PRODUCT DEVELOPMENT OF A FIRE HOSE BASKET–

PROMOTING ERGONOMICS FOR FIREFIGHTERS

BSc in Mechanical engineering
Product development

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Summary

In this project a fire hose basket was developed. Field trips to different fire stations and the interviews during these visits gave better understanding of the problems with current product. The product development involved collection of information and constructing a 'house of quality'. Based on the collected information, an idea generation was made in two phases. By using an evaluation matrix the best concept was picked for detailed development. A choice of materials was studied partly using CES Selector 3.2 on the winning concept. The concept was then designed in the CAD program Creo Parametric 4.0 and a prototype was made. The prototype was then tested at fire stations and concluded with mixed results from firefighters. The new hose basket became better for the shorter people but for the longer persons the basket was more difficult to lift.

Acknowledgement

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Borås
May 10, 2018

Best Regards,
Moa Rask

Abstract

This report comprises a product development of an ergonomically designed hose basket that can be used by the firefighters when storing or carrying a fire hose. A study on ergonomics in the profession as a firefighter conducted by the Research Institutes of Sweden (RISE) showed that fire hose deployment was very physically exhausting. This study also revealed that some load may become too heavy and difficult to carry due to the design of the equipment. Injury to the user during lifting is common within the profession. Therefore there is a need for equipment that is more ergonomically designed.

The project follows a product development phase that includes market research and feasibility study which was accomplished by a literature study and through study visits and interviews at fire stations.

A common type of hose basket was used as the starting point for the project. This hose basket is in this report referred as "Skövde basket" and was considered heavy and un-ergonomic to carry, especially for shorter people. From the gathered information a ‘house of quality’ and a two-step idea generation was created. Several concepts that were made opposed the Skövde basket in an evaluation matrix. A material selection using a program, CES Selector 3.2 was made on the winning concept that became a hose basket which is carried under the arm.

The hose basket was then constructed in the program Creo Parametric 4.0 and detail drawings were created. A prototype was then made and tested by firefighters of both sexes and of different heights. The results pointed out improvements and deteriorations from the Skövde basket. The deterioration was that the basket became more difficult to pack, which was due to the reduced number of bars. Improvements were noticed on lift height; significant increase on lift height facilitated easy carrying by shorter individuals.

Sammanfattning

Denna rapport omfattar en produktutveckling av en ergonomiskt utformad slangkorg som kan användas av räddningstjänsten då brandslang ska placeras ut. Enligt en studie kring ergonomi inom räddningstjänsten gjord av Research Institutes of Sweden, RISE, ansåg många brandmän att slangutläggning var mycket fysiskt ansträngande. Syftet är att främja ergonomi inom brandmannayrket. Trots de fysiska kraven hos brandmän, kan vissa laster bli för tunga och svåra att bära på grund av utrustningens utformning. Därför behövs utrustning som är mer ergonomiskt utformad.

Projektet följer övergripligt en produktutvecklingsfas där det ingår dels en marknadsundersökning och en förstudie vilket gjordes genom en litteraturstudie, intervjuer och studiebesök på brandstationer.

En vanlig variant av slangkorg användes som utgångspunkt för projektet, denna slangkorg kallas i rapporten för ”Skövdeväskan” och ansågs tung och oergonomisk att bära, framför allt för kortare personer. Utifrån den information som samlats in gjordes ett kvalitetshus och en tvåstegs idégenerering där koncept togs fram. Koncepten ställdes mot varandra och mot Skövdeväskan i en konceptvalsmatris. Materialval med programmet CES Selector 3.2 gjordes på det vinnande konceptet som blev en slangkorg som bärs under armen.

Slangkorgen modellerades sedan i programmet Creo Parametric 4.0 och detaljritningar skapades. En prototyp konstruerades och denna testades av brandmän av båda könen och av olika längd. Testpersonerna fick därefter göra en utvärdering som visade på både förbättringar och försämringar jämfört med Skövdeväskan. Försämringar som uppkom var att korgen blev mer svårpackad vilket berodde på det reducerade antalet stödstänger i ramen. Förbättringar gjordes på lyfthöjd vilket underlättade framför allt för de kortare personerna.

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1. Introduction

This thesis focuses to develop a hose basket for fire fighters. Hose baskets are used to carry flexible pipes that transport water to the required places, for example, to a burning apartment on third floor in a building. It is one of the common tools that the fire fighters use in their working environment. Fire fighters carry the hose basket to different floors and through terrain and this have to be done quickly. Fire department at Research Institutes of Sweden (RISE) has realized problems within ergonomics in the existing hose basket and it is determined to develop a new hose basket to address the problems. RISE gives the outline of the project and it guides the project actively.

The theme of this work is to find the problems faced by the fire fighters with respective to hose basket, analyse the problems and give possible solutions.

1.1. Background

In 1832, Sweden's first fire department was formed, but it would take over 100 years for a requirement that all municipalities should have fire department (Brandhistoriska sällskapet 2018). Since then the fire department has developed. The fire regulation changed in 1972, since the new fire regulation the fire department should take care of all emergencies that comprise protecting humans, property and environment (Räddningstjänsten syd 2015). Today the rescue operations include for example drowning accidents, chemical accidents, traffic accidents and fire quenching (Krisinformation.se 2017). Nearly 20 % of the alarms go to traffic accidents and 26 % goes to fires which 12 % of them to fire in buildings (Myndigheten för samhällsskydd och beredskap 2010).

The work of the profession requires physical strength and fitness. To be employed as a full-time firefighter, a 2-year education is required and to be admitted to the education, one has to go through several physical examinations. The tests include treadmill test, strength test, work-related course and swim test. All tests require a certain level of fitness and strength (Myndigheten för samhällsskydd och beredskap 2009). Every year, firemen perform a new treadmill test to maintain the physical requirements. During a treadmill test, the individual must go for 6 minutes on a treadmill with 8° tilt in full alarm equipment (Johansson, B. 2009). The standard equipment weighs around 24 kg (Myndigheten för samhällsskydd och beredskap

2009). A study shows that firefighters often work close to the maximum physical capacity of an individual. The firefighters are burdened by the heavy equipment and due to the fact that they can be exposed to much heat, it is one of the most physically challenging professions (Schmidt & Mckune 2012).

According to the agency looking after work environment (Arbetsmiljöverket) loading weight often occurs in heavy lifting, it can also occur in uncomfortable, stressful or strenuous postures and movements. The agency also says that the vibration can cause damage to the body. According to Arbetsmiljöverket the human is made for movement and it is good as long as the body has the opportunity to rest and recover physically. The agency puts forward the regulations on load ergonomics (Arbetsmiljöverket 2016). In ergonomics regulations 4 § (AFS 2012:2) states the following: "Riskerna ska bedömas utifrån belastningarnas duration (hur länge), frekvens (hur ofta) och intensitet (hur mycket)". It can be translated in English as: "The risks should be assessed based on the duration of the load (how long), frequency (how often) and intensity (how much)" (Middelman 2011, s. 6).

A study has been done within construction environment where the spinal stress was studied. Masonry is also a very physically demanding work with heavy lifting. The study clearly showed a difference in the spinal load when lifting a light weight and heavy weight. In a specific case when a weight of 42.7 kg and 21.4 kg were lifted, there was a difference of about 15% for the compression load on the spine (Davis, Kotowski, Albers & Marras 2010).

In a survey conducted by Fire Department at Research Institutes of Sweden (RISE) it is the carrying of hose that is considered to be the most difficult in the event of fire in a building. In the survey, civil servants responded to the question how hard they thought this equipment was to carry when the hose was to be transported to the third floor of a building. Around 20% responded that they needed to use "much" or "all their strength" to carry; and around 25% felt it was "very exhausting" to carry (Ochoterena & Vylund 2018). It is important that even though the firefighters have carried the hose five or six floors, they have energy left for continued work (Glans & Rother 2007).

Another problem on hose carrying was discussed in interviews and in field studies conducted during the survey. For short persons, it is difficult to carry the hose baskets in stairs because the baskets hit the stairs if they are not lifted enough and these firefighters therefore usually

carry the weight of the hose basket with their shoulders. Different problems could occur depending upon the height of the firefighter.

A study based on full-time, part-time, and non-firefighters clearly shows that women take more time to carry a hose basket than the other categories (Malm, Lindberg & Stene 2005). Women have also a height average in Sweden that is 11.8 cm lower than the men; the average height of a woman is 167.36 cm with a standard deviation of 6.8 cm (Högskolan Skövde 2011).

Recently there have been more women interested in the work as a firefighter. A study showed that there were only 49 women out of 3000 fulltime workers in 2006 in Sweden. It accounts to less than 2 %. But in 2010 there was a substantial increase to around 80 women (Resare 2010). It is therefore important to adjust the equipment to both sexes. Regulation 7 § from diskrimeneringslagen (2008:567) states that the employer should promote a balanced gender distribution at workplace. In accordance with 5 §, they are also expected to work actively for good working conditions. Studies have also demonstrated a link between gender equality and better work environment, greater productivity and profitability within organizations (Glans & Rother 2007).

1.2. Theory

The inner diameter of the hose determines the dimensions of the hose baskets. Most of the dimensions come from the time when the measurement system used inches. Two commonly used hose types are “narrow hose” and “rough hose”. Rough hose has bigger diameter and it is used when a greater flow is needed. Each type of hose has two common dimensions as follows: narrow hose diameters are 38 mm and 42 mm, and rough hose diameters are 63 mm and 76 mm. The standard length of a hose is often 25 m (Särdqvist 2013). A 42 mm hose weights around 0.23 kg/m to 0.31 kg/m due to the variants. A 25 m hose weighs approximately 5.75 kg to 7.75 kg. (Hydab Scandinavia AB w.d.) (swebab w.d.).

Predominantly, the extinguishing agent that are used by the firefighters are water, it is low cost and easy to transport. It also serves the purpose in most cases. The foam is used mainly against liquid fires and when the firefighters are not supposed to penetrate into dense smoke in buildings. Generally, the foam consists of stabilizers, solvents, preservative, pH adjusting agents, firming and water. The foam shall be resistant to hard and salty water. The foam

should not get in touch with copper, and should be stored in containers made of plastic or stainless steel (Särdqvist 2013).

There are different types of hose baskets on the Swedish market. For example there are baskets for single and double rolled fire hoses, Figure 1. And then there are hose baskets with folded hose, Figure 2.

Figure 1. Hosebaskets for rolled hose, Södertörn bag on left and Quick bag on the right (Brinab w.d.)

Södertörn hose basket and Quikbag are the hose baskets that are used with rolled hoses. A double rolled hose can be used in two different ways. Both of the hose couplings are on the outside of the hose roll, so the roll can either be thrown out or run out. When throwing a hose the couplings stays at the throwing location and the hose unfolds while rolling away from the user. And in the second way, to run out a hose the user has to carry the hose and deploy it while walking. The double rolled hose are lighter to throw because the length is half as long as the single rolled hose. A single rolled hose always throws out and throwing a hose needs some technique and the ground have to be relatively flat (Särdqvist 2013).

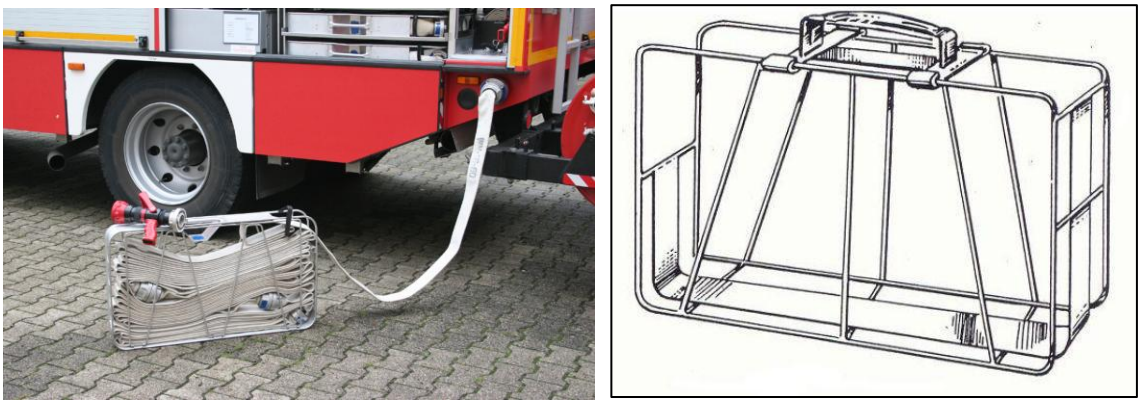


Figure 2. Hosebasket for folded hose (Mayer, Jürgen 2009; Brinab w.d.)

The folded fire hoses are often connected to the fire truck as shown to the left in Figure 2, and then the firefighter walks or runs out the hose. Feed hose is always stored folded (Särdqvist 2013). According to the study by RISE, the most used fire hose basket for transporting hose in forest is the one that have the folded hose and it is the type of hose basket that is shown in Figure 2. Some of those responded to the questions told that they used all their physical capacity for this activity. This type of hose basket was also the only one among four other types, which the respondents felt they used all of their ability for to carry (Ochoterena & Vylund 2018).

Arbetsmiljöverket has developed regulations that deal with ergonomics and safety when using work equipment. For example, the work equipment must have adequate strength and stability. The work equipment must also be designed in a way that a good work position can be attained (Arbetsmiljöverket 2010). In addition, the Swedish standard SMS 2205 Brandmateriel – Slanglådor states the requirements for the hose basket. Hose basket should withstand bumps and do not harm the hose while in packaging or during operation. It should also be as lightweight as possible. The handle of the hose basket should be refrigerant insulated and should not disturb the operation while the hose being removed or packed (SIS, 1969). The hose is made to withstand a temperature range of -30 degrees Celsius to 100 degrees Celsius. The hose should also be resistant to many chemicals, oil and UV (Hydab Scandinavia AB, w.d.).

1.3. Problem Description

A survey has been made by Research Institutes of Sweden (RISE) in 2017 among firefighters in Sweden. It was found that around 25% considered hose carrying as a very strenuous element during fire in a building.

1.4. Purpose Statement

Despite the physical requirements of firefighters, some load may become too heavy and difficult to carry due to the design of the equipment. Damage during lifting is common within the profession. Therefore there is a need for equipment that is more ergonomically designed.

1.4.1. Research Questions

The following research questions will be studied:

I. *What are the problems on the existing products available on the market when it comes to moving hose?*
II. *How can the problems be avoided considering the requirements of a hose basket?*
III. *How can the equipment be improved in ergonomics?*

Both regulations and firefighter's requirements that affect the development of hose basket will be looked into.

1.5. Limitations

This work will not specifically follow the procedure of the actual implementation due to limited time. The thesis will aim to investigate the problems and recommends the possibilities to overcome the issues. The work will only cover a construction of a hose basket to be used by fire service department. No calculations will be made on strength.

1.6. Delimitations

The change in the hose basket will mainly affect the firefighters which contribute to their work environment, health hazard and efficiency. RISE provided their previous work to study the same in detail. This thesis is connected to several courses during last three years within the program.

1.7. Work Distribution

This work is solely performed and the time distributed for each tasks was pre-planned. Supervisors from RISE and University of Borås were informed in advance about the tasks performed. Meetings with firefighters and other respondents were conducted without supervisors' presence. Studying the previous work, gathering information from firefighters and product development were given priority.

