably less than requirement level.


**Tensile and Tear Strength**

The aim of tensile test method is to measure fabric durability in both directions by using tensile test machine and taking test specimens to fabric rupture. Stress/strain graph achieved as a result of this test method shows fabric strength in relative direction. The aim of tear strength test method is to determine the tear characteristic of sample fabric by taking the fabric to defined load value in test method.

Test results obtained indicate outstanding tensile and tear strength values for all tested fabrics and this can be read as an indication on how resilient the selected fabrics are.

**Colour fastness to Light**

The aim of this test method is to assess fabric surface colour change upon exposure to concentrated light as outlined in test method. Result of this test method serves as an indication on how well fabric colour performs under exposed light conditions.

According to test results only Fabric C and Fabric H were observed to be in requirement borderline whereas rest fabrics performed well in this test.

**Colour fastness to Dry rubbing**

The aim of this test method is to assess fabric surface colour change upon rubbing fabric sample with a dry rubbing cloth of specified size and warp/weft colour change and/or staining are reported.

All fabric samples were observed to perform over requirement level and hence will stand dry rubbing action in actual use.
Colour fastness to Rubbing Shampoo

The aim of this test method is to assess fabric surface colour change upon rubbing dry fabric sample with a wet rubbing cloth of specified size dipped into shampoo solution as outlined in test method, and warp/weft colour change is reported.

According to test results only Fabric G was observed to perform below requirement level in warp colour change whereas rest fabrics were above acceptable levels.

Colour fastness to Rubbing Perchloroethylene

The aim of this test method is to assess fabric surface colour change upon rubbing dry fabric sample with a wet rubbing cloth of specified size soaked with perchloroethylene solution as outlined in test method and warp/weft colour change is reported. Perchloroethylene is the main chemical employed in dry cleaning procedures world wide.

According to test results all fabrics passed requirement level and Fabric G was noted to stay on edge in terms of warp colour change.

Colour fastness to Washing

The aim of this test method is to quantify and assess colour fastness properties (colour change and staining) of fabric samples when washed. Adjacent multifibre strip consisting of 6 different fibre types (cotton, polyacrylic, polyester, acetate, wool and polyamide) is attached to fabric specimen and staining to each fibre is assessed using suitable mask.

All fabric specimens (water washable fabrics only) were observed to have good colour fastness properties to washing and were above requirement level.
Colour fastness to Dry cleaning

The aim of this test method is to quantify and assess colour fastness properties (colour change and staining) of fabric samples when dry cleaned. Adjacent multifibre strip consisting of 6 different fibre types (cotton, polyacryllic, polyester, acetate, wool and polyamide) is attached to fabric specimen and staining to each fibre is assessed using suitable grey scale.

All fabric specimens were observed to have good colour fastness properties to dry cleaning and were above requirement level.

Colour fastness to Perspiration

The aim of this test method is to assess colour change and staining of fabric samples when exposed to alkaline and acid solutions as outlined in test method. Multifibre strip consisting of 6 different fibres are used to assess relative staining in acid and alkaline solutions respectively.

Only in Fabric F staining to cotton for alkaline and acid both were observed as below requirement level, rest fabrics all passed requirement level.

Colour fastness to Water

The aim of this test method is to assess colour fastness properties of fabric samples when exposed to water. Colour change and staining of fabric specimens to multifibre fabric consisting of 6 different fibre types are observed using suitable mask and grey scale.

According to test results all fabrics were observed to perform good colour fastness to water and above requirement level.
**Colour fastness to Water spotting**

The aim of this test method is to assess colour fastness properties of fabric samples in surface and edge of water mark formed on fabric surface when exposed to water. Cross staining of colours stemming from darker shades bleeding onto lighter shades is also observed.

According to test results all fabrics were observed to perform good colour fastness to water spotting and above requirement level.

**Resistance to Abrasion**

The aim of this test method is to assess fabric durability and colour change by applying a specific load onto round test specimens that are being abraded continuously against wool abradant and 2\textsuperscript{nd} thread breakage is observed under microscope. The value at which 2\textsuperscript{nd} thread breakage observed is written and stands as Martindale value for this fabric. This test method is widely adopted within upholstery fabrics industry and often utilised as a marketing tool for furniture retailers to communicate their fabrics’ durability levels.

Although all fabrics were observed to stand far above requirement level, there is a clear distinction between different levels observed within fabrics. 100% cotton fabrics were observed to hold lowest 2\textsuperscript{nd} thread breakage values followed by polyester/cotton/linen/viscose blended fabrics and finally polycotton blend fabrics.

In terms of colour change, Fabric C, Fabric E and Fabric G were observed to stay in edge with requirement level whereas other fabrics were above acceptable level.
Resistance to Pilling

The aim of this test method is to assess surface pilling in upholstery fabrics after agreed number of machine cycles caused by continuous friction of fabric sample with abradant cloth. Surface fuzzing and/or pilling are both assessed and noted.

Apart from Fabric A, all fabric samples were observed to perform above requirement level which translated into good pilling properties and hence improved durability.

As we mentioned in previous chapter, the focus of these tests was to self monitor current IKEA range upholstery fabrics and better understand where IKEA currently stands in quality scale. As test results showed, minor improvements are needed in certain fabrics and fabric specific issues must be highlighted and tackled accordingly.
7 Proposed Ideas and Benchmarking

In this chapter ideas gathered as a result of specification reviews, suppliers visit and cross-functional brainstorming will be presented along with an elaborative study attempt to comprehend the logic behind certain test values and chapter will end with explanation of cross-industry benchmarking and competitors’ analysis studies for upholstery fabrics under investigation.

Stain repellence properties

It was obvious from customer interviews that customers favour fabrics having better stain repellent properties since it was understood from the fact that they like to eat, drink and socialise while sitting on the sofa. Customers want edibles like red wine, ketchup and even honey to be rolled off completely without trace. Prestudies also showed that stain is second biggest problem with upholstery covers. Therefore, it was discussed extensively with product development and textile finishing experts in fabric suppliers as well.

The most common suggestion was to apply stain repellent finishes during processing of fabric. Since IKEA is not a chemical friendly company being environmentally responsible, it was important to have a better understanding of contents of certain stain repellent finishes available on the market. A well known chemical producer, Clariant was visited for this purpose. They presented NanoSphere® technology introduced by Schoeller Technologies AG, Switzerland. The nano particles in Nanosphere finish form a fine structure on the textile surface. Water and substances such as oil or ketchup simply run off the surface, any residual can easily be rinsed off with small amount of water.
Textiles with Nanosphere require less frequent washing and that can be washed at lower temperatures. This in a way protects environment and the fabric from wearing out quickly. In any surface without this type of finishes, the level of adhesion between water drop and dirt particles is very large. On the other hand, if we apply these finishes water drops or parts of dirt lie only on the peaks of nano particles and therefore have a lower contact area.

![Figure 5 – Water droplet on fabric surface](image)

This reduces adhesion significantly, water runs off, dirt is repelled or can simply be rinsed off. This can also help in abrasion resistance if protective function is retained with frequent washing and cleaning.

The patent of Nanosphere is owned by Schoeller Technologies and they claim that it is approved by Bluesign® standards to guarantee the highest possible exclusion of substances which are harmful to humans or the environment and promotes the economical use of resources in the manufacturing. According to them, they use C6 variants in these finishes which are least hazardous to environment.

Water repellence can be achieved by reducing critical surface tension of fabrics than that of liquids. This is done by using fluorocarbons. Fluorocarbons are carbon compounds containing per-fluorinated carbon chain. Their role is to form thin layer around the fibres due to having very low surface tension, not allowing drop to adhere to the fabric.¹

When this idea was scientifically evaluated and brainstormed with laws and standards responsible persons in IKEA, it was decided to have an independent view also from some chemical and textile finishing experts.

According to experts, fluorocarbons have fluorine based hydrophobic molecules that make the surface water repellent. There are two types of variants used in such treatments: C6 and C8. Concerning difference in properties between C8-variant (which is banned by IKEA,) and C6, C8 variants are banned by IKEA because they are not degradable and hence can cause hazards to human health.

According to Stefan Posner, an expert at Swedish research institute, Swerea (who works a lot with these issues), it is true that one would expect the C6-variety to be less bioaccumulative than the C8 ones. It is yet very little known about toxicity about C6 chemicals.

Another aspect to be expected is that a chemical of this kind will never be of 100% purity, i.e. it will always consist of a mixture of different substances. This means C6 chemicals will also contain although very little but certain amount of C8 which is very hard to trace.

It was therefore concluded that it would be better if other solutions to making the fabrics easy to care for than by adding a finish of fluorocarbons. Today IKEA does not have an absolute ban on C6 fluorocarbons, but since the toxicity of these substances is unknown, and since the similar substances of C8 show such negative properties, there is a high risk that the future will bring bad news also concerning the C6 variety.²

The next alternative way was to study some fibres that can be synthetically developed to have certain properties and solve stain issues at raw material formation stage. IKEA contacted Wallentin Bygg & Konsult AB whose consultant Hans Wallentin has worked for 40 years for a well-known chemical producer Ciba. Hans was of the view that we

² Swedish Research Institute, Swerea
need stain repellence properties on the surface of materials, not in the fibres because that will not affect when we produce them in fibres. Also, even if we synthetically develop fibres, we will still need fluorine base to have those stain repellence properties. Ciba textile division has been merged into Huntsman now and they are working together with Du pont. A project is going on for CF chemicals for upholstery fabrics. The purpose is to find both stain release and stain repellent properties. There is no C6 that is as good as C8 for repellent but for stain release, C6 chemicals can be used to their effect. Therefore, for water washable upholstery covers, soil release products that can help because if dirt particles still stay in the surface, they can be released easily after wash.

