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Abstract:

This thesis aims to highlight the less used parameters in the European Lighting Standards 12464 tables. After we developed a vision for the project, we started from the research question: How to address lighting quality in improving understanding of European lighting standard, 12464, and make it more applicable. Then two criteria were established for success, first consider the effect of a better understanding of the standards on design, and the second considers the effect of the distribution of lighting on the use of the place. This vision led to the problem statement: How can we encourage and motivate lighting designers to extend the concept of good lighting quality to all standards. A reference study was conducted on how the concept of lighting quality evolved, and how the researchers dealt with various parameters. Then an analysis was made of the current European specifications, to show the mechanism of its use, and its effectiveness in working life. We concluded that cylindrical lighting and modeling are important parameters, but are not widely used. Therefore, the aim was to carry out a photometric and analytical study of these two parameters to simplify them. A model was designed by Dialux's room software, which was lit up with LED lights. The aim is to simplification the concept of cylindrical lighting, by studying the effect of changing room surfaces reflection factors on the amount of cylindrical lighting and modeling. Several tests were performed in, which the reflections of the ceiling and walls were changed. Then we changed the position of the measuring points and changed the arrangement of the light fixtures. As a result, we found , that the brighter walls give higher cylindrical lighting values and better modeling values. Also, the arrangement of lamps greatly affects the values of cylindrical lighting and modeling, as the values of cylindrical lighting decrease directly below the lamp, while it increases if the measurement point is between two lamps.

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Photometric study for better understanding of cylindrical illuminance and Modeling.

Abstract:

This thesis aims to highlight the less used parameters in the European Lighting Standards 12464 tables. After we developed a vision for the project, we started from the research question: How to address lighting quality in improving understanding of European lighting standards, 12464, and make it more applicable. Then two criteria were established for success, first consider the effect of a better understanding of the standards on design, and the second considers the effect of the distribution of lighting on the use of the place. This vision led to the problem statement: How can we encourage and motivate lighting designers to extend the concept of good lighting quality to all standards. A reference study was conducted on how the concept of lighting quality evolved, and how the researchers dealt with various parameters. Then an analysis was made of the current European specifications, to show the mechanism of its use and its effectiveness in working life. We concluded that cylindrical lighting and modeling are important parameters, but are not widely used. Therefore, the aim was to carry out a photometric and analytical study of these two parameters to simplify them. A model was designed by Dialux's room software, which was lit up with LED lights. The aim is to simplify the concept of cylindrical lighting, by studying the effect of changing room surfaces reflection factors on the amount of cylindrical lighting and modeling. Several tests were performed, in which the reflections of the ceiling and walls were changed. Then we changed the position of the measuring points and changed the arrangement of the light fixtures. As a result, we found that the brighter walls give higher cylindrical lighting values and better modeling values. Also, the arrangement of lamps greatly affects the values of cylindrical lighting and modeling, as the values of cylindrical lighting decrease directly below the lamp, while it increases if the measurement point is between two lamps.

Table of content

1- Introduction:

Lighting design: is a term that considers the provision of good, stimulating, and creative lighting in various studied environments. However, designers have framed this term. Most lighting designers restrict this concept of achieving numerical values according to international recommendations, With no consideration for the hidden aspects of lighting, and the extent of their impact on the aesthetic of the scene or its effect on the psychological comfort of users.

The international standards were established to achieve the minimum level, and it refers to notes that leave room for the imagination and creativity of the designer.

Lighting organizations and associations laid the foundations for lighting. These foundations are primarily aimed at ensuring adequate lighting, that meets established standards, and provides visual requirements for people. These bodies propose any adjustments they deem appropriate according to the development in the world of technology, as these standards are relied upon, and it is considered the basis upon which the lighting designer relies upon studying his project.

Lighting quality is a term that includes several criteria and has been expressed according to the literature by making specific measurements that require achieving the required values in space. These standards include illumination and uniformity intensity, CCT, RCI, glare, flicker, cylindrical lighting, and modeling. However, through my observations in two different companies working in the field of lighting design, it was noted that when working on a new lighting project, the goal is to achieve the European standards recommended. I noticed that the designers do not give all standards the great importance when designing; they are only focused on achieving the required lighting level, and checking the value of the uniformity factor, while they are leaving the imagination and the creativity for the architect. During Scholastic life, we learned all aspects that affect the lighting, as well as we studied the effect of lighting in the surrounding environment, whether on things or people. However, in reality, it was found that few designers mentioned these aspects when designing, what are the reasons for this. This case created some questions for me. What is the effectiveness of the standards set in reality? so it was a motive, to carry out a study, that will be the subject of a master's thesis research. In this thesis, we will try to investigate the effectiveness of less used criteria of lighting quality in a specific area. In order to conduct this study, it was necessary to study the currently approved standards, so we could understand how to rely on the less used parameters, what the weaknesses in these standards are, and what the possibilities of improvement are.

1-1 Vision:

The idea of this master's thesis is to study and analyze the standards of the current specification, that describe the lighting quality. In addition, we will do a literary review of lighting quality concept development. and we will show how the idea of setting standards emerged. Then we will do research on the reasons for not using all the criteria to the same extent in the designing. where It seems that lighting design is limited to achieving one or two of the approved standards.

The lighting design includes several criteria, that should be compatible with the needs of the surrounding environment, as well as the people present. What are the most used and reliable standards, and why are other standards not used to the same extent? Is it difficult to measure or describe other criteria? What is the reason? Is it lack of understanding of how these standards work? Therefore, the idea of the study is to conduct a study reviewing the current standards, and we will focus on the two norms, average cylindrical lighting, and modeling. Furthermore, we will highlight their importance, and we try to simplify the concept of each of them, which will motivate and help the designer to use them in practical life more.

Through this vision, the following imaginary question can be established to be the beginning of the search for a problem to solve, and it will be the basis of this thesis.

Researcher question:

How to address lighting quality in improving the understanding of the European lighting standard* 12464*, and making it more applicable.

1-2 Success criteria:

The aim of this thesis is to discuss the lighting standards currently adopted. Moreover, we aim in this study to show weaknesses in these standards, and how they can be improved. As a lighting designer, do you observe all these standards in practical life? We will try to highlight marginal or less used criteria, and demonstrate how important they are in design. Therefore, we have identified two success criteria, that are based on the foundations adopted in the design and are mentioned below:

Engineering: How could a better understanding of standard affects positively on the design concept.

Functionality: How could good lighting distribution allow better use of space

1-3 Problem statement:

Based on the previously reviewed vision, and imaginative question, a problem statement was created to be the basis of this thesis. Moreover, through it, we introduce a clear understanding that helps in describing the lighting quality in a specific place, that is in line with the standard specifications. According to that, we come with the below problem statement:

How can we encourage and motivate lighting designers to extend their good lighting quality concept to include all the criteria

The multiplicity of lighting quality measurement methods leads to a long time. Therefore, it is important to identify the most effective elements in the lighting quality, to know how to measure them. the best method, which will be more clear to determine how many points and locations of measurement are possible. It will be a criterion for anyone who wishes to express the quality of lighting somewhere.

1-4 Hypothesis:

This problem statement leads us to develop and suggest a hypothesis. It will be a way to ascertain, or it can be a future proposal to describe and improve less used parameters of lighting quality:

Providing good lighting distribution, in a specific space will improve fiscal communication and better use of the space.

We believe that the good distribution of the light has a better effect on the people, and it will provide a comfortable atmosphere. Our task is to show how we can do that by various room surface reflectance factors, and how we can investigate that, by changing the arrangement of the lights fixtures.

1-5 Methodology:

Based on what was mentioned in the introduction, the general objective of this thesis is to combine knowledge, research, and analysis of the currently approved standards 12464, in order to develop a proposal that helps in understanding the less used specifications that are necessary.

To answer the problem statement we developed and based on, we will use methods based on a quantitative and qualitative analysis of a hypothetical model in which we test the ability to measure and analyze the required standards. Which helps to better understand to reach the best proposal that meets the desired goal.

During the thesis, we rely on everything we learned during our study, and the problem-based learning model and the "lighting design experience" model were adopted. Where will be the guide for research and the engine of the work and study mechanism:

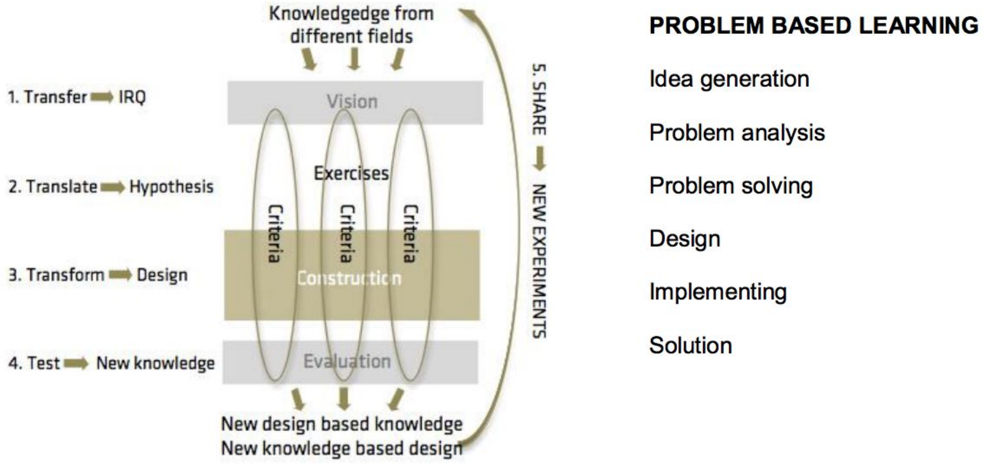

Figure [1]: PBL model/lighting experience.

The beginning of this thesis was through a comprehensive review of the literature and publications, which deals with the concept of lighting quality and studies standards and their development over time. As for this thesis, we conducted a comprehensive analysis of European standards 12464 to understand and evaluate how the various parameters actually exist. Documenting our observations and adopting the analysis and discussion as a tool that helps confirm and visualize our arguments in designing or developing the appropriate proposal for this thesis. This analysis leads to the use of brainstorming to generate ideas that help define the vision of this thesis and the appropriate success criteria.

2- Background:

2-1 lighting quality definition:

In order for us to understand the current standards, we must take a look at the evolution of the term lighting quality, and how it started thinking about the concept of laying the foundations, and standards governing lighting design. In this context, taking a historical look at the definition and development of lighting quality was considered, as an introduction to understanding the rest of the standards.

Is there a definition of lighting quality? A complete answer to this question cannot be adopted. Several factors affect lighting quality. One of the most important of these factors is people's expectations and experiences of electric lighting. Expectations differ from one region to another, and culture affects them. For example, the expectations of residents of developing regions differ from those of developed regions, as well as the needs of workers in offices in developed countries differ from workers in developing countries, that follow the lifestyle and concept of visual comfort as well.

The investigation is essential for understanding visual comfort. For example, lighting that is comfortable in a recreational environment may be described as inappropriate and considered annoying if it is adopted in the workspace, (Boyce 2003).

The lighting quality is not only about ensuring the right amount of light on the work surface. Other factors that are considered components of lighting quality. For example, lighting distribution, light color characteristics, and glare are the same as lighting, (Veitch and Newsham 1998).

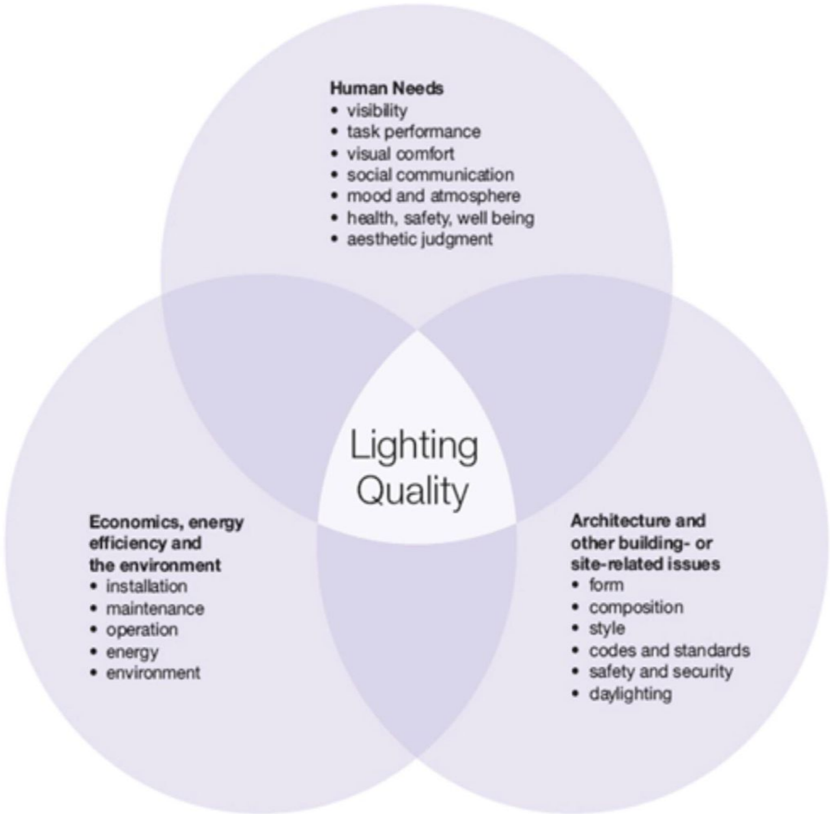

Figure [2]: shows the relationship between the body needs and lights
(https://www.iald.org/Advocacy/Advocacy/Quality-of-Light. accessed 20-4-2020)

There are many physical and physiological factors, which have an impact on perceiving lighting quality. Lighting quality is not easily described in terms of optical parameters, and there is no single method that can be applied universally to describe high-quality lighting (Boyce 2003, Veitch 2001). The level of visual comfort and performance required for our activities is an important component in assessing the lighting quality. This includes the visual aspect. It can also be expressed based on the aesthetics of the visual environment, and its suitability with the properties of space and activity. This is considered a psychological aspect. In addition, there are also effects of light that may last for long periods of our health. These effects are related to either stress on our eyes due to poor lighting (again, it is a visual aspect), or the invisible effects related to the relationship of light to the daily system of man (Brainard et al. 2001, Cajochen). et al. 2005).

Researchers have proposed many theories and methods aimed at determining the lighting quality (Bear and Bell 1992, Loe and Rowlands 1996, Veitch and Newsham 1998, Boyce and Cuttle 1998). The definition based on securing the lighting needs of the place, that meets the approved standards, and that fulfills the desire of the designer and the customer is the most effective definition applied (Boyce 2003).

