Establishing a Unified Symbolic System for Fire Safety Engineers in Finland

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ABSTRACT

This Bachelor's thesis was commissioned by L2 Paloturvallisuus Oy, a Jensen Hughes company. The purpose of the thesis was to draw up a unified and standardized system of visual markings for different elements of fire safety drawings used in Finland. At the time of writing, no such system exists, which leads to miscommunication between companies and authorities, creates delays, and negatively impact project costs.

The thesis is research-based and concentrates on the results of a professional survey conducted among Finnish fire safety experts. As an outcome of the thesis, a collection of element symbols was created. The chosen elements are suitable for use by groups of people with special needs (e.g. colour blindness), but are also distinguishable, intuitively understandable and easy to memorize.

Keywords fire safety, guideline, standard, visual system

Pages 19 pages including appendices 6 pages

CONTENTS

1 INTRODUCTION

This thesis was commissioned by L2 Paloturvallisuus Oy, a Jensen Hughes company.
L2 offers a full spectre of fire safety and risk management solutions, from planning phase and creating building permit material, all the way to construction and commissioning. Most comman contracts include buildings' fire safety consulting and planning, performance-based design and risk analysing, fire technical calculating, simulating hazardous substance spread etc. L2 designs residential buildings, educational institutions, sports facilities, hospitals, shopping centres, underground buildings, tunnels etc.

The author of the thesis is employed in the company in the role of a technical drawer. This position entails working with architectural blueprints and processing them into a fire drawing using a technical task in plain text as a guideline. The aim of this thesis is to ease the drawing process and ensure a smooth cooperation between different groups of professionals that work with fire plans. The author is directly involved in the creation of fire safety drawings and has experienced first-hand the problem of miscommunication due to differences in the use of symbols. Therefore, this document strives to create a set of standard visual marks that would be uniformly used within the fire safety industry in Finland to minimize confusion and provide smooth cooperation between companies and authorities.

To ensure that these symbols are commonly understood and accessible to everyone including people with color vision deficiencies, a detailed research on the psychology of colour and variations in perception was conducted. Based on the result of the research, sets of common features have been worked out that are crucial to their unique qualities.

To ensure that the symbols are practical and convenient for everyday use, a questionnaire was sent to professionals to find out their views.

2 PROJECT WORK BREAKDOWN

In this section of the document a detailed step-by-step project plan will be presented.

2.1 Phase 1. Setting the scope of the project work

During the first stage of this project it is important to assess the scope of work, create a research plan and think of the topics that will need to be covered.

The list of topics includes:

-Fire safety field overview

-Basics of colour physics and colour psychology
-Basics of colour vision deficiencies
-Basics of sign design

Also, a sign table needs to be compiled that would include existing information regarding the symbols used in the biggest Finnish fire safety companies.

2.2 **Phase 2. Conducting research**

During this stage of the project research work will be conducted concerning the topics mentioned in the previous paragraph. Also, different companies will be contacted to gather relevant information about the symbols used. People with colour deficiencies working in the fire safety field will be interviewed to ask about the problems in working. A list of requirements for symbols will be created.

2.3 **Phase 3. Creating preliminary design**

During this stage of the project, symbols will be chosen/created based on the information gathered during Phase 2.

2.4 **Phase 4. Sending out design drafts**

During this stage of the project, the chosen elements will be presented to fire safety field specialists in a questionnaire (Appendix 1), which will allow them to provide feedback and propose changes based on their experience.

2.5 **Phase 5. Implementing proposed changes**

During this stage of the project, the data collected via surveying will be processed, checked for suitability and conformity to the standards, and then added as changes/new elements to symbol design.

2.6 **Phase 6. Final design approval**

Lastly, the final version of symbol design (Appendix 3) will be submitted to TopTen group for approval and assessment.

3 **PROJECT BACKGROUND**

In this section of the document the scope of the main problems will be explained.

3.1 **Introduction to fire safety**

Fire safety is a discipline that aims to prevent fires from occurring, recognize fire hazards and keep them in check, and save lives and minimize the damage in case of a fire.