But for fixed upholstery covers, there is no option but to have stain repellent properties. For fatty stains like ketchup, wine and oil repellence the only solution is to have these fluorocarbons as fatty stains penetrate in the surface and difficult to get rid of.\(^3\)

Hence, keeping in mind all the facts, the only conclusion to have these stain repellence properties in upholstery fabric is to answer some questions. The question is if we really need it, how much and for which articles we will need it. Therefore, a certain limit can be set to achieve desired results. Another environment friendly solution is using plasma surface treatment of textiles but that is only possible so far on laboratory scale, hence very costly.

**Lotion Test**

Hand creams, body lotions and anti-acne creams are often used by customers and these chemical substances might get in contact with fabric sofa covers, result of which might cause bleaching or similar fading effect on fabric. According to our investigations there had been quality claims in the past regarding shade differences and obvious spots across the fabric surface.

\(^3\) Wallentin, H., 2010, Interview on stain repellence properties by Zubair Mahmood [discussion] Wallentin Bygg & Konsult AB
According to a senior person in IKEA Laws & Standards department, the origin of these claims have been Norway and when they investigated further they concluded that this fading effect might be caused due to chemical substances remaining on fabric surface and the effect is believed to worsen by sunlight’s interaction with chemical substance. In this context we have researched on current test methods related to lotion rubbing effect on fabric surface and collaborated with technical experts from dyestuff and chemical companies.

Wilfried Herter, chemicals expert of Huntsman chemical company was contacted successively and following remarks are made as a result of this proposed test idea;

- Currently there is no standard test method assessing hand cream or various lotions’ effect on fabric surface caused by rubbing or activation through another external stimulus (e.g. sunlight),

- There is a British Standard test method to assess shampoo fastness for carpets using usual cleaning agents (e.g. detergents, traditional laundry agents),

- Wilfried mentioned about a Huntsman internal test to measure sensitivity of fabrics to benzoyl peroxide which is a component in anti-acne creams. Although suspicious, he mentioned about possible presence of benzoyl peroxide in lotions and further commenting: “Nevertheless we had cases from time to time, where this chemical has caused damage, especially on terry towels and t-shirts which came in contact with the chemical from acne cream or lotion. Benzoyl peroxide is a bleaching and disinfecting agent, several reactive dyes on cotton can be heavily damaged when in contact.”

- According to Wilfried; “oxidative and anti-oxidative agents both might cause colour change effects on fabric surface by reacting with dyestuff. Possible presence of perborate (which serves as an oxidizing agent) in chemicals used by

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customers may lead to oxidation of several blue and red colours. On the other hand, anti-oxidative compounds are readily present in many creams and lotions in order to increase storage stability and prevent oxidation. Fats in these compounds will get rancid e.g. by oxidation, of odourless alcohols to rather smelly carbonic acids. By their nature, anti-oxidatives can have a potential for reductive destruction of certain dyes. (e.g. some reactive reds are rather sensitive)⁵.

As a result of our investigations and efforts we have concluded that there are no concrete grounds to follow a test method to assess hand lotion effect on fabric surface since the claim received by IKEA was limited to Norway and information available do not fully verify the fading spots were due to hand lotions or any other chemical compounds.

However if there are further claims suspected of hand or body lotions, a test method including an agreed commercial lotion diluted in a solvent shall be employed and applied either similar to spotting tests ISO 105-E05 to E07 or by following colour fastness to rubbing test.

⁵ Herter, W., 2010, Lotion Test, [email] Message to Kocer, A.Y. Sent Friday 23 July 2010, 10:00
**Colour Migration**

Colour migration is a serious flaw in terms of upholstery fabric colour fastness properties and arouse as another argument for our project although having a secondary level importance. As a result of our discussions, following two angles of colour migration were noted:

- Migration of colours present on fabric surface to another substrate with which sofa cover interacts. For example, there have been cases where the sofa fabric colour migrated onto wall in customer homes.

- Secondly, migration of different colours present in the same fabric pattern due to cross staining. In this case migration of dark colour shade onto light shades is most probable scenario.

Second approach was taken onboard and cross staining of colours in multicolour fabrics (e.g. printed fabrics) was evaluated as an addition to following standard test methods:

- Cross staining in dry rubbing,
- Cross staining in wet rubbing (to water, shampoo and PCE),
- Cross staining in colour fastness to washing,
- Cross staining in resistance to abrasion test methods.

As explained in fabric test results section, Fabric B (100% Cotton, multi colour print fabric having 5 different print colours) was evaluated for its cross staining performance in all above test methods. Cross staining of Black/Orange, Black/Yellow and Black/White combinations in dry rubbing were noted to perform below requirement level and White/Black cross staining in shampoo rubbing failed. As a result we can conclude that dark shades, especially black, might lead to poor cross staining results when rubbed under dry and wet test conditions.
Further research on migration of fabric colours onto wall or wall covering substrate (e.g. PVC) onto sofa cover shall be undertaken if necessary although cross staining of colours in multicolour fabrics, especially in printed fabrics must be evaluated with maximum care and kept in mind during fabric development process.

**Logical study for test values**

Taking example of abrasion resistance test as one of the most important one, it was decided to find logics behind test values. According to EN ISO 12947-2 the total effective mass of the abrasion load (i.e. the mass of the specimen holder assembly and the appropriate loading piece) is (795±7) g for upholstery fabrics, i.e. a nominal pressure of 12 kPa whereas the area of specimen holder was calculated as 0.00065 m$^2$.

Now, if we try to simulate it to real life, we have the following results:

- Average human mass = 75 kg
- Average human area of contact with sofa fabric while sitting = 31×20cm i.e. 0.062 m$^2$
- Hence, load applied by an average person = 11854 N/ m$^2$ ~ 12 kPa

*Values mentioned are our approximate findings after extensive research*

Although we can find a relationship between abrasion resistance test and real life, it is still hard to find out relationship between test result and length of time. For instance, if a typical fabric has abrasion resistance of 15,000 rubs at 2$^{nd}$ thread breakage according to ISO 12947-2, we can not relate it to any length of time the fabric should last in real life in terms of hours. Although it is known from customer studies, that an average daily use of sofa is 5 hours but we still can not say what the proportion of abrasion or rubbing action is during these 5 hours to relate it to 15,000 cycles for a typical fabric.

We had collaboration in our efforts with European Committee for Standardisation (CEN) who established ISO EN 14465 test methods and specifications for upholstery fabrics.
According to them, it is very hard to find this proportion that can lead us to length of usage in terms of hours.

The following findings were shared by CEN on the query on relationship between abrasion test and real life:

Results of Martindale testing should be interpreted very cautiously.

“The test results are fairly reproducible when applied to the same or to very similar structures. In this sense Martindale is a good instrument for quality control.

However, the test method can not be applied to all types of structures and the correlation with real behaviour in-use is often poor. This confirms that wear is a much more complex phenomenon than just abrasion. This explains probably also why other test methods, e.g. Weissenbeck, provide different results. They are influenced by other parameters and thus reveal other aspects of the wear in-use.

As already stated in the EMPA study, there is absolutely no straight correlation between abrasion test results and useful life-time of furniture. Therefore the use of the categories of EN 14465 for this purpose is at least questionable. This issue should be considered when the standard is revised. We are open to further research and testing in this area.”

CEN also gave an example of an upholstery fabric that had finer warp yarns and coarser weft yarns. According to ISO EN 14465, it was a Class A fabric as it had abrasion resistance of more than 35,000 rubs. Coarser weft yarns were protecting finer warp yarns from being broken. But when it comes to real life, this fabric was worn out in very short time. Therefore, CEN concluded that Martindale test is not the only decisive factor for fabric wears off as results were contradictory in this case.

---

The following deductions can be made in terms of abrasion resistance test for upholstery fabrics:

- Martindale test can not be generalised for all types of materials for testing abrasion resistance as end use varies a lot. It is to remember that this test method was originally developed for socks.

- There is a German organisation, Heimtex that is studying an alternate test method for Martindale test to simulate real life in some cases. They can be coordinated in this regard for further research. There is another research going in Ghent University, Belgium on simulation of football shoes on artificial turf. Therefore, CEN TEX BEL can act as a common platform for further research depending upon end use of fabric.

**Categorisation of the requirements (ISO, Möbelfakta, SIS, ITS, Du pont)**

One of the important dimensions of this project was to classify the test requirements based on test results and end use. One reason for classifying the fabrics is that there is a major difference in test results depending upon material contents within current range of fabrics. Secondly, since the customer profiles in focus for removable fabric sofa covers are customers with children and mature customers (whose children have moved out), it is a good idea if we are able to match the test results based on fabric construction with end use. It was decided to take ISO EN 14465- Specification and test methods for upholstery fabrics, as a guideline. The properties set basis for this classification are given in Table 4 below.

These standards were jointly established by European committee for standardisation (CEN) and they classified the requirements for different types of fabrics based on performance level. But IKEA’s interest for fabric sofa covers project was only in flat woven fabrics. At the same time, if we take example of one of the most important characteristic of upholstery fabrics i.e. abrasion resistance, none of IKEA fabric falls into performance level B or less. Even 100% cotton fabrics are more than 30,000 rubs. It is to remember that according to EN ISO 12947-2 test for abrasion resistance, three threads
are completely broken to check abrasion value. But since in IKEA, abrasion values at 2\textsuperscript{nd} thread breakage are noted as IKEA follows Swedish möbelfakta requirements right from the beginning.