2. Method

The purpose of this study is to address the problems of the existing hose basket for firefighters and develop a new ergonomically designed hose basket. It is necessary to study previous work, gather information through interviews, develop ideas, choose right material and model the component in Creo Parametric 4.0. Creo is a CAD (computer aided design) computer based program that is used to design drawings within construction. It is important to select valid methods to conclude the work qualitatively.

The develop method used will be based on the product development phase in the book "*Produktutveckling, effektiva metoder för konstruktion och design*" (Johansson, Persson & Pettersson 2013).

2.1. Literature Study

First, a meeting with supervisor at RISE led to gain the knowledge on the project and the report on previous study by RISE was studied in detail to understand the project. Similar studies were also studied to understand the developments in the area. Further, scientific articles, books, Swedish regulations on the topic were used to gather information.

2.2. Market Study

A simple market analysis was conducted to find out the product solutions that already exist in the market. Then a pilot study began with a visit to the fire station in Skövde. They demonstrated and showed the variant of hose baskets they were using. The development of the basket started from this point.

Later, a study visit also was made to the fire station in Borås and they used different type of basket. The development made in this work is related to hose basket at fire station in Skövde but it can also be used in Borås fire station. The hose basket used in Skövde is the one that this project works on and it will furthermore in this report be called the “Skövde basket”

2.3. Interviews

Both semi-structured and unstructured interviews have been held during the visit to the fire stations for deeper knowledge on the subject.

During the first visit to the fire station in Skövde, a semi-structured interview with predetermined questions was held about what they consider to be good and bad with the product they had. Later, an unstructured interview with no predetermined questions was held during the visit to fire station in Borås about rolled hoses and how they clean and pack their firehoses.

2.4. Idea Generation

An idea generation started based on the requirements and wishes that came forward during literature study, market study and interviews. The ideas were created using three methods, the six thinking hats, edge storming and the "opposite method". The ideas were written in a mind map and from that concepts were created (Westling w.d.). The five best ideas were taken forward to the concept development phase where they were compared in an evaluation matrix.

The "Skövde basket" was the starting point and the five new concepts were rated in comparison to that hose basket. The winning concept was the one that got the highest rating and this concept was taken to the next phase. In this phase the details of the winning concept were focussed, and a similar idea generation was made.

2.5. Material Selection

The choice of material is an important part of the thesis as the hose basket will inevitably get in contact with all the chemicals in the foam that is transported through the hose. Hose basket should with stand all these in addition to the mechanical strength. Material selection was reasoned during the concept development.

Given the long requirements of chemical resistance and mechanical performance, CES Selector program was used. CES Selector is a standard tool for material selection and graphical analysis of material properties.

2.6. CAD Construction

Later, the final concept was designed and constructed using computer-aided design software Creo Parametric 4.0. In this program detail drawings were made.

2.7. Prototyping

Finally, a prototype was made and this prototype was compared to the Skövde basket by firefighters in Skövde. They loaded both the fire hose baskets and then walked with them in the stairs, and on flat ground. The prototype was made by hand using similar material that was chosen during material selection (section 2.5).

2.8. Reconceptualise

After the test the firefighters had to answer some questions about the feeling of the new hose basket when compared to the Skövde basket. The question paper is shown in appendix 1.

The tools and methods that were used worked well.

3. RESULTS AND DISCUSSION

The important results from the study are put forward and discussed in this section. The outcomes from developing the hose basket are certainly incomplete given the requirements of the product and time needed for the implementation. Nevertheless, I believe that this small project will definitely give a fundamental knowledge on hose baskets and possibilities to improve the product based on user requests.

These results will be used by RISE and the concepts could be further developed for actual implementation of the product.

3.1. Literature study

The literature study has been made all though the work. Many sources cited in this report are not peer-reviewed texts but the information comes from some reliable sources like documents from Arbetsmiljöverket or standards. It was hard to find articles that correspond to Sweden as there was too little work done on this topic.

The firefighters in other countries can have other ways to work, or the people are shorter or longer than the average person in Sweden. Therefore, it is important to take only relevant information from these international sources and it is more relevant to take sources such as Swedish fire department (Räddningstjänst) and Swedish agency for work environment (Arbetsmiljöverket) that fit to Swedish conditions.

During the literature study patents in the area was sought but no Swedish patents were found.

Anthropometric measurements were found for both women and men. The dimensions that were relevant in this case were the length of the underarm and overarm, and the height of shoulders for both sexes. A picture of how the values of elbow-wrist and forearm-fingertip length are measured is presented in Figure 3 together with the length of the arm (from shoulder to elbow).

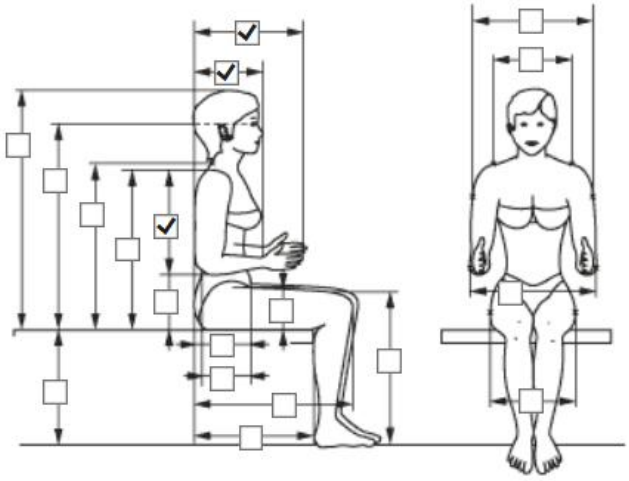


Figure 3. Measurement points for the anthropometric values of the arm (Högskolan Skövde, 2011)

A representation of how the measurement values are taken for the body height and shoulder height is shown in Figure 4.

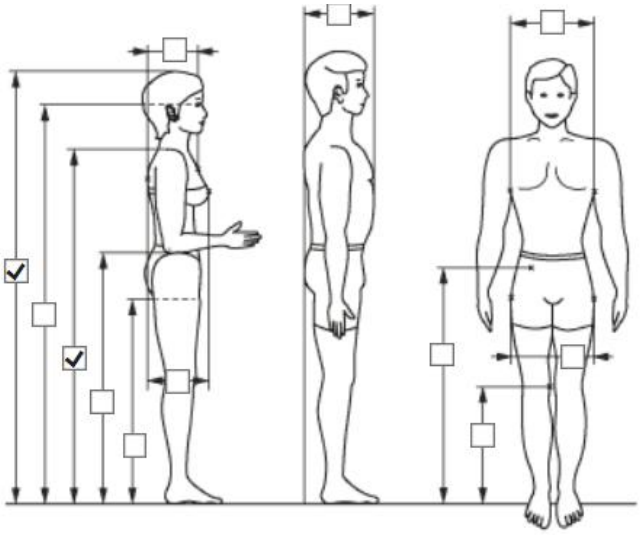


Figure 4. Measurement points for the anthropometric values of the height (Högskolan Skövde, 2011)

The values of the measurements and the standard deviation for women and men are shown in Table 1. The values are in millimetre.

Table 1. Measurements mean values and standard deviation (S.D.) of men and women, values in mm. (Högskolan Skövde, 2011)

	Women		Men	
	Mean	S.D.	Mean	S.D.
Forearm-fingertip length	437.60	26.24	484.24	26.86
Elbow-wrist length	251.73	20.74	283.89	20.46
Shoulder-elbow length	340.59	19.71	370.49	19.70
Stature (body height)	1673.57	67.79	1791.62	70.28
Shoulder height	1358.78	63.23	1454.06	65.76

3.2. Market Study

All the fire stations in Sweden work in their own way. There is little coordination in terms of equipment purchases between Skövde and Borås. The visit to Skövde fire station was made in the beginning of the project and therefore the work assumes from how they worked and the equipment that they used. It was noticed during a visit to Borås fire station that Borås uses newer equipment and is bigger in size compared to Skövde. Inputs from both the fire stations weren't compatible with each other. Therefore, the decision was made collectively that the project should have its starting point from the information from Skövde. Opinions from the firefighters from the both fire stations are found under section 3.3 (Interviews).

It is worthwhile to mention that RISE makes more visits to these two fire stations to get more opinions for further development of the hose basket. Additional visits to these places could narrow down the opinions and their agreements.

The plan was also to make an opinion poll within the organization "Kvinnor inom räddningstjänsten" (women in fire service) but there were communication issues with sending it out. The information from the above organization was never collected. This made the requirements and wishes harder to decide.

After the use in case of any event, the hose is washed and dried. At the fire station in Skövde the hoses were packed by hand. There were often two persons packing one basket at a time. The hose were laid out in a long corridor so it was lying flat. They had a machine that helped

pulling the hose into the basket while the firefighters placed the hose in a good way inside the basket.

In Borås, firefighters used the Quick Bag as shown in Figure 1. They had a machine that first washed and dried the hose. Then the firefighters could choose if they wanted a single rolled or double rolled hose and the machine managed both.

Firefighters at different fire stations carried the hose basket differently. In Skövde one person often carried two hose baskets meanwhile other one took nozzle holder and other essential things. While carrying two baskets, the load was in equilibrium between both arms and it was considered easier to walk with two baskets than just one. In Borås, firefighter carrying a hose basket could take a nozzle as well because the Quick bag had a shoulder strap that left the hand of the firefighter empty.

The Quick bag basket carry two pairs of 25 m hose are 18,5 cm wide, 50 cm long and have a height of 40.5 cm. Meanwhile, the Skövde basket dimensions are as follows: width 18.5cm length 78cm and height 50 cm. The Skövde basket weighs 3.5 kg whereas the Quick bag weighs 2.35 kg without hose. In Skövde, staff thought that the width of a Quick bag could make it inconvenient.

3.3. Interviews

Predetermined questions were prepared for semi-structured interview during the study visit to Skövde fire station. The questions were asked at the point of departure for the discussion. A lot was learned during this interview and the key outcomes from this section are listed below. The problems varied from simple to complex design features.

Eight firefighters participated in the discussion and one of them was a woman. The biggest problem for her was that she had to lift the hose basket using her shoulders. This was mainly because she was shorter than all of the other firefighters. She had to make a big effort when walking upstairs or in the trail. In the interviews, it was also found that the handle of the model they used in Skövde was fairly sharp and not comfortable in long distance carrying. It was also learned that the underarms and hands had to strain quite much. The neck and shoulders were parts of the body that had to work hard.

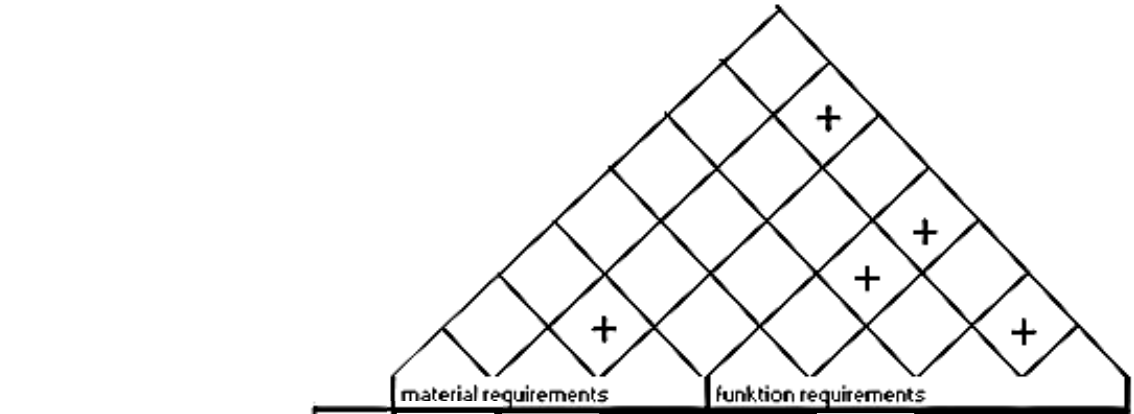
When carrying the hose the firefighter often had two baskets which had 100m hose or 50 m each. A 42 mm hose weighs around 0.23 kg/m which will make up to 23 kg of hose. The weight of the hose basket is added on top of that.

Firefighters echoed several problems they faced during their work. One of them pointed out that closing the hose basket by the hatch has led to problems. While closing the basket one could jam the fingers quite easily. The fire hose basket could be handled roughly in the work environment and can be thrown against hard surfaces often, therefore the basket have to handle the mechanical impacts and shocks. The hose baskets in Skövde have been used for more than 10 years and only some small repairs have to be made during this time.

In the visit in Borås there were told that the hose basket preferably should not be stuck on the body as this could harm the person if he or she should fall. If the hose basket is not fastened to the person, then the basket could tumble away from the body and injury can be minimized.

The hose baskets were placed next to each other in the back of the fire truck in both fire stations. The hose basket had to be packed compactly and not bulky. There is limited space in the fire truck, so too much space between the baskets should make the space not utilized optimally.

A product specification was created with requirements and wishes from these interviews, and from the information that came up while doing the literature study. From the product specification a quality house was made. The quality house is presented in Figure 5.



Costumer wishes	priority	Shock proof	Light weight	Water and chemical resistence	Flexible	Volume utilize	Adjustable	Lift height
Room for 2*25 m hose	5					+		
Hose should run out while the user walks	5							
Easy to clean	4			+				
Ergonomic carried by long and short people	4		+		+		+	+
Help for shoulders and neck.	4		+		+		+	+
Help for arms and hands	4		+		+		+	+
Easy to close	3					+		
Easy to place in truck	3				+	+		
Easy to pack	3					+		
Sustainability	3	+		+				
No risk of getting stuck	3				+		+	+
Cheap to produce	2							
Sum		3	12	7	18	9	15	15

Figure 5. House of quality

This step concluded that the flexibleness, the opportunity to adjust the basket and the lift height are the features that should be a priority when designing. The shockproof requirement

is listed in the matrix but not considered as less significant. The basket will not function well if the basket deforms by bumps and hits.

3.4. Idea generation

The idea generating was made in two steps. In the first step, ideas concerning different types of hose baskets, different ways to carry and different shapes were studied. In the second step when the hose basket type was selected, the details of the basket were investigated to develop the hose basket according to the requirements.

3.4.1. Step 1

In the first step of idea generating a mind map was made from ideas that had its starting point in the house of quality. The mind map of step 1 is shown in Figure 6.