During a fire safety risk assessment event, the correctness of the following things is generally considered:

-emergency routes and exits
-fire detection and warning systems
-fire combatting equipment
-safe storage of hazardous substances
-emergency fire evacuation plans
-accessibility for vulnerable people
-staff training in case of an emergency

Structural fire safety also plays an important role in minimizing fire risks and consequences, and it must be heeded already during the planning stage of a new building. Fire safety design can be generally divided into two parts: functional design and design carried out by applying the fire classes and numerical criteria specified in regulations and guidelines. Fire safety design is based on complying with the requirements of the E class of the National Building Code of Finland. Rescue authorities are charged with the duty of providing guidance regarding fire safety issues. (City of Helsinki, 2019)

3.2 **Lack of a unified symbolic system in the fire safety sector**

Fire safety sector in Finland lacks a universal, officially approved symbolic system for referencing fire safety drawing elements. Initially, authorities created a unified symbolic system for electrical engineers. They were also used by fire engineers, but they were not enough for full fire planning. Because of that, after some time, every fire consultancy company has created its own fire marks that made the design process easier and clearer for them to work. However, this leads to difficulties in perception of signs and miscommunication between companies, authorities etc.

3.3 **TopTen Group**

The basis for this thesis project was laid down by TopTen Group. TopTen is a construction inspectorate body that strives to ensure the standardization of regulations and regulatory changes in a unified manner on the territory of major Finnish cities. The full list of cities includes Helsinki, Espoo, Tampere, Vantaa, Oulu, Turku, Jyväskylä, Lahti, Kuopio, Pori and Kouvola, and is supplemented by Kauniainen, Vaasa, Lappeenranta and Lohja.

The main task assigned to the inspectorate is the improvement of the quality of control procedures. This goal is achieved by creating common interpretations of regulations and

instructions in the construction field. The organization's activities cover such areas as construction engineering design, HVAC design and fire safety design.

3.4 **The biggest fire consultancy companies in Finland and their symbology**

The following list contains the biggest fire consultancy companies in Finland:

- KK-Palokonsultti Oy (KK)
- L2 Paloturvallisuus Oy, a Jensen Hughes company (L2)
- Markku Kauriala Oy (Kauriala)
- Paloässät Oy
- Paloff
- Ramboll
- Sampel

The Symbol Table presented in Appendix 2 provides some symbols used by companies for fire safety design drawings. It should be noted that this is only a share of the symbols used, and often text or hatching is used for denoting different objects. This table vividly shows that multiple symbols are near-identical or are similar in shape. Besides, many elements are denoted with arrows, as this symbol is the most convenient and effective way of conveying direction.

Upon comparing these symbols, it can be concluded that not only the shape of an element, but also its colour can be difficult in perception. For instance, some symbols are identical in shape with colour being the only difference, which might prove to be problematic for people suffering from colour blindness. Red/green and blue/yellow colour combinations are especially prone to misinterpretation.

4 **RESEARCH**

4.1 **Users and work specificity**

Any project consists of many stages interconnected with each other. For this reason, when creating fire signs, it is needed to consider all specialists who take part in work. Table 1 below provides information about specialists and difficulties they can face during a project (Table 1). The most relevant qualities of symbols are also highlighted for each step.

Table 1. Users and work specificity

Users	Work specificity concerning fire marks	Key features

Fire safety engineers	• Creation of fire technical drawings	• Symbols should remain legible and distinguishable even when their size is reduced.
Architects	• Correction of project plans to meet fire building regulations	• Fire plans should be unambiguous, consistent and logical
HVAC designers	• Parallel work with architects and fire engineers that is aimed to provide safe and convenient HVAC planning	• Fire plans should be unambitious, consistent and logical
Fire safety inspectors	• Verification of compliance with fire design regulations • Working with different fire consultancy companies	• Drawings must adhere to the same standards and symbols should be the same
Firemen brigade	• Working directly inside buildings o Fire plans help to optimize time and understand situation • Working in difficult conditions (smoke, bad visibility)	• Plans should utilize contrasting colours for easy readability
Construction site workers	• Working with fire technical drawings during the construction/renovation phase • Occasionally drawings could be printed in black and white	• Plans should be consistent and intuitively understandable • Colour shades should be different enough to be discernible even if printed in grey hues

In addition to specifics of work, it is important to take into account that each person may have needs associated with vision. One of the most significant issues is colour blindness which will be discussed in Chapter 3.6.