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Units</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>EN ISO 13934-1</td>
<td>N</td>
<td>&gt;600</td>
<td>≥400</td>
<td>≥350</td>
<td>≥250</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN ISO 13937-3</td>
<td>N</td>
<td>≥40</td>
<td>≥30</td>
<td>≥25</td>
<td>≥20</td>
<td>≥15</td>
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<tr>
<td>Tear Strength</td>
<td>EN ISO 13936-2</td>
<td>mm</td>
<td>≤4</td>
<td>≤5</td>
<td>≤6</td>
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<tr>
<td>Seam Slippage</td>
<td>EN ISO 13938-1</td>
<td>kPa</td>
<td>≥600</td>
<td>≥400</td>
<td>≥200</td>
<td></td>
<td></td>
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<tr>
<td>Bursting Strength</td>
<td>EN ISO 13938-1</td>
<td>kPa</td>
<td>≥600</td>
<td>≥400</td>
<td>≥200</td>
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<td></td>
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<tr>
<td>Abrasion Resistance</td>
<td>Flat Woven</td>
<td>×1000 rubs</td>
<td>≥35</td>
<td>12-30</td>
<td>4-10</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Chenille</td>
<td></td>
<td>≥35</td>
<td>12-30</td>
<td>4-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knitted</td>
<td></td>
<td>≥35</td>
<td>12-30</td>
<td>4-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cut Pile</td>
<td></td>
<td>≥45</td>
<td>25-40</td>
<td>10-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uncut pile</td>
<td></td>
<td>≥45</td>
<td>25-40</td>
<td>10-20</td>
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<td></td>
<td>flock</td>
<td></td>
<td>≥45</td>
<td>25-40</td>
<td>10-20</td>
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<td></td>
<td>nonwovens</td>
<td></td>
<td>≥45</td>
<td>25-40</td>
<td>10-20</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>raised fabrics</td>
<td></td>
<td>≥35</td>
<td>12-30</td>
<td>4-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilling resistance</td>
<td>EN ISO 12945-2</td>
<td>grade 1-5</td>
<td>≥4-5</td>
<td>4</td>
<td>3-4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>after 2000 rubs</td>
<td>EN ISO 105-B02 (method2)</td>
<td>grade 1-8</td>
<td>≥6</td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color fastness to light</td>
<td>EN ISO 105-X12</td>
<td>grade 1-5</td>
<td>≥4</td>
<td>3-4</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color fastness to rubbing dry</td>
<td>EN ISO 105-X12</td>
<td>grade 1-5</td>
<td>≥3-4</td>
<td>3</td>
<td>2-3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textbf{Table 4} – Classification into different performance levels ISO EN 14465:2003
After getting test results of IKEA fabric under study, we can see a clear difference between 100% cotton and blends when it comes to abrasion, pilling and tear strength properties. Change in appearance is another critical factor in differentiating but colour fastness results not vary much as seen in Table 5.

Keeping in mind customer profiles targeted for fabric sofa covers and test results, it was our idea to classify IKEA fabric range into two types of end uses within domestic use. It was deducted that 100% cotton materials can be used for normal home use where results are far better than minimum IKEA requirements but comparatively on the lower side. Whereas blended materials having very high results in critical properties can be referred for extensive home use where customers have kids and pets.

### Table 5 – Comparison of IKEA and EN 14465 requirements

<table>
<thead>
<tr>
<th>Desired properties</th>
<th>Test Name</th>
<th>Test Methods</th>
<th>IKEA Req.</th>
<th>EN 14465</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100%C</td>
<td>PC</td>
</tr>
<tr>
<td>Strength</td>
<td>Tensile (warp/weft)</td>
<td>EN ISO 13934-1</td>
<td>600/500</td>
<td>&gt;600</td>
</tr>
<tr>
<td></td>
<td>Tear (warp/weft)</td>
<td>EN ISO 13937-2</td>
<td>25/25</td>
<td>≥40</td>
</tr>
<tr>
<td>Colour fastness</td>
<td>Light fastness</td>
<td>ISO 105-B02</td>
<td>≥5</td>
<td>≥6</td>
</tr>
<tr>
<td></td>
<td>Rubbing Dry (st/cc)</td>
<td>ISO 105-X12</td>
<td>≥4</td>
<td>≥4</td>
</tr>
<tr>
<td></td>
<td>Wet Staining</td>
<td>ISO 105-X12</td>
<td>≥3</td>
<td>≥3-4</td>
</tr>
<tr>
<td>Pilling</td>
<td>Pilling at 2000c</td>
<td>EN ISO 12945-2</td>
<td>3</td>
<td>≥4-5</td>
</tr>
<tr>
<td>Abrasion</td>
<td>2nd thread break *1000</td>
<td>ISO 12947-2</td>
<td>&gt;15</td>
<td>≥35</td>
</tr>
<tr>
<td></td>
<td>Colour change at 5000c</td>
<td>ISO 12947-2</td>
<td>2-3</td>
<td>≥3-4</td>
</tr>
</tbody>
</table>
This idea was discussed with CEN experts but as discussed in previous sections, it is not 100% solid due to the fact that abrasion results do not always simulate actual wearing off at home. However, they agreed that it reduces many exceptions if we interpret abrasion results combined with pilling, tear and change in appearance. Further testing can lead IKEA to more concrete results in setting an opinion for classifying fabric requirements according to properties.

**Competitors’ analysis/other industries benchmarking**

Although it is very important to listen to the voice of customer to set the product requirements, it is always useful to see which trends other competitors on the market are following. The following steps were decided to be taken in this regard by IKEA:

- Get support from sales leaders in each market and analyse which markets are the most competitive ones in removable sofa covers,

- Buy similar constructions of fabrics from those markets and test them to compare the results with IKEA fabrics,

- Analyse their communication strategies with their customers in accordance with test results/product capabilities.

Different competitors were chosen to study from five different markets including China, Austria/Germany, US, UK and Sweden. Since delivery lead times from most of competitors are long it was not possible to complete that task within the current research timeline although IKEA has initiated the process and it will be fulfilled according to plan.

According to our analysis so far, most of the competitors use blended fabrics and many of them are dry cleanable only. IKEA can take this sustainable competitive advantage by working more on water washable covers rather than dry cleanable ones. This idea very well suites to IKEA’s business strategy as dry cleaning is expensive in most of the
countries. For example, commercial dry cleaning cost in Sweden is as much as it costs to buy new Ektorp sofa covers.

The purpose for benchmarking was to evaluate what kinds of test methods other similar industries are currently following. Test methods applied by a famous automobile producer were studied. Further research can be made by studying test methods followed by other similar industries like aviation and railways industries that make seat cushion covers for their seating.
8 Proposed Tests

In this section you will find detailed explanation of the test methods implemented starting with stretch/recovery test and followed by washing simulation test. Test design procedure will be described in detail and discussions are given at the end of each test method.

Stretch/Recovery Test

Background

Stretch/elongation and recovery are two important virtues of sofa covers since there will be continuous force(s) exerted on them and determination of the fabric elasticity stands as a vital information during cover stitching and design. Fabric bagginess or loose covers impose aesthetical discomfort which is disapproved from a quality perspective.

There are two angles of fabric stretch and recovery phenomenon, both requiring different set of approach;

- **Fabric stretch over time**: Due to extensive customer usage as seen in Figure 6, upholstery fabric might get loose and bagginess might create aesthetic discomfort as mentioned previously.
- **Fabric stretch during handling**: Subsequent handling processes (e.g. fabric winding, transportation, laying and cutting) before the fabric is stitched into a cover creates deformation and tension on fabric which is expected to release after certain time and imposes challenge in terms of fitting of different parts (see Figure 7).

In line with our project, second approach to fabric stretch/recovery was followed and this decision takes its roots from the supply visit.
Stretch in fabric sofa covers

IKEA fabric sofa covers manufacturer is observed to encounter problems when they’ve experienced a variable degree of extensibility (stretch) of fabrics as they are unwound from the roll. Fabric handling during spreading, marking and cutting impose certain amount of stretch on fabrics. Relaxation of this stretch needs to be allowed for, since distortion in either direction (warp/weft), and perhaps by differing amounts, can result in misshapen components and a poor fit in IKEA sofa covers hence overall poor workmanship.

Fabrics cut according to pre-designed standard templates might not fit due to stretch and therefore; the sewing and fitting of covers can be unpredictable and involve an unacceptable number of units requiring re-work to correct defects before the furniture can be dispatched.

This problem was diagnosed during supplier visit and the answer to it lies in the correct utilisation of a test method where we can simulate various factors/forces involved in fabric handling before it is stitched to a sofa cover. By predicting the mechanical properties of fabrics; especially percentage elongation at fixed load and consequent
permanent extension, we can better understand the elastic properties of fabrics and this can serve as a tool during fabric selection process for different sofa families.

**Test Selection**

Upon problem diagnosis the next step was to determine a suitable way to quantify stretch characteristics of upholstery fabrics. By investigating industry set standards and meticulously analysing the set of data necessary in predicting stretch/recovery properties of upholstery fabrics; 2 sets of measures were found vital for our proposed test and can be described as;

- extension at a given load (sometimes known as modulus) which is a measure of how easily the fabric stretches;
- the other is how well the fabric recovers from stretching to this load, usually measured as growth or residual extension which we will refer as ‘permanent extension’ throughout this paper.