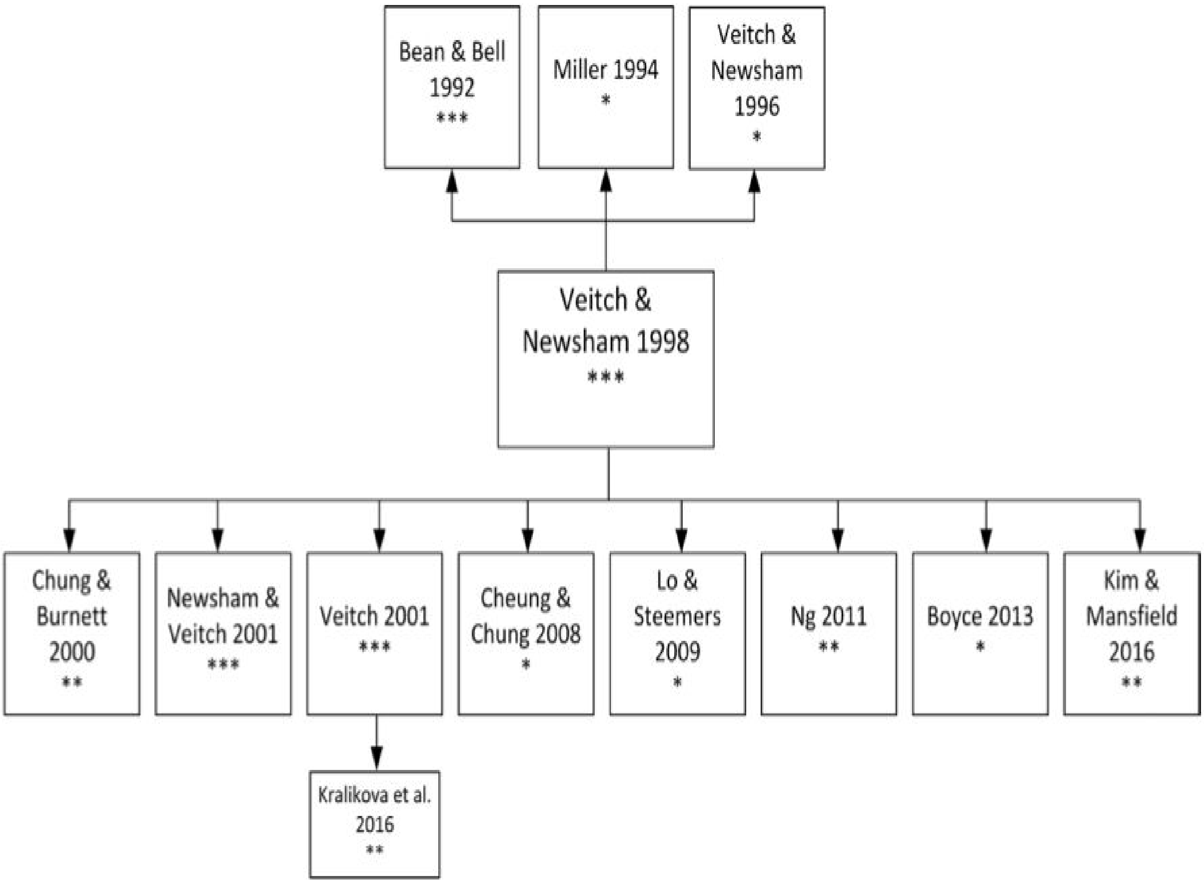

Figure [3] shows the evaluation of the lighting quality by researchers (Thijs Kruisselbrinka,b,∗, Rajendra Dangola,b, Alexander Rosemanna, b, 2018,)

In this way, the lighting quality is related to the psychological and physical factors, and its goals are achieved such as developing the performance of related tasks, creating specific impressions, creating the desired behavior pattern, and providing visual comfort. As for the constraints, it can be determined through the available financial resources and budgets, the plans and timetables for completing the project, the practices followed, and specifying the design methods that must be followed to achieve the required.

2-2: Review of the publications:

In this context, we will look at the evolution of the concept of lighting quality. Moreover, we will review how the researchers have addressed the concept of standard, that regulates and determine the required lighting values appropriate for each space.

2-2-1 Critical analysis of current methods:

In this part, we will highlight the evolution lighting quality concept, and what are the main parameters that were the focus of the attention of researchers.

The principle of lighting quality concept was divided into three stages. Lighting systems should provide the appropriate amount and quality of light for a particular task. The good lighting is not too faded, or excessively bright. Instead, it provides uniform illumination without glare.

Continuing the first approach of old developers in the field of lighting is the only way to reach high-quality lighting while improving the current standards to keep up with the development. The first lighting code issued by the Lighting Designers Association is the beginning of the right path. Whereas, with the development of lamp technology, and with the arrival of fluorescent lamps, the following indicators such as color rendering index and glow indicator are becoming important parameters that are used to determine the quality of lighting. Also, The development of computer screens prompted researchers to develop new parameters to determine the quality of lighting.

Currently, as LED lighting technologies evolve, studies are underway to adjust some parameters, such as replacing the color-rendering index and focusing on more flicker and glare indicators. A common feature of all of these metrics and research is that they aim to avoid visual disturbance or reduce it to a lower value, in other words, avoid illogical illumination.

The second approach to achieving high-quality lighting is to make the most of daylight. Daylight is an attraction for people, especially in places with little daylight, but this light must be studied to achieve the aesthetic required of it in the specified area [. Veitch, J.A., Newsham, G.R.2000 , Al Marwaee, M., Carter, D.J.,2006]. Good daylight control reduces visual discomfort and reduces thermal discomfort. It can contribute to improving and creating a comfortable and stimulating visual environment, which are criteria for assessing people for the quality of the space. In addition, daylight is the secret to the success of any design if it achieves visual comfort and thermal balance, and is also an indicator that gives people an impression of time as the color and intensity of light change [Veitch, J.A., Galasiu, A.D.. 2006]

The third approach is to work to improve the current specifications, which focus on horizontal lighting and to develop a procedure, that covers the entire area studied. Also, it works to meet the lighting with high quality. Cuttle was one of the first people to start focusing on other aspects of lighting to ensure good visibility. Cuttle says [Cuttles.C, 2010] that over the past 30 years, there have been many hard-to-distinguish tasks visually, such as reading a carbon copy of a project, that has been done multiple times, while current technology can provide better visual insight. Through computer monitors in such cases, except for the increased use of these new technologies such as telephones and computer monitors, high lighting may have a negative impact on the ability to read them. Consequently, recommendations based on securing a sufficient amount of light at the horizontal level may not be appropriate for this stage, and measures should be taken to improve them. There is a lot of truth to this. Instead, it is proposed to change the basis for lighting recommendations to provide something it calls "perceived sufficiency". This standard refers to the exit light from the measured surface to the observer's eye. This meter ignores the direct light from the luminaires and is only the light reflected from the surface of the room. Adopting a medium outlet to the surface of the room, as a basis for lighting recommendations will have some interesting effects because the light distributions that illuminate the walls and ceiling become more energy-efficient than those whose production focuses on the horizontal work level. Researchers [Cuttle, C, 2013] have gone further in recent times by proposing an additional standard called target / ambient light ratio and design to illuminate space first and then any important things in it. This procedure is comprehensive because it allows the design of both art galleries and speculative office space in the same process, although the former will result in completely different lighting from the latter. Interestingly, this procedure can still lead to a composition that produces uniform illumination for a horizontal work surface, but it will now be the result of a thoughtful opinion rather than not sticking to the schedule of lighting recommendations. This approach has potential, for four reasons. First, it draws attention away from the horizontal worktop to the entire space, a consideration that often underlies what is evaluated as good lighting. Second, it sets new lighting standards designed to ensure proper brightness and scene hierarchy. Third, the proposed design method can be easily implemented through programs, and so lighting is designed entirely today by programs.

2.2.2 Standards in publications:

In this section, we review how researchers and specialists in the field of lighting analyzed various standards of European standards EN 12464-1. In 2011, the European lighting standard EN 12464-1 was developed. These updates will lead to changes in lighting design rules and principles for indoor workplaces.

The main objectives behind updating these new normative requirements are the desire to improve the current work environment. As the proposed values aim to improve the lighting distribution, which is reflected in the improvement of visual communication conditions for workers in the internal work environment.

Where some recent studies have shown that increasing levels of lighting in the work environment can increase focus, and facilitate the identification of people. We review below how the various criteria were discussed by researchers.

2.2.2.1 Light levels:

The intensity of light in a specific area is the most important thing in it, and it is the first thing that requires your attention. For this, EN 12464-1 specifies that office lighting for writing, reading, and data processing be a minimum of 500 lux on average, regardless of the size or condition of the structure. Moreover, the intensity of the light required for each place, and every space was determined precisely by the standard specifications, which made the task easier for the designer. As the task of the designer is limited to checking the required value, according to the case studied. The fifth section of the European standards has defined and shown the values assigned to various internal locations. The designer must harmonize these values in place. Most of the researchers were in agreement with these values, as the European specifications left some freedom for the designer to be creative in design.

Figure [4] the difference between uniformity and task lighting.
(https://www.slideshare.net/mobile/MohammedAzmatullah1/lighting-systems-and-their-designmaujmi2014. accessed 5-5-2020)

2.2.2.2 Uniformity

Uniformity is defined as the ratio of the minimum illumination level to the average illumination level in a given area. It is considered one of the most important parameters expressing the quality of the lighting distribution in the place.

The values required for the different work or study environments were determined by the standard specifications, and are detailed in Part 5. The task of the designer or lighting engineer is to choose the appropriate lamps that achieve these proportions. For example, the research found that if the uniformity value is 0.60. it is considered an appropriate, good ratio, and it achieves a good distribution of lighting in the place. Moreover, It creates comfort and creates an atmosphere that does not cause eye strain. In addition, it will be able to adapt easily to the good distribution of lighting for each of the work areas And the surrounding area. Raising the ratio to 0.65 will give you better regularity, making people with poor vision more comfortable.

Some researchers believe that achieving uniformity values and creating an equal lighting distribution creates an atmosphere that lacks creativity. As the aesthetic of lighting focuses on creating contrast in the place and making lighting a more aesthetic element. Some studies examined making comparisons to verify people's satisfaction with this standard, where the same place is illuminated in two different ways, in the first place, an equal lighting distribution is achieved in each place, and in the second case, the place is illuminated with creating contrast on parts of the place. As some designers, consider this to create more creative lighting.figure[4].

2.2.2.3 Glare

Glare is one of the most studied parameters by researchers and specialists. This research aims to research possible mechanisms to reduce their value. It is also known that the glare is expressed by "the feeling and feeling resulting from increased luminance in the eye, which causes a disturbance or may cause blurred vision and difficulty in performing tasks for people, due to eye strain to adapt to the surrounding environment" [M.S. Rea,2000]. The glare was divided into three types: (1) disability glare, (b) uncomfortable glare, and (c) reflections of the veil [L. Halonen, E. Tetri, P. Bhusal, 2010,S. Carlucci, F. Causone, F. De Rosa, L. Pagliano, 2015,W.K.E. Osterhaus, 2004]. Two types of glare can occur together, such as glare of disability and discomfort, although they are distinctly different phenomena [M.B. Hirning, G.L. Isoardi, I. Cowling, 2014].

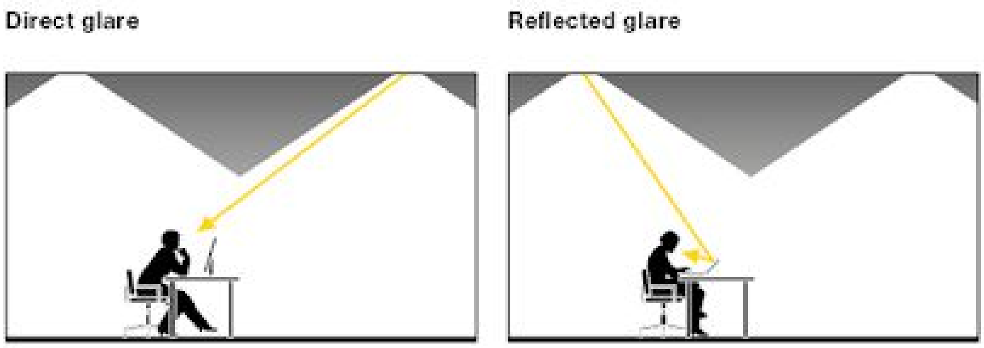

Figure [5] shows how the glare happened (https://images.app.goo.gl/xe3sQRkwCH91bT5y5. accessed 17-4-2020)

2.2.2.3.1 Disability glare

Disability glare, this type of glare is rarely occurring in the interior. it occurs often in external places such as car lights and lighting poles [R.G. Hopkinson, P. Petherbridge, J. Longmore, 1966], which is a strong instantaneous stray light that enters the eye, which may cause instantaneous loss of vision, and that the light is dispersed inside Al-Ain [J.A. Veitch, 2001,W.K.E. Osterhaus,2004]. It immediately reduces the ability to see and reduces visual performance, as tasks are difficult to perform *[S. Carlucci, F. Causone, F. De Rosa, L. Pagliano,2015],* characterized by it may not be due to discomfort as the other type of glare [R. Clear, Discomfort glare,2013].

2.2.2.3.2 Discomfort glare:

Discomfort glare is defined as the sensation of disturbance caused by high luminance variations or inconsistent distributions within the visual field, which may not cause difficulty seeing or reducing visual performance [M.B. Hirning, G.L. Isoardi, I. Cowling, 2014] necessarily, as is the case with glare disability. This type of glare is difficult to define because it is considered a personal visual sense, and cannot be measured directly [R.G. Hopkinson, P. Petherbridge, J. Longmore, 1966]. Consequently, studies and research have not found a deep and accurate understanding of this type of glare [R. Clear, Discomfort glare, 2013]. As the results of the research do not show any effect of glare discomfort on the visual performance now, but some researchers confirm that it has a bad impact in the end, it may be one of the causes of the decline. Concentration, headache, and fatigue [L. Bellia, G. Spada, 2013].

To date, no scale has been reached that accurately reflects the inconvenient glare, as a number of indicators have been developed that describe it [J. Wienold, J. Christoffersen, 2006]; With the difficulty of determining its association with the personal situation [M.B. Hirning, G.L. Isoardi, I. Cowling,2014, M.L. Eble-Hankins, C.E. Waters,2005]. These indicators are divided into four sections: the luminance of the source of the glare, and the luminance of the adjustment, the displacement of the source of the glare with respect to a line of sight, and the solid angle of the source of the glare [J. Wienold, J. Christoffersen, 2006].

The glare indicator used in the standard specification is Unified Glare (UGR) [CIE, Discomfort Glare in the Interior Working Environment, Vienna, and Austria.1995]

Other indicators have been mentioned to determine the uncomfortable lighting glare caused by daylight or by both the electric light source and sunlight together.

2.2.2.4 Colour appearance:

Many studies examine the relationship between light and color. Where it is known that the appearance of color is generally related to the clear color of the emitted light [NEN-en 12464–1,2009] which results from the various wavelengths that make up the visible spectrum, and has the same features of brightness, color, and gradation [M.B.C. Aries, M.P.J. Aarts, J. van Hoof, 2015]. Researchers differ in confirming the effect of the appearance of the color on the visual aspects, but most emphasize its role in improving the level of comfort [B. Manav,2007,H. Li, M. Luo, X. Liu, B. Wang, H. Liu,2016]. However, the appearance of the appropriate color is actually related to the activity-taking place. There are some studies that confirm that the appearance of the room is related to the appearance of the color [B. Manav,2007,H. Li, M. Luo, X. Liu, B. Wang, H. Liu,2016], while others did not find this link to effect [50]. Finally, studies conclude that the appearance of color has an effect on perceived brightness [P.R. Boyce, C. Cuttle,1989,M. Wei, K.W. Houser, B. Orland, 2016,S.A. Fotios,2016-E.E. Dikel, G.J. Burns, J.A. Veitch,2014]. The appearance of the color of the light sources is expressed by the term correlated color temperature symbolized by (CCT), many studies that examine the effect of color temperature on the health and psychological state, and its effectiveness in increasing alertness and performance. Where the new research aims to create lighting that simulates natural lighting in terms of the associated color temperature. What is called circadian lighting? The following pictures show how the difference between two lighting sources is in terms of color temperature.