4.2 **Important aspects of fire symbols**

To conclude Table 1 every stage of a project requires certain qualities from fire safety drawings. The most relevant technical and visual criteria for symbols are listed below:

Technical aspects:

- Ability to scale symbols
- Ability to change text marks if they are a part of a symbol

Visual aspects:

- Colours that are easy to distinguish from one another in black and white printing
- Bright colours

- Readable fonts for text marks
- Sharp and recognizable form

4.3 **Introduction to schematic symbols**

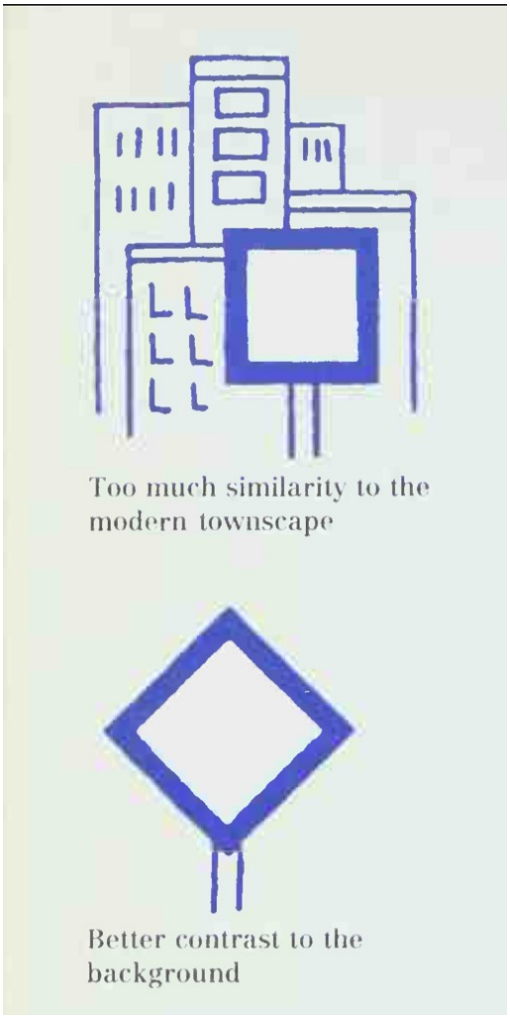

Figure 1. Better contrast to the background *(Frutiger, 1928)*

A symbol provides a visual representation of a concept. In the context of fire safety field, symbols are used to represent an event, action, object or place in a conspicuous, clear and consistent way.
Symbols can be generally divided into concrete and abstract symbols. Concrete symbols physically resemble what they represent, and can signify an object, a part of an object, a gesture or any other thing that evokes strong feelings of association. Abstract symbols, on the other hand, are less direct and may be easier to misinterpret. (Durkel, 2015)

Better schematics practices result in:

-Improved readability and design quality
-Fewer design errors
-Increased designers' productivity
-Better products (Iacob, Rules for Schematic Symbols, 2018)

It is also important to note the peculiar features of elements that surround a sign to make sure that it stands out (Figure 1).

There are a few internationally accepted rules for warning and hazard signs that are important to note in the context of this study. The same applies to shapes (Figure 3). These rules ensure effective communication of these symbols regardless of cultural differences and geographical position in the country in question.

Furthermore, to increase noticeability and uniqueness of the sign, it is important to use:

-Large, bold print (due to better contrast with most backgrounds)
-Contrasting colours (preferably avoid red/green, blue/yellow combinations to avoid confusing colour-blind people)
-Pictorial symbols (to denote concepts and evoke association)
-Special effects (shading, hatching, etc.)

-Borders (signs with thick, colourful borders are more noticeable) (Wogalter M., 2002, pp. 219-230)

Figure 2. Colours of the road signs *(Torney, 2018)*

4.4 **Introduction to colour**

In physics, 'colour' is 'the aspect of any object that may be precisely specified by its hue, lightness, and saturation'. As mentioned in Figure 2, different colours are used to convey particular pre-determined meanings.