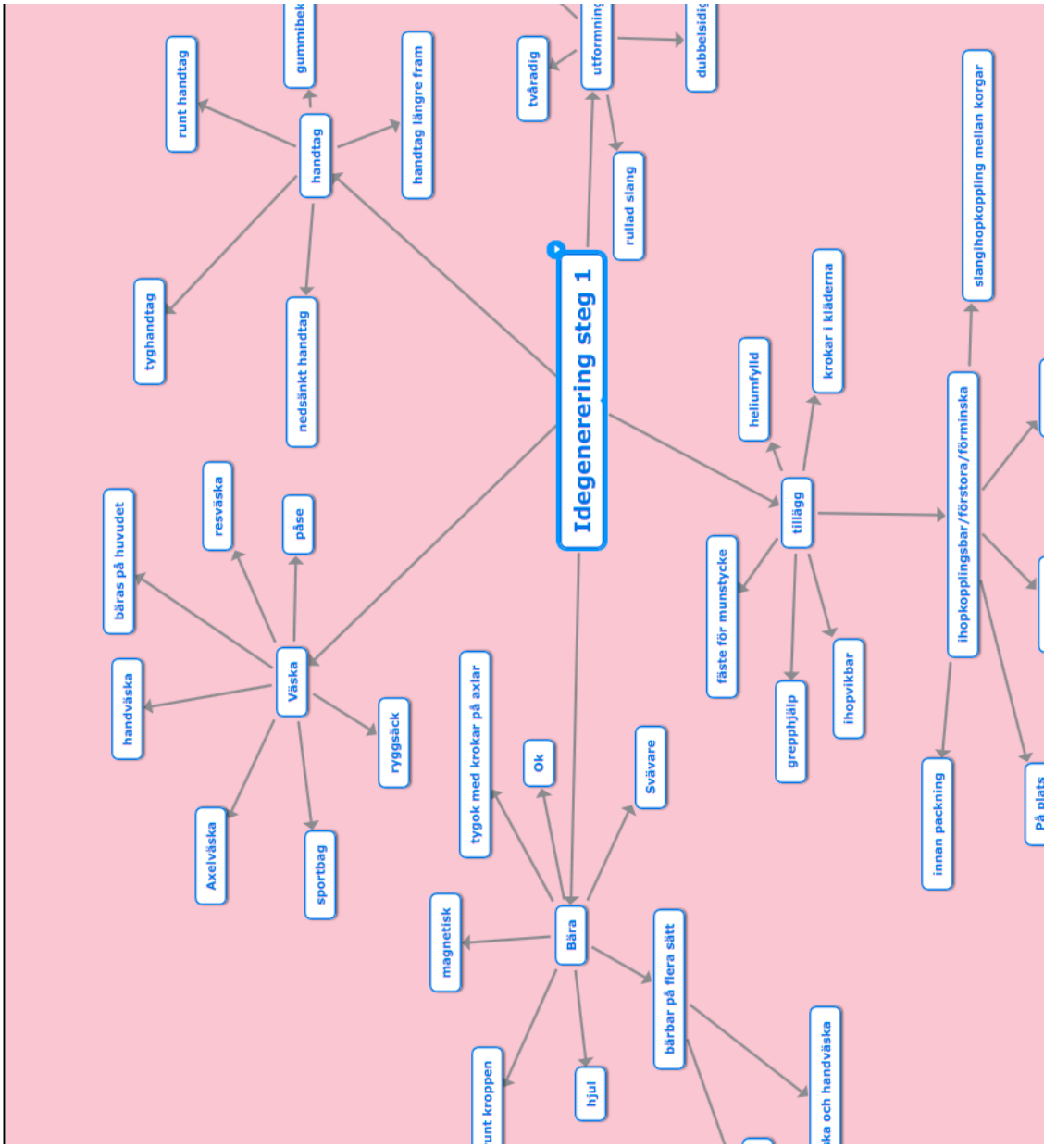


Figure 6. Mind map of ideas in step 1 in the idea generation phase

The ideas from the mind map were used to make five concepts.

The first concept, Concept 1.1, shown in Figure 7 was a basket that should be carried under the arm which made the base of the hose basket move away from the ground. In this way, the user carrying load of the basket on the shoulders when walking in stairs or terrain can be avoided. A padded fabric was incorporated to the parts that come in contact with the body to make the basket carrying comfortable.

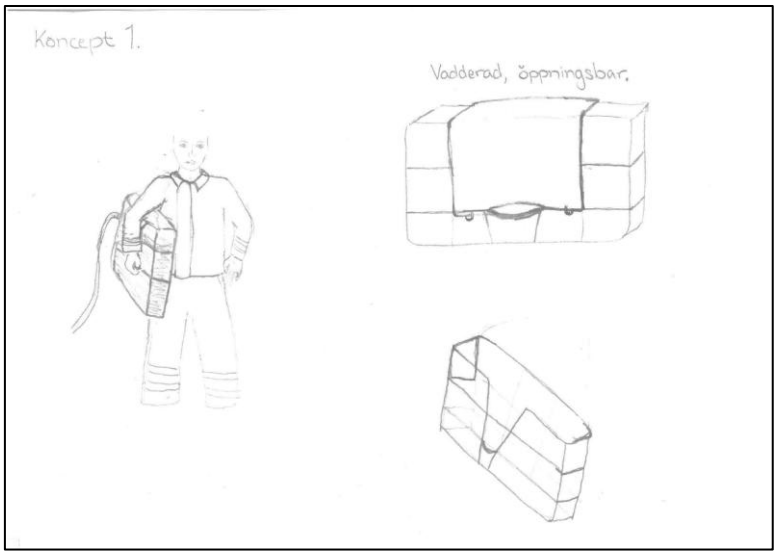


Figure 7. Concept 1:1

Concept 1:2 shown in Figure 8, was a basket made only in fabric, the basket has a shoulder-strap and opens with a zipper. There was also a handle on the top to give the opportunity to carry the basket in different ways.

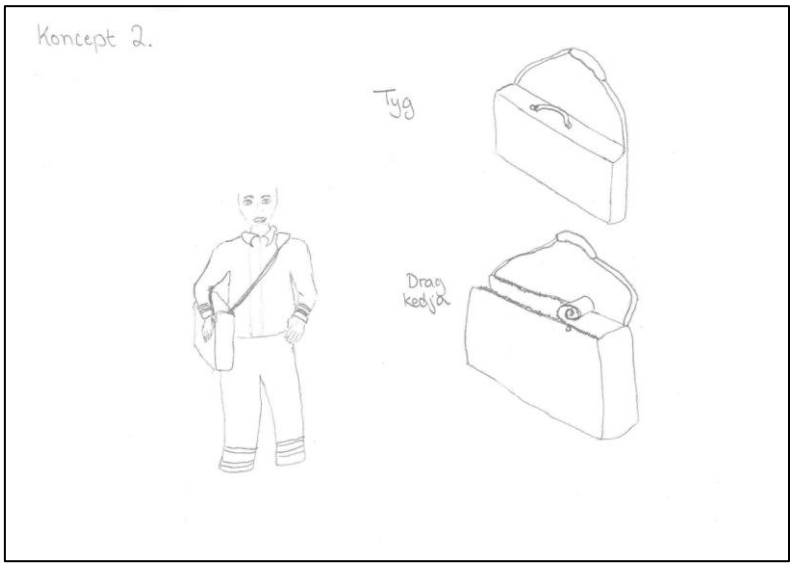


Figure 8. Concept 1:2

The third concept, Concept 1:3, shown in Figure 9, was also a hose basket made in fabric but this one had a carrying device in the shape of a belt. The belt had an extendible hook that would be attached to the basket. In this fashion, the firefighters don't have to carry all the weight of the basket with their hands. The basket should also be wider as two hoses had to fit in the given width. This arrangement should lower the height of the basket and raise the base of the basket from the ground.

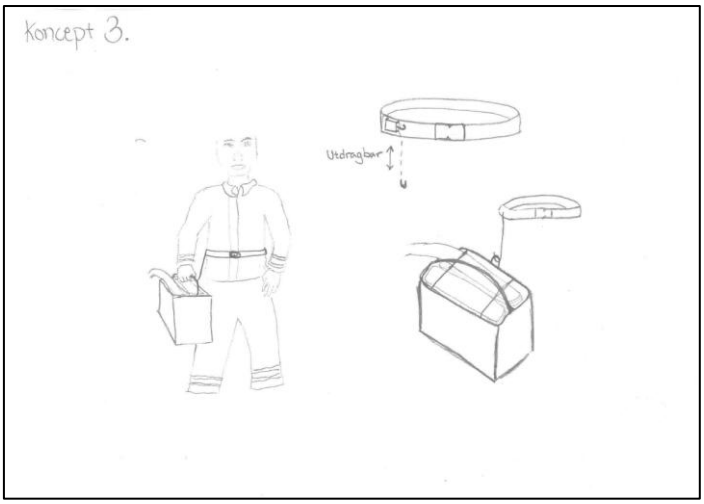


Figure 9. Concept 1:3

Concept 1:4, shown in Figure 10, was made to carry the hose in both hands. The hose was then meant to be double as long as the length of a hose in one Skövde basket. The handles were placed down into the basket unlike other concepts. This concept increased the lift height marginally. The hose could lay behind the user which made the hose basket not have to be high by itself.

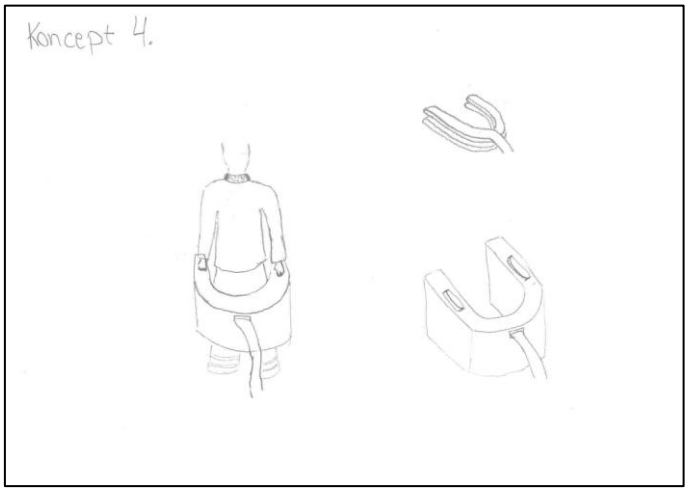


Figure 10. Concept 1:4

In Concept 1:5 is shown in Figure 11. In this concept, the Skövde basket wasn´t changed significantly. Instead a yoke-like application was added. The yoke was made in fabric and had hooks on the shoulders that the user could to fasten a strap from the basket.

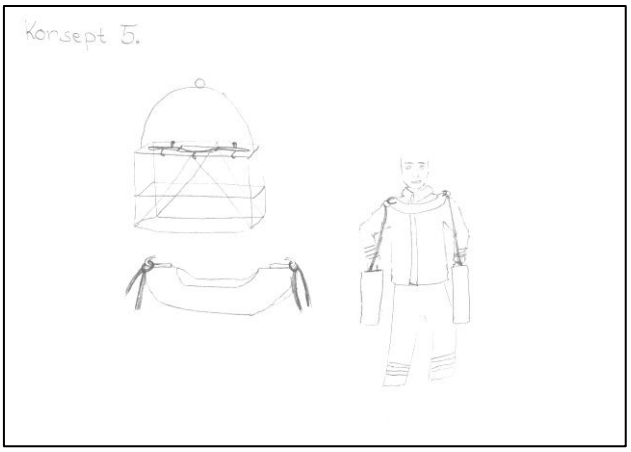


Figure 11. Concept 1:5

The concepts were compared with each other and also towards the “Skövde basket” in a Pugh’s matrix. The requirements were stimulated by a matrix (Table 2) and the rating was from minus 2 to plus 2. The one with the highest score was the best one. Concept 1 earns 5 points and outperforms other concepts.

Table 2. Evaluation matrix phase 1

	Concept 1:1	Concept 1:2	Concept 1:3	Concept 1:4	Concept 1:5	Skövde basket
Easy to clean	-1	−1	−1	−1	0	0
Easy to close	+1	+1	+1	−1	0	0
Shock proof	-1	+2	+1	0	0	0
Light weight	+1	+1	+1	−1	0	0
Easy to pack	0	-1	+1	0	0	0
Cheap to produce	−1	0	-2	0	−1	0
Adjustable	+1	+2	+1	-1	+1	0
Room for 2*25m hose	0	0	0	+2	0	0
Hose should run out while the user walks	0	0	0	0	0	0
Volume utilize	0	-1	-1	−2	0	0
Water and chemical resistance	−1	−2	-2	0	0	0
Lift height	+2	+1	0	+1	+1	0
Help for shoulders and neck	+1	-1	+2	+1	+1	0
Help for arms and hands	0	+2	+1	0	+2	0
Flexible	+1	-1	−2	-2	-2	0
Sustainability	−1	−2	−2	0	−1	0
Risk of getting stuck	0	-2	-2	-2	-2	0
Sum	+5	+3	+1	−1	+1	0

Concept 1:1 have few undesired properties such as the fabric that can be dirty and is harder to dry after it have been in contact to water. And by adding different materials the production process will have more steps and that affects the cost directly. However, this concept addresses the issues put forward by firefighters. The concept increased the lift height when compared to the Skövde basket. It also gets more stable while carrying as the basket is carried closer to the body than before.

In Concept 1:2 the basket is completely made out of fabric. In this case, the basket can be heavier when it is wet and the fabric generally has lower resistance to chemicals. On the other hand, the flexible fabric material will be relatively bump proof. But the fabric will also cause the shape to collapse easier which can cause instability while packing. The hands will be subjected to lower load with the shoulder strap. Nevertheless, the shoulders will compensate that load.

Concept 1:3 is also made of fabric which causes the same problems as in Concept 1:2 when comes in contact with water and chemicals. This concept makes the basket easier to pack. The extra gadget can increase the cost of production. Additional gadget to the basket could get stuck to the body which could cause injury to the user. Most of the load will be carried on the hip but it have to be held by the hand.

Concept 1:4 creates instabilities while carrying and takes a lot of space in the fire truck. It has room for the double length of hose but it is possible to carry only one hose at the time. The concept gets the lowest rating in the matrix. When the basket goes around the body the risk of getting hurt if the user falls is relatively high. The basket is in this case quite hard which makes it even more hazardous. The shape of the basket can also make it hard to get through small passages.

Concept 1:5 also has an external gadget which affects the results in a similar way as in Concept 1:3. The weight of the hose basket is positioned on the shoulders; nonetheless, the application can be difficult to use while carrying just one basket. The yoke can be twisted if the load is just on one side.

Concept 1:1 became the winning concept and the concept went on to step 2 of idea generation.

3.4.2. Step 2

Then the winning concept was designated for step 2 of idea generation. The mind map and the idea generation have now its staring point from the winning concept. The details like the design, handle and the opening of the basket were focussed. The mind map of the ideas that was created in step two is shown in Figure 12.