Picture [1] shows how the difference between two lighting sources is in terms of color temperature (https://www.facebook.com/1124421077645768/posts/2932445973509927/?d=n. accessed 2-5-2020)

2.2.2.5 Color rendering

The color rendering index expresses the ability of the visual source to show colors in the best condition, denoted by CRi, expressing the quality of products, as lamps manufacturers aspire to reach the ideal value of 100. The value 85 is good and sufficient to distinguish the colors and ease of reading the features of people. On the other hand, with the development of LED lights, the value of 90 has become the approved standard for most of the lamps produced. Some studies believe that this standard is weak and insufficient, which prompted researchers to adopt another standard that reflects light embodiment is TM-30-15. This standard is more comprehensive, being able to determine the extent of the lamps' ability to embody dark red color, which is difficult to achieve in the CRI standard since it deals only with eight color components. However, the new standard requires a deeper understanding and more study.

2.2.2.6 Illuminance on walls and ceilings:

The lighting of the surfaces in the place is no less important than the lighting of the task area or the surrounding area. Many studies stress the need to give importance to lighting the walls and ceilings, which has an impact on visual comfort and reduces stress.

Specifications recommend that the luminance value be 30 lux for the ceiling and 50 lux for the walls, to achieve a visually comfortable atmosphere while achieving uniformity of 0.10. However, raising these values to 75 lux for walls and 50 lux for the ceiling improves the distribution and provides greater comfort, especially in work environments that require spending a long time indoors. It contributes to improving visual communication at various levels.

2.2.2.7 Median cylindrical illuminance

The new updates in lighting standards have adopted medium cylindrical lighting in areas with a high level of activity, as an additional parameter designed to improve the lighting conditions in the place. As it would improve the clear identification of things and assets, it added to the occupants of the place, which contributes to supporting communication. In addition, it is easy to perform the basic tasks now, as a horizontal level is adopted. It is based on the distinction between the activity, when sitting, at a height of 1.2 meters, and the activity of persons, when standing, at 1.6 meters. The values used here are the general minimum values for both uniformity and cylindrical lighting. Areas such as offices, meeting rooms, and classrooms each need to be taken into separate accounts.

Picture [2]: Two levels of the cylindrical illuminance.(https://glamox.com/ie/better-visual-communicatio. accessed 16-4-2020))

There is a question that presents itself in the midst of these updates, but is it use these updates when designing a new project?

With these updates, other lighting requirements are required depending on the place studied, related to the quantity and quality of lighting. However, there is still no consensus on concrete solutions. These new rules aim to support lighting designers when creating lighting concepts to provide good visual conditions that contribute to improving visual comfort in the place.

Therefore, the cylindrical lighting standard is a good basis for initially motivating designers. Accordingly, light can be designed based on this standard while maintaining the freedom that gives us the option to find solutions ourselves. The exchange of ideas with colleagues contributes to increasing the experience, which helps to verify the effectiveness of using this standard and whether any real benefit has been achieved. However, at this stage where experiences are few and matters did not reach the point where this criterion could be adopted as a basis for designs. Where the number of experiences and information exchanged as a result of practical application is still small. Through the daily work that requires communication between lighting designers and lighting producers, there are still indications that this new standard has not been very popular and is still in the foundation stage. This leads many lighting designers to avoid adopting it in designs, as no evidence has been presented or checking the values of the room surfaces in the case of lighting approval. Special experiences and current experiences confirm that it is also possible to offer a good lighting concept without relying on these updates. The impression is that many designers resort to applying only parts of the new standard. Whereas, this applicable part is what has been established and improved since the 2003 release.

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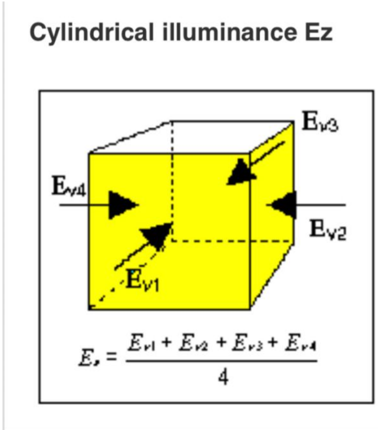


Figure [6] how to calculate the cylindrical illuminance (https://www.facebook.com/1124421077645768/posts/2932445973509927/?d=n .Accessed 25-4-2020)

Cylindrical illuminance easily can be defined by calculating the average value of the vertical illuminance on a cylinder at a measurement object. The standard states that cylindrical illuminance value should be equal to or higher than 50 lux.

In offices, As good visual communication is important, cylindrical illuminance shouldn't be under 150 lux at the measurement point, Where uniformity should be equal to or higher than 0.10.

2.2.2.8 Modelling

The direction is one of the features that express the quality of lighting. Several studies have examined the effect of the direction on lighting quality. The direction of the light scene can be expressed somewhere with the flow of light in this place. The concept of light flux is divided into two parts: the first expresses the direction of the light flux and the second expresses the force of the light flux. There are studies that define the strength of light flux, by calling it modeling, the balance between the amounts of diffused and focused light in an illuminated environment [M.N. Inanici, M. Navvab, 2006].

Picture [3] shows the effect of the different values of the modeling on the face recognizer (https://glamox.com/gsx/better-visual-communication. accessed 16-4-2020)

One of the advantages of adequate direction is that it helps to distinguish and show details of the illuminated task and distinguishes between the superficial texture of objects and three-dimensional objects, including the faces of people in place [N. Gentile, M.-C. Dubois, W. Osterhaus, 2016, M.N. Inanici, M. Navvab, 2006]. Which is reflected in the communication between people, and affects the shape and appearance of the surrounding environment [C. Cuttle, 1971]. As a result, the direction of light is one of the effects on health and well-being as the heterogeneous distribution of cells makes it difficult to see a clear picture in the eye [P. Khademagha, M. Aries, A. Rosemann, E. Van, 2016]. In general, the direction of light generates three distinct patterns that affect things: the light pattern, the selection pattern, and the shadow pattern [C. Cuttle, 1971]

Modeling is a term, expressing a balance between indirect lighting and direct directed lighting. This feature is considered as, the light provides illumination for an object so that it appears natural, meaning that all-terrain is shown to the illuminated body so it does not seem very flat or very harsh or be illuminated in a very focused form. Values appropriate to modeling enhance the general appearance of space when its structural components are illuminated appropriately, including objects and people in place, so that the texture and shape appear comfortable, enjoyable, and clear. The fall of light mostly from one direction happens. Where shades are suitable for good modeling without defects.

One directive in this area is, that the amount of direct lighting in one direction shouldn't be excessive because this may lead to the formation of severe shades. And it should not be too scattered and spread too, because things, space, and people are then seen as very faded and unclear, and it becomes difficult to see the place and its details, which leads to visual discomfort.

The recommendations state that in order to achieve good results through the modeling standard, it is necessary to control the ratio between cylindrical and horizontal lighting. Values between 0.3 and 0.6 are considered to be effective values since good modeling is achieved in place. To verify this, practical calculations of cylindrical and horizontal lighting values must be made and evaluated at the same measurement point.

2.2.2.9 the effect of the cylindrical illuminance and modeling

We note that the complexity of the new lighting schemes increases somewhat, as new updates place recommendations and requirements that increase the number of parameters to be checked. In environments that require more visual contact, such as modern offices, classrooms, and hospitals. It is necessary to follow the specified and recommended values. The impact of these new rules on the industry is still unknown, which requires, after more practice, to find a comfortable solution that improves productivity and raises the level of worker welfare in various work environments.

The adoption of the new standard in most cases leads to major improvements in the working environment, but on the other hand, it may cause increased lamp consumption and more in the number of lighting lamps. Consequently, the lighting designer, electrical engineer, end-user, and customer should enter into a dialogue to understand the expected consequences of applying these new requirements. Several studies have examined the impact of the new standard on different work environments for school, office, and health care.

In many cases, it was found that the wattage of the lamps should be increased or the required number increased. One of the results of studies is that light quality should be prioritized over thinking about energy saving, and suggests focusing on turning off light as an energy-saving option when no one occupies the place. Individual and energy-saving lighting solutions are a flexible solution that must be focused on for all users and clients..(*https://glamox.com/ie/en-1246. accessed 15-4-2020.* accessed 19-4-2020*)*

2.2.2.10 Discussion and conclusion:

In a review of the research published on lighting quality and the standard EN 12464. It can be said that most studies were based on measuring the main parameters that determine lighting quality and then matching these values with the standards approved by each country.

In order to be able to provide good lighting, it is necessary to understand what is meant by lighting quality. Definitions of lighting quality varied. Some definitions express lighting quality is an individual experience, while the other part considers it a group experience. There is also a difference in how they are measured and what important parameters express the lighting quality. Some studies and standards focus on horizontal illuminance and attach importance to lighting distribution somewhere without focusing on other parameters. This may cause problems between designers and customers. Because each work environment differs from the other, as the designer must be able to know the most relevant and useful parameters in the studied work environment. As many studies have studied the influence of cylindrical lighting and modeling in place, these less used standards are of great importance, as achieving the recommended values improves visual vision and helps distinguish things. We **conclude** the importance of cylindrical illuminance and modeling as a new indicator of the quality of lighting in the indoor environment.

3-Analysis:

3.1 Introduction:

BS EN 12461-11 is the most important document that lighting designers rely on most European countries when designing lighting. However, designers often rely only on only part of this document, the tables of brief task lighting given in Section 5 of the Standard are considered the most considered without the other parameters.

With the current development, visual tasks have become easier in many work environments. Especially office environments where the use of illuminated computer screens has become the most common optical task; it also applies to popular laser printed documents as well. Moreover, upon the design, the proposed lighting for many buildings and working environments is determined and fixed long before the building users begin working on the location of any specific visual tasks. In other words, lighting is guaranteed in the work environment in theory without any practice or practical testing, and this is an important aspect in that the theoretical values correspond to and meet the needs of the visual tasks in the place. The results are that it is often by providing a large amount of light for the visual tasks, which leads to the spread of light by reflecting the tasks in the whole place, instead of providing them only when needed and for the task required. Thus, with the current development in which we have to reduce energy consumption, it is more logical to provide constant lighting in the place required to meet the minimum lighting of the place, then to provide additional local task lighting for any specific tasks

[Peter Raynham, 2017.]

3-2- Analysis Standard 12464:

We will try to address the various parameters in this standard, how they are defined and measured, and the recommended values. Different working environments require a wide range of values, we can summarize Lighting design standards bellow:

3.2.1 Luminous environment

In order to practice good lighting, in addition to achieving the required lighting, it is necessary to meet the specific quality and quantity needs. Lighting requirements are determined by satisfying three basic human needs:

-Providing a good level of visual comfort, which improves the feeling of well-being of people, as this indirectly, contributes to increasing productivity and improving the quality of work.
-Improving visual performance, which makes workers easily perform their visual tasks, even under pressure where difficult conditions are or if longer times are required;
-Increased safety.
As for the main parameters that describe the luminous environment, it comes to describing the determinants of all artificial light and daylight, which are divided into:
Luminance distribution
Lighting; the directivity of light and illumination in the interior space;
Light diversity (light levels and color);
Color rendering and color appearance.
Glare
Flickr
Through this standard, the illumination values have been approved, and the uniformity in each of the task or activity areas, and general lighting in the specified area. In addition to disturbance glow and the determination of the value of the color display indicator, the other parameters have been described in the following Item.[European Committee for Standardization, DRAFT prEN 12464-1]

3.2.2 Luminance distribution.

The luminance distribution controls the level of adaptation to the eye, which affects the visual field and thus the vision of the task.
It is necessary to provide well-balanced lighting, as appropriate, which is reflected in the increase in:
-visual acuity (visual acuity), i.e. better focus and vision.
-Calculate variance sensitivity (which helps to distinguish between small relative differences).
-Increased efficiency of eye functions (such as eye movements, pupillary contraction, convergence, etc.).
In addition, the luminance distribution affects the visual field, which is reflected in the visual comfort. However, there are things that should be avoided for the reasons outlined below:
-High luminance values and high luminance variation cause glare.

-The significant difference in luminance values leads to fatigue and fatigue due to eyestrain from continuous adaptations;[European Committee for Standardization, DRAFT prEN 12464-1].

Low lighting values with less contrast in lighting create a tiring, non-stimulating, and boring work environment. To achieve a well-balanced and appropriate luminance distribution, the illumination of all surfaces must be determined by the reflection of light. It is advised to light the internal surfaces in an appropriate amount, which contributes to improving levels of adaptation, creating a comfortable atmosphere, and reducing depression in buildings. The brightness of the room is expressed by setting and measuring the lighting on both the walls and the ceiling. Although the luminance requirements will be more accurate, however, the luminance requirements are considered impractical for their dependence on presentation positions and material characteristics. One of the things that a lighting designer should consider is choosing the appropriate lighting and reflectance values for the interior surfaces.

3.2.3 Surface reflection

High values and surface reflections result in energy savings and better visual comfort. The standards recommend the following values for reflections for material selection, as follows:

Roof: 0.7 to 0.9

Walls: 0.5 to 0.7

Floor: 0.2 to 0.6

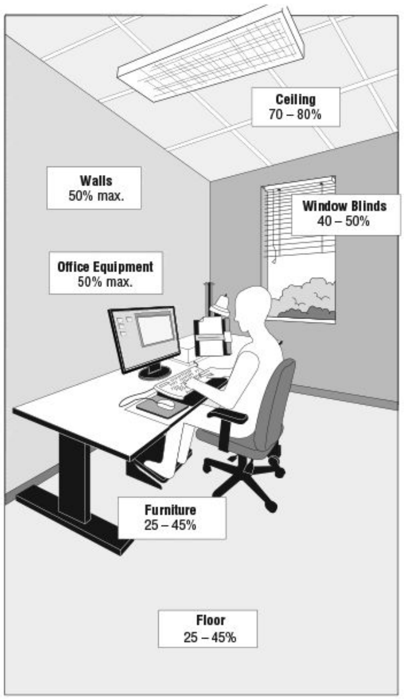


Figure [7] The minimum and the maximum value of the reflector factor in the room (

As for the main things (such as furniture, machines, etc.), the reflection values should be in a range

From 0.2 to 0.7. In the case of transparent glass, it should have a reflection of 0.1.

In design calculation procedures, determine the reflection values of the surfaces, if the values are as close to the actual surfaces as possible, despite the difference in the reflection values across the surface.

As for the requirements for the uniformity values of the walls and ceiling shall be within the limits of Uo, 0,10. Where the brightness of the space or room is expressed through lighting on the walls and ceilings, taking into account surface reflections.[European Committee for Standardization, DRAFT prEN 12464-1]

3.2.4 Illuminance

The illuminated areas are divided into several sections, which are the areas of activity, where most movement is in them, the areas around, and the immediate background which are the areas surrounding the mission areas, then the walls, the ceiling, and the other things in space.

Where lighting distribution ways affect the important area and the surrounding area, which reflects directly on the ability of people to perceive this visual task and carry out it with comfort and safety.

The European standard specifies the appropriate values for lighting different places in order to achieve visual comfort and meet performance needs.