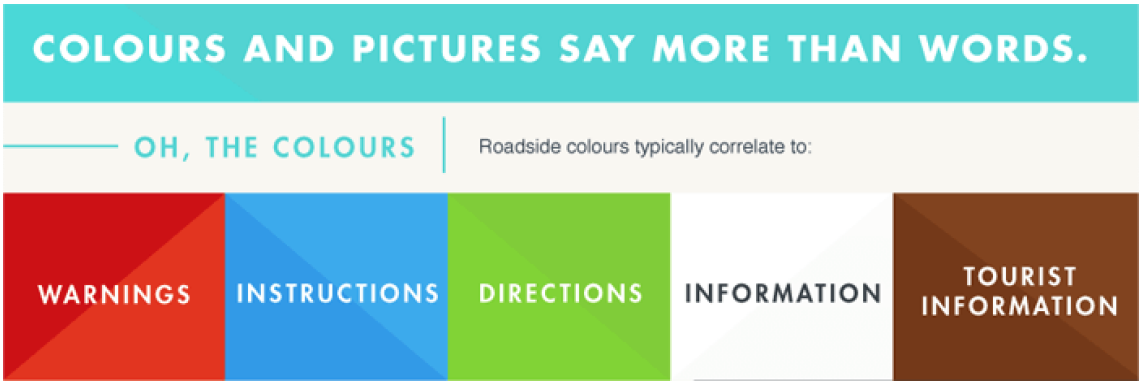

Figure 3. Shapes of the road signs *(Torney, 2018)*

The phenomenon of colour allows humans to differentiate otherwise identical objects, as the human eye is physiologically wired to differentiate between various ranges of electromagnetic radiation also more commonly known as 'light'. The hue of colour is what is typically known as green, blue, red and so on. The saturation of colour is the relative purity of it, which can be adjusted by changing the amount of white present in a hue. The brightness of colour is defined by the amount of light energy present in it, which directly affects its intensity. (Nassau, 2020)

From the physiological standpoint, colour is the result of stimulation of photosensitive cells in the human eye. The cells are called 'cones' and 'rods'. Cones exist in three different modifications, and each type is sensitive to a different wavelength of light. Most people have about 6 million cones in the eyes, which, when agitated, send a signal to the brain. The brain processes the number of activated cells and creates a colourful

image. Rods, in turn, are only stimulated in dark environments, and allow to discern only various shades of grey, even though their number in the human eye is significantly greater and makes for about 110 million cells. The human eye can distinguish up to 10 million colours. (Mukamal, 2017)

However, the perception of light is not only based on the physical phenomenon of light and the mechanisms of the human body. Brain also plays a certain role in interpreting colour. Different colours and their relationship with emotions, behaviour and physiological reactions is a topic known for its controversy and lack of credible and conclusive experiments. Regardless of that, color psychology as a discipline is often utilized in marketing, art, design and other areas. (Cherry, 2019)

4.5 **Colour categorization**

Colours can be categorized into chromatic and achromatic colours. Chromatic colours are commonly defined as yellow, red, green, etc., e.g. colours that have hues and are on the colour spectrum. Achromatic colours are shades of black, grey and white. (Nassau, 2020)

Red, green and blue colours are called primary colours, because they compose almost all other colours. Equal intensity light beams of these primary colours will produce a white coloured light beam (Figure 4). (Nassau, 2020)