For the sake of better clarification of the terminology involved, below we will explain the terms related to our test.

**Permanent Extension**

When a textile material has been subject to a force even for a short period of time the complete removal of the force allows the specimen to recover its original dimensions, rapidly at first and then more slowly with perhaps a small amount of residual extension remaining. This remaining extension is known as permanent set. Instantaneous extension can be considered to be composed of 2 quantities;\(^7\)

- Elastic extension, which is completely recoverable
- Plastic or permanent extension, which is not recoverable.

According to this simplified theory when a material is subject to forces below its Yield Point then most of the extension is recoverable, whereas if the force is sufficient to take the material beyond its Yield Point a fraction of the extension will be permanent.

**Elastic Recovery**

Elastic recovery is the ability of a textile material showing how rapid the material recovers back to its original state upon the removal of force(s) applied and elastic recovery changes in nature in the region of the yield point. At this point it is worthwhile mentioning that;

- The longer the material is held at a given extension, the lower is the level of recovery, and
- the extent of recovery from extension is a property which is dependent on the type of material.

**Test Method**

In accordance with required quantities that are determined to be measured, an in depth study of standard test methods was carried out evaluating various ASTM and ISO test methods. The biggest challenge imposed was the lack of a test method truly applicable to non-stretch upholstery fabrics.

Bearing in mind the approach to stretch/recovery issue and successive feedback from industry experts and external test labs, “ISO EN 14704-1:2005 Determination of the elasticity of fabrics – Part 1: Strip tests” test method was observed to best represent the solution for our approach.

**ISO EN 14704-1:2005**

In this test method a woven fabric test specimen of specified dimensions is extended at a constant rate either to a specified force or elongation for an agreed number of cycles, and its elasticity determined by measuring certain characteristics.
Vital aspects of this test method can be described as:

- the number of stretch cycles before the actual measurements (stretching of fabric for a consecutive 5 cycles is believed to represent various handling related forces the fabric is exposed to),
- the load test specimen taken to,
- the time held at the fixed load and,
- the time allowed for recovery.

**Equipment & Sampling**

- CRE Tensile testing machine in accordance with EN ISO 10012:2003 (Figure 8)
- Machine gauge length 200 mm (distance between upper and lower jaws)
- Test specimen template measuring 60 mm x 300 mm
- Scissors, marker and fraying equipment
- Calibrated metal ruler graduated in millimetres

![Figure 8 - CRE testing machine](image)
Fabric samples are cut to 60 mm x 300 mm dimension (5 warp and 5 weft) and edges are frayed to form a balanced specimen structure. Reference bench marks of 100 mm are placed in centre, parallel to the short side of specimen to measure permanent extension.

**Test Procedure**

CRE test machine is engaged for recording the force and elongation measurements required. The cross-head put in motion and the test specimen was cycled between gauge length and the required force (or elongation value) for 5 cycles. On the final cycle the CRE testing machine is set to ‘hold’ at the maximum force for 60 seconds.

To measure un-recovered elongation, the test specimen is carefully removed from the CRE testing machine and laid on a flat surface for a chosen period (1 min, 30 min and 24 hours). The distance between the reference marks previously made on the specimen is re-measured, using the calibrated steel rule.

**Recording**

- Extension and/or elongation at the maximum force is recorded, from the stress/strain curves or data generated in the test.
- The un-recovered elongation on each test specimen is recorded by using calibrated steel rule and results are noted down.
- Finally the average of all elongation/extension at defined load/elongation and un-recovered elongation values are calculated.

A number of tests were run in IKEA Test Lab and efforts to design and apply this test method are divided into two parts; Test-1 and Test-2 where you will find information related to activities and methods followed throughout stretch/recovery test application.
Test-1: Elongation at 100 N Load

Eight fabrics selected for our project purposes were used during test runs and their stretch characteristics were observed by extensive tests applied in 2 stages. Test-1 included the application of 100 N load on both warp and weft specimens following ISO EN 14704-1 test method.

As a result of 1st test round following points are made and consequently the need for a 2nd round of test was identified;

- 100 N load was observed not to give promising and comparable permanent extension results in certain fabrics (e.g. Fabric B and Fabric F) since warp and weft values noted were alike preventing any comments to be made on elastic recovery properties of those fabrics,
- 100 N load selection was also noticed to be low for certain fabrics to push their maximum elongation limits and arrive a conclusive point in terms of their stretch and recovery characteristics.

Bearing our conclusive points in mind, discussions are made with industry experts who lead textile committees across the world (ASTM and ISO committees) in order to lead a more elaborative test method for non-stretch upholstery fabrics and will be explained more in detail.

Test – 2: Stretch under fixed elongation

Although 1st test round gave certain indications of the stretch properties of selected fabrics, permanent extension values for certain fabrics e.g. Fabric B, F and G were so low, making the comparison harder for both fabric directions and the need to apply a 2nd round of stretch tests arouse after discussions within fabric team and wide feedback of test experts in textile industry were received during this process.
In this context, Ms. Sylvia Hillier of Tinius Olsen Co., UK (ISO EN 14704-1:2005, CEN/TC 248 committee member) and Mr Kam Viengkham of NIKE Inc., USA subcommittee D13.59 member developing proposed standard ASTM WK27572 “Test Method for Elastic/Stretch Properties of Textile Materials” were both phone interviewed and consulted. Their vast experience in stretch fabric test was taken into consideration during the design of 2nd round stretch tests at IKEA Test Lab.

According to Sylvia, applying a fixed load e.g. 100N, would not help to reflect the true elasticity nature of all fabrics and a load limit, which the fabric is taken to throughout 5 test cycles, has to be defined for each specific fabric. She further commented on her experience in Du Pont USA, where they were measuring elasticity of various suiting fabrics including stretch yarns in their construction and the permanent extension of fabrics were measured consequently. Du Pont was following an ASTM method (ASTM D3107-03) where the fabric is taken to 85% elongation of its available stretch for a consecutive 3 cycles and stage held in 4th cycle for a period of 30±1 minutes. The fabric specimen is then removed and the permanent extension in fabric is measured by means of a steel ruler after agreed number of minutes/hours.

The same approach was followed for our 2nd test round and 85% average available stretch values for each fabric in warp/weft directions were calculated and can be seen in Table 5. Due to limitation in stretch test software (Ondio), fabric specimens could not be taken to fixed elongation (fabrics can only be taken to a fixed load) and instead tensile strength (ISO 13934-1) test results were used to identify approximate load values that correspond to 85% strain values in stress/strain graphs and are included in the Table 5 below.

---

8 Hillier, S., 2010, Interview on fabric elasticity Interviewed by Yusuf Kocer [phone]
<table>
<thead>
<tr>
<th>Breaking Strength (N)</th>
<th>85%</th>
<th>1275</th>
<th>1100</th>
<th>935</th>
<th>935</th>
<th>935</th>
<th>800</th>
<th>1190</th>
<th>1190</th>
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</thead>
<tbody>
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<td><strong>Warp</strong></td>
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<td>1300</td>
<td>1100</td>
<td>1100</td>
<td>1100</td>
<td>950</td>
<td>1400</td>
<td>1400</td>
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<tr>
<td><strong>Fabric</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Fabric A</strong></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Fabric B</strong></td>
<td>1500</td>
<td>1300</td>
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<td>1100</td>
<td>1100</td>
<td>950</td>
<td>1400</td>
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<tr>
<td><strong>Fabric C</strong></td>
<td>850</td>
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<td>775</td>
<td>600</td>
<td>1050</td>
<td>750</td>
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<td>935</td>
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<td><strong>Fabric E</strong></td>
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<td>1400</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Fabric F</strong></td>
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<td><strong>Fabric G</strong></td>
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<td><strong>Max. Elongation (%)</strong></td>
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<td>21</td>
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<td>25</td>
<td>30.5</td>
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<td></td>
<td>85%</td>
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<td><strong>Corresponding Load (N)</strong></td>
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<td>860</td>
<td>850</td>
<td>650</td>
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<td>1130</td>
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<tr>
<td><strong>Breaking Strength(N)</strong></td>
<td>1400</td>
<td>680</td>
<td>950</td>
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<td>750</td>
<td>1200</td>
<td>920</td>
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<td><strong>Weft</strong></td>
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<td></td>
<td></td>
<td></td>
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<td><strong>Fabric B</strong></td>
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<td>680</td>
<td>950</td>
<td>990</td>
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<td>1200</td>
<td>920</td>
<td>900</td>
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<tr>
<td><strong>Fabric C</strong></td>
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<td>775</td>
<td>600</td>
<td>1050</td>
<td>750</td>
<td>750</td>
<td></td>
</tr>
<tr>
<td><strong>Fabric D</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fabric E</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fabric F</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fabric G</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Max. Elongation (%)</strong></td>
<td>18</td>
<td>12</td>
<td>20.5</td>
<td>17</td>
<td>17.5</td>
<td>16.5</td>
<td>13</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>85%</td>
<td>15.3</td>
<td>10.2</td>
<td>17.43</td>
<td>14,45</td>
<td>14.88</td>
<td>14</td>
<td>11</td>
<td>14,45</td>
</tr>
<tr>
<td><strong>Corresponding Load (N)</strong></td>
<td>1190</td>
<td>500</td>
<td>725</td>
<td>775</td>
<td>600</td>
<td>1050</td>
<td>750</td>
<td>750</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5** – Correspondent load values

As previously mentioned, all fabric specimens (warp/weft) were taken to 85% elongation of their pre-measured available stretch values. For example, Fabric F warp and weft available stretch values were measured as 20% and 18% respectively hence 85% elongation for this fabric will be 17% and 15.3% for warp and weft directions respectively. Since the software could not take the specimen to defined elongation, load values corresponding to 85% strain on stress/strain curve noted down and as a result Fabric F warp specimens were stretched to 1275N and weft specimens to 1190 N (corresponding load).
Test Method (2\textsuperscript{nd} test)

Same test method as outlined in Test-1 (ISO EN 14704-1:2005) was followed with modification in varying fixed load selection across warp/weft specimens and measurements for permanent extension were taken after 1 minute, 30 minutes and 24 hours upon removal of test specimens off the jaws of tensile testing machine.