To reach these values, calculations and measurements are required for both the illumination and uniformity averages. It is recommended to use the network specifications and dimensions in bellow:

3	Offices				
Ref. no.	Type of interior, task or activity	$\bar{E}_m$ lx	UGR_L -	R_a -	Remarks
3.1	Filing, copying, etc.	300	19	80	
3.2	Writing, typing, reading, data processing	500	19	80	DSE-work: see 4.11.
3.3	Technical drawing	750	16	80	
3.4	CAD work stations	500	19	80	DSE-work: see 4.11.
3.5	Conference and meeting rooms	500	19	80	Lighting should be controllable.
3.6	Reception desk	300	22	80	
3.7	Archives	200	25	80	

Figure [8] shows the standard value of the uniformity and light level on the office by [European Committee for Standardization, DRAFT prEN 12464-1]

3.2.4.1 Illumination scale

This scale was defined to ensure cognitive difference, when moving from one level to another, in other words, these values are the internationally approved values, for example, there is no value of 400 lux is widely known in the case of designing any space. Whereas, the lighting steps recommended in this standard (in lx) are largely compatible with EN 12665.

20 - 30 - 50 - 75 - 100 - 150 - 200 - 300 - 500 - 750 - 1000 - 1500 - 2000 - 3000 - 5000 – 5000

3.2.4.2 Illuminations on the important area or activity

Depending on the task surface position, lights above the mission or activity area may be horizontal, vertical, or inclined.

If the average lighting required for each task is not less than the chosen and specified value, without regard to the age or condition of the case. The values that must be achieved require meeting the normal visual conditions and taking into account the following factors:

Physiological and psychological aspects, such as luxury and visual comfort.

Ensure the requirements for performing visual tasks;

- The nature of the work environment visually;
- The amount of work experience in the field;

The extent to which lighting contributes to ensuring the required job safety;

- Its impact on the economy

If conditions are different from normal and standard conditions, then the specific illumination value for each case can be adjusted by an increase of at least one step according to the illumination scale.

Conditions that require increased lighting include:

- If the required visual work is extremely important and there is room for error.
- If errors were committed, they were costly to correct;
- If the work requires accuracy or if the increase in productivity is important to clients, which requires an increase in focus;
- If the requested task is a small size or requires low contrast to show dimensions;
- If the task requires more time than usual to complete it;
- When there is little daylight in the mission area or activity area.

- When the operator has little visual ability.

Taking into account the first two cases when the users are older, which necessitates increasing the brightness of the important area.

The second case when there are persons with disabilities. To determine the appropriate lighting, it is necessary to know the size of the mission and its location or an accurate description of the activity area and document this, in cases where the location or size of the activity areas is unknown, and it is dealt with according to the following cases:

-The whole area can be considered an important region.

- to adopt a constant uniformity value over the entire area of the area (Uo o 0,40) as determined by the designer; If there is information about the important area, then the lighting should be redesigned and the lighting scheme adjusted to secure the required lighting value.

-If the type of task is not known, it is left to the designer to make assumptions that he deems appropriate about the potential tasks and the light requirements that meet the task if the task is unclear.

-If there are multiple tasks in the area, it is necessary to comply with the requirements that meet all these tasks. Including the activity area.[European Committee for Standardization, DRAFT prEN 12464-1]

3.2.5 Illuminance on the surrounding area

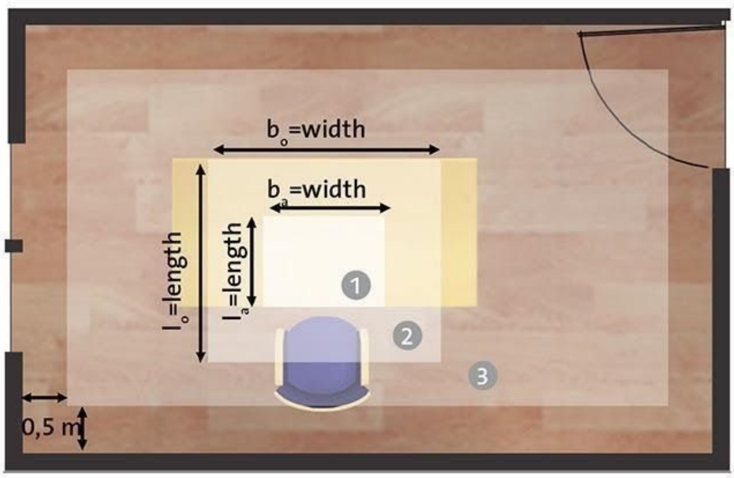
The area surrounding the task area is expressed as a 0.5 m wide belt surrounding the task area. The lighting of the surrounding area is closely related to the illumination of the task area, as it affects visual comfort and performs well. As the great difference between lighting the surrounding area and the task area may cause fatigue and eye fatigue. The lighting may be less than the brightness of the important area, but it should not be less than the values in the following figure.

Task illuminance lx	Illuminance of immediate surrounding areas lx
≥ 750 500 300 ≤ 200	500 300 200 E_{task}
Uniformity: ≥ 0,7	Uniformity: ≥ 0,5

Figure [9] shows the minimum illuminance value for the background area in relation to the task and the immediate surrounding area.[European Committee for Standardization, DRAFT prEN 12464-1]

3.2.6 Illuminance on the background area

The large area that surrounds the area immediately surrounding the task site. It is known by the name of "The background area", it is a strip adjacent to the immediate surrounding area and is especially important in workplaces with little daylight. Moreover, it must determine the dimensions of such areas by 1/3 of the value of the immediate surrounding area. In the case of large rooms, the bandwidth is preferably at least 3 meters. The posterior region is described as an extension of the surrounding area horizontally to the floor level. With the necessity to describe and mention the location and size of the posterior region.



Picture [4] shows the division of the area on the room,1 task area.2 surrounding area.3 background area (https://www.fagerhult.com/knowledge-hub/EN-12464-1/Principles-for-the-working-area/ . accessed 26-4-2020)

3.2.7 Uniformity lighting

The uniformity of the lighting (U0) must be provided no less than the minimum in the accompanying tables in the task or activity area. In cases of light from artificial lighting or daylight from the ceiling, the uniformity values of the lighting are given as follows:

- Determines in the immediate surrounding area UO, 0.40.

-The uniformity values for walls and ceiling should be UO, 0.10.

Many designers consider uniform uniformity in lighting is always a good feature in all cases!

In fact, it is only required on the work surface and is overrated distorting the view of the place.

The secret of lighting beauty is the use of focused lighting and the presence of contrast within the place. where the attractions have luminescent lights higher than the rest of the place. Thus to create a natural atmosphere in which contrast, light, and shade to complete beauty, so the secret of lighting is with focused lighting.

3.2.8 Glare

Glare is defined as the sensation caused by bright areas to affect visual vision. This glare is caused by the reflection of illuminated surfaces, windows, and/or parts of lamps as ceiling lights. Glare values should be minimized to avoid fatigue and fatigue, thereby reducing accidents and errors. Glare is divided into two types: discomfort glare or disability glare. In internal workplaces, if the glare value of disability is set according to the recommended values, it is not considered a major problem.

Reflections on the mirrored surfaces can be expressed as the reflected glare. When the direction of vision is above the horizontal, this requires more care to avoid and reduce glare.

3.2.8.1-discomfort glare

To assess the occurrence of discomfort, the classification of disturbing glare caused directly by luminaires is determined. The CIE Unified Glare Rating (UGR) method is used. Whereas, the value of the illumination UGR does not exceed the value of RUGL in § 6.

It is necessary to mention all assumptions related to the luminaires in the scheme documentation including room dimensions, spacing ratio, and room surface reflection when specifying RUGL (formerly: UGR). So that it does not exceed the RUGL value as indicated in the tables in item 6.

The recommended boundary values for determining a value for RUG form a chain in between which significantly affects glare. There is a difference between the glare caused by daylight, and the glare caused by lamp sources in terms of the size of the source of the glare, the method of lighting distribution in addition to the extent to which users accept these values.

The RUGL series is made up of the following values: 16, 19, 22, 25, 28 Low values express "a low probability of uncomfortable glare" and high values mean "a high probability of uncomfortable glare.

3.2.8.2 Shielding against glare.

Bright light sources indoors cause glare, which impairs people's ability to see objects. It should be avoided, for example, by properly distributing light sources especially ceiling lamps, or by controlling the bright daylight coming through the windows. In the event that the light source is visible and not directly covered, the minimum values of the protection angles in the optical field mentioned in figure 10 must be applied to the luminance of the specified light source.

Light source luminance kcd m-2	Minimum shielding angle α
20 to <50	15°
50 to < 500	20°
≥ 500	30°

Figure [10] the minimum values of the protection angles in the optical field mentioned[European Committee for Standardization, DRAFT prEN 12464-1]

If the lights block the direct view where we cannot see the light source visually, the highest luminance value should be applied to the values of the protection angle given in Table 3. The reflections of the veil and the reflected glow

The values of high brightness reflections affect the visual task's work mechanism, which may lead to a change in the mission's visibility and knowledge of its details, often unhelpful. There are several measures by which to prevent or reduce the veil reflections and the glare reflected from these procedures:

Show workstations and their arrangement in terms of lamps, windows and ceiling lights;

- surface refinishing (especially matte surfaces);
- Control and control the lighting of lamps and windows, especially ceiling lamps
- Providing a bright roof with bright walls.

3.2.9 Indirect glare and Display screen equipment (DSE)

Vertical display screens, so ubiquitous in the modern office, can produce indirect glare, causing discomfort for users due to the reflection on bright surfaces. To keep this problem under control, a certain maximum luminance limit is required for luminaires at certain downward vertical angles

(65 degrees and above). EN 12464-1 mandates that, depending on the screen luminance, luminaires should have maximum luminance values at or above certain angles: 1500cd/m2 for medium luminance screens and 3000cd/m2 for high luminance screens.[European Committee for Standardization, DRAFT prEN 12464-1]

Screen high state luminance	High luminance screen $L > 200$ cd·m^{-2}	Medium luminance screen $L \leq 200$ cd·m^{-2}
Case A (positive polarity and normal requirements concerning colour and details of the shown information, as used in office, education, etc.)	≤ 3 000 cd·m^{-2}	≤ 1 500 cd·m^{-2}
Case B (negative polarity and/or higher requirements concerning colour and details of the shown information, as used for CAD colour inspection, etc.)	≤ 1 500 cd·m^{-2}	≤ 1 000 cd·m^{-2}
NOTE Screen high state luminance (see EN ISO 9241-302) describes the maximum luminance of the white part of the screen and this value is available from the manufacturer of the screen.		

figure [11] maximum luminance values at or above certain angles[European Committee for Standardization, DRAFT prEN 12464-1]

3.2.10 Illumination in the interior space:

Lighting should not be limited to the mission area and activity areas. To achieve appropriate lighting, lighting should include the full size of the space occupied by people. The required light is necessary to highlight things, in terms of texture and details, and also helps to identify people inside space by improving the appearance. Terms describing lighting conditions include "average cylindrical lighting", "directional illuminance", and modelling.

3.2.10.1 Mean cylindrical illuminance:

Average requirements for cylindrical illuminance. In cases where visual communication is necessary in addition to identifying the contents of the place of things, as this improves the movement and activity of people in the place. An appropriate means of cylindrical illumination, $\bar{E}z$, must then be provided in space.

Figure 12 shows how the new version of DRAFT prEN 12464-1 2019 looks, it shows the average cylindrical illuminance required to be set at a horizontal level in the interior space, according to the type of task or activity. Taking into account that the uniformity of the average cylindrical illumination Uo ≥ 0,10. This standard is determined at the height of the horizontal level 1,2 m in the sitting position and 1.6 m in the standing position.

Task or activity area design					Room or space design		
Task or activity related requirements					Importance of objects and people	Brightness appearance of rooms (4.2.2/4.2.3)	
$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx

Figure 12 shows the adding colony on the section 6 of the version of DRAFT prEN 12464-1 2019[European Committee for Standardization, DRAFT prEN 12464-1]

Greater importance is given to areas that require high levels of visual recognition and communication. In the case where the entire area is treated as a task or activity region, the value of the average cylindrical illuminance Ez may be identical to the calculation of the required horizontal illuminance mean, Ēm. In the event that there are sufficient details about when each of the important area / direct surrounding area/background area and it is possible to define each of them separately, then the requirements for cylindrical illuminance must be complied with according to Figure 13 for each of the previous areas within the area.

Ref. no.	Type of task/activity area	$\bar{E}_{m,r}$ lx	$\bar{E}_{m,u}$ lx	U_o	R_a	R_{UGL}	$\bar{E}_z$ lx	$\bar{E}_{m,wall}$ lx	$\bar{E}_{m,ceiling}$ lx	Specific requirements
6.26.1	Filing, copying, etc.	300	500	0,40	80	19	100	100	75	
6.26.2	Writing, typing, reading, data processing	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.3	Technical drawing	750	1 500	0,70	80	16	150	150	100	DSE-work, see 4.9. see 5.7 room brightness
6.26.4	CAD work stations	500	1 000	0,60	80	19	150	150	100	DSE-work, see 4.9.
6.26.5.1	Conference and meeting rooms	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.5.2	Conference table	500	1 000	0,60	80	19	150	150	100	Lighting should be controllable.
6.26.6	Reception desk	300	750	0,60	80	22	100	100	75	
6.26.7	Archiving	200	300	0,40	80	25	75	75	50	

Figure [13] shows value of cylindrical illuminance on the office[European Committee for Standardization, DRAFT prEN 12464-1]

3.2.10.2 Modeling

It is important to obtain harmony in the interior lighting, which improves the overall appearance, as it helps to illuminate the people and objects that exist, which facilitates the process of recognizing and revealing things in terms of texture and shape clearly.

Illuminance should not be directional, or it will produce sharp shades, and at the same time, it should not be diffused and scattered widely in order not to lose the effect of modelling, as scattered and diffused illuminance causes a very faint luminous environment. Likewise, when there is directional illuminance in more than one position, it will produce sharp shadows, which indicates visual weakness and confusion.

Modelling expresses the balance of interior lighting between the amount of light spread in a place and directed light.

As for the indicator that determines and measures the modelling value, it is expressed by the ratio of the amount of cylindrical illuminance at one point to the horizontal at the same point. The value between 0.30 and 0.60 for modelling in the case of uniform arrangement of ceiling lamps is a good indicator.[European Committee for Standardization, DRAFT prEN 12464-1]

3.2.10.3 Directional lighting of visual tasks:

The presence of directional lighting in the place may have a positive effect in terms of showing the details of the visual task, as focusing the lighting in a specific direction raises the level of vision and distinguishes details, which helps to carry out the task easily. But pay attention to the possible repercussions and the effect of unintended glow. Harsh shadows are a bad feature in the place, and work is done to reduce them, but the presence of shadows in the place creates contrast to things and people, which improves the recognition of the details of things, not to mention the aesthetic it gives to the place.

3.2.11 Aspects of color

The color white or near daylight is expressed with two features:

- The first feature is the appearance of the color of light.
- The second feature is color rendering.

3.2.11.1 Appearance of color

Expresses the apparent color (color) of light from the light source. It is measured by the expressed correlated colour temperature (TCP), and it is measured by Kelvin.

It is known that the appearance of the color of daylight varies throughout the day.

The appearance of the artificial light color is described in the following table.

Colour appearance	Correlated colour temperature T_{CP}
warm	below 3 300 K
intermediate	3 300 to 5 300 K
cool	above 5 300 K

Figure [14] - Light source color appearance combinations[European Committee for Standardization, DRAFT prEN 12464-1]

The choice of the luminous appearance of the luminescent source is related to several factors, most of which are psychologically dependent on the state in which the task is. The colours differ between warm in cases of rest and sleep or cold in cases of focus and activity. Currently, the color of the light source is given special importance as it affects the performance and productivity of people in performing tasks.