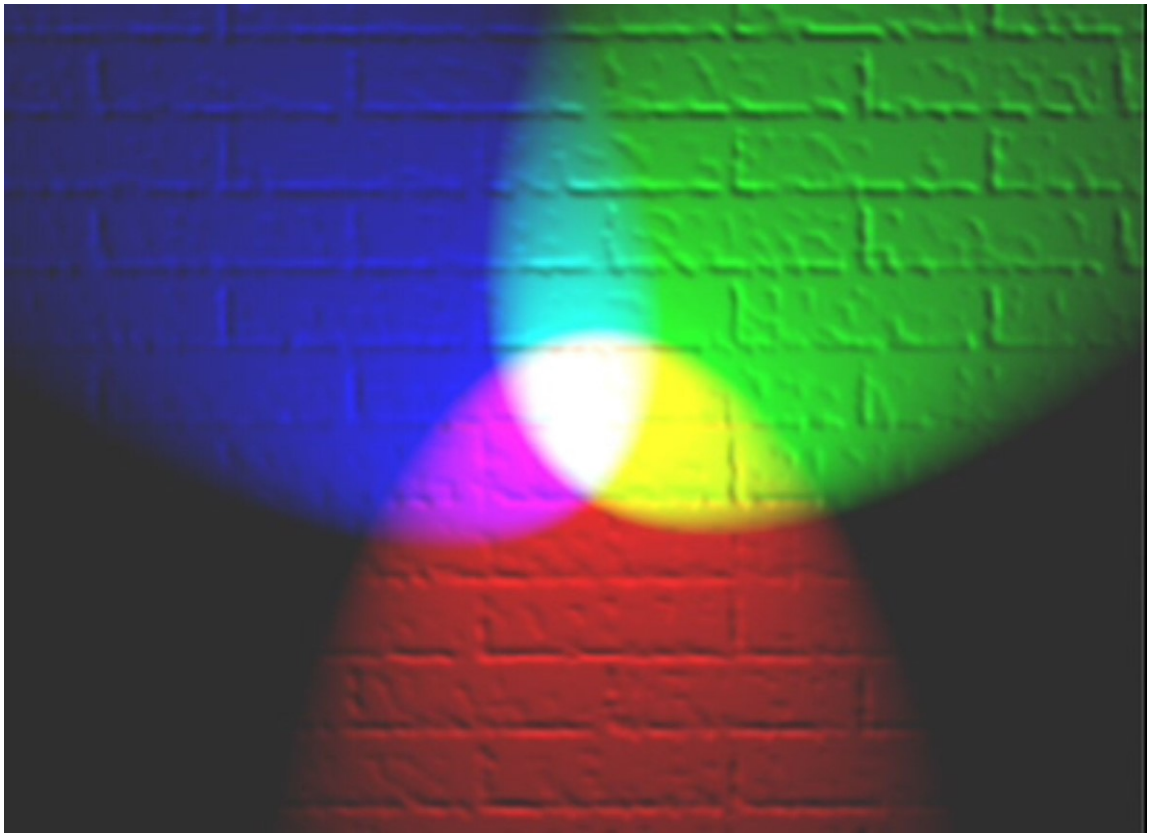

Figure 4. RGB Pantone *(Lanthem, 2017)*

4.6 **Colour vision deficiencies**

As mentioned above, there are three types of cones in the human eye: red-, green-, and blue-sensitive cones. In certain individuals some of the cones can be absent, defunct or can detect a different colour than they should. This condition is called 'colour vision deficiency' or 'colour blindness'. The most common type of colour blindness is red-green, and the second most common is blue-yellow. (Mukamal, 2017) This means that the person cannot distinguish red colour from green, or blue colour from yellow. (Figure 5)