Results

In this section, a detailed analysis of the elasticity test results of each fabric will be given; explaining the influence and contribution of various fabric-specific factors (weave construction, yarn type, threads/cm etc.) on the overall stretch characteristics of selected fabrics. Comparisons and referral will be made wherever applicable between 1\textsuperscript{st} and 2\textsuperscript{nd} test results to draw a sound conclusion of this test method on upholstery fabric stretch properties.

Before starting our analysis, below a summary of fabric characteristics are given as guidance (see Table 6).

RS – ring spun cotton yarn
OE – open-end cotton yarn

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Fabric</th>
<th>Fabric</th>
<th>Fabric</th>
<th>Fabric</th>
<th>Fabric</th>
<th>Fabric</th>
<th>Fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>B</td>
<td>G</td>
<td>E</td>
<td>H</td>
<td>C</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Composition</td>
<td>65/35 PC</td>
<td>100% Cotton</td>
<td>46 % cotton, 40 % viscose, 10 % polyester, 4 % flax</td>
<td>84 % cotton, 16 % polyester</td>
<td>75 % cotton, 25 % polyester</td>
<td>40 % cotton, 20 % flax, 20 % viscose, 20 % polyester</td>
<td>100% Cotton</td>
</tr>
<tr>
<td>Weave Effect</td>
<td>Twill</td>
<td>Half Panama</td>
<td>Plain</td>
<td>Panama+Plain</td>
<td>2 Beam, dobbby</td>
<td>Twill</td>
<td>Twill</td>
</tr>
<tr>
<td>Weave Density (thr/cm)</td>
<td>45 x 23</td>
<td>29 x 12</td>
<td>23 x 16</td>
<td>14 x 11</td>
<td>18 x 18</td>
<td>17 x 17</td>
<td>28 x 15</td>
</tr>
<tr>
<td>Yarn Count (s)</td>
<td>Ne12 x Ne10 (RS)</td>
<td>Ne10 x Ne6 (OE)</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Ne10/2 x ne10/2</td>
<td>Ne7 x Ne6 (OE)</td>
</tr>
<tr>
<td>Weight (gsm)</td>
<td>372</td>
<td>300</td>
<td>545</td>
<td>506</td>
<td>672</td>
<td>440</td>
<td>408</td>
</tr>
</tbody>
</table>

Table 6 – Detailed fabric characteristics
Discussion of test results (Test-1 and Test-2)

Fabric A

Below is the summary of stretch test results for Fabric A.

- 1<sup>st</sup> and 2<sup>nd</sup> test results correspond to each other and verify the stretch properties of Fabric A.
- Alike with Fabric D, Fabric A represents similar fashion in terms of test results; higher elongation across warp direction which is attributed to warp twill structure and comparatively lower elongation across weft as a consequence of warp twill leaving weft yarns less prone to elongation.

<table>
<thead>
<tr>
<th>Test-1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elongation @100N (%)</td>
<td>warp 13,0%</td>
</tr>
<tr>
<td></td>
<td>weft 5,0%</td>
</tr>
<tr>
<td>Permanent Extension (mm%)</td>
<td>warp 3,7</td>
</tr>
<tr>
<td></td>
<td>weft 1,5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test-2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elongation @85% Stretch</td>
<td>warp 27,8%</td>
</tr>
<tr>
<td></td>
<td>weft 11,6%</td>
</tr>
<tr>
<td>Permanent Extension (mm%)</td>
<td>warp 17,4</td>
</tr>
<tr>
<td></td>
<td>weft 7,0</td>
</tr>
</tbody>
</table>

Table 7 – Fabric A test results

Fabric B

Below is the summary of stretch test results for Fabric B.

- After 1<sup>st</sup> test, weft elongation and permanent extension values were observed to be higher than warp direction which gave corresponding results only after 2<sup>nd</sup> test.
- Higher warp elongation can be attributed to half panama weave effect since the warp crimp is higher which allows higher stretch along the warp direction.
Below is the summary of stretch test results for Fabric C.

- 1\textsuperscript{st} and 2\textsuperscript{nd} test results correspond to each other and verifies the stretch properties of Fabric C.
- Higher warp elongation in Fabric C can be attributed to twill weave effect that allows higher crimp and cover factor along warp direction.
- Double ply yarns used in warp direction also gives increased stretch due to yarn construction.

<table>
<thead>
<tr>
<th></th>
<th>Test-1</th>
<th>Test-2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elongation @100N (%)</td>
<td>Elongation @85% Stretch</td>
</tr>
<tr>
<td></td>
<td>warp 6%</td>
<td>warp 13,8%</td>
</tr>
<tr>
<td></td>
<td>weft 7%</td>
<td>weft 12%</td>
</tr>
<tr>
<td></td>
<td>Permanent Extension (mm%)</td>
<td>warp 10 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weft 1,8</td>
</tr>
<tr>
<td></td>
<td>Permanent Extension (mm%)</td>
<td>warp 6,3 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weft 7</td>
</tr>
</tbody>
</table>

**Table 8 – Fabric B test results**

**Fabric C**

**Table 9 – Fabric C test results**
Fabric D

Below is the summary of stretch test results for Fabric D.

- $1^{\text{st}}$ and $2^{\text{nd}}$ test results correspond to each other and verify the stretch properties of Fabric D.
- Although similar count 100% cotton open-end yarns are used both in warp and weft directions; warp elongation is noted dominantly higher than weft elongation and this characteristic can be attributed to the warp twill effect in fabric construction which is believed to allow greater elongation along warp direction and as a result reduced elongation in weft direction.

<table>
<thead>
<tr>
<th></th>
<th>Test-1</th>
<th>Test-2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Elongation @100N (%)</td>
<td>Elongation @85% Stretch</td>
</tr>
<tr>
<td>warp</td>
<td>13,0%</td>
<td>25,5%</td>
</tr>
<tr>
<td>weft</td>
<td>8,0%</td>
<td>15,0%</td>
</tr>
<tr>
<td>Permanent Extension (mm / %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>warp</td>
<td>5,3</td>
<td>19,4</td>
</tr>
<tr>
<td>weft</td>
<td>2,6</td>
<td>11,2</td>
</tr>
</tbody>
</table>

Table 10 – Fabric D test results
**Fabric E**

Below is the summary of stretch test results for Fabric E.

- Elongation and permanent extension results of both 1\textsuperscript{st} and 2\textsuperscript{nd} test overlaps and verifies each other in a visible manner.
- Plain + half panama weave effect on Fabric E along both directions gives fairly comparable permanent extension results coupled with the same yarn counts used in both directions.

<table>
<thead>
<tr>
<th>Test</th>
<th>Elongation @100N (%)</th>
<th>Permanent Extension (mm%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp 11.0%</td>
<td>warp 2.1</td>
</tr>
<tr>
<td></td>
<td>weft 8.0%</td>
<td>weft 1.5</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp 20.0%</td>
<td>warp 7.0</td>
</tr>
<tr>
<td></td>
<td>weft 16.0%</td>
<td>weft 6.0</td>
</tr>
</tbody>
</table>

**Table 11** – Fabric E test results

**Fabric F**

Below is the summary of stretch test results for Fabric F.

- As it is clearly seen on table .., 1\textsuperscript{st} and 2\textsuperscript{nd} test results correspond each other in terms of permanent extension values.
- Although warp elongation is slightly higher than weft elongation, permanent extension both in warp and weft directions are noted as 5%. This can be explained by the dense weave structure of Fabric F in both directions which allows a fairly
balanced stretch limit for both directions and almost same count polycotton yarn used along both warp/weft directions.

<table>
<thead>
<tr>
<th></th>
<th>Elongation @100N (%)</th>
<th>Permanent Extension (mm/%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp</td>
<td>weft</td>
</tr>
<tr>
<td></td>
<td>4,0%</td>
<td>5,0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elongation @85% Stretch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp</td>
<td>weft</td>
</tr>
<tr>
<td></td>
<td>17,8%</td>
<td>15,3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permanent Extension (mm/%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp</td>
<td>weft</td>
</tr>
<tr>
<td></td>
<td>5,0</td>
<td>5,0</td>
</tr>
</tbody>
</table>

**Table 12** – Fabric F test results

**Fabric G**

Below is the summary of stretch test results for Fabric G.

- After 1st test, weft elongation and permanent extension values were observed to be higher than warp direction which gave complementary results only after 2nd test.
- Higher weft elongation and permanent extension in Fabric G can be attributed to relatively loose weft construction and especially to the presence of Ne1,5 chenille yarn along the weft direction. Locking structure in chenille yarn allows higher stretch and this is truly reflected in our results as higher weft elongation.
Below is the summary of stretch test results for Fabric H.