3.2.11.2 Color rendering

To provide an objective indicator of the color rendering properties of the light source, the Ra global color-rendering index is used. The maximum value of Ra is 100. The color rendition is also affected by the surrounding environment and visual vision. To get an accurate color for people and things, special color rendering index Ri must be observed.

3.2.12 Flicker

Flashing is one of the negative effects in the lighting field, as it has many disturbing effects, psychologically and physically, causing visual disturbance and fatigue, which is reflected in the performance of tasks, and may also cause headaches and fatigue. It can also cause malfunctions in the precision reciprocating machines, which requires precise lighting control Flash is expressed as a short-term flash index (Pst).

3.2.13 Discussion and conclusion:

By studying the different details of the standards mentioned in European Standard 12464. We note that they focus on some parameters more than others do, where standardization is one of the most important values that must be achieved in the design, taking into account the value of UGR and Ra. This gives the impression to the designers that these values are sufficient to achieve the objective of lighting. The standard mentions some criteria, but is not included in the design tables; they are notes or recommendations. This may not be apparent and surprising when the designer is novice or doesn't have enough details. Therefore, it is necessary to meet other standards, due to the development in the manufacture of lamps and changes in working environments. Where other criteria such as cylindrical illuminance and modelling are among the important criteria that must be taken into consideration, besides, the modelling standard is important, because it strikes a balance between direct lighting and diffuse lighting. We conclude from an analysis that Cylindrical illuminance is an essential aspect of lighting quality, but its usage is not very clear.

4- Photometric study for better lighting design:

4.1 Introduction

The introduction of updated standards such as medium-cylindrical Illuminance and modelling. This poses a new challenge for lighting designers. About the mechanism and method of measuring these new parameters, and how long it will take. As it is known that accurate field measurements require modern and accurate tools. It may be considered too expensive, which may be the reason why lighting designers and consulting firms are reluctant to focus on checking these standards. The most common way to check cylindrical illuminance values. It is by installing a small solid cube at the required measurement point and then measuring the illumination value on each side of this cube, respectively. Roland Low [Rowlands E and Loe D. 1975] used this method previously. Some researchers considered this method boring and time-consuming, which is reflected in the design costs as well. They did not comment on the difficulty of measurement, [Cuttle, C. 1997].

Therefore, we will try to make a hypothesis in this research about simulation by the Dialux program. This is based on previous research [Puech C, Sillion F and Vedel C. Prec of 1990]. The goal is to try to make the cylindrical illuminance characterization method easier for the designer while checking the effect of ceiling and wall reflections on cylindrical illuminance and modelling. Where some factors will be installed and the effect of the variable will be studied on the rest.

[James-Thomas Duff, Arup,Kevin Kelly DIT , 2015].

4.2 Idea generation

After reviewing the literature and publications that talk about standard values in determining the quality of lighting, and after an analytical study of European standards 12464. We found that each of the standards for cylindrical lighting and modelling, as well as factors for surface reflections, roofs, walls, and floors, play an important role in reaching Good and comfortable lighting. However, these standards are not used sufficiently, or even not mentioned when discussing any project. Rather, the idea of achieving the values of horizontal lighting and unification overwhelms the concept of achieving good lighting. The idea was to try to show the effect of these values on space, in an attempt to facilitate the assimilation of these standards and push towards their greater use. Where the verification method may be the obstacle to its use. Therefore, the idea is to set a model by the Dialux program for a room in which these values can be tested, through which values are measured, explaining how cylindrical lighting and modelling are measured, and studying the effect of changing factors of reflection of both walls and ceiling on these values.

In order for us to be able to make cylindrical illuminance measurements, we must take a look at the concept of illumination vector and cubic lighting, in terms of radiation distribution, here is a brief summary of the concept of measuring cylindrical illuminance.

4-2-1 The illumination vector

The vector is defined as a ray falling on a given point. It is composed of two compounds that can be analysed according to the X and Y-axes. The presence of a light source leads to the fall of several vectors at the point from different directions. This vector consists of two vehicles, to obtain the vector at this specific point; the arithmetic mean of the sum of the vectors at the specified point is calculated, by grouping the vehicles on the X and Y-axes. As shown in the following representative figure.

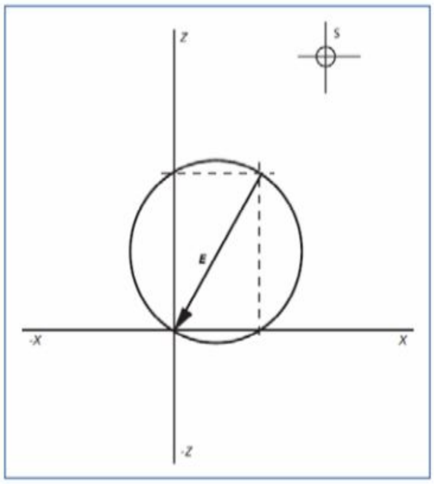


Figure [15] The illumination vector[James-Thomas Duff, Arup,Kevin Kelly DIT , 2015]

4-2-2 Cubic illuminance

Cubic illumination describes the intensity of illumination projected at a point in a vacuum, as it expresses the sum of the incident illumination on the six different faces of the cube. Where the rays consisting of three compounds converge on the X, Y, and Z-axes and perpendicular to the faces of the cube. As shown in the following figure.

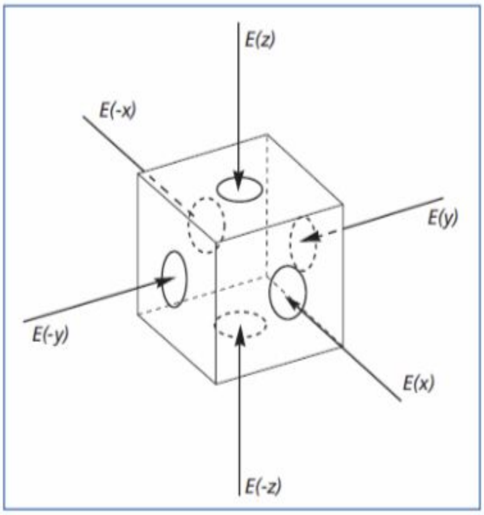
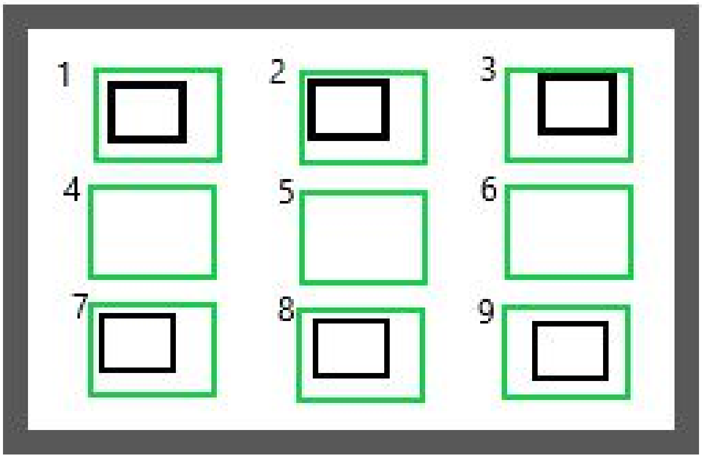


Figure [16] the illuminances on the six faces of cube [James-Thomas Duff, Arup,Kevin Kelly DIT , 2015].

4-3 Methodology

A virtual room has been created that will be used to prepare various tests for measuring cylindrical lighting and modelling while studying the effect of wall and ceiling reflection factors on them. The dimensions of this room are 6.1 m in length and 4.5 m in width with a height of 3.2 m. The ceiling and walls are painted with concrete; there are no windows or a source of daylight in the room, just virtual people. This room is lit by 35W LED lighting units (see Appendix):

1. The room is created using Dialux with the specified dimensions.
2. At least 9 points of measurement are specified, in which both cylindrical lighting and modelling are measured. As it did not mention in the standard the number or method of calculating the number of points required, or where it should be.
3. The Light Maintenance Factor (MF) in the Dialux model is set to 0.85.
4. Both cylindrical and horizontal lighting is measured. At the level of 1.2 m, 1.6 m with the representation of people by default in the sitting and standing situations.
5. The resulting modelling value is calculated and verified as the ratio of the horizontal illumination to the cylindrical illumination.
6. We will study the effect of changing ceiling and wall reflection factors on achieving the values required for modelling and cylindrical lighting.



Figure[17] the position of the measurement points (green rectangle) and the position of the fixtures (black square).

4-4 Study case

In this study, we will measure the value of cylindrical illuminance at the nine points specified in the room, as well as to measure the value of modelling, where the measurement is done at two different levels, the level of sitting at a height of 1.2m and the level of standing 1.6m. we will do different experiments.

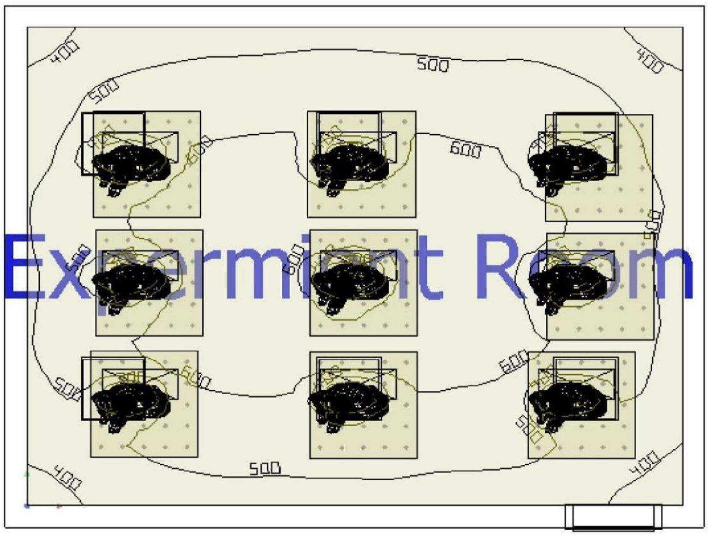


Figure [18] rendering of the room by dialux.

4-5 The test:

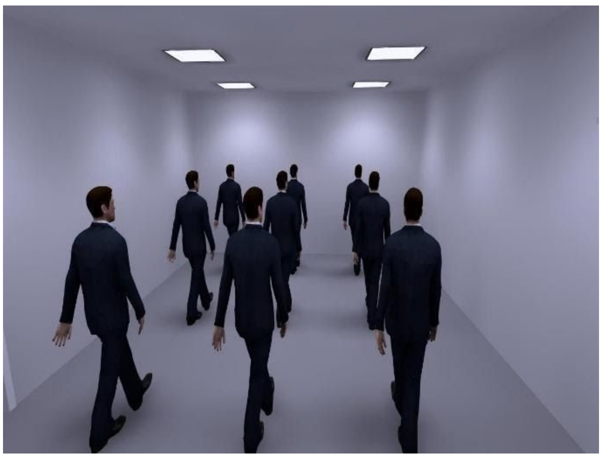
4-5-1 The first experiment:

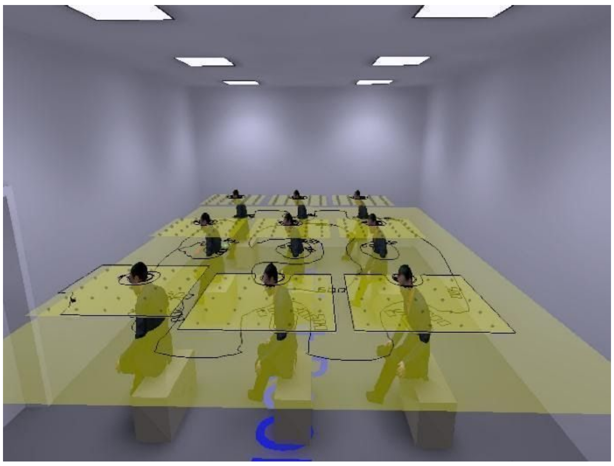
In this experiment, we will measure the value of cylindrical illuminance at the points specified in the room, as well as to measure the value of modelling, where the measurement is done at two different levels, the level of sitting at a height of 1.2m and the level of standing 1.6m. Constant values for the ceiling, wall, and floor reflection factors were adopted, as follows (see Appendix):

Room surface	ceiling	walls	floor
Reflector (%)	70	50	20

Point	Sitting			Standing		
	H	C	M	H	C	M
1	466	132	0,28	618	170	0,27
2	498	140	0,28	648	169	0,26
3	456	135	0,30	630	176	0,28
4	444	142	0,32	555	198	0,36
5	490	156	0,32	564	197	0,35
6	456	153	0,34	547	201	0,37
7	454	127	0,28	618	164	0,26
8	476	133	0,28	632	163	0,26
9	456	131	0,29	622	167	0,27

Table [1] result of the first experiment.





Picture [5a, 5b] rendering of the room on the sitting and standing level.

4-5-2 Discuss first results

Through checking the previous results, and in spite of achieving the required values for uniformity and horizontal illuminance in the room, as well as the values of cylindrical illuminance, the modelling value has not been reached which expresses the ratio of cylindrical illuminance to horizontal lighting. This is when taking the minimum reflection values factors of ceiling, walls, and floor reflection according to the recommended specifications. Where we note in each of the points measured at the level of sitting on a high 1,2m 1, 2,7,8,9. Modelling values have not been reached. As for the points 3,4,5,6, the minimum modelling values have been fulfilled. On the standing level on a high 1,6 m, we notice that 1,2,3,7,8,9 points have achieved the required percentage. While the required values were not reached in each of the remaining points 4, 5,6. Consequently, because of this experiment, it can be said that achieving the values recognized by designers may not achieve the values of the rest of the criteria, which necessitates modification to the design, such as raising the values of surface reflection factors. As the importance of reaching specific modelling values is indicative of the quality of the design. Construct modelling parameter values that help improve reading people's expressions and seeing things more clearly and naturally.

4-5-3 The second experiment:

In this experiment, the reflection factor values for both the ceiling, walls, and floor are raised to the following values, assuming that each of them is cleaned or coated with higher reflection materials. Where the previous accounts will recalculate, at the level of sitting and standing. The following table shows the calculated values by the Dialux module:

Room surface	**ceiling**	**walls**	**floor**
Reflector (%)	**80**	**60**	**20**

Point	Sitting			Standing		
	H	C	M	H	C	M
1	488	149	0,31	643	191	0,30
2	515	153	0,30	667	184	0,28
3	463	139	0,30	638	181	0,28
4	464	156	0,34	579	218	0,38
5	505	166	0,33	582	211	0,36
6	461	155	0,34	554	205	0,37
7	477	144	0,30	644	186	0,29
8	494	147	0,30	651	179	0,28
9	464	136	0,29	632	173	0,27

Table (2)

Room surface	ceiling	walls	floor
Reflector (%)	90	70	20

Point	Sitting			Standing		
	H	C	M	H	C	M
1	519	173	0,33	679	222	0,33
2	544	175	0,32	699	212	0,30
3	594	162	0,33	675	212	0,31
4	593	177	0,36	616	247	0,40
5	533	186	0,36	615	236	0,38
6	492	177	0,36	590	234	0,40
7	510	169	0,33	681	217	0,32
8	524	169	0,32	685	208	0,30
9	494	157	0,32	668	202	0,30

table (3)

Table [2+3] result of the second experiment where we change the reflector of the wall and the ceiling.