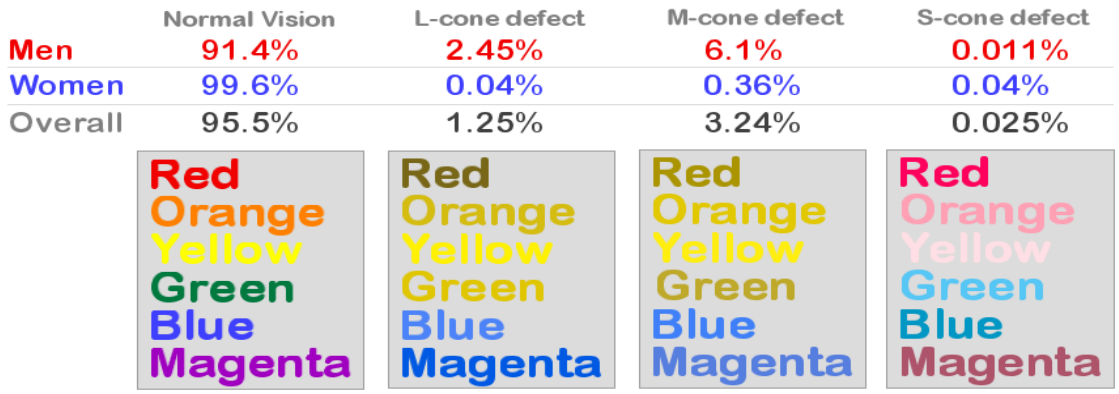

Figure 5. Types of colour deficiency *(IRIS, 2019)*

Colour deficiency can have various degrees of severity, depending on the amount and types of cones missing. A mild colour deficiency is when a person can see colours well in good lighting but struggles to distinguish them in dim lighting. A more severe case is when a person cannot see certain colours at all. Colour deficiency usually affects both eyes equally and remains stable throughout life. (Turbert, 2019)

Colour blindness is estimated to affect about 8% of males and less than 1% of females. Most color vision problems are hereditary and already present at birth, but they can also be triggered by aging, certain medications and medical conditions. (Prevent Blindness, n.d.).

In some countries colour deficiency is more spread due to isolated communities with limited gene pools. Hungary, Finland and some Scottish islands are examples of countries where the prevalence of all colour blindness types is higher. (Mandal, 2019)

4.6.1 Ishihara test

A common way of detecting colour vision deficiencies is called 'Ishihara testing'. A set of images consisting of dots of varying sizes is presented to the subject, and they have to discern a differently coloured pattern or a number 'hidden' in the image. The images, or so-called 'plates' (Figure 6), are created using a carefully selected array of colours that will make it difficult for a colour blind person to pass the test, while allowing a person with a normal vision to pass it at a glance. (Rauch, 2017)

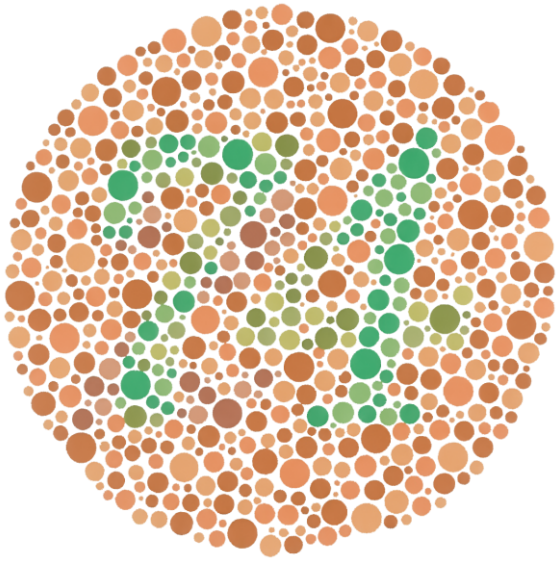

Figure 6. Ishihara plate *(Ishihara, 1917)*

4.6.2 Colour deficiency and its effect on peoples' lives

Colour deficiency can seriously affect professional activity or career choices of people suffering from it. Doctors who have colour deficiency may have troubles giving a visual evaluation of their patient, since rashes, blushes and other colour manifestations in the human body are imperceptible by people with colour blindness. Another few occupations worth mentioning include electricians, pilots, drivers, chefs, designers, etc. (McDowell, 2017)

Besides, having colour deficiency can create learning difficulties in kids, since colours are often used to help with learning process. Preparing food might also be difficult since, for example, a colour-blind person would hardly be able to tell whether meat is fully cooked or fruits are sufficiently ripe. Safety warnings and signs can go unnoticed, medications being taken can be confused, etc. (National Health Service, 2019)

4.7 **Colour constancy**

The human brain perceives colour not only based on the visual input, but also based on the experience. 'Colour constancy' defines a subjective way of processing colour under various light conditions. For example, the same object would be perceived by us similarly during midday, when the visibility of colour is high, and in the evening, when the amount or quality of light should be insufficient to make any conclusions regarding the object's colour qualities. The human vision system compensates for the lack of information using previous experience of interacting with the object, in a way that allows the perceived colour of the object to remain the same. This mechanism is meant to help us recognize things. (Choudhury, 2015)

4.8 **Colour and its effect on attention**

“Attention refers to the cognitive process of selecting information that is available in the environment” (Dzulkifli, 2013, pp. 3-9). When humans focus their attention, they are selecting information to be processed in the cognitive system. Attention and memory are directly related to one another, so when more attention is focused on an object/subject, memory performance and reaction also rise.