- 1\textsuperscript{st} and 2\textsuperscript{nd} test results correspond to each other and verify the stretch properties of Fabric H.
- Warp elongation is noted slightly higher than weft elongation however permanent extension values are measured as 9mm for both directions which can be explained by same weave density (18x18) and yarns used along both weave directions.
- Although warp specimen are taken to 850 N load and respectively weft specimen to 600N, elastic recovery of warp and weft are the same irrespective of the scale of elongation.
<table>
<thead>
<tr>
<th>Test</th>
<th>Elongation @100N (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>weft</td>
<td>10,5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp</td>
<td>11,0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permanent Extension (mm/%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>weft</td>
<td>2,0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp</td>
<td>2,0</td>
<td></td>
</tr>
<tr>
<td>Test-2</td>
<td>Elongation @85% Stretch</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>weft</td>
<td>21,0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp</td>
<td>22,6%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Permanent Extension (mm/%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>weft</td>
<td>9,0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>warp</td>
<td>9,0</td>
<td></td>
</tr>
</tbody>
</table>

**Table 14 - Fabric H test results**

**Conclusions**

Once all fabrics are reviewed and analyzed for their stretch characteristics below conclusive points are made as a result of our modified stretch tests:

- Elastic recovery is higher in synthetic blended fabrics compared to 100% cotton fabrics.

- Fabric weave effect (i.e. plain, twill, panama etc.) is seen to play a crucial role along with yarn type (i.e. synthetic or natural fibre) on fabric stretch properties, namely warp/weft percentage elongation and permanent extension.

- It is noted that there is a parallel fashion between load applied and permanent extension; as the load applied on fabric increases (both warp and weft directions) so does the permanent extension. This point must be kept in mind during fabric cutting, since excess force exerted on fabric will result in poor recovery of fabric making it harder for the fabric to recover to its original state.
• Yarns used in fabric construction are believed to play a major role in overall fabric stretch properties. Ply yarns (double or more plies) and low twist yarns inherently allow a limit for higher elongation. Yarn twist, along with other factors, has to be born in mind during determination of respective fabric elongation and residual extension.

• Although we can relate certain fabric properties to their resultant stretch characteristics it is hard to estimate and propose a general guideline determining stretch properties of non-stretch yarn woven upholstery fabrics.

• Due to lack of stretch yarns in fabric constructions it is hard to estimate fabric recovery in both directions and hence setting a requirement level is an ultimate challenge which has to be investigated further.

• In terms of further recommendation in stretch test design; determination of ‘yield point’ with the help of stress/strain curve is believed to be an important parameter, which defines the elastic limits for a specific fabric where the fabric behaves truly elastic and efforts of ASTM subcommittee D13.59 shall be taken into further consideration.

To sum up, in conjunction with our test initiations it is observed that there are various factors involved in determining the stretch and recovery properties of upholstery fabrics and the lack of stretch yarns in fabric construction poses another major challenge during determination of the elastic behaviour of upholstery fabrics.
**Washing Simulation Test**

**Background**

After we came to know that Martindale test can not be generalised for all types of end uses of fabrics, it was decided to develop a test method that simulates customer use & washing at home. The initial idea was taken from fatigue test of wooden frame. IKEA guarantees sofa frames for 10 years. For upholstery covers, it is known from customer survey that customer washes upholstery covers every 4 months (2-3 times a year). Hence, if a complete sofa including covers is guaranteed for 10 years and tested for static load, it should be washed in between to simulate use at home as customer washes covers after use of 4 months. This means during this test, covers should be removed after each fatigue test cycle and washed according to standards. The idea is to see after 30 washes if the covers can still be used or not.

The covers should also be tested for fabrics after certain period of usage to know how durable, colour fast or comfortable still they are.

![Simulation of customer use at home](image)

**Figure 9** - Simulation of customer use at home
<table>
<thead>
<tr>
<th>Sofa Family</th>
<th>Fabric Sofa Covers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fabrics</td>
</tr>
<tr>
<td>Ektorp So3</td>
<td>Fabric A</td>
</tr>
<tr>
<td></td>
<td>Fabric I</td>
</tr>
<tr>
<td></td>
<td>Fabric C</td>
</tr>
<tr>
<td>Karlstad So2</td>
<td>Fabric D</td>
</tr>
<tr>
<td></td>
<td>Fabric E</td>
</tr>
<tr>
<td>Klippan So2</td>
<td>Fabric F</td>
</tr>
<tr>
<td>Kivik So2</td>
<td>Fabric G</td>
</tr>
</tbody>
</table>

Table 15 - Selection of fabrics for washing simulation test

Tests to be done

1. Combined (For Frames + Covers)
   According to IOS-PRF-0028 referred to standard ENV 12250 and EN 1728, 6.9
   Domestic furniture – Seating – Test methods for determination of strength and durability with the following modification of the cycles:
   - Shall only test “combined seat and back fatigue, clause 6.9” using 1700 cycles each for 30 times instead of stated 20000 cycles in ENV 12250. Dress the wooden pads with stitched denim covering.

2. For covers:
   1. Water washing test for upholstery covers (instructions are given below)
   2. Dry clean for upholstery covers (instructions are given below)

3. For fabrics acc. to IOS –PRF-0025 and IOS-TM-0007

Fabric tests after 1-10-30 washes
1. Resistance to abrasion, furniture fabrics, ISO 12947-1 and 12947-2
2. Resistance to pilling, ISO 12945-2
3. Resistance to seam slippage, ISO 13936-2
4. Colour fastness to light, ISO 105-B02
5. Colour fastness to rubbing, ISO 105-X12
6. Colour fastness to water spotting, ISO 105-E16
7. Colour fastness to washing, ISO 105-C06

Additional Information for fabric tests:
- Before & after wash tests for Fabric I.
- Note cross staining for multicolour fabrics in abrasion test and colour fastness to washing test.
- Test 1-4
  - To be carried out after every check point i.e. 1, 10, 30 washes
  - Visual assessment to be made for pilling after every wash.
- Test 5-7
  - To be done completely after 1st wash only and in case of abnormal result, to be done after 10th and 30th washes.

Limitations
- One of the limitations about this test was representation of ideal sitting action which includes vertical pressure caused by gravitational force and horizontal friction effect. During test runs, it was not possible to provide horizontal rubbing action to simulate the exact sitting action customer follows. But this action can be produced using same or different equipment in future test runs.
- IKEA does not have dry cleaning facility in its own test lab. Therefore, covers had to be commercially dry-cleaned where contents of dry cleaning solution are different from standard ISO test method. Logistically it was not possible to send it
to external labs for dry cleaning because it had to combine with fatigue test successively.

**Instruction for “Water washing test for upholstery covers”**

**Contents**
This is an instruction for how to perform a multiple washing test on upholstery covers. The test includes dimensional change, change of colour and appearance after wash.

**About this test method**
This test method is based on the ISO standards listed below.

**References**
Conditioning, ISO 139
Preparation, marking and measuring for determination of dimensional change, ISO 3759
Domestic washing and drying procedures, ISO 6330
Determination of dimensional change after washing and drying, ISO 5077

**Equipment**
Washing machine: Type -A washer, front loading according to ISO 6330, section 5.1.1.
Detergents: IEC with optical brightener, and sodium per borate according to ISO 6330 1984, section 4.1.3.
<table>
<thead>
<tr>
<th>Wash Sample</th>
<th>Complete Set</th>
<th>Frame Cover</th>
<th>Cushion Covers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample 2</td>
<td>Test after 1st Wash</td>
<td>Only dimensional change</td>
<td>Change of color and fabric tests</td>
</tr>
<tr>
<td>Sample 3</td>
<td>Test after 10th Wash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample 4</td>
<td>Test after 30th Wash</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 16** – Sampling plan per each fabric group

**Additional Information:**
- Wash frame covers and the cushion covers separately, using two washing machines.

**Test procedure**

The frame covers to be marked with “shrinkage square” on the reverse side. The square must be drawn on a flat fabric part, with no seams. IMPORTANT! The marking shall be permanent to withstand the total number of washes stated in the test order. Sew markings might be needed in a multiple washing procedure.

The dimensional change is to be measured after every wash. The measurements should be made at three different places on the “shrinkage square” in both directions, and the mean value is to be reported.

**Determination of dimensional change**

Figure 10 and 11 below show the vertical and horizontal directions:
Figure 10 – Sofa cover directions

Figure 11 – Sofa cover directions
Note for dimensional change in complete covers:
Also, measurements to be noted after dressing the frames with covers after 1, 2, 3, 4, 5, 10 and 30 washes according to points of measurement (POM’s) for respective sofa family attached separately.

Assessment of colour change and change of appearance

This part of the test shall be performed on the cushion covers. One sample in size 20x30 cm to be cut out from the cushion covers after the 1st, 10th and 30th wash. These samples are to be used for the assessment of change of colour and appearance. Every sample to be marked with the number of washes it has gone through.
NOTE! On multicoloured fabrics it is important to try to cut similar pattern parts for every assessment, in order for as many colours as possible to be represented.