4-5-4 Discuss second results

In this experiment, the objective is to study the effect of raising the value of the reflection factor of ceiling and walls. Where two cases of different values of the ceiling and wall reflection factor were studied. We note that with the increase in the value of the reflection factor in the first case, and in both the sitting and standing levels. Cylindrical illuminance and modeling values were reached at all points except one or two points. In the second case, the value of cylindrical illuminance and modeling was reached at all points. The highest modelling value was 0.40, the lowest was 0.30. Also Raising the value of surface reflection factors led to an increase in the value of cylindrical illuminance from the value of 139 to 189 at the sitting level, but on the level of parking the value has increased Cylindrical illuminance from 173 to 247 lux. Not only did the cylindrical lighting increase, but also the horizontal illuminance increased, so the value on the worktop increased by 0.85 m, from 550 lux to 600 lux. The uniformity value also increased from 0.58 to 0.66. The lighting on the walls and ceiling also improved.

We extract from these values the importance of surface reflection factors in place to reach a good lighting distribution and achieve all the recommended standards of European standards values. Achieving a comfortable visual vision and creating an environment with a harmonious atmosphere motivates people and creates comfort. We note that it is easy to achieve the values of cylindrical illuminance, while Modelling values are required either after modifications or after improvement in the surrounding environment.

4-5-5 Third experiment

This experiment has two parts. In the first part, we will keep the ceiling reflectance value constant and change the wall reflectance values. In the second part, we change the ceiling reflection values and keep the wall reflection value constant.

points	sitting						standing					
Wall Reflector %	40	50	60	70	80	90	40	50	60	70	80	90
1	0,27	0,29	0,32	0,34	0,37	0,41	0,26	0,28	0,31	0,34	0,38	0,42
2	0,26	0,29	0,31	0,33	0,36	0,39	0,25	0,27	0,30	0,32	0,36	0,39
3	0,26	0,29	0,31	0,34	0,38	0,41	0,24	0,27	0,30	0,33	0,37	0,41
4	0,31	0,33	0,35	0,38	0,40	0,43	0,35	0,37	0,40	0,43	0,46	0,50
5	0,31	0,33	0,35	0,37	0,39	0,42	0,34	0,36	0,39	0,41	0,44	0,48
6	0,31	0,33	0,36	0,38	0,41	0,44	0,34	0,36	0,39	0,42	0,45	0,49
7	0,26	0,29	0,31	0,34	0,38	0,41	0,25	0,28	0,31	0,34	0,38	0,42
8	0,26	0,28	0,31	0,34	0,36	0,40	0,24	0,27	0,29	0,32	0,35	0,39
9	0,26	0,28	0,31	0,34	0,37	0,40	0,24	0,26	0,29	0,32	0,35	0,39
Average	0,277	0,301	0,325	0,351	0,38	0,412	0,278	0,305	0,331	0,358	0,393	0,432

Table [4] the result of part 1 of the third experiment where we will keep the ceiling reflectance value constant and change the wall reflectance values.

points	sitting						standing					
Ceiling Reflector %	40	50	60	70	80	90	40	50	60	70	80	90
1	0,29	0,29	0,29	0,29	0,29	0,29	0,28	0,28	0,28	0,29	0,29	0,29
2	0,28	0,29	0,29	0,29	0,29	0,29	0,27	0,27	0,27	0,27	0,27	0,28
3	0,28	0,29	0,29	0,29	0,29	0,29	0,27	0,27	0,27	0,27	0,28	0,28
4	0,33	0,33	0,33	0,33	0,33	0,33	0,37	0,37	0,37	0,37	0,37	0,37
5	0,33	0,33	0,33	0,33	0,33	0,33	0,36	0,36	0,36	0,36	0,36	0,36
6	0,33	0,33	0,33	0,33	0,33	0,34	0,36	0,36	0,36	0,36	0,37	0,37
7	0,29	0,29	0,29	0,29	0,29	0,29	0,28	0,28	0,28	0,28	0,28	0,28
8	0,28	0,28	0,29	0,29	0,29	0,29	0,26	0,27	0,27	0,27	0,27	0,27
9	0,28	0,28	0,29	0,29	0,29	0,29	0,26	0,26	0,27	0,27	0,27	0,28
Average	0,298	0,301	0,303	0,303	0,303	0,305	0,301	0,301	0,303	0,304	0,306	0,308

Table [5] the result part 2 of the third experiment where we will keep the wall reflectance value constant and change the ceiling reflectance values.

4-5-6 Discussion results of the third experiment

Through the results that we obtained, we note that changing the walls reflection factors and keeping the ceiling reflection factor constant, has a significant impact on raising the value of cylindrical lighting and modelling, where we obtained a value of 0.5 for the modelling at the value of the wall reflection factor 90% and the fixed ceiling reflection factor 60%. While raising the ceiling reflection factor value to 90 while maintaining the wall reflection factor 50%, the highest modelling value was 0.37. Changing the ceiling reflection did not achieve the required modelling values except in the 5,6,7 centre points, while the modelling values remained in the rest of the points did not achieve the required values. It is noticeable that, with the reflectance values of the walls 60% and above all the measurement points, that modelling value achieved above or equal to 0.3. The following diagram shows the average modelling values for each experiment:

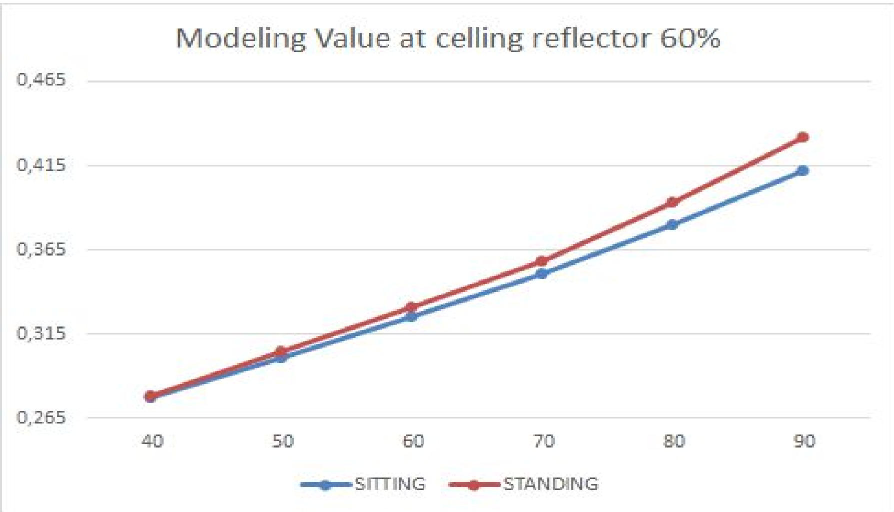


Figure [19] the chart shows a graphic representation of the results of the first part of the third experiment

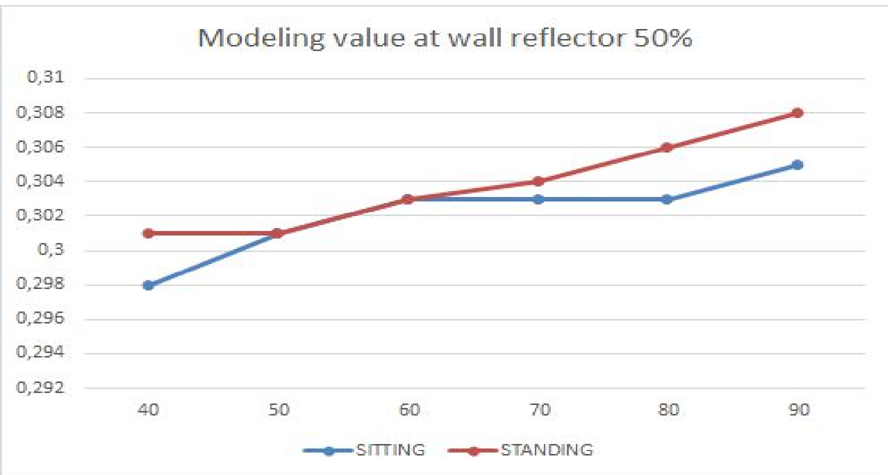


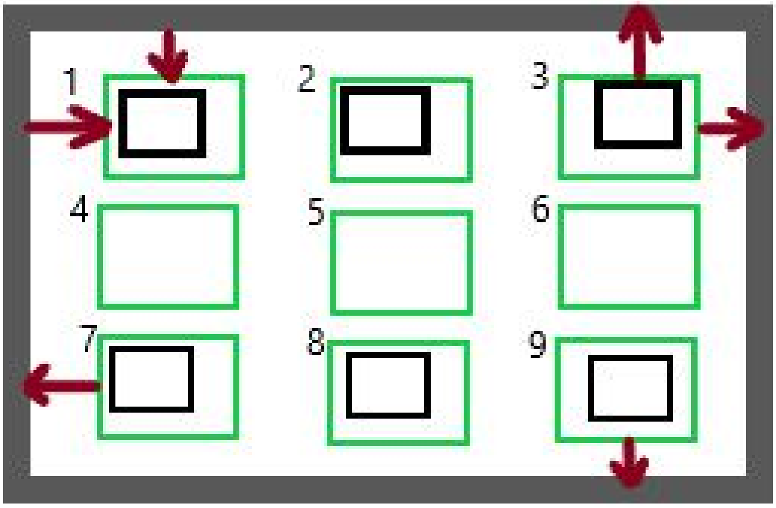
Figure [20] the chart shows a graphic representation of the results of the second part of the third experiment

4-5-7 The fourth experiment:

In this experiment, we will study the effect of changing the arrangement of the position of measurement points and the position of lights fixtures on cylindrical illuminance and modelling. Where we will repeat the last test where the reflection of the walls is 90% and the ceiling is 60%. In this test, we obtained the highest modelling value of 0.5.

points	sitting			standing		
	H	C	M	H	C	M
1	666	271	0,41	775	323	0,42
2	668	262	0,39	773	302	0,39
3	635	262	0,41	766	314	0,41
4	658	284	0,43	687	344	0,50
5	657	276	0,42	688	328	0,48
6	622	273	0,44	682	334	0,49
7	646	264	0,41	770	320	0,42
8	645	255	0,40	763	298	0,39
9	600	238	0,40	752	292	0,39

Table [6] the result part 2 of the third experiment where we change wall reflector 90% and ceiling reflector 60% .



Figure[20] then new position of the measurement points (green rectangle) and the position of the fixtures (black square).

points	sitting			standing		
	H	C	M	H	C	M
1	687	306	0,45	697	339	0,49
2	668	262	0,39	773	302	0,39
3	612	283	0,46	709	322	0,45
4	658	284	0,43	687	344	0,50
5	657	276	0,42	688	328	0,48
6	622	273	0,44	682	334	0,49
7	647	268	0,41	775	321	0,41
8	645	255	0,40	763	298	0,39
9	564	243	0,43	674	288	0,43

Table [7] the result part 1 of the fourth experiment where we change the point's measurement position and keep the fixture position constants.

4-5-8 Discussion results of the part 1 of fourth experiment

The first part, we will change the position of the measurement points for each of the points 1,3,7,9. we note that the values increased in each of the points 1, 3, 9 as the value of the cylindrical illuminance increased and the modelling increased. As for point 9, the change was not clear. In point (1), we increased the distance from the walls in the direction of the interior, as it approached the centre, and the values of cylindrical illuminance and modelling were improved. Point 3 we decrease the dimension, as it becomes closer to the wall. Cylindrical illuminance and modelling improved despite the decrease in the value of cylindrical illuminance. Point seven we reduced the dimension from the wall while preserving the other dimension as before. There was no significant change in the cylindrical illuminance and modelling. As for point 9, the dimension was diminished in the other direction, opposite to point 7, while maintaining the other dimension as previously. Both cylindrical illuminance and modelling were improved, and it is noticeable that the horizontal illuminance value decreases.

points	sitting			standing		
	H	C	M	H	C	M
1	634	257	0,41	746	310	0,41
2	567	274	0,48	537	310	0,58
3	696	283	0,41	827	350	0,42
4	687	283	0,41	738	348	0,47
5	668	267	0,40	737	328	0,44
6	645	290	0,45	667	348	0,52
7	726	278	0,38	887	353	0,40
8	515	264	0,51	482	297	0,62
9	653	251	0,38	815	314	0,39

Table [8] the result part 1 of the fourth experiment where we change fixture position and keep the points measurement position constants.

4-5-9 Discussion results of the part 2 of fourth experiment

In this second part, we changed the arrangement of the light fixtures, instead of them being two rows, we made them like ches. We repeated the previous experiment, while maintaining the position of the measurement points as before. We notice that we got high values for modelling and cylindrical illuminance, at the standing level we got two high values of 0.58 at the measurement point 2, and at the measurement point 8, we got a value of 0.62. Likewise, at the sitting level, we obtained a modelling value of 0.51, at point 8. By checking, we note that the points that became positioned under the fixture decreased the modelling and cylindrical illumination values, which are points 4, 6. Where the lighting distribution changed because of changing arrangement of fixtures in the room. As for points 2.8, the values increased significantly and close to the recommended higher values. As these two points became positioned between the light fixtures. where a suitable distribution and a good cylindrical illuminance ratio to the horizontal illuminance, which is the modelling.

Note that the average modelling increased when changing the arrangement of the light fixtures. It increased from the value of 0.412 in the sitting level to 0.425. It also increased at the standing level from 0.432 to 0.472. (See Appendix).

5. Conclusion:

5.1 Discussion and conclusion:

The main objective of this study is to highlight the less used parameters of the European lighting standard 12464 for the indoor environment. Therefore, that requires conducting a review study of previous research and publications related to describing lighting quality. In addition to an analytical study of the current standard specifications, 12464. We note that previous literature made efforts to define the concept of lighting quality. Where updates to this concept were consecutive through researchers, starting with the concept that was limited to achieving lighting, that helps people in performing tasks without linking it to any other factors. Then, they developed the concept of lighting quality. and linking it to psychological and physical factors. This led to the emergence of other criteria that contribute more to achieving the desired goal. then it appeared the concept of standards. Where it only recommends achieving an equal level of illumination in place, i.e. uniformity, or the achievement of horizontal lighting values required to link it to the concept of color vision and distinction. The concept was then developed to reach lighting that creates a comfortable visual vision that motivates people. CCT and CRI standards. Aims to create lighting that is closer to natural lighting. Among the latest updates to these standards were the cylindrical illuminance and modeling. Many studies examined these two criteria, but the designers' lack of use created a catalyst for researching the details of these two criteria and the mechanism of their use. and their measurement through reality or simulation programs. Simplifying the understanding of these standards and finding an easy way to measure, they would motivate the designer to adopt them. Since Dialux provides the ability to quickly and easily measure, a lack of awareness among designers of the benefits of these two criteria may be the reason for not using it. In this Thesis, we created a model that demonstrates how to measure cylindrical illuminance and modeling with Dialux. The study was also conducted on the effect of raising ceiling and wall reflection factors on cylindrical and horizontal illuminance values and modeling. The results were positive, as cylindrical lighting, modeling, and horizontal lighting increased by increasing the value of surface reflection factors while adhering to the recommended values.

We conclude that the brighter walls have a greater impact on the values of cylindrical illuminance and modeling than the effect of ceiling brightness. Therefore, it can be said that bright walls lead to high values of modeling and cylindrical lighting. Which achieves the desired goal. We also found that the values of modeling and cylindrical illuminance are achieved when the measurement point does not fall directly under the light fixtures, where we found that the highest values of modeling and cylindrical illuminance are achieved in the center of the room between electric fixtures.