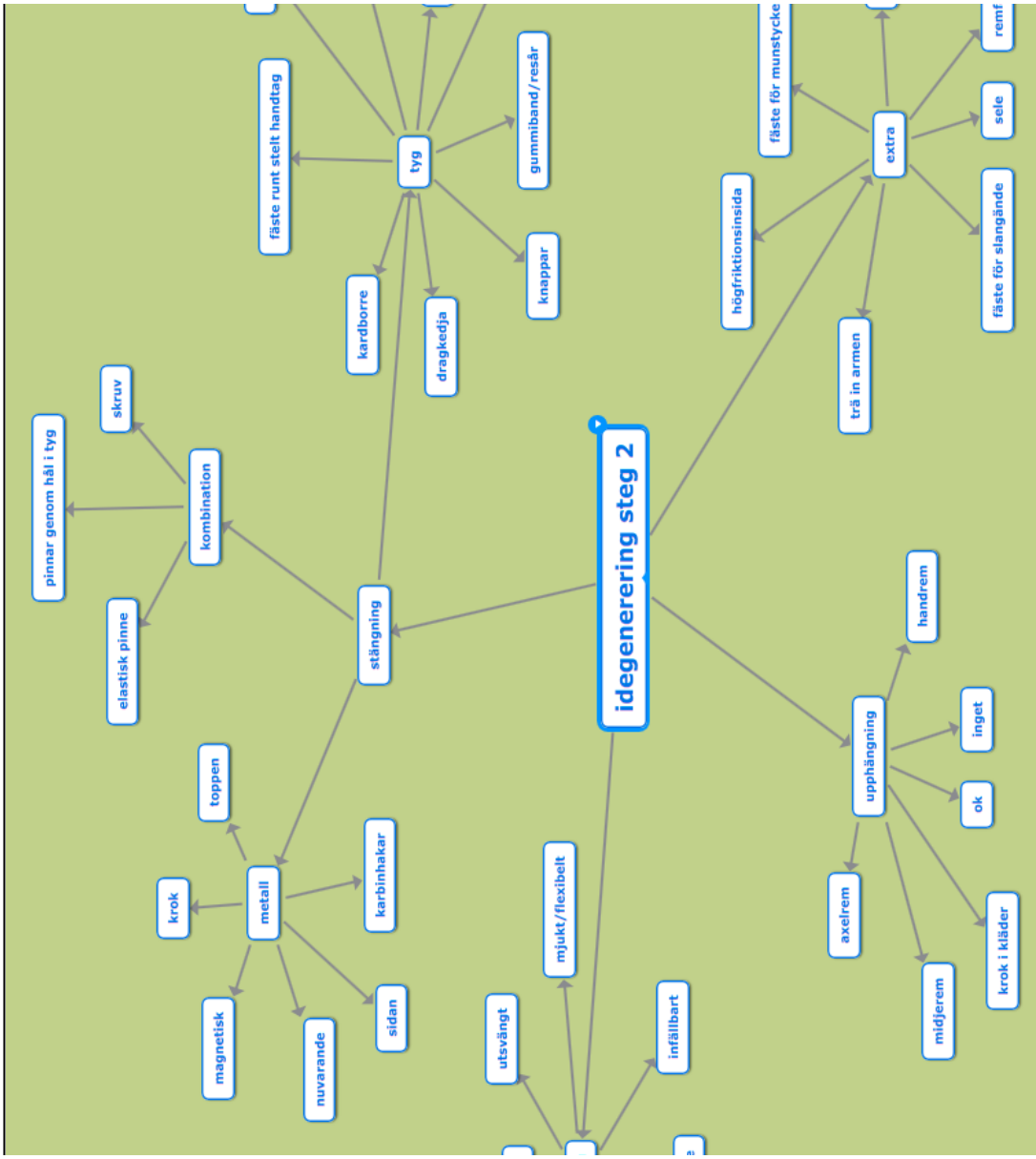


Figure 12. Mind map of ideas in step 2 in the idea generation phase

Four concepts were then made stretched out in the mind map and those were compared to each other in a matrix.

Concept 2:1 shown in Figure 13 has a handle that is designed to prevent the hand to be too weary. The handle goes around the wrist and takes support to reduce the load of the fingers. The basket closes by the application of a carabiner hook in a ring. The metal frame is just on the frontside whereas on the backside (that side towards the body) is made of hard plastic for comfortable carrying.

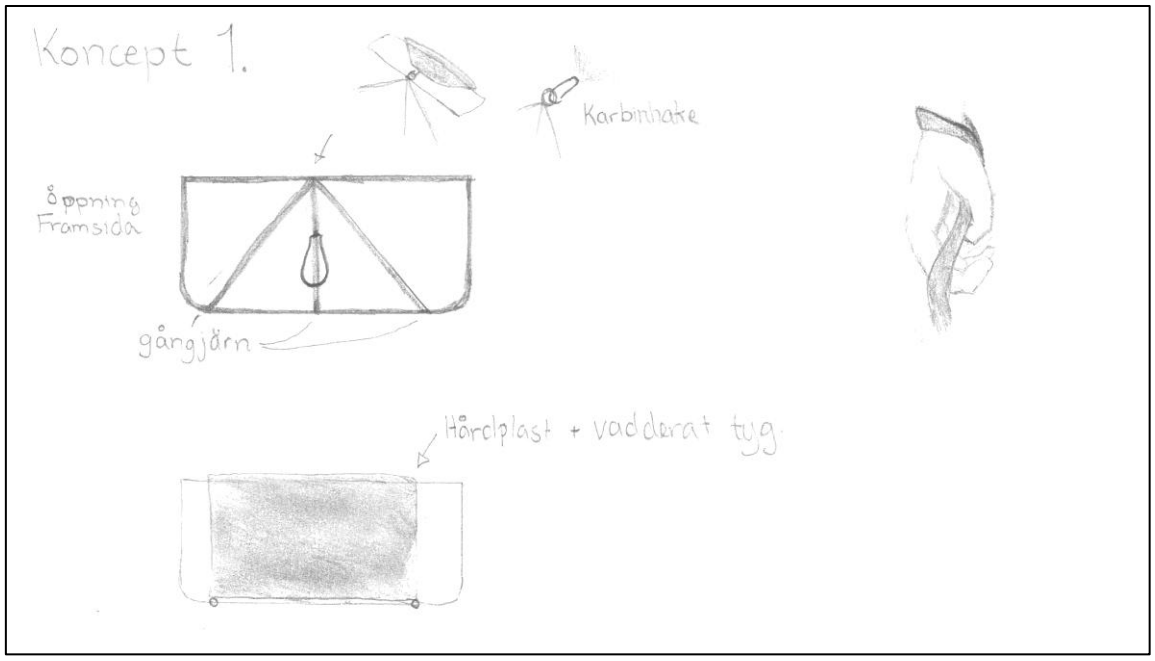


Figure 13. Concept 2:1

Concept 2:2 shown in Figure 14 consists of a square frame and a fabric cover. The basket closes with a zip and there are two flexible handles outside the fabric.

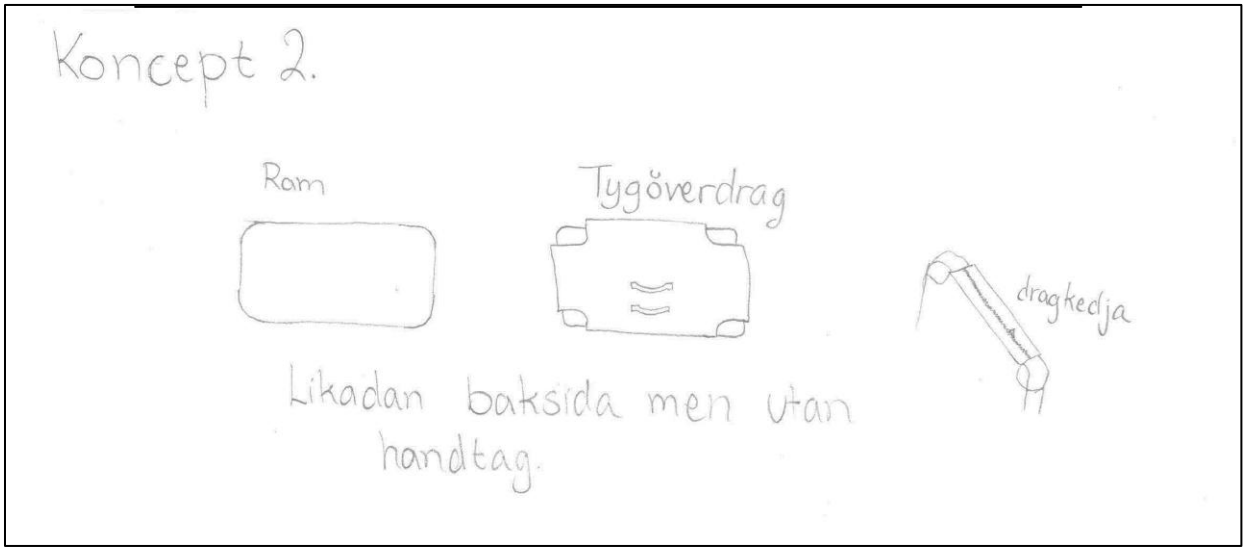


Figure 14. Concept 2:2

The third concept shown in Figure 15 is opened by unclipping the clasp and unfolding the fabric around the basket. Then the hatch in the backside is folded outwards. There are three handles in different levels to adjust the lift heaight and they are made out of a flexilbe materal. The fabric is fixed using a fastener on the bottom.

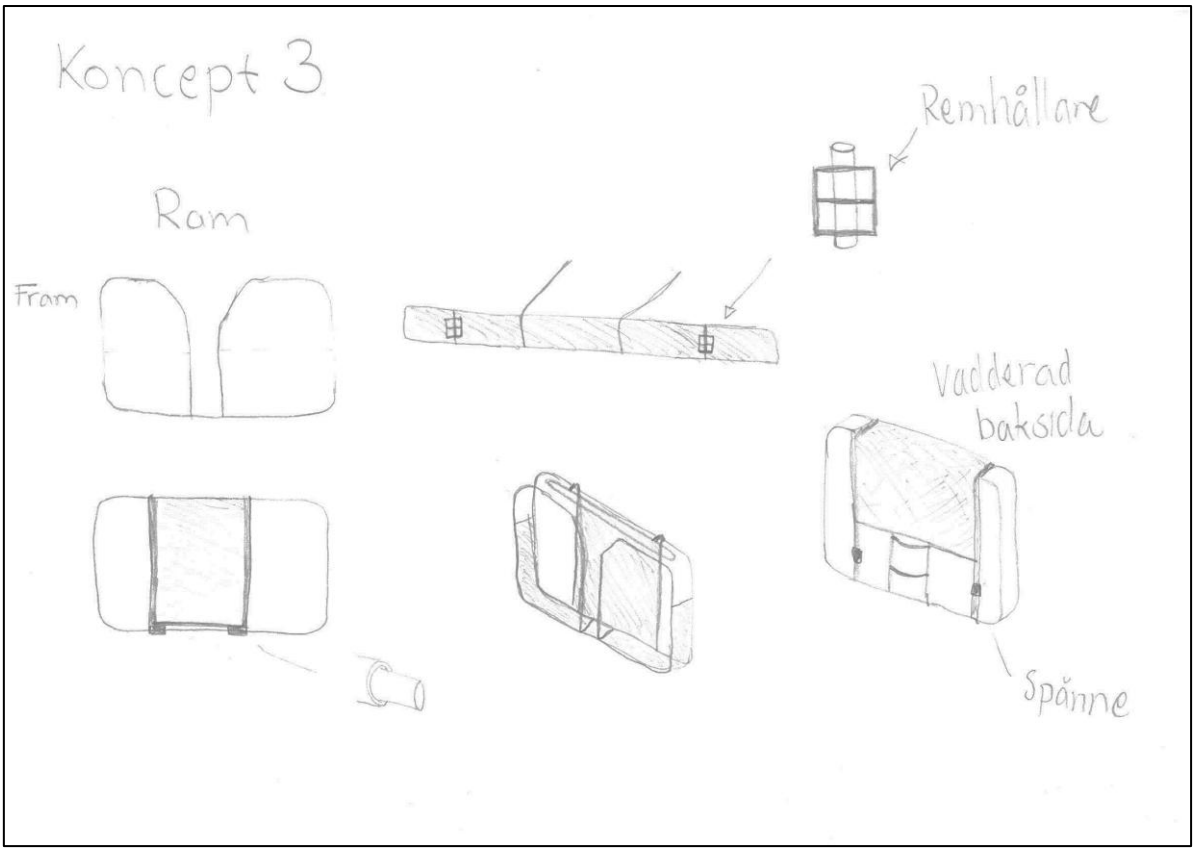


Figure 15. Concept 2:3

The last concept, shown in figure 16, is quite simular to the third concept but the handle is adjustible instead of on three different levels. The fabric is fixed in the bottom using carbiner hooks and closed using fasten hooks in rings on the frame. The hatch is on the top in this case.

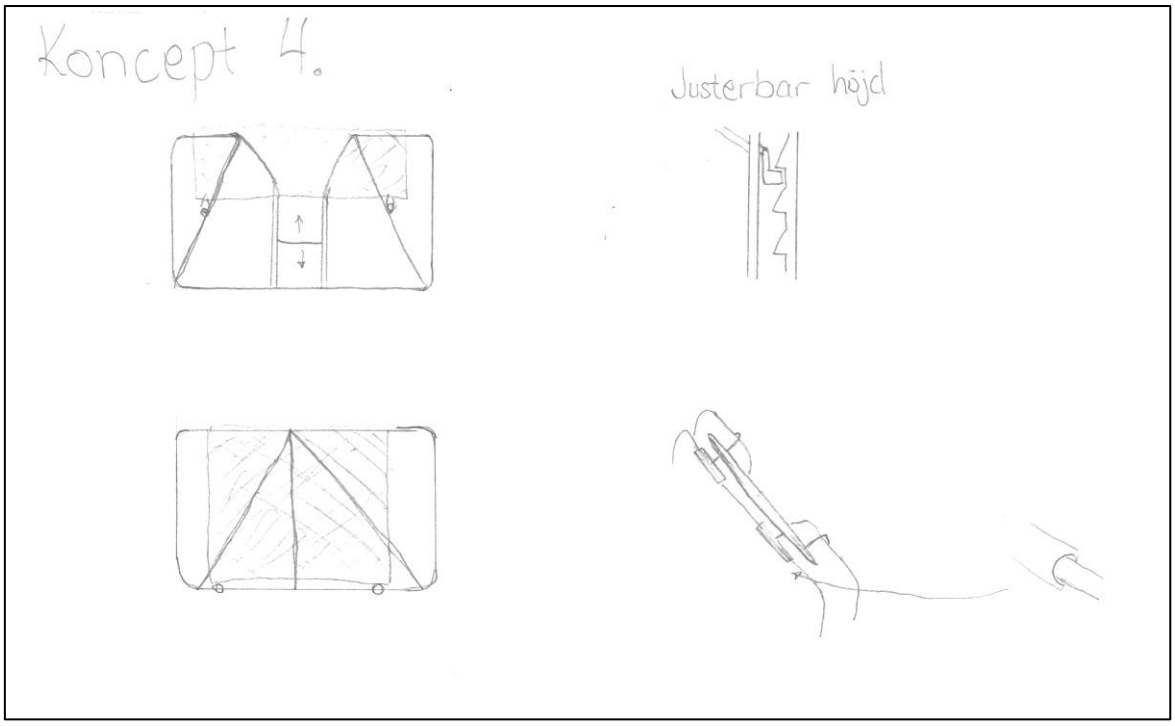


Figure 16. Concept 2:4

The concepts were compared to each other in the evaluation matrix, Table 3. The requirements in this case were the same as in the first step. In step 2, the winning concept was concept number 3.