Washing procedure
All washing to be done according to IOS-TM-0007 “Dimensional change after washing and drying, ISO 6330, ISO 3759, ISO 5077”

Special Instructions:
- No wash load shall be added for this particular test
- The covers to be washed, hang dried and ironed after each wash according to the care and cleaning instruction sewn into the covers.
- Colour fading for care and instruction label is also to be noted after each wash. If a care and cleaning label is missing, the orderer must provide the information before the testing starts.
- All zippers to be open and the cover should not be turned inside out during wash.
- Conditioning after hang drying before and after ironing may be skipped.
- Squeeze marks or washing wrinkles to be observed and noted.
Dry Cleaning Procedure

The dry cleaning shall be performed in a commercial dry cleaning apparatus in the procedure described in section 4 with the following exceptions:

- Addition of water 6% (see Table 17) in each cycle.
- No wash load shall be added.
- The covers shall be ironed between dry cleaning cycles according to given care and cleaning instructions.
  - If care and cleaning instructions are missing, the test orderer shall provide the information before the testing starts.
- All zippers shall be open and the cover shall not be turned inside out during dry cleaning.
- Load the machine with one complete set of covers.

1. Material: Upholstery covers to be provided by IKEA of Sweden

2. Reagents
   2.1 Tetrachloroethene, CCl2 = CCl2 distilled, sold for the purpose of dry cleaning.
   2.2 Sorbitan mono-oleate.
   In order to prevent foaming, it is important to use redistilled, clean solvent solution and not overfill the still.

3. Equipment

3.1 Dry cleaning machine
Consisting of a commercial reversible rotating cage type, totally enclosed machine, intended for use with tetrachloroethene. The diameter of the rotating cage shall be 600 mm minimum and 1 080 mm maximum. Its depth shall be 300 mm minimum. It
shall be fitted with three or four lifters. The speed shall be such as to give a $g$-factor of between 0.5 and 0.8 for cleaning and between 60 and 120 for extraction.

NOTE: The $g$-factor is calculated according to the following formula:

$$ g = 5.6 \times 10^{-7} n^2 d $$

where

$n$ is the rotational frequency, in rotations per minute;

$d$ is the rotating cage diameter, in millimetres.

3.1.1 The machine shall be fitted with the means to control solvent and air temperature as required (see Table 17).

3.1.2 The machine shall have suitable facilities to allow the emulsion (see 4.1.3) to be introduced gradually into the solvent between the cage and drum below the level of the solvent.

3.1.3 The machine shall be equipped with a means of measuring the temperature of the solvent during washing and either the incoming or the outgoing air during drying to within ±2 °C.

3.2 Finishing Apparatus for applying the appropriate finishing treatment to the test pieces is Iron, with an approximate mass of 1.5 kg and a sole surface area of 150 cm$^2$ to 200 cm$^2$.

4. Procedure for normal materials

4.1.1 The whole material load will consist of the mass of covers.

4.1.2 Place the conditioned load in the machine and charge the machine with distilled tetrachloroethene, containing 1 g/l of sorbitan mono-oleate so that the liquor ratio, calculated from the volume of solvent in the drum, is (5.5 ± 0.5) l/kg of the load. Maintain the solvent at (30 ± 3) °C throughout the cleaning operation.
4.1.3 Prepare a fresh emulsion by mixing, per kilogram of load, 10 ml of sorbitan mono-oleate with 30 ml of tetrachloroethene and then whilst stirring adding 20 ml of water. This corresponds to 2 % of water calculated on the mass of the load. If the mixing of the detergent with tetrachloroethene outside the machine is not permitted, a mixture of the detergent and water may be added directly into the machine. Precautions shall be taken to avoid uneven distribution of the individual components in the load. Any deviation from the procedure shall be noted in the test report. Start the machine with the filter circuit shut off, and 2 min after the cage inlet has closed, add the emulsion slowly over a period of (30 ± 5) s to the machine between the cage and the drum below the level of the solvent.

4.1.4 Switch the machine on and allow it to run for 15 min. Do not use the filter circuit for the duration of the test.

4.1.5 Drain the solvent and centrifugally extract the solvent from the load for 2 min (including at least 1 min at full extraction speed).

4.1.6 Introduce pure dry solvent at the same liquor ratio as that given in 4.1.2 and rinse for 5 min. Drain and extract again for 3 min (including at least 2 min at full extraction speed).

4.1.7 Dry the load in the machine air for an appropriate time, preferably using an automatic solvent dryness control. After drying, blow air, at ambient temperature, through the rotating load for at least 5 min.

4.1.8 Immediately remove the test piece from the machine. Place upholstery covers individually on hangers for at least 30 min before finishing.

4.1.9 Carry out finishing treatments appropriate to the test specimen from the following methods and record the processing conditions used.
Table 17 - Dry Cleaning Procedure

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Load ratio(a)</th>
<th>Solvent temperature</th>
<th>Detergent charge(b)</th>
<th>Addition of water(c)</th>
<th>Cleaning cycle time</th>
<th>Drying temperature(d)</th>
<th>Deodorization time(e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>50 ± 2</td>
<td>30 ± 3</td>
<td>1 + 2</td>
<td>2</td>
<td>15</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Sensitive</td>
<td>33 ± 2</td>
<td>30 ± 3</td>
<td>1</td>
<td>0</td>
<td>10</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Very sensitive</td>
<td>33 ± 2</td>
<td>30 ± 3</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

All values to be used from the table are for normal materials.

a see 4.1.1   b see 4.1.2   c see 4.1.3   d see 4.1.4

e see 4.1.5   f see 4.1.6   g Machine is set to control on In or Out condition

5. Test report

The test report shall include the following information:

a) Name of testing authority and report identification;
b) Date of testing;
c) Details of the item evaluated (description and reference);
d) Variations in procedures and parameters specified above.

Complete Test Instructions

1. Document all the specification given for frame.
2. Dress the frame and cushion with covers.
3. Take all measurements of covers according to specifications.
4. Document all visual assessments mentioned to be taken before test.
5. Fatigue test according to ENV 12250 and EN 1728, 6.9. Mark test cycle number on the back of frame. Mark Sample number, face side (side which is in contact
with wooden pads. Use care and instruction label for marking on the right seat cushion cover and centre, back cushion covers.

6. Un-dress the covers, mark right back cushion cover with wash number for every individual sample.

7. Mark shrinkage square on the frame cover for dimensional change, record horizontal and vertical measurements. Mark velcro, zipper and non woven also for dimensional change. (See Instruction for “Water washing test for upholstery covers”)

8. Hang dry the covers for 24 hours.


10. Iron all the covers according to care and instruction label, condition for one hour and measure shrinkage square for dimensional change again.

11. Dress the sofa again, take after wash measurements according to measurement specification.

12. Record all visual assessments according to instruction given for reporting.

13. Send samples for fabric test according to list above after 1st, 10th and 30th wash. Take test specimen from the face side of covers that is in contact with wooden pads during fatigue test. Use centre seat cushion for light fastness and side seat cushions for other tests in the list.
Figure 12 – Washing simulation test simplified

Assessment

Colour change of the tested sample to be assessed according to ISO 105-A02, using mask no. 3. When assessing change of colour and staining, use the mask specified in “Assessment of results/ selection of mask” in IOS-TM-0007.

Every 20x30 cm sample is to be assessed against the original cover colours. When testing a multicoloured cover, each colour to be assessed and documented individually. It is important that the 20x30 cm samples are cut from the same parts of the repeat of the fabric to secure that we always compare the same parts.
All marked/assessed pieces to be stored and documented together for final evaluation. Digital photos to be taken when something particular should be shown to the orderer.

**Reporting**

All remaining test material, the reference cover and the documented measurements and any other observations and the marked 20x30 cm samples to be returned to the orderer. The dimensional change, in the vertical and horizontal directions is to be reported according to above. It is very valuable to have all other observations documented as well: E.g. broken seams, worn out piping, touch-and-close fastenings, and care instruction label not readable after a certain number of washes, washing wrinkles, pilling, etc. for both main fabric and non-woven.

**Before testing**

**A. Frame**
- Article Number
- Supplier
- Measurement according to documentation

**B. Covers**

- Major measurements according to standard POM’s (attached separately) are to be taken and reported after dressing the covers on frames.
- % deviation of back panel from back frame
- The following to be checked along with cover technicians and reported:

1. Article Number
2. Sofa Family
3. Fabric type, construction, material

- 86 -
4. Fabric Supplier
5. Stitching supplier
5. Cover weight

6. Zippers
- Type, material, brand, colour, colour coordination and width. Mark for shrinkage.

7. Lining
- Document type, material, brand, colour, colour coordination and weight. Mark for shrinkage.

8. Velcro
- Type, material, brand, colour, colour coordination and width. Mark for shrinkage.

9. Stitching thread
- Document thickness, type, material, and brand and colour coordination

10. Fit
- Measurement according to documentation
- Decide standard POM’s
- Before wash measurements
- Evaluate fit over frame (loose or tight)
- Comparison of cover and frame measurement (smaller or bigger)

11. Stitching
- Type, SPI, straightness of the seam, loose threads
Grain line/pile direction
During Testing after first wash

Washing standards
- Size (wash-ability according to machine size), tumbling turns/min., water, energy consumption

Dry cleaning
- As above and use of chemicals

After each wash
- Change in appearance, shape, colour of materials (fabric tests) and all accessories for no. 6-11. Wear and tear on the frame after each mechanical test,
- Dimensional change in fabric,
- Visual assessment for pilling in photocell.

After 1st, 10th, 30th Wash for 5-11
- Dress sofa after 1-5th, 10th, and 30th wash and take measurements according to points of measurements (POM’s). Cover fit on frame is also to be noted
- Dimensional change in accessories (non woven, zipper, Velcro) after 1-5th, 10th, and 30th washes

Partial reporting: A partial report together with the frame cover to be sent to the orderer after 1st, 10th, and 30th wash.