Colour has been proven to increase attention rates in humans, therefore helping memorize information. In a study that compared colour and non-colour multimedia presentations on memory performance, the coloured multimedia presentations attracted more attention. It was noted that warm colours such as orange, red and yellow had been found to boost attention rates considerably more than cool colours like gray and brown. Another study has also found colours to have a greater impact on working memory and visual attention than shapes. Also, higher levels of colour contrast have been found to have a greater impact on attention and memory. (Dzulkifli, 2013, pp. 3-9)

During the process of conducting research and analysing relevant information it has been concluded that colour should not be the key element in symbol design. Firstly, only two colours can be precepted by all colour-blind people: blue and yellow (black and white) but using only these colours is impractical. Secondly, colour blindness varies wildly from one person to another, and every colour-blind person has their own perception peculiarities. Therefore, the emphasis during design should be placed upon using different shapes and textures.

Apart from features mentioned in Chapter 3.2, the chosen symbols have to comply with the following requirements:

-compact and minimalistic (for ease of interpretation and correct scaling of symbols)
-telltale (meaning is conveyed via association, intuitively recognizable)
-should take into account comments from the relevant parties noted in Chapter 3.1
-noticeable in the drawing (symbols’ shapes/colours stand out in regard to other elements in the drawing)
-diverse and unique (difficult to mistake for one another, contrasting colours)
-categorized and consistent (different symbol groups should be of the same colour, and recurring element features (such as manual/mechanical handling, etc.) should use the same elements to indicate their qualities)

4.9 **Professional survey**

In order to gather feedback and make changes to the fire symbols, a questionnaire was sent to 35 specialists in the fire safety sector. Half of the respondents left comments and 15% of them had a color vision deficiency. The main changes implemented included color, shape and annotation modifications.

To give a few examples of such modifications, the colours of some symbols were changed to brighter hues to achieve a better contrast with surrounding elements. Some

text elements were corrected, as many people noted that the names are misleading and/or easy to mistake for one another, and it was important to find abbreviations that would be easy to recognize. Also, some details in some symbols had to be omitted, to ensure that they are displayed sharply and correctly even when their scale changes.

Due to their extensive experience in the fire safety sector the questionnaire respondents were able to provide relevant comments and point out important features that are needed for an efficient design process.

To ensure precise visualization of the proposed changes, the questionnaire was sent out again after every new set of implemented features.

5 **CONCLUSION**

As the result of this thesis, a symbolic guideline document was created. The document features unique and memorable symbols that are suitable for people with special needs and takes into account the wishes and comments of industry professionals. The goal was achieved via research and information gathering, as well as collaborating with fire safety sector specialists and data cross-comparison. Upon the completion of this project, the final symbol designs will be forwarded to Top Ten Group for assessment and approval. Although the symbols are likely to undergo further correcting before they get officially approved and put to use in all TopTen related establishments, this project lays a base for all future iterations, and acts as a starting point.

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APPENDIX 1. Questionnaire

Palomerkkien yhtenäisen käytännön luominen Suomessa

Tämä projekti on jatkoa Top Ten-ryhmän aloittamalle työlle. Projektin tarkoituksena on pyrkiä standardisoimaan paloturvallisuusalan palomerkkien käytö Suomessa sekä vähentää epäselvyyttä ja tarjota sujuvaa yhteistyötä yritysten ja viranomaisten välillä. On tärkeää saada tietoa, mitä mieltä alan ammattilaiset ovat valituista palomerkkimalleista, jotta tutkimuksen tulokset ovat tosiasiallisia. Sinun mielipiteesi ja palautteesi auttaa kehittämään palomerkkejä, helpottamaan muutosta ja varmistamaan, että jokainen suunnitteluprosessin vivahde on otettu huomioon.