Table 3. Evaluation matrix phase 2

	Concept 1:1	Concept 1:2	Concept 1:3	Concept 1:4	Skövde basket
Easy to clean	-1	−1	−1	−1	0
Easy to close	0	+1	+1	0	0
Shock proof	0	+1	+1	+1	0

Light weight	+1	+1	+1	0	0
Easy to pack	+1	-1	+1	0	0
Cheap to produce	−1	-1	-1	-1	0
Adjustable	0	+1	+1	+1	0
Room for 2*25m hose	0	0	0	0	0
Hose should run out while the user walks	0	0	0	0	0
Volume utilize	0	0	0	0	0
Water and chemical resistance	−1	−1	-1	-1	0
Lift height	+2	+2	+2	+2	0
Help for shoulders and neck	0	0	0	0	0
Help for arms and hands	+1	0	0	0	0
Flexible	0	+1	+1	+1	0
Sustainability	−1	−2	-1	-1	0
Risk of getting stuck	-2	0	+1	0	0
Sum	+2	+5	+6	+2	0

Concept 2:1 had a handle that could get stuck to the user. And the handle could also make the basket unstable because the handle just had one fastening point that lies in the middle of the hose basket. The user can therefore not manoeuvre the basket easily.

In Concept 2:2, the top part is opened to load or unload hose. This could make the packing a slightly difficult especially when the side is so dense. The zipper could also get worn out easily. The positive aspect about the concept is that it can be carried easily by both long and short people because of the levels of the handles.

Concept 2:3 was the winning concept and had only few drawbacks. There are no extra gadgets to help shoulders or hands, but that are maybe not necessary when the basket is easy to carry in other ways. Just like in the previous concept the handles are in different levels that make it easier to carry for people with different heights.

Concept 2:4 had a complex handle that could be worn out or get dirty after which it may not work the way it should. There are more steel rods in this basket frame than the previous concepts. That made the weight close to the Skövde basket.

In this step when the concept was clear, the exact material had to be selected. The chosen concept had some difficult parts to design and selection of material was made cautiously. The choices of fabric materials that should lean against the hip and high friction material to keep the hose basket in place were studied extensively.

Even though there is satisfaction on this section generating ideas and developing concepts, the idea generation could have been better if there were more people in the group. Collective idea generation would probably have given more and even better ideas. With more time and more study visits to different fire stations the information base would have been better. The visit to Borås fire station was done when the concept was chosen. With the information from that visit the result could have been different. The fact that they used rolled hoses and had a machine that reduced the worktime for the firefighters considerably created an insight that even Skövde could use that kind of hose.

3.5. Material choice

There are several parameters to think about choosing a material. One has to think about mechanical properties, chemical resistance, cost and density. Each of these aspects is discussed below briefly.

The material of the frame had to be stable and had to manage the water and foam that would inevitably get into contact to the hose basket. The hose baskets that already is on the market are often made of hard drawn medium carbon steel with 0.35 % C. Bending and welding is used to form the hose basket shapes. The hose baskets are galvanized after the welding process. In a literature study, it was found that the low carbon steel with 0.05-0.25 % C production was easier to form with the hard drawing method. But at the same time it is not as strong as the high carbon steel with 0.55-0.95 % C. The high carbon steel on the other hand is difficult to process. The medium carbon steel has properties that are in between high and low carbon steel. There is also a possibility to use stainless steel, the mechanical properties of a stainless steel is better than the above mentioned carbon steels but the disadvantage is that it is more expensive (26-39 SEK/kg compared to 4-7 SEK/kg for carbon steel). The carbon steel has to be galvanised to not rust but the stainless steel does not have to. The weight of the material is an important parameter to reduce the weight. The stainless steel and the carbon steel have almost the same density (7.6 kg/dm^3 for stainless steel compared to 7.7 kg/dm^3 for carbon steel). (CES Selector 3.2)

The best choice in this case should therefore be medium carbon steel.

Diagrams in this section justify the selection of material through CES Selector Software. The fabric around the frame had to be sustainable and also had to be resistant towards weak acids.

During the material selection, two common fabric materials fit to the requirements that where set previously. Polyethylene terephthalate (PET) and polyamide (PA), in the Figure 17 shows the density against the glass transition temperature.

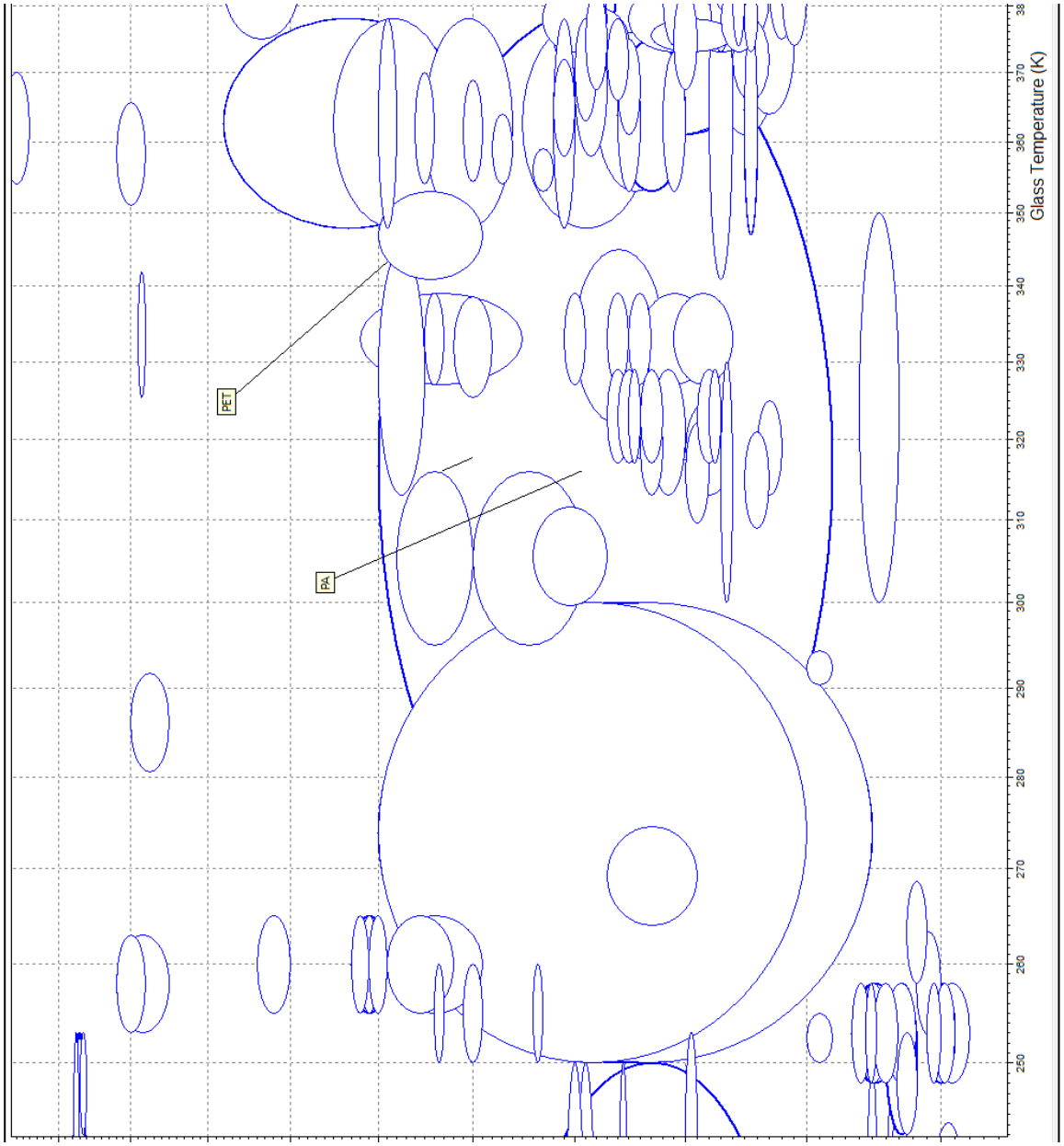


Figure 17. Material diagram for glass transition temperature and density

The glass temperature should be as high as possible, the requirements of a hose is to work in a temperature span from -30 to 100 degrees Celsius. The hose are often closer to the heat or the fire than the hose basket, so for the hose basket the above mentioned requirement is well enough. PA has a glass transition temperature (Tg) of 317-329 Kelvin and that corresponds to 44-56 degrees Celsius while the PET has a higher Tg, 341-353 K which is around 68-80 degrees Celsius. That makes the PET more suitable for this application.

The second requirement is that the hose basket fabric should have a high Young's-modulus. The density and the Young's-modulus were placed in Y-axis and X-axis respectively, and the Young's-modulus was over 3 GPa for both materials. The difference in Young's-modulus between PET and PA is negligible, see Figure 18.

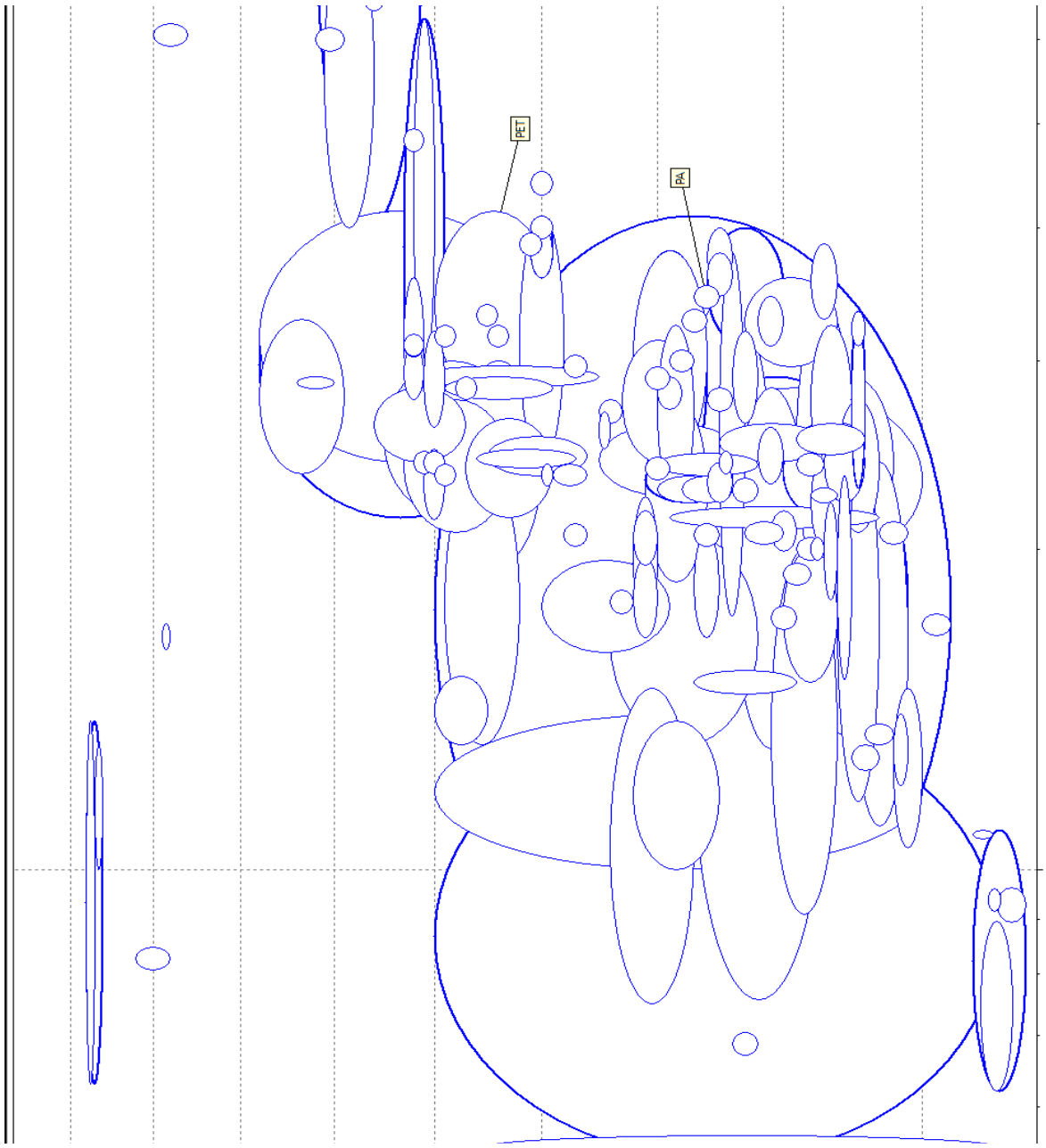


Figure 18. Material diagram for glass Young's modulus and density

The economic part was not that vital according to the house of quality. The density was set against the price to see which one of those was the cheapest. PET costs around 15-16 SEK/kg

and PA 30-33

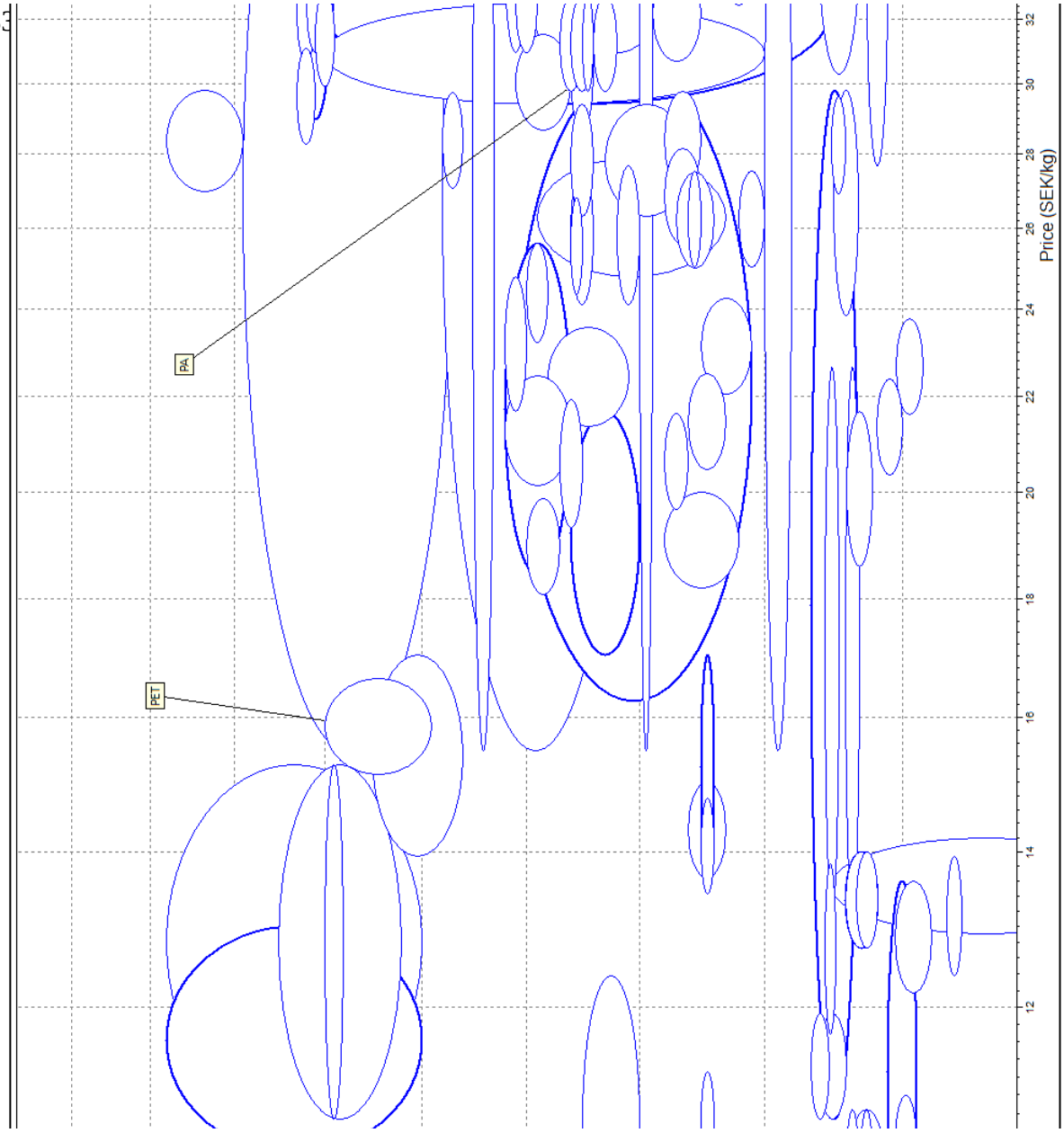


Figure 19. Material diagram for price and density

Another important thing is that the material should be resistant to acid as there are many possibilities that these baskets could come in contact with acids. And the fire hose have those requirements, so it would make sense if the hose basket has the same. The software shows that the PET has “very good” resistance towards the acids and the PA has “good” resistance. See figure 20. So, in this case both materials will work.