Results
As a pilot test, we started with a decided frame with Fabric A which is 100% cotton. This fabric is both water washable and dry cleanable.
Limitations with Dry Cleaning

Dry cleaning facilities are not there in IKEA test labs. Therefore, it was not logistically, feasible to send the samples to external labs because it had to be tested for fatigue in between. Therefore, a nearby commercial dry cleaning facility was used. But the equipment does not allow using all contents mentioned in ISO test method for dry cleaning. It does not use any water in cleaning. The only chemical used is tetra chloroethene. Therefore, results are not comparable with ISO test method in this case.

Dimensional change after washing

It is evident from the chart below (see Table 18) that 100% cotton fabric has progressive shrinkage and this fabric stabilizes dimensionally after 10\textsuperscript{th} wash. It is important to notice that the decision to cut the template for covers is made on the basis of 1\textsuperscript{st} wash shrinkage result but on the other hand customer washes covers far more than once which means it becomes hard to put covers on frame with this much shrinkage in the fabric.

Table 18 - 100% Cotton Fabric shrinkage result during 20 washes
It is clear from the results that 100% cotton fabrics have progressive shrinkage in them after 1\textsuperscript{st} wash. Warp shrinkage is up to -7% which is very high whereas tolerance limit is -3%. If the covers are made as big as to cover this shrinkage, they will look ugly in the store. One way is to sell covers in the store after wash. But this requires more cost during the process for washing and ironing. The only left way is not to have hundred\% cotton fabrics. If cotton is blended with synthetics, it will not only result in better shrinkage but also better abrasion resistance properties.

Also, there should be process control in the suppliers and fabric should not be accepted for cutting if it has more than 3\% shrinkage or if the difference in shrinkage from different lots is more than 1\%. Two different cutting templates can be used in latter case.

Another solution to avoid unexpected shrinkage issues is to have measurements trials in stitching supplier. This can be done by cutting some covers from different lots and check before and after wash measurements on the actual sofa. Measurement results will always be different in shrinkage square and stitched cover because of stretch points in construction of frame. Therefore, only shrinkage square results and that also after 1\textsuperscript{st} wash only are not reliable enough. But one important point to take into consideration here
is that customers never thought shrinkage as a problem in pre-studies. This contradiction was discussed a lot and it was concluded that due to stretch in the fabric with usage, the fabric adapts to the shape of frame after some time and hence it looks fine again. An example is wearing denim jeans right after washing which is a little hard to wear but after some hours of use, it is relaxed.

![Figure 13 - Before Wash](image1)

![Figure 14 - After two washes](image2)

**Dimensional change after dry cleaning**

It is interesting to notice that there was no or minor change in dimensions after dry cleaning. Apparently, visual appearance was also much better as compared to the appearance after same number of water washes. The only significant change was puckering in fabric attached to non-woven due to different shrinkage behaviours of non-woven and woven fabrics.

**Fabric test results**

According to the test results for the properties mentioned in the test instructions the fabric passes the entire tests according to IKEA requirements for acceptable quality and there is no significant change in durability or colour fastness properties of fabric.
Visual Assessments

- Appearance of the fabric after 20 washes was within IKEA acceptable standards but overall look of sofa was not very good because of washing out. It had washing marks and creases.

- It was noticed that seat covers were a bit tight even before wash though measurements were according to specifications.

- Non-woven was melted after 1st wash along the seam. It is recommended to have washing test for non-woven before purchasing.

- Due to different shrinkage behaviour in fabric and cotton corded piping, significant puckering was observed after 20 washes (see Figure 16)

- The colour of zipper was changed after 20 washes. It is recommended to have a test method for zippers that secures the quality for the same life as covers have.
Conclusions for test and further research

From this test, it is concluded that after as many as 20 washes with fatigue test, which is a simulation of almost 7 years of usage, fabric is still durable enough so it does not wear out but it washes out in that period due to which customer may think of replacing the covers keeping the same sofa. This test can be tried on covers with blended materials and other sofa families as well to have concrete results for the whole range.
9 Communication Strategy

In this chapter communication strategies deducted as result of test runs and continuous discussions within IKEA will be presented. Communicating with customers is key to success for IKEA retail strategy and forms an inevitable part of business perspective.

Communication with customers plays an important role in appropriate usage and right handling of sofa covers by them and during project implementation and research, it was concluded that IKEA needs to make improvements in its sofa covers communication strategy in the following areas:

Drying of sofa covers after washing

- Although it is defined on care and instruction label that covers should not be tumble dried it is still not mentioned with appropriate symbol that customers should hang dry them.

Washing & ironing instructions

- Ironing of non-woven fabric is not recommended in the instructions but placement of this label near non-woven part of sofa cover might confuse customers whether it is for non-woven or for the whole cover.

- Although, it is advisable to put the cover back on frame when it is slightly damp but not completely dry; there should be a way to communicate to customer about the level of fabric dampness.

- It is not advisable to wash the covers when zippers are open turning inside out but it is never communicated to the customers which might sound misleading.
Communicating test results

- Although IKEA has an extremely durable range of fabrics in terms of abrasion resistance or colour fastness properties, there is no method or strategy to communicate good fabric characteristics to the customers unlike other competitors on the market.
10 Conclusions and further research

This project embraced various aspects of product requirements for fabric sofa covers centring around 4 quality parameters and target customer profiles. Keeping previous actions in mind and efforts taken throughout our timeline, conclusive remarks of our project are summarised as below.

Two new test methods were implemented and the outcomes of these tests were welcomed pertinently by relevant functions in IKEA. Washing simulation test was designed as a prototype method which reflects actual customer use and assessments carried out during test runs pinpointed certain flaws in sofa covers and highlighted fields for further development especially in overall cover appearance and fit. Washing simulation test can be further developed by adding horizontal rubbing action which reflects wear off effect caused on fabric surface by actual human sitting on sofa and results can be reinforced by applying this test on synthetic blend fabrics to arrive solid results.

A suitable test method to determine fabric elongation and elastic recovery was developed and proved successful delivering reliable results and robust approach to problem associated with identification of fabric elastic behaviour during sofa cover production. During fabric development process elastic behaviour of fabrics can be identified and this information shall be shared with cover technicians and stitching suppliers to avoid elasticity related problems in future. Fabric bagginess caused by customer usage over time constitutes another part of stretch problem and in this context ISO EN 14704-2:2007 test method must be examined further.

After collaborative research on logic behind abrasion test values with legislative European standards bodies and correspondent committee members, relationship between test values and actual fabric wear off was concluded not to follow a proportionate fashion and classification of fabrics in accordance with test methods was found unreasonable. Related functions in IKEA shall stay in touch with these legislative bodies in respective
committees and collaborations are highly recommended to stay updated with developments in field.

At various stages of this project the importance of synthetic blended fabrics were emphasized since they are proved to deliver better durability, colour fastness and elasticity results and hence advantages of blend fabrics must be highlighted with further investigations on fibre characteristics and prospects with blend fabrics must be evaluated more carefully.

Finally, findings of this project are believed to form grounds in sofa covers product development process and stand as input for sofa covers standardization as well taking part in product communication strategy to customers.
References


[2] Swedish Research Institute, Swerea

[discussion] Wallentin Bygg & Konsult AB


[phone] Comité Européen de Normalisation (CEN TEX BEL)


Tinius Olsen Co., Ltd. UK
### Appendix A

<table>
<thead>
<tr>
<th>Sofa Family</th>
<th>Fabric</th>
<th>Finished weight (gsm)</th>
<th>Dyeing Method</th>
<th>Construction</th>
<th>Fabric Content</th>
<th>Yarn count</th>
<th>Dry cleanable</th>
<th>Machine washable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyksele</td>
<td>Fabric B</td>
<td>300</td>
<td>Print</td>
<td>Half panama</td>
<td>100% Cotton</td>
<td>Ne 10/6</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Klippan</td>
<td>Fabric F</td>
<td>372</td>
<td>Piece-dyed</td>
<td>Twill</td>
<td>65% Cotton, 35% PET</td>
<td>Ne 12/10</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Kivik</td>
<td>Fabric G</td>
<td>545</td>
<td>Piece-dyed</td>
<td>Plain</td>
<td>46% cotton, 40% viscose, 10% polyester, 4% flax</td>
<td>Effect yarns used (slub and chenille)</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Beddinge/Sandby</td>
<td>Fabric H</td>
<td>672</td>
<td>Yarn-dyed</td>
<td>2 beam - dobby</td>
<td>75% cotton, 25% polyester</td>
<td>Ne 21/2 cotton, Ne 1.2 T/C 65/35</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Ektorp/Karlstad</td>
<td>Fabric A</td>
<td>400</td>
<td>Fiberdyed</td>
<td>Twill</td>
<td>100% Cotton</td>
<td>Ne 7/7</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Karlstad/Poäng</td>
<td>Fabric D</td>
<td>425</td>
<td>Bleached</td>
<td>Twill</td>
<td>100% Cotton</td>
<td>Ne 7/6</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Karlstad</td>
<td>Fabric E</td>
<td>506</td>
<td>Yarn-dyed</td>
<td>Irregular (Panama+Plain)</td>
<td>85% Cotton, 15% PET</td>
<td>Ne 4/2/20/2</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Ektorp/Hagalund</td>
<td>Fabric C</td>
<td>440</td>
<td>Yarn dyed</td>
<td>Twill</td>
<td>40% cotton, 20% flax, 20% viscose, 20% polyester</td>
<td>Ne 10/2</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

|                |        |                       |               |              | cotton, viscose, flax, polyester blend   |            |               |                  |

**Figure 18** – Detailed fabric characteristics