We can be concluded that the distribution of light fixtures has a significant impact on the values of cylindrical illuminance and modeling. We can say that the arrangement of lamps in the traditional way, regular rows, is not the best distribution because this method does not achieve the values of cylindrical illuminance and modeling at the measurement points on the ends.

5-2 limitation in measurement

The difficulties with this method are that the values are all simulated values since the reflectance values for the ceiling, walls, and floor are set according to European standards. The space we tested is suitable for various activities, such as a classroom, office, or meeting room. No furniture was placed in the room, only people were assumed to be in the room, and each person was considered a reference measurement point for the valuesof all horizontal and cylindrical lighting, including modeling value. Consequently, there might be a slight difference if the people in the field measurements, caused by the reflection of the lighting of the people. The advantage of this measurement method is the time it takes to collect and compare data, since in this area with nine reference points, it takes about an hour to collect data to make the required comparison to change the reflection factor in the ceiling or wall, but it requires accuracy and definition of the points required to measure. We did not mention the daylight or the effect of the windows if they found it. It was also a problem with time, as Corona disease appeared, so we couldn't make real measurements.

5-3 Future work:

After we discussed the importance of cylindrical lighting and its influence in lighting design. This opens the way for research and study, in terms of finding mechanisms to make cylindrical lighting easier to measure through computer programs available in this regard. The default measurements must be accompanied by field measurements on the site to confirm the effectiveness and feasibility of the calculations through programs. The manual calculation requires mathematical equations to get to the required values, so developing a way to reach simple values more easily may be the focus of a future study as well. Making values easy and more comprehensible motivates designers to observe them in any future design. Achieving the required values would make the design more impressive and achieve visual comfort

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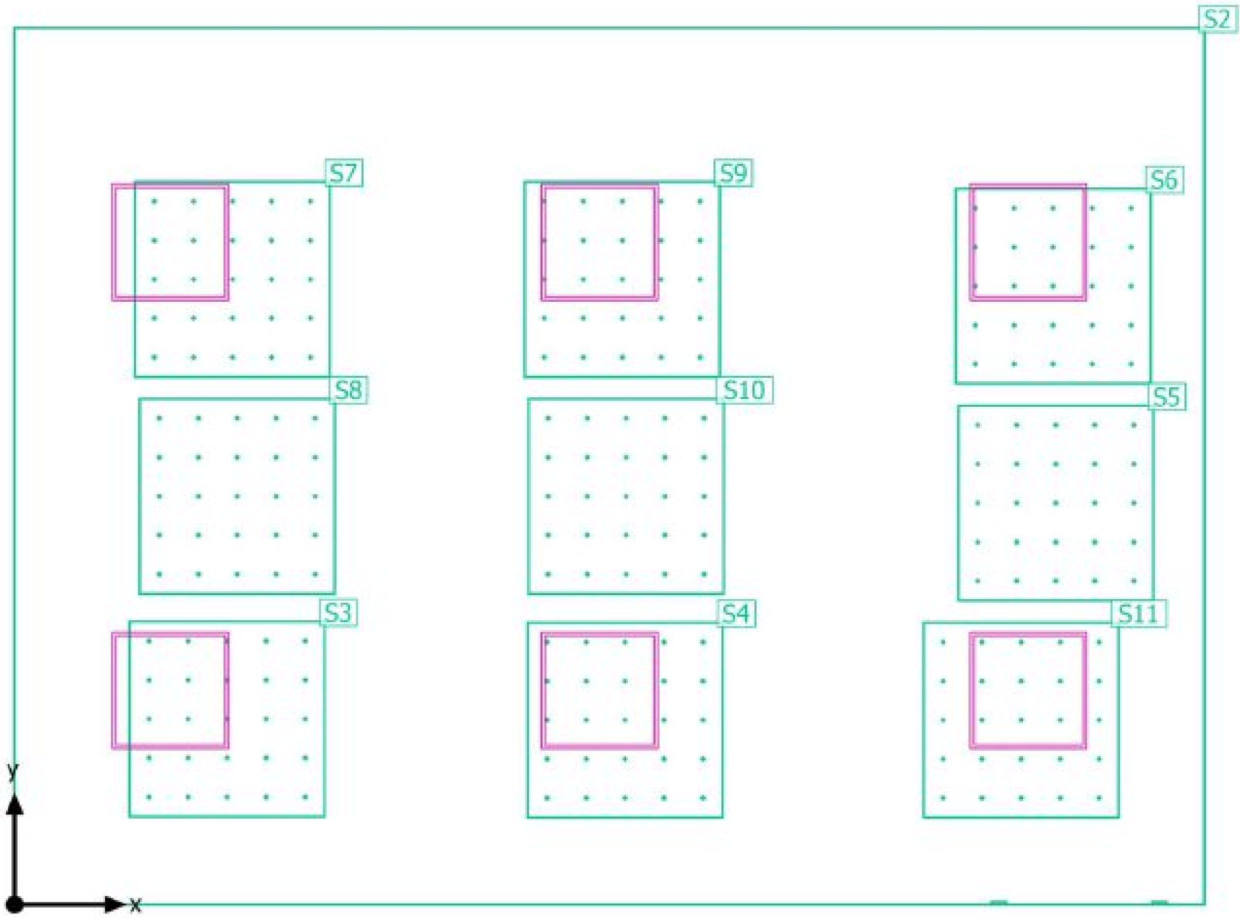
Appendix

1- Rustle of the first experiment where the reflector factors are: wall 60%, ceiling 80%, floor 20%.

1-Sitting level:



Work planes

Properties	Ē (Target)	Emin	Emax	g1	g2	Index
Workplane (Expermient Room) Perpendicular illuminance (adaptive) Height: 0.850 m, Wall zone: 0.000 m	459 lx (≥ 500 lx) ✗	96.7 lx	598 lx	0.21	0.16	S2

Areas of activity

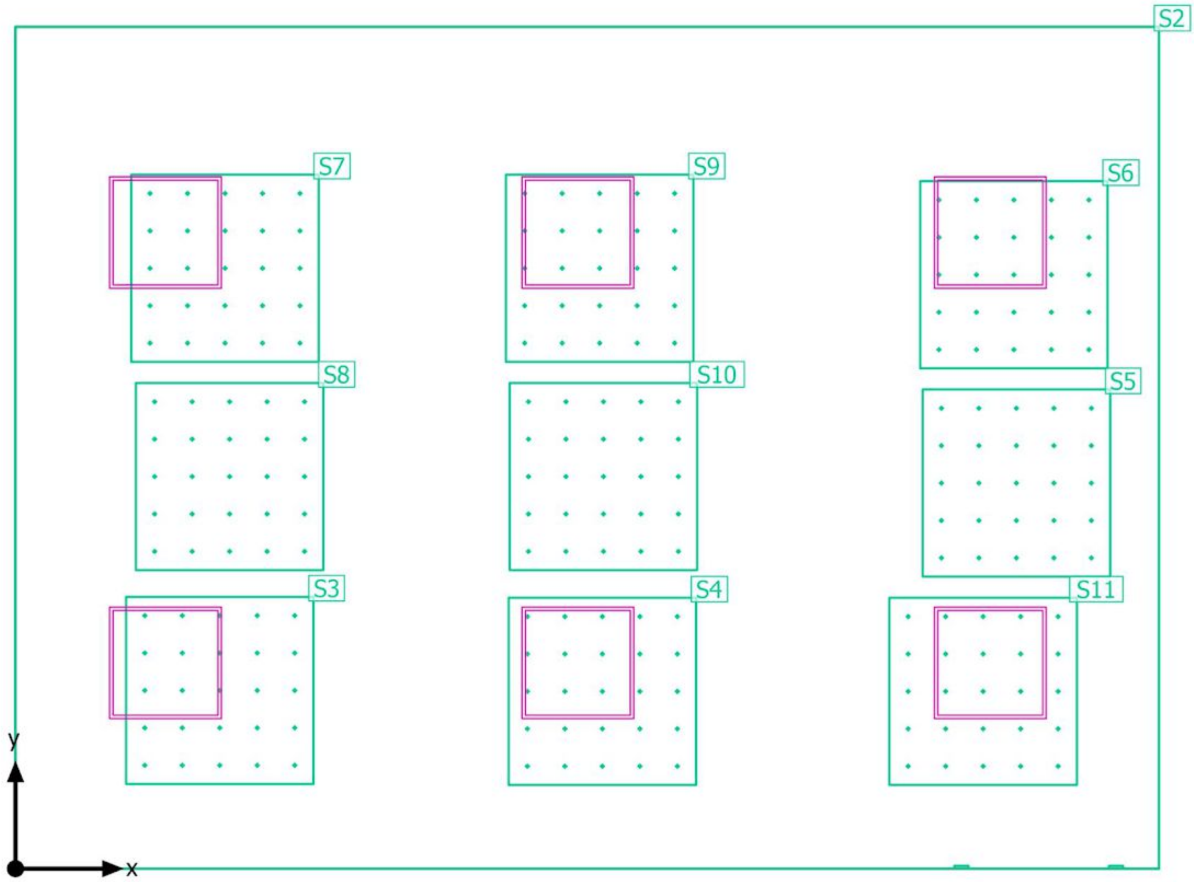
Properties	Ø (Target)	min	max	g1	g2	Index
Area of activity 7 Horizontal illuminance Height: 1.200 m	477 lx (≥ 50.0 lx) ✓	0.00 lx	605 lx	0.00	0.00	S3
Area of activity 7 Cylindrical illuminance Height: 1.200 m	144 lx (≥ 50.0 lx) ✓	0.00 lx	192 lx	0.00	0.00	S3
Area of activity 7 Modelling	0.30 [0.30 - 0.60] ✗	-	0.32	-	-	S3
Area of activity 8 Horizontal illuminance Height: 1.200 m	494 lx (≥ 50.0 lx) ✓	0.00 lx	627 lx	0.00	0.00	S4
Area of activity 8 Cylindrical illuminance Height: 1.200 m	147 lx (≥ 50.0 lx) ✓	0.00 lx	188 lx	0.00	0.00	S4
Area of activity 8 Modelling	0.30 [0.30 - 0.60] ✗	-	0.30	-	-	S4
Area of activity 6 Horizontal illuminance Height: 1.200 m	461 lx (≥ 50.0 lx) ✓	0.00 lx	572 lx	0.00	0.00	S5
Area of activity 6 Cylindrical illuminance Height: 1.200 m	155 lx (≥ 50.0 lx) ✓	0.00 lx	187 lx	0.00	0.00	S5

Properties	Ø (Target)	min	max	g_1	g_2	Index
Area of activity 6 Modelling	0.34 [0.30 - 0.60] ✓	-	0.33	-	-	S5
Area of activity 3 Horizontal illuminance Height: 1.200 m	463 lx (≥ 50.0 lx) ✓	0.00 lx	594 lx	0.00	0.00	S6
Area of activity 3 Cylindrical illuminance Height: 1.200 m	139 lx (≥ 50.0 lx) ✓	0.000 lx	185 lx	0.00	0.00	S6
Area of activity 3 Modelling	0.30 [0.30 - 0.60] ✗	-	0.31	-	-	S6
Area of activity 1 Horizontal illuminance Height: 1.200 m	488 lx (≥ 50.0 lx) ✓	0.00 lx	607 lx	0.00	0.00	S7
Area of activity 1 Cylindrical illuminance Height: 1.200 m	149 lx (≥ 50.0 lx) ✓	0.00 lx	208 lx	0.00	0.00	S7
Area of activity 1 Modelling	0.31 [0.30 - 0.60] ✓	-	0.34	-	-	S7
Area of activity 4 Horizontal illuminance Height: 1.200 m	464 lx (≥ 50.0 lx) ✓	0.00 lx	605 lx	0.00	0.00	S8
Area of activity 4 Cylindrical illuminance Height: 1.200 m	156 lx (≥ 50.0 lx) ✓	0.00 lx	216 lx	0.00	0.00	S8
Area of activity 4 Modelling	0.34 [0.30 - 0.60] ✓	-	0.36	-	-	S8
Area of activity 2 Horizontal illuminance Height: 1.200 m	515 lx (≥ 50.0 lx) ✓	0.00 lx	624 lx	0.00	0.00	S9

Properties	Ø (Target)	min	max	g_1	g_2	Index
Area of activity 2 Cylindrical illuminance Height: 1.200 m	153 lx (≥ 50.0 lx) ✓	0.00 lx	202 lx	0.00	0.00	S9
Area of activity 2 Modelling	0.30 [0.30 - 0.60] ✗	-	0.32	-	-	S9
Area of activity 5 Horizontal illuminance Height: 1.200 m	505 lx (≥ 50.0 lx) ✓	0.00 lx	617 lx	0.00	0.00	S10
Area of activity 5 Cylindrical illuminance Height: 1.200 m	166 lx (≥ 50.0 lx) ✓	0.00 lx	209 lx	0.00	0.00	S10
Area of activity 5 Modelling	0.33 [0.30 - 0.60] ✓	-	0.34	-	-	S10
Area of activity 9 Horizontal illuminance Height: 1.200 m	464 lx (≥ 50.0 lx) ✓	0.00 lx	606 lx	0.00	0.00	S11
Area of activity 9 Cylindrical illuminance Height: 1.200 m	136 lx (≥ 50.0 lx) ✓	0.00 lx	179 lx	0.00	0.00	S11
Area of activity 9 Modelling	0.29 [0.30 - 0.60] ✗	-	0.30	-	-	S11

Utilisation profile: DIALux presetting, Standard (office)

1-Standing level:



Work planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1	g_2	Index
Workplane (Expermient Room) Perpendicular illuminance (adaptive) Height: 0.850 m, Wall zone: 0.000 m	459 lx (≥ 500 lx) ✗	96.7 lx	598 lx	0.21	0.16	S2