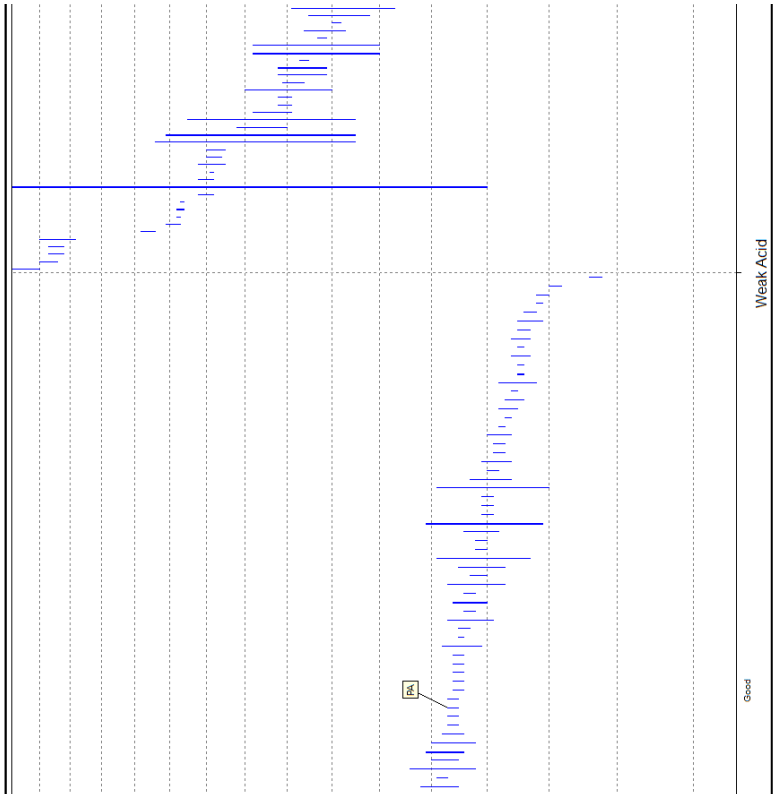


Figure 20. Material diagram for weak acid resistance and density

The last requirement was that the fabric should be UV resistant, because it could be exposed to sunlight. Here the PET has “good” resistance towards UV whereas PA has “average” resistance. See figure 21. The hose basket generally not placed is in the sunlight for long duration, therefore both will be good enough.

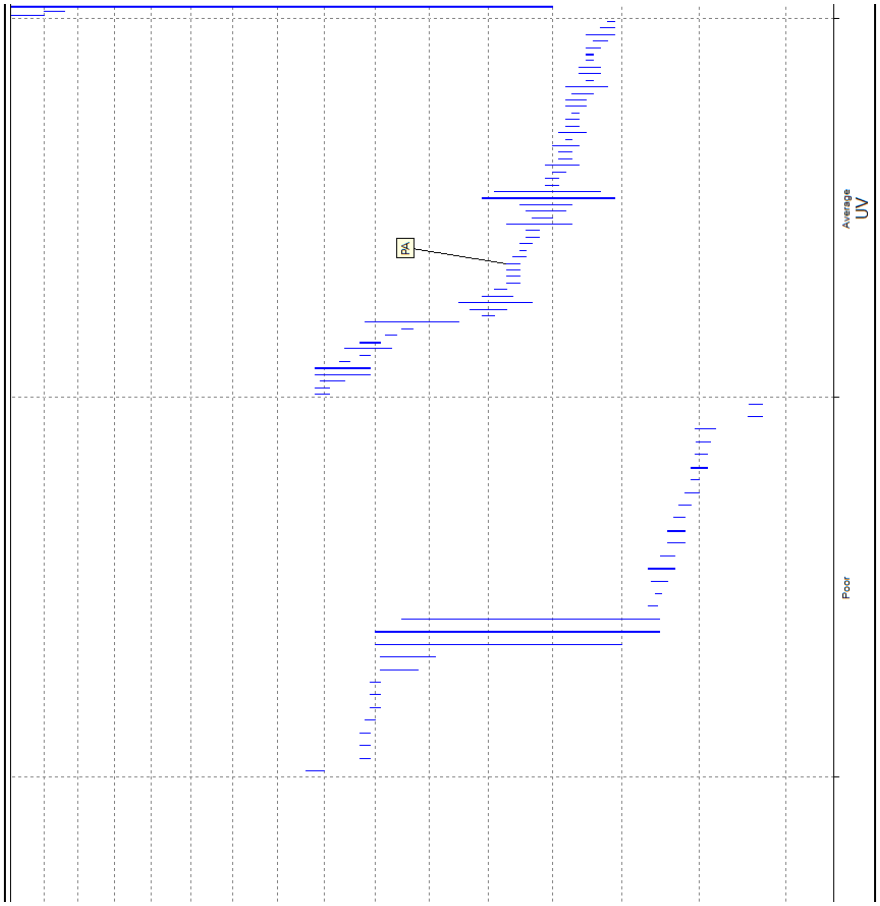


Figure 21. Material diagram for UV resistance and density

The density of the PET (1.35 Mg/m3) is slightly higher than the PA (1,15Mg/m3) but while counting on the weight difference the distinction between densities of the two materials is negligible. The fabric that will be used is roughly around 0.0006 m^3. With PET as material the fabric will weight approximately 0.81 kg and with PA as material the fabric will weight approximately 0.69 kg. That is 0,12 kg difference and when compared this to what the hose and hose basket weights, the weight of the fabric is negligible (Creative mechanisms, w.d.).

PET which is a commonly available affordable fabric is the material that the developed hose basket is going to have as folder. The decision was made considering all the technical factors and the cost. Despite the fact that the cost was not that important as the other factors according to the house of quality, the PET was the best choice for the application.

The backside or the side that should lean against the firefighter should absorb some of the forces to make a comfortable support. It should be made out of high friction material as it ought to to keep the hose basket in place and make in not sink when walking. The material also had to be good thermal insulator, so the firefighter protects from eventual heat from the frame. The CES Selector program did not have those requirements to choose for material, so

the selection was made by literature study. Three types of common used polymer materials were found that could fit the purpose. Those were synthetic rubber, acrylonitrile butadiene rubber (NBR) and silicone. Table 4 compares the properties of these polymers.

Table 4. Properties of polymers. (Minesota rubber and QMR plastics, 2003)

Material	Vibration dampening	Water resistance	Acid resistant (Diluted)	UV-resistant
Synthetic rubber	Fair-good	Poor-good	Fair- excellent	Good- excellent
NBR	Fair-good	Good-excellent	Good	Poor-good
Silicone	Fair-good	Excellent	Fair-good	Excellent

The friction coefficients were around 1 for all the materials and changed on different environment. The silicone materials give the impression to be the best option for this application due similar applications of silicone.

3.6. CAD Construction

The concept was constructed in Creo Parametric 4.0. Some details were looked upon while drawing in the program. The handles that should have been fastened in specific heights got fixed in some arches on the frame due to technical hitches. The position of the handles was constructed based on the dimensions of men and women´s forearms. The placement of the highest handle is calculated based on measurement from women´s forearm-fingertip to elbow-wrist. The length from elbow to the handle is between those two measurements when clutching the handle. As the handles are made out of flexible material the handles will bend a bit when lifting the heavy basket. A mean value between the measurements from elbow to fingertip and from elbow to wrist of the smallest women can be calculated using Eq. 1 the values for the equation is shown in Table 1 page 12:

$$\frac{Mean_{fingertip_{women}} - S.D._{fingertip_{women}} + Mean_{wrist_{women}} - S.D._{wrist_{women}}}{2} = 321\ mm \qquad \textit{(Eq. 1)}$$

The placement of the lowest handles is calculated from longest underarm of a man. See Eq. 2 the values for the equation is shown in Table 1 page 12:

$$\frac{Mean_{fingertip_{men}} + S.D._{fingertip_{men}} + Mean_{wrist_{men}} + S.D._{wrist_{men}}}{2} = 408\ mm \qquad \textit{(Eq. 2)}$$

If one more handle would be placed in between these two, then it would be hard to grab any handle with gloves as it got cramped. Therefore, it was decided to adjust upper and the lower limits in order to bring in extra handle. The middle handle is positioned between the calculated upper and lower limits. The upper and the lower handles are then placed 5 cm above and 5 cm below the middle handle. See Figure 22.
The dimensions of the frame were set approximately like the Skövde basket. A 42 mm hose have a diameter of 42 mm when it is stretched out completely during the liquid flow but the dimensions vary when the flow decreases (or no flow). The width should be calculated when the hose is empty as this will give the maximum width of the pipe that should fit into the basket. The hose will be flat in that case which means that the width of this flat hose is half of the circumference, Eq. 3:

$$\frac{d * \pi}{2} = 65.97\ mm \qquad \textit{(Eq. 3)}$$

The width of a flat hose is around 66 mm and this indicates the inside diameter of the hose. Considering the hose thickness and the outside diameter, the hose basket storage width was set to 75 mm.

The vertical rods that the handles are fastened to have to be set apart from each other considering a hand with a glove should fit. According to antropometri.se (Högskolan Skövde 2011) the mean value of a man hand's width is approximately 87 mm and the standard deviation is around 5 mm that makes the widest hand having width 92 mm. With gloves the width increases. Considering the design and dimensions of the basket together comfortableness the rods were placed apart with a distance of 172 mm, see Figure 22.

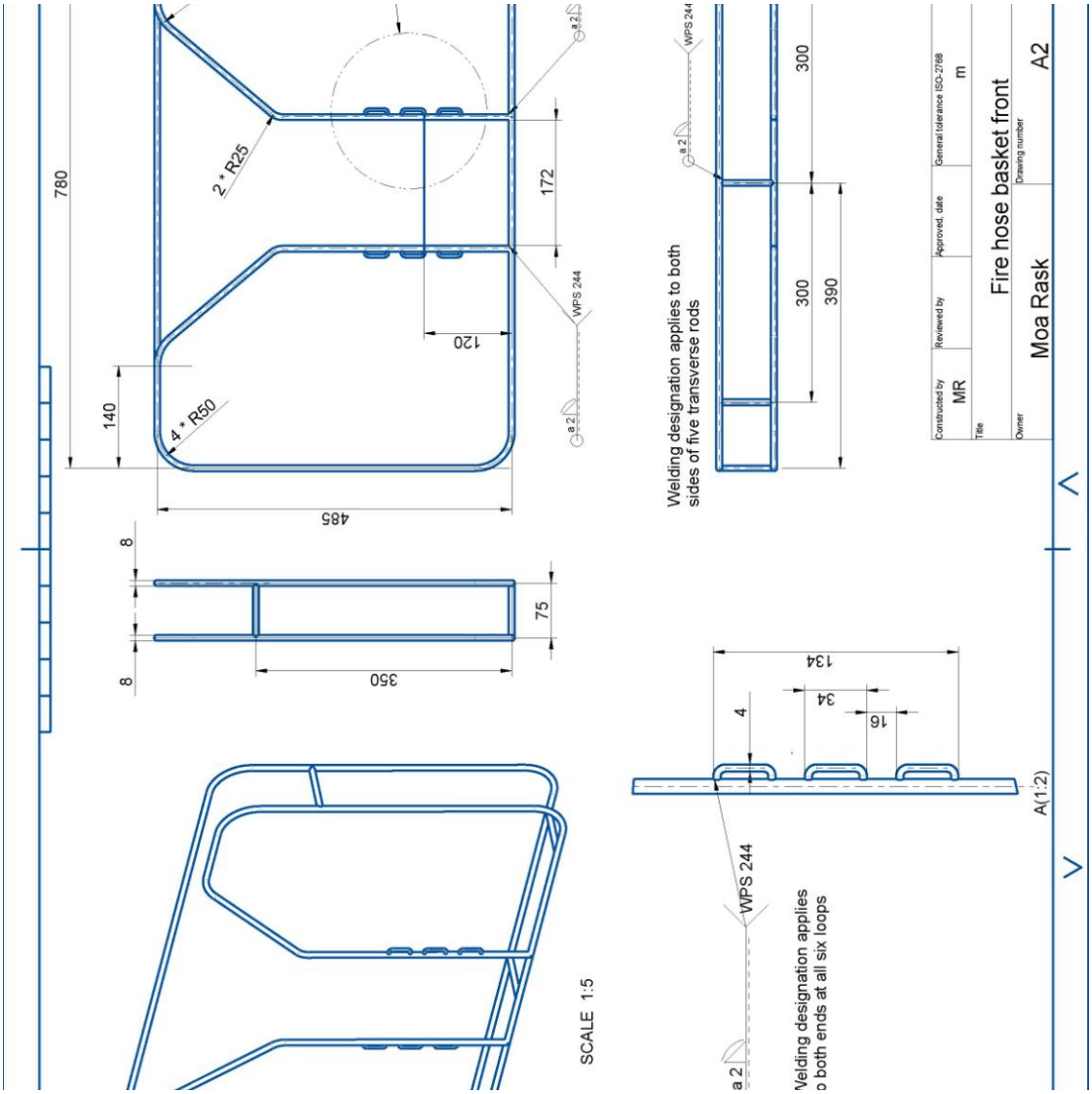


Figure 22. Drawing of fire hose basket front

The hose end will be placed on the top of the hatch and will be rolled on to the oblong rod. For this reason, it has to be smaller than the inner diameter of the hose. The part was set to 16 mm width which should make the hose end easy to roll on to the rod, see Figure 23.