1. Valitse toimialasi:

- ○ Palotekninen suunnittelija
- ○ Arkkitehti
- ○ LVI-suunnittelija
- ○ Palotarkastaja
- ○ Pelastuslaitoksen operatiivinen henkilö
- ○ Rakennustyöntekijä
- ○ Rakennesuunnittelija

Muu (täsmennä)

Seuraavien asioiden pääteltiin olevan merkkien tärkeitä ominaisuuksia tutkimuksen aikana:

- yhtenäisyys ja minimalistisuus (helppo tulkita ja skaalata oikein)
- tunnistettavuus (merkin tarkoitus on helppo mieltää ja tunnistaa)
- huomattavuus piirustuksissa (merkkien muodot/värit erottuvat muista piirustuksen osista)
- monipuolisuus ja ainutlaatuisuus (hankalaa sekoittaa toiseen merkkiin, vastavärit)
- luokittelu ja johdonmukaisuus (merkkiryhmillä tulisi olla omat värit ja toistuvien tunnusmerkkien (kuten manuaalinen/koneellinen jne.) tulisi käyttää samoja piirteitä, jotka osoittavat niiden ominaisuudet)
- värit ovat hyvin erotettavissa muista väreistä jopa mustavalkoisessa tulostee ssa
- värien tulisi olla sopivia henkilöille, joilla on värinäkökyvyn puute

Kommentteja piirrosmerkkeihin

Tämän vuoksi on pidettävä mielessä, että kaikki ehdotukset ja muutokset noudattavat edellä mainittuja vaatimuksia. Jos mieleesi tulee muita asioita, jotka tulee ottaa huomioon, muistathan kertoa ne vapaassa kommenttikentässä.

2. Kommenttikentä:

3. Onko värinäkökykysi normaali?

- ○ Kyllä
- ○ Ei

Kiitos palautteesta! Palautteen saaminen on hyvin tärkeää meille kaikille.

Parannetaan paloturvallisuusalaa yhdessä!

APPENDIX 2. Examples of symbols currently used in companies

Description in English	KK	L2	Ramboll	Kauriala	Sitowise	Paloässät	Description in Finnish
Direction and width of exit	2000	1200	LEVEYS		1200	1200	Uloskäytävä
Attack passage	NO DATA						Sammutusreitti
Escape route	NO DATA			NO DATA	45m	NO DATA	Poistumistie
Fire compartment						NO DATA	Palo-osasto
Smoke zone				NO DATA	NO DATA	NO DATA	Savuosasto
Smoke extraction, manual			NO DATA	Manuaalinen:	NO DATA		Savunpoisto, painovoimainen
Smoke extraction, mechanical				Koneellinen:	S	NO DATA	Savunpoisto, koneellinen

Description in English	KK	L2	Ramboll	Kauriala	Sitowise	Paloässät	Description in Finnish
Make-up air				NO DATA	NO DATA		Korvausilma
Make-up air, mechanical	S 		NO DATA	NO DATA	NO DATA	NO DATA	Korvausilma, koneellinen
Smoke extraction hatch or window	NO DATA		NO DATA		NO DATA		Savunpoistoluukku
First-aid fire hydrant	NO DATA				PPP	NO DATA	Pikapaloposti
Fire extinguisher	NO DATA		NO DATA		KS		Käsisammutin
Water for firefighting (input)	NO DATA			NO DATA	NO DATA		Sammutusvesi, syöttö
Water for firefighting (outlet)	NO DATA			NO DATA	NO DATA		Sammutusvesi, ulosotto

Description in English	KK	L2	Ramboll	Kauriala	Sitowise	Paloässät	Description in Finnish
Smoke compartment	SL1 			NO DATA	NO DATA	NO DATA	Savulohko
Fire alarm central panel	NO DATA			NO DATA			Paloilmoitinkeskus
Smoke extraction control board	NO DATA			NO DATA			Savunpoiston ohjauskeskus
Sprinklered area	NO DATA				NO DATA	NO DATA	Sprinkleri vesivalelu

APPENDIX 3. Designed fire symbols