Areas of activity

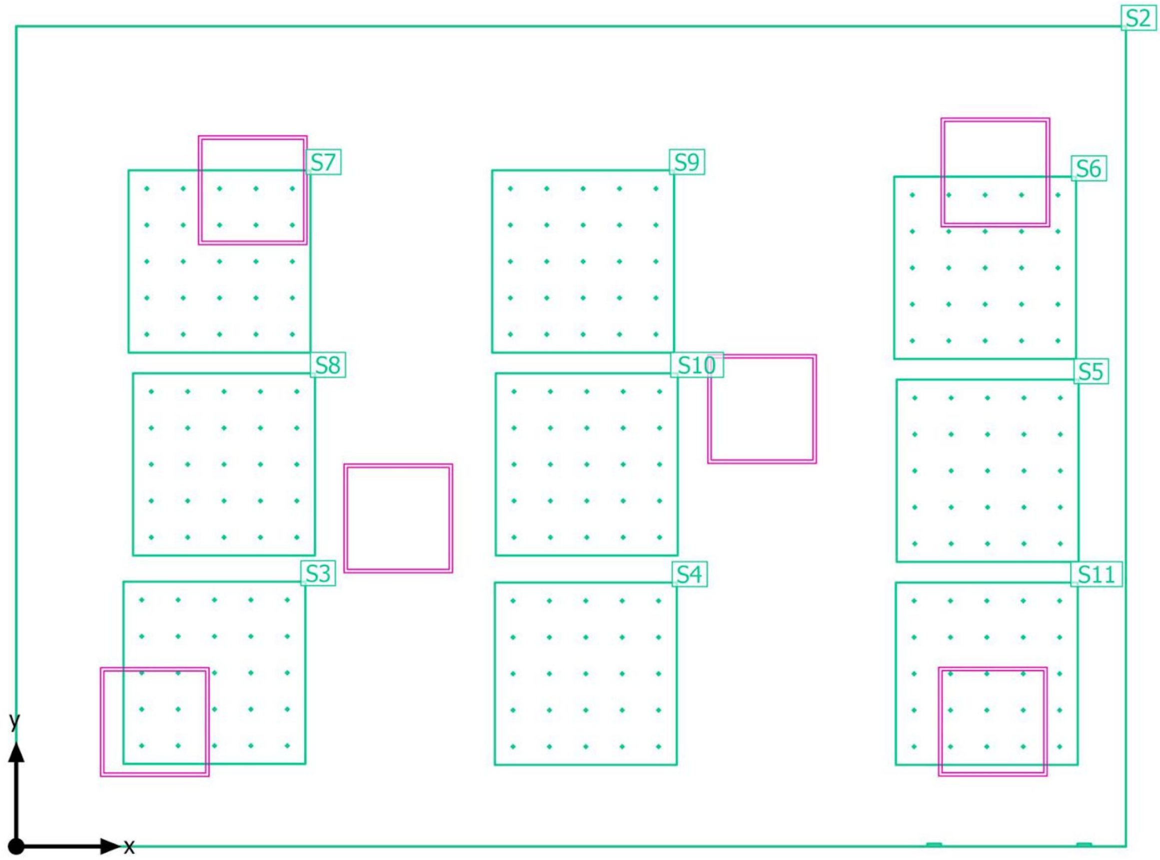
Properties	⌀ (Target)	min	max	g_1	g_2	Index
Area of activity 7 Horizontal illuminance Height: 1.600 m	644 lx (≥ 50.0 lx) ✓	0.035 lx	743 lx	0.000	0.000	S3
Area of activity 7 Cylindrical illuminance Height: 1.600 m	186 lx (≥ 50.0 lx) ✓	0.00 lx	225 lx	0.00	0.00	S3
Area of activity 7 Modelling	0.29 [0.30 - 0.60] ✗	0.00	0.30	-	-	S3
Area of activity 8 Horizontal illuminance Height: 1.600 m	651 lx (≥ 50.0 lx) ✓	0.013 lx	746 lx	0.000	0.000	S4
Area of activity 8 Cylindrical illuminance Height: 1.600 m	179 lx (≥ 50.0 lx) ✓	0.006 lx	211 lx	0.000	0.000	S4
Area of activity 8 Modelling	0.28 [0.30 - 0.60] ✗	0.28	0.45	-	-	S4
Area of activity 6 Horizontal illuminance Height: 1.600 m	554 lx (≥ 50.0 lx) ✓	0.007 lx	673 lx	0.000	0.000	S5
Area of activity 6 Cylindrical illuminance Height: 1.600 m	205 lx (≥ 50.0 lx) ✓	0.011 lx	227 lx	0.000	0.000	S5

Properties	Ø (Target)	min	max	g_1	g_2	Index
Area of activity 6 Modelling	0.37 [0.30 - 0.60] ✓	-	0.34	-	-	S5
Area of activity 3 Horizontal illuminance Height: 1.600 m	638 lx (≥ 50.0 lx) ✓	0.029 lx	723 lx	0.000	0.000	S6
Area of activity 3 Cylindrical illuminance Height: 1.600 m	181 lx (≥ 50.0 lx) ✓	0.011 lx	213 lx	0.000	0.000	S6
Area of activity 3 Modelling	0.28 [0.30 - 0.60] ✗	0.30	0.37	-	-	S6
Area of activity 1 Horizontal illuminance Height: 1.600 m	643 lx (≥ 50.0 lx) ✓	0.018 lx	741 lx	0.000	0.000	S7
Area of activity 1 Cylindrical illuminance Height: 1.600 m	191 lx (≥ 50.0 lx) ✓	0.005 lx	233 lx	0.000	0.000	S7
Area of activity 1 Modelling	0.30 [0.30 - 0.60] ✗	0.29	0.31	-	-	S7
Area of activity 4 Horizontal illuminance Height: 1.600 m	579 lx (≥ 50.0 lx) ✓	362 lx	672 lx	0.63	0.54	S8
Area of activity 4 Cylindrical illuminance Height: 1.600 m	218 lx (≥ 50.0 lx) ✓	146 lx	239 lx	0.67	0.61	S8
Area of activity 4 Modelling	0.38 [0.30 - 0.60] ✓	0.36	0.40	-	-	S8
Area of activity 2 Horizontal illuminance Height: 1.600 m	667 lx (≥ 50.0 lx) ✓	0.005 lx	739 lx	0.000	0.000	S9

Properties	Ø (Target)	min	max	g_1	g_2	Index
Area of activity 2 Cylindrical illuminance Height: 1.600 m	184 lx (≥ 50.0 lx) ✓	0.016 lx	222 lx	0.000	0.000	S9
Area of activity 2 Modelling	0.28 [0.30 - 0.60] ✗	-	0.30	-	-	S9
Area of activity 5 Horizontal illuminance Height: 1.600 m	582 lx (≥ 50.0 lx) ✓	0.016 lx	684 lx	0.000	0.000	S10
Area of activity 5 Cylindrical illuminance Height: 1.600 m	211 lx (≥ 50.0 lx) ✓	0.008 lx	237 lx	0.000	0.000	S10
Area of activity 5 Modelling	0.36 [0.30 - 0.60] ✓	0.35	0.52	-	-	S10
Area of activity 9 Horizontal illuminance Height: 1.600 m	632 lx (≥ 50.0 lx) ✓	0.011 lx	728 lx	0.000	0.000	S11
Area of activity 9 Cylindrical illuminance Height: 1.600 m	173 lx (≥ 50.0 lx) ✓	0.022 lx	204 lx	0.000	0.000	S11
Area of activity 9 Modelling	0.27 [0.30 - 0.60] ✗	0.28	1.97	-	-	S11

Utilisation profile: DIALux presetting, Standard (office)

2: Results of Fourth experiment part 2:



Building 1 · Storey 1 · Expermient Room

Calculation objects

Work planes

Properties	Ē (Target)	E_{min}	E_{max}	g_1	g_2	Index
Workplane (Expermient Room) Perpendicular illuminance (adaptive) Height: 0.850 m, Wall zone: 0.000 m	567 lx (≥ 500 lx) ✓	196 lx	731 lx	0.35	0.27	S2

Areas of activity

Properties	Ø (Target)	min	max	g_1	g_2	Index
Area of activity 7 Horizontal illuminance Height: 1.600 m	887 lx (≥ 50.0 lx) ✓	790 lx	945 lx	0.89	0.84	S3
Area of activity 7 Cylindrical illuminance Height: 1.600 m	353 lx (≥ 50.0 lx) ✓	337 lx	362 lx	0.95	0.93	S3
Area of activity 7 Modelling	0.40 [0.30 - 0.60] ✓	0.38	0.43	-	-	S3
Area of activity 8 Horizontal illuminance Height: 1.600 m	482 lx (≥ 50.0 lx) ✓	339 lx	667 lx	0.70	0.51	S4
Area of activity 8 Cylindrical illuminance Height: 1.600 m	297 lx (≥ 50.0 lx) ✓	270 lx	318 lx	0.91	0.85	S4
Area of activity 8 Modelling	0.62 [0.30 - 0.60] ✗	0.48	0.79	-	-	S4
Area of activity 6 Horizontal illuminance Height: 1.600 m	667 lx (≥ 50.0 lx) ✓	544 lx	784 lx	0.82	0.69	S5
Area of activity 6 Cylindrical illuminance Height: 1.600 m	348 lx (≥ 50.0 lx) ✓	334 lx	358 lx	0.96	0.93	S5

Properties	Ø (Target)	min	max	g_1	g_2	Index
Area of activity 6 Modelling	0.52 [0.30 - 0.60] ✓	0.46	0.61	-	-	S5
Area of activity 3 Horizontal illuminance Height: 1.600 m	827 lx (≥ 50.0 lx) ✓	645 lx	917 lx	0.78	0.70	S6
Area of activity 3 Cylindrical illuminance Height: 1.600 m	350 lx (≥ 50.0 lx) ✓	327 lx	360 lx	0.93	0.91	S6
Area of activity 3 Modelling	0.42 [0.30 - 0.60] ✓	0.39	0.51	-	-	S6
Area of activity 1 Horizontal illuminance Height: 1.600 m	746 lx (≥ 50.0 lx) ✓	595 lx	824 lx	0.80	0.72	S7
Area of activity 1 Cylindrical illuminance Height: 1.600 m	310 lx (≥ 50.0 lx) ✓	279 lx	336 lx	0.90	0.83	S7
Area of activity 1 Modelling	0.41 [0.30 - 0.60] ✓	0.41	0.47	-	-	S7
Area of activity 4 Horizontal illuminance Height: 1.600 m	738 lx (≥ 50.0 lx) ✓	582 lx	881 lx	0.79	0.66	S8
Area of activity 4 Cylindrical illuminance Height: 1.600 m	348 lx (≥ 50.0 lx) ✓	335 lx	358 lx	0.96	0.94	S8
Area of activity 4 Modelling	0.47 [0.30 - 0.60] ✓	0.41	0.58	-	-	S8
Area of activity 2 Horizontal illuminance Height: 1.600 m	537 lx (≥ 50.0 lx) ✓	404 lx	695 lx	0.75	0.58	S9

Properties	Ø (Target)	min	max	g_1	g_2	Index
Area of activity 2 Cylindrical illuminance Height: 1.600 m	310 lx (≥ 50.0 lx) ✓	287 lx	333 lx	0.93	0.86	S9
Area of activity 2 Modelling	0.58 [0.30 - 0.60] ✓	0.48	0.71	-	-	S9
Area of activity 5 Horizontal illuminance Height: 1.600 m	737 lx (≥ 50.0 lx) ✓	682 lx	785 lx	0.93	0.87	S10
Area of activity 5 Cylindrical illuminance Height: 1.600 m	325 lx (≥ 50.0 lx) ✓	310 lx	333 lx	0.95	0.93	S10
Area of activity 5 Modelling	0.44 [0.30 - 0.60] ✓	0.42	0.45	-	-	S10
Area of activity 9 Horizontal illuminance Height: 1.600 m	815 lx (≥ 50.0 lx) ✓	698 lx	882 lx	0.86	0.79	S11
Area of activity 9 Cylindrical illuminance Height: 1.600 m	314 lx (≥ 50.0 lx) ✓	284 lx	341 lx	0.90	0.83	S11
Area of activity 9 Modelling	0.39 [0.30 - 0.60] ✓	0.39	0.41	-	-	S11

Utilisation profile: DIALux presetting, Standard (office)

3:Fixtures data sheet:

Product data sheet

FAGERHULT Multilume Flat Delta VTB 4000K Ra90

Article No.	23784
P	36.0 W
Φ_{Lamp}	3804 lm
$\Phi_{Luminaire}$	3803 lm
η	99.97 %
Luminous efficacy	105.6 lm/W
CCT	4000 K
CRI	90

Installation

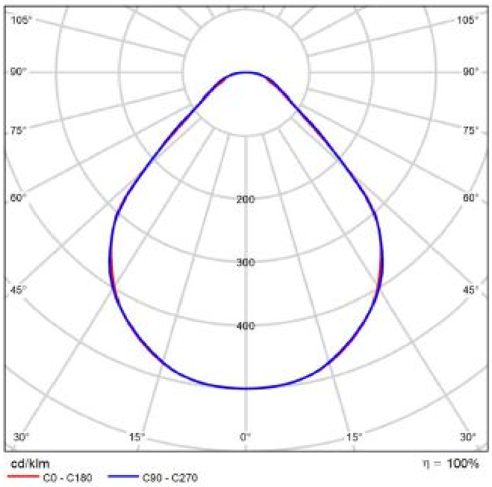
Recessed mounting in ventilated or unventilated suspended ceilings. Two optional designs.
VTB - for suspended ceilings with visible T-bars 25 mm. 300x300 also for fixed suspended ceilings.
HB - for suspended ceiling with concealed T-bars. Supplement with fixing brackets for fixed suspended ceiling, see accessories.
The luminaire must not be covered with insulation. For further details please refer to the assembly instructions on our website

Connection

nection in ballast box. The ballast box can be detached and positioned next to the luminaire. Snap-in terminal block 3x1,5?mm² (5x1,5?mm² where dimming is required). Through-wiring possible for 600x600.

Design

Luminaire body in white enamelled sheet steel (RAL 9016).



Polar LDC

Glare evaluation according to UGR

ρ Ceiling		70	70	50	50	30	70	70	50	50	30
ρ Walls		50	30	50	30	30	50	30	50	30	30
ρ Floor		20	20	20	20	20	20	20	20	20	20
Room size X	Y	Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis				
2H	2H	14.8	16.0	15.1	16.2	16.4	14.8	15.9	15.1	16.1	16.4
	3H	15.4	16.4	15.7	16.7	17.0	15.4	16.5	15.7	16.7	17.0
	4H	15.8	16.7	16.1	17.0	17.3	15.8	16.8	16.1	17.1	17.3
	6H	16.2	17.1	16.5	17.4	17.7	16.2	17.1	16.6	17.4	17.7
	8H	16.4	17.3	16.8	17.6	17.9	16.4	17.3	16.8	17.6	17.9
	12H	16.6	17.5	17.0	17.8	18.1	16.6	17.4	16.9	17.7	18.1
4H	2H	15.0	16.0	15.3	16.3	16.5	15.0	15.9	15.3	16.2	16.5
	3H	15.9	16.7	16.2	17.0	17.4	15.8	16.6	16.2	16.9	17.3
	4H	16.4	17.2	16.8	17.5	17.9	16.4	17.1	16.7	17.4	17.8
	6H	17.0	17.7	17.4	18.0	18.4	17.0	17.6	17.4	18.0	18.4
	8H	17.3	18.0	17.8	18.3	18.8	17.2	17.9	17.7	18.2	18.7
	12H	17.7	18.3	18.1	18.7	19.1	17.5	18.1	18.0	18.5	18.9
8H	4H	16.6	17.2	17.1	17.6	18.0	16.6	17.2	17.0	17.6	18.0
	6H	17.4	17.9	17.9	18.3	18.8	17.4	17.9	17.8	18.3	18.8
	8H	17.9	18.3	18.3	18.8	19.2	17.8	18.3	18.3	18.7	19.2
	12H	18.4	18.7	18.9	19.2	19.7	18.3	18.6	18.7	19.1	19.6
12H	4H	16.7	17.2	17.1	17.6	18.1	16.6	17.2	17.0	17.6	18.0
	6H	17.5	18.0	18.0	18.4	18.9	17.5	17.9	18.0	18.4	18.8
	8H	18.0	18.4	18.5	18.9	19.4	18.0	18.4	18.5	18.8	19.3
Variation of the observer position for the luminaire distances S											
S = 1.0H		+0.5 / -0.6					+0.5 / -0.6				
S = 1.5H		+1.0 / -1.0					+1.0 / -0.9				
S = 2.0H		+2.0 / -1.4					+2.1 / -1.2				
Standard table		BK05					BK05				
Correction summand		0.5					0.5				
Corrected glare indices referring to 3804lm Total luminous flux											

UGR diagram (SHR: 0.25)

Louvre

Delta - microprism louvre in acrylic (PMMA) with a thin opal diffuser (acrylic/PMMA) on the inside (PMMA).

Miscellaneous

Enclosure class IP 44 under suspended ceilings and IP 20 above suspended ceilings.