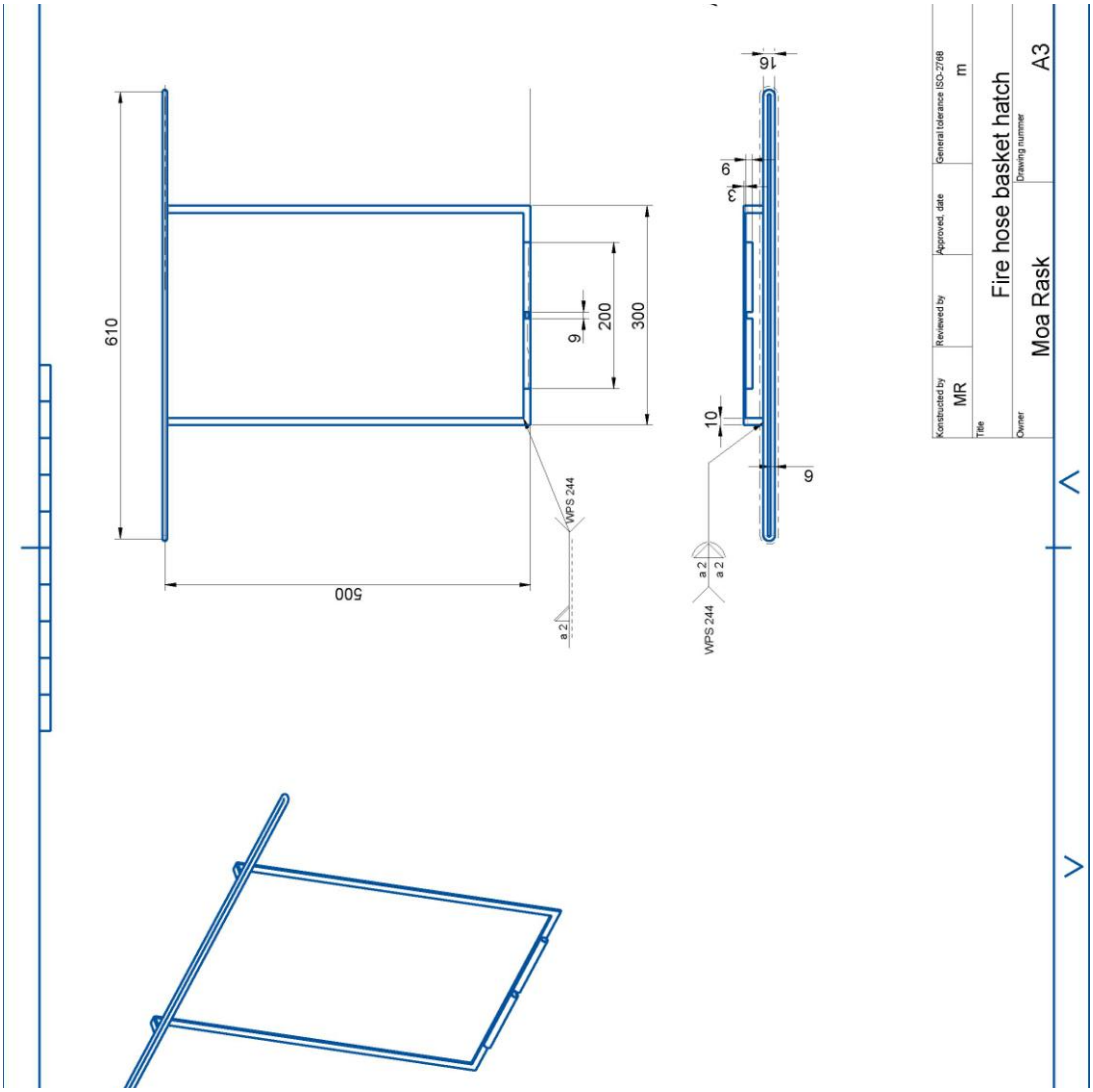


Figure 23. Drawing of fire hose basket hatch

The strap fastener on the bottom had to be designed aptly so that the fabric could be removed when needed. This would allow the fabric to be washed or changed without difficulty. It was then constructed as an S-shaped fastener, see Figure 24. The width of the strap was set to 60 mm and that decided the inner length of the fastener which has to be at least the same width. Another consideration had to be made as the fastener had to be distanced from the rod to make room for the strap. A 3 mm block was then mounted on the fastener which will

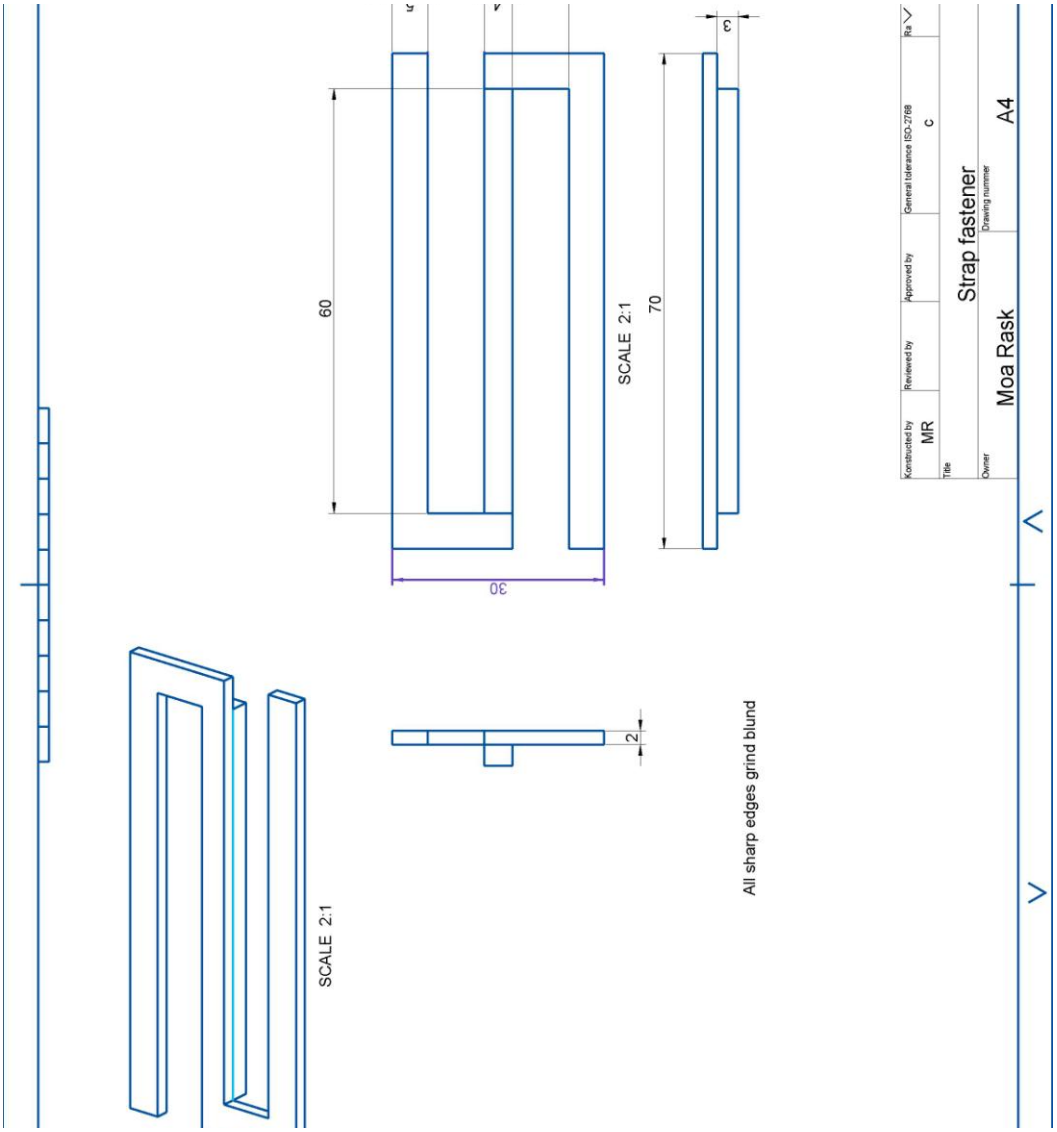


Figure 24. Drawing of strap fastener

In Figure 25, the hose basket without the fabric cover is shown. It is difficult to construct soft materials in Creo. The handles will be wrapped around by a tube for cushion effect on carrying. The handle design is shown better in Figure 31 under section 3.7 (Prototype).

A metal sheet will cover the bottom of the basket, and that one will be fastened by bending around the rods. It is also welded in the bottom. The hatch and the frame create a hinge by a pipe as shown in Figure 25.

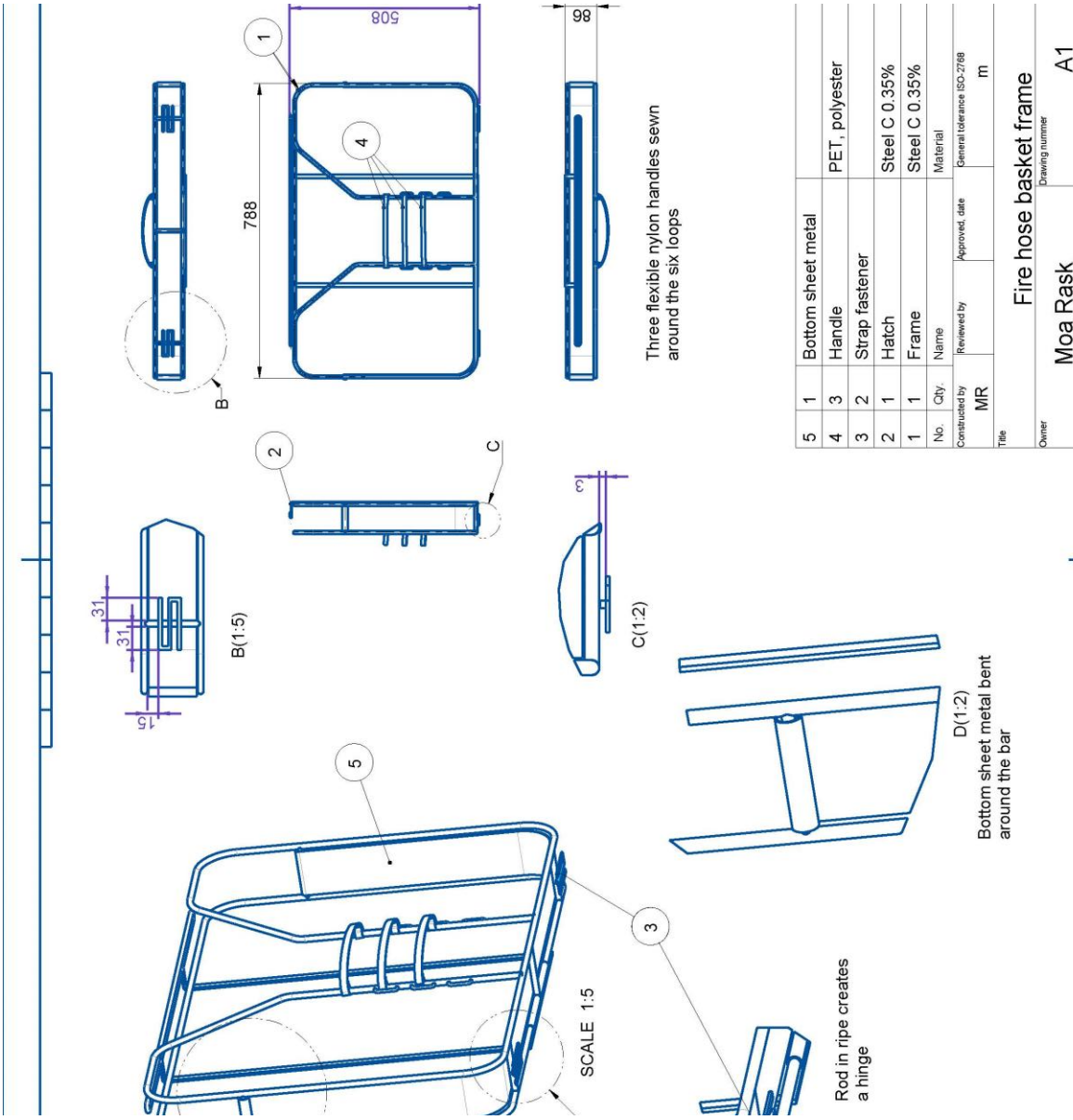


Figure 25. Drawing of fire hose basket frame

The fabric cover consists of a strap, a buckle, a silicone sheet and the fabric. The buckle is going to be a part that is bought directly from the market. And therefore no drawings are made for it. The silicone sheet will dampen the shocks to the hip, see Figure 26.

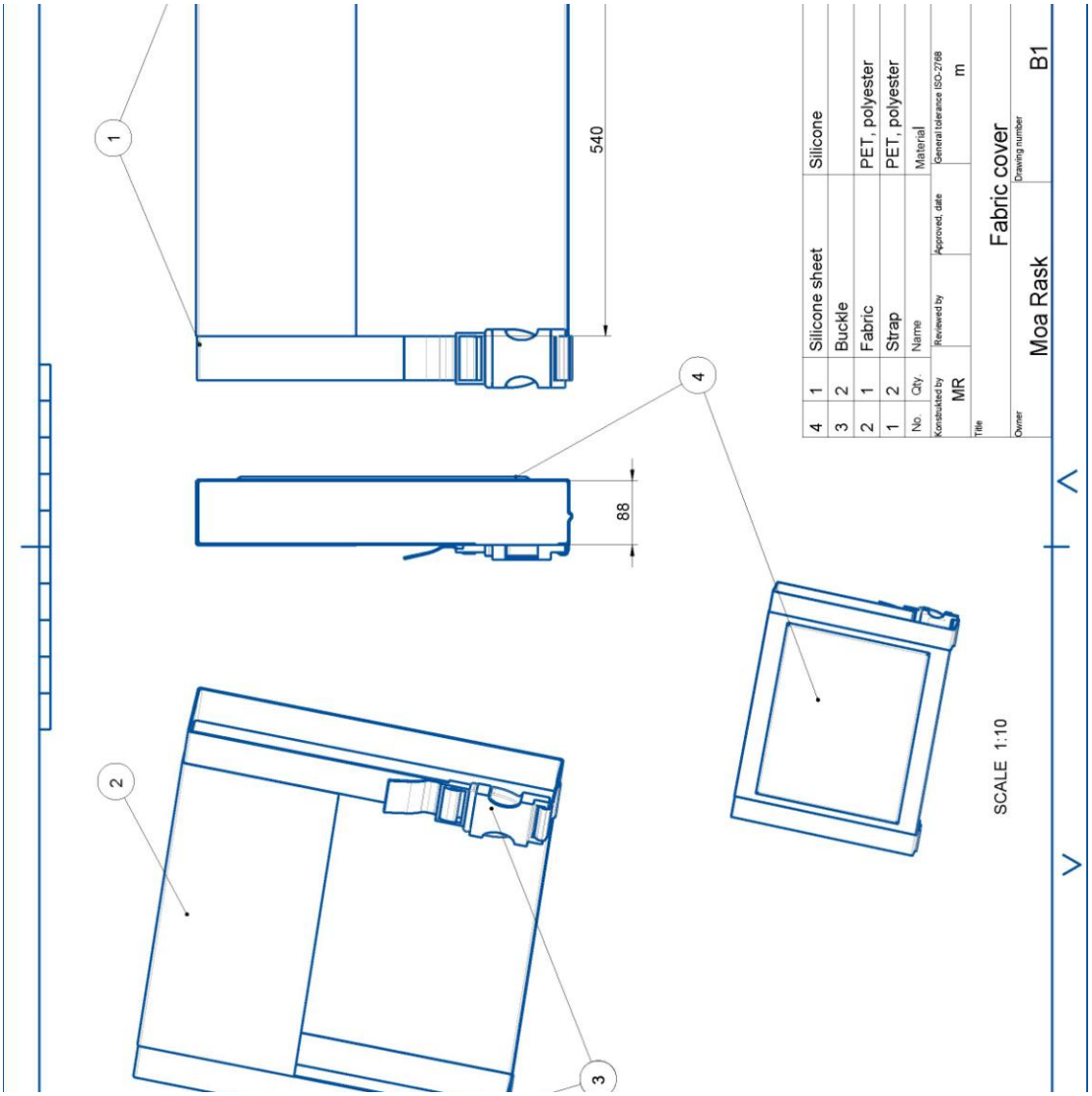


Figure 26. Drawing of fabric cover

The whole hose basket is shown in Figure 27. The drawing is to be found in the appendix 2.

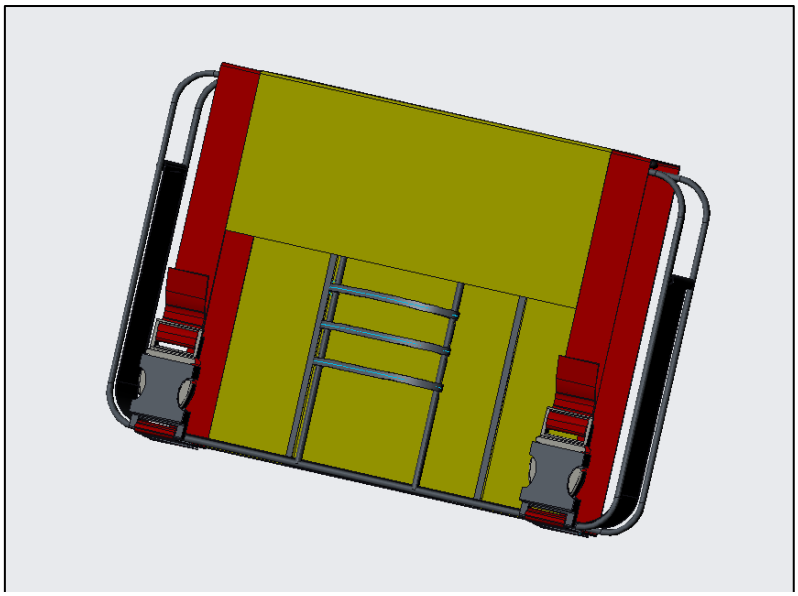


Figure 27. CAD construction of fire hose basket

3.7. Prototyping

A prototype was made from the drawings, the material used was different but they had similar properties. The prototype frame was made of iron and the fabric was a hardwearing fabric. The fabric used in prototype was too flexible material, see Figure 28. It is encouraged to have a more stiff fabric in reality.

Figure 28. Picture of fire hose basket

At garage scale, bending the iron rods was hard and it was difficult to uphold the radius that was designated. The radius on the prototype was marginally smaller than it supposed to be but this did not affect the functionality significantly. The bending would be more precise with an industrial machine. The model construction is showed without the fabric cover in Figure 29. The square profiles of the hatch are slightly bigger than what the hose basket is supposed to have and this was due to limited tools in the garage. The prototype dimension is 3*15 mm whereas CAD dimension is 3*10 mm. This will be easily rectified in industrial process.

Figure 29. Picture of fire hose basket frame

The silicone sheet was replaced with a sleeping mat to absorb shocks, see Figure 30. Nevertheless, this material did not possess as much as friction I wished and undoubtedly it was not that bump proof either. This justifies the section 3.5, material selection, to be crucial.

Figure 30. Picture of bump proof sheet

The handle was intended to be sewn into place but that was not possible with the available equipment. Velcro straps were used as a replacement for handles. The handles that were covered in a tube are shown in Figure 31.

Figure 31. Picture of handles

The metal sheet in the bottom of the prototype had to be split in the middle for the reason that the access to material was limited. That could make the edges a little sharp which the real product is not supposed to have, see Figure 32. The figure also shows the hinge of the prototype.

Figure 32. Picture of hinge and joint

The weight of the prototype was 3.9 kg without the hose as it was made of iron which is heavier than intended carbon steel (7.7 kg/dm^3 for carbon steel and 8.3 kg/dm^3 for iron). So, the real hose basket will weigh approximately 3.6 kg which is lower than prototype. When prototype basket was compared to the Skövde basket that weights 3.5 kg there is an increase of 0.4 kg. There are number of possibilities to take that prototype weight below the reference weight. One of the heaviest parts of the prototype basket is the hatch. As stated earlier, the hatch is not made with the right dimensions of the profile which affected the result. The hatch could also maybe be made of lightweight steel rods instead of heavy flat iron. The reason it was made in square profiles was that it should be flat against the cover and the body but in retrospect round rods probably would be a better option.

3.8. Reconceptualise

The last step of the process was to test the prototype. Five professional firefighters tested the prototype, one woman and four men. The lengths of the persons are showed in Table 5.

Table 5. Height of test people

Firefighter	Height [m]
Male 1	1.89
Male 2	1.86

Male 3	1.91
Male 4	1.79
Female	1.65

The first step was to pack the hose basket and the firefighters used machine to do it. The dimension of the prototype was noteworthy and the flat hose was placed in the basket effortlessly. Nevertheless, there is more room to develop when it comes to functionality, see Figure 33. The hose basket had to stand straight when using the machine that feed the hose as hose got unstable after several layers when the hose basket was made to lay down while packing.

The basket would need stand straight for it to be packed with machine assistance whereas the current prototype is intended to lie down for easy packing. In the evaluation, all the firefighters gave the prototype a “-1” in a scale from -2 to +2 for packaging. In this scale “-2” refers a basket that is inferior to the Skövde basket and “+2” refers a basket that is better than the Skövde basket. Suggestion from professionals after the test was to add a vertical rod that could steer up the hose pile.

Figure 33. Picture of hose packed in basket

The way prototype closed got +1 from three firefighters and +2 by two of their colleagues. One of them suggested not having a hatch on the back, rather just on the top. He also suggested that it was needless to have a hatch on the whole side as the baskets stands straight

while packaging and a stable backside would make the basket more shockproof. Furthermore, the basket would not take bigger room while packing if the hatch was positioned on the top. The packed hose basket is shown in Figure 34.

Figure 34. Picture of the hose basket packed and closed

The handles considered to be placed in a good way by four out of five firefighters. The fifth person thought that the handles were placed too close to each other as he felt that it was hard to hold the handle with the gloves. Furthermore, he felt that the hose was too close to the handles as some of the weight could end up on the fingertips that could make it heavier to carry. The rate of the feeling of the handles was rated between -1 to +1. The two longest persons, male 1 and 3, were those that thought that the handles were more uncomfortable to grab than the Skövde basket. A picture of the hand with gloves holding the basket is shown in Figure 35.

Figure 35. Hand grabbing handles with glove

The approach of carrying the basket under the arm got positive results. However, there was one concern about initial lifting from the ground. One had to make a deeper squat to get it into place. The above concern was put forward by the tallest one, Male 3. When the basket was in place, all of the test people thought it was more comfortable than the Skövde basket. The shockproof sheet concept was appreciated but majority of the test people felt it was not enough and this was expected as prototype did not have actual material. They thought that the basket was hard against the hip. The result was significantly affected by the substitute material used for prototype purpose. The basket got rates from 0 to +2 of the test persons for carrying the basket in stairs and in terrain. The "0" meant that it was approximately as easy to carry the Skövde basket as the new one, "+1" and one "+2" mean new basket was easier than Skövde basket. One person rated "0", three people rated "+1" and one person rated "+2". The difference of lift height for the baskets is approximately 40 cm. For a person that is 1.86 m tall the lift height of the Skövde basket is around 20 cm from the ground. With the new basket the lift height is almost 60 cm for the same person if he was holding on to the lowest handle.
A summary of the results is shown in Table 6.

Table 6. Result summary

	Rate				
Part	Male 1	Male 2	Male 3	Male 4	Female
Packing	-1	-1	-1	-1	-1

Closing	+1	+2	+2	+1	+1
Handle	-1	+1	-1	0	+1
Moving	0	+1	+1	+1	+2

Several suggestions came up during the discussion. Test people suggested a handle on the top side as well. It would be handy especially when the basket should be carried short stretches or lifted in and out of the truck. Another suggestion was to add a shoulder strap. This gives the possibilities for the firefighter to carry something else in the hand at the same time. They also pointed out that the fabric could be hard and strain resistant to keep it clean. Although the fabric used in the prototype was not the material that was chosen but the problem will probably still remain if the fabric is not strain resistant.

3.9. Proposals for further research

Further development is required for the product to function optimally. Adding a shoulder strap to the hose basket could be the next phase for improvement. From personal experiences, a shoulder strap may make strain the neck muscles as the shoulder must be raised slightly to make the strap remain on the shoulder. But investigating the theory further can give better understanding. Finite element analysis of the forces that the basket can manage can be studied. The dimensions chosen may need to be adjusted or thinner rods may be used which would reduce the weight.

If the project is to be resumed or if a similar study should be done, it is recommended to visit several fire stations and to investigate the different ways to work with the hose for in detail concept selection. Rolled hose may be preferable as it is easier to handle and consumes less time to pack. The method of packing the basket would need to be improved, either by another method of packing by the firefighters, or by designing the hose basket in different way. It is also worth mentioning equipment available today to pack the hose basket. If the method of packing the basket changes then new equipment will be needed or adjustments have to be made to the equipment that Skövde Fire Station already has.

The handles are also a part that could be improved in order for ideal function of the hose basket. Protruding handles could consume more volume in the truck but it would facilitate the grip.

4. Conclusion

The results advocated both improvements and setbacks of the new hose basket. Primarily, the hose basket became better for short people. Taller people on the other hand could find it little difficult to lift and position it in place. However, all the firefighters tested the product felt that the new hose basket was more comfortable than the Skövde basket to carry when it is positioned, especially in terrain and in stairs. Certainly, some improvements are needed for ideal functioning of the hose basket. The method used for packing the hose into the basket has to change. Alternatively, the hose basket could be re-designed to fit the existing packing equipment.

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Appendix 1

Kön ☐ Man ☐ Kvinna

Längd _____

Hur anser du den nyframtagna slangväskan fungerar i jämförelse med standardväskan? Fyll i tabellen med en skala från -2 till +2 för varje kriterium

-2 = Mycket sämre än standardväskan
-1 = Sämre än standardväskan
0 = Varken bättre eller sämre
+1= Bättre än standard
+2 = Mycket bättre än standardväskan

Lätthet att packa	
Lätthet att stänga	
Känsla att bära (handtag)	
Känsla att bära (helhet)	
Enkelhet att förflytta sig med (plan mark)	
Enkelhet att förflytta sig med (trappor/terräng)	
Helhet	

Vad tycker du om handtagens höjdplacering på den nyframtagna väskan?

☐ För höga handtag

☐ För låga handtag

☐ För tätt placerade handtag

☐ För glest placerade handtag

☐ Bra placering av handtag

Hur tyckte du det var att bära slangväskan under armen?

_____

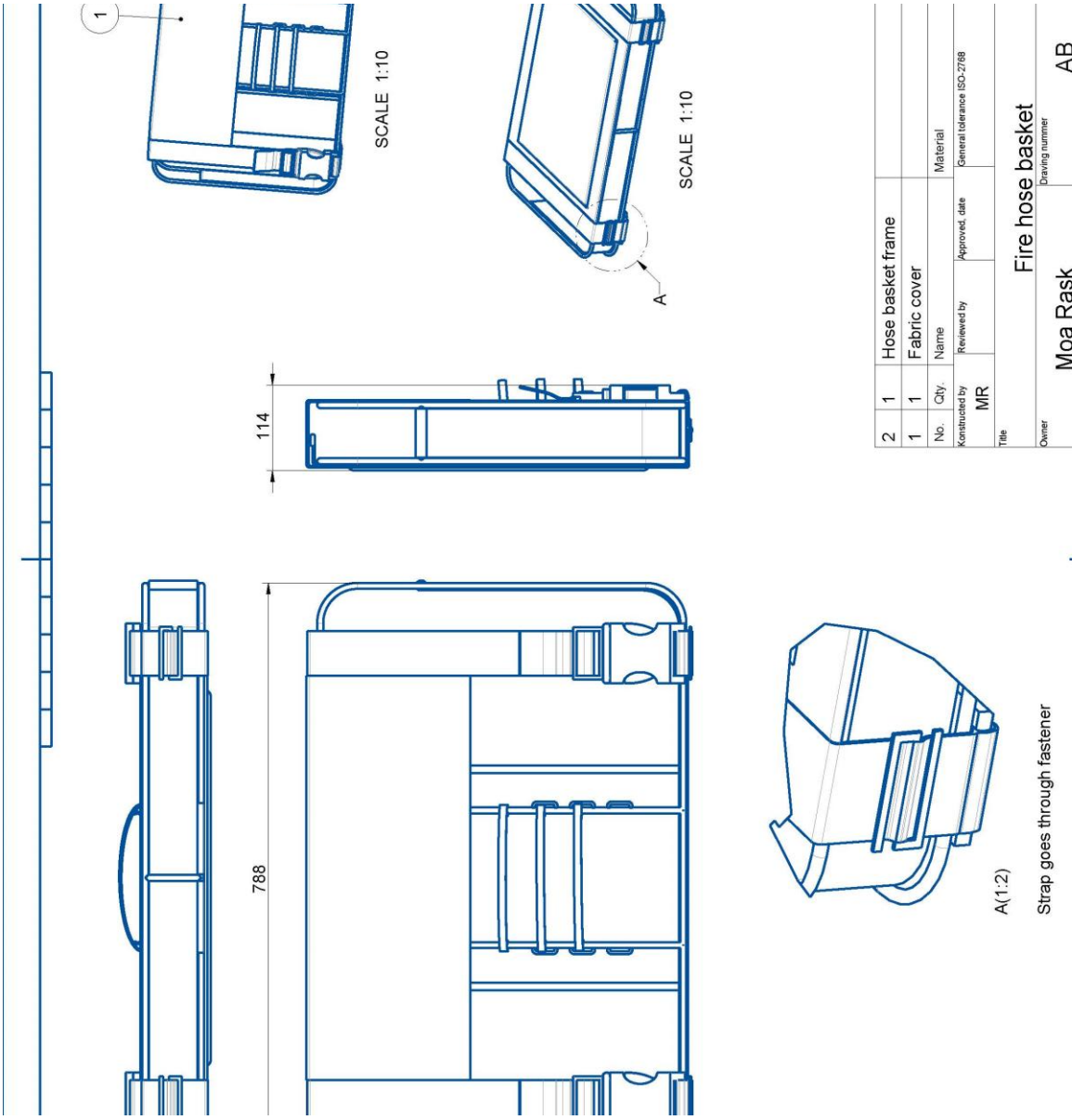
Hur tror du den nyframtagna väskan skulle fungera i en reell situation? Styrkor och svagheter med modellen?

_____

Övriga kommentarer:

_____

Appendix 2


1
SCALE 1:10
SCALE 1:10
A
114
788
A(1:2)
Strap goes through fastener
2 1 Hose basket frame
1 1 Fabric cover
No. Qty. Name Material
Konstructed by MR
Reviewed by
Approved, date
General tolerance ISO-2768
Title
Fire hose basket
Owner
Draving nummer
Moa Rask
AB

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