# NEAR EAST UNIVERSITY



# **Faculty of Engineering**

# Department of Electrical and Electronic Engineering

# DESIGN, CONSTRUCTION AND INSTALLATION OF AN INTERNATIONAL BANK

**Graduation Project** 

**EE-400** 

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## LIST OF ABBREVIATIONS

| AC   | Alternative Current                                   |
|------|---|
| DC   | Direct Current  |
| RCD  | Residual-current Devices                              |
| RCBO | Residual-current Breakers with Overcurrent Protection |
| CU   | Consumer Unit   |
| МССВ | Moulded Case Circuit Breakers                         |
| BMC  | Bold Moulded Compound                                 |
| AUX  | Auxiliary   |
| UVT  | Undervoltage Release                                  |
| ST   | Shunt Trip  |
| AS   | Alarm Switch  |
| РІК  | Plug in Kit   |
| RH   | Rotary Handle   |
| MOD  | Motor Operating Mechanism                             |
| PFC  | Power Factor Correction                               |

## ABSTRACT

In the present day we have a branch for engineering as illumination enginnering. So we can understant the importance of the illumination.For satisfying the consumer requirements, electrical installation should be well designed and applied with a professional knowledge, because in the present day when we are choosing an armature we are not looking only to its watt value.We are considering the lumen of the lamp the type and design of the armature if its suitable or not for the project, and sometimes the working temperature.

Our project is about the electrical installation of an international bank, and this project needs well knowledge about electrical installation and also researching the present systems. This project consist the installation of lighting circuits, the installation of sockets, the aircondition, telephone, data sockets and a local compensation system

## **INTRODUCTION**

Design an electrical installation project, in most efficient way, is one of the essential subject in Electrical Engineering. This is taken into consideration in our project.

In this project all the related, electrical installation and some rules designing will be shown according priority.

Chapter one is based on Energy saving which has good information for our daily life.

Chapter two presents 'Reflected Light'. This subject one mentioned since in the illumination of the project this technique is used.

Chapter three gives information about flourescent lamps, advanteges and disadvantages of it.

Chapter four, five, six are concerned on the most important parts in electrical installation system. Three chapter give detailed information and various examples about 'Distribution Board, MCCB and Grounding'

Chapter seven and eight are devoted to two essential subjects. In these chapters 'Voltage Drop and Power Factor Correction' one cowered in daily applications.

Chapter nine is composed of the entire calculations in the project. The calculations are illumination, power, current, voltage drop, compensation calculations and also 'Total Investment' is reffered in this chapter.

The conclusion presents useful points and important results obtained from the theory and also comment belong to the students who prepared the project.

## **1.ENERGY SAVING**

The operating ambits of public lighting plans are the following:

from a technical point of view they plan the lighting of the territory, the interventions of updating of the plants and their maintenance;

An economic point of view they allow to plan in advance the interventions and to manage the costs in a rational way, leading to a considerable energy saving.

## 1.1 What is a Public Lighting Plan

A Public Lighting Plan consists in a project and a complex of technical dispositions aimed to regulate the installations of public and private outdoor lighting. Such a plan, will be realized according to the specifications and in full observance of the Lombardy Regional law no. 17 of 03.27.2000 and the possible current regional or national provisions

The dispositions coming from such a plan have application on the whole municipal territory for installations of future realization, while if such territories are comprised in areas of tutelage of the regional astronomical observatories (according to the lists drafted by the regional council), the lighting plans must already arrange also for the planned replacement and for the adjustment of the existing installations.

Another necessity of these plans is also to tutelate the territory and his image either during day and the night, supporting choices which increase its value.

## 2. REFLECTED LIGHT

Reflected light is used when a specimen is opaque. It's obvious that we can't shove light through a thick metal specimen so how do we look at one? Well the answer is to bring the illuminating light down through the objective and use the objective as a condenser.

Since 99% of reflected light modules are used in materials quality control and research there will be a shifting of gears in this book. Specimen is now something used in industry; ie: metals, semi-conductors, materials of all kinds. Its to bad that biology hasn't discovered reflected light since it is really neat stuff.

The key to reflected light is the word reflected. We are dealing with reflection as well as refraction. If the material doesn't reflect then there is no image. Refraction is an image source from knife edged plateaus on the specimen. An example of this is semiconductor lines located above the silicon substrate.

To get reflected light we must have a light source, a powerful one, and an illuminator. The light source should be a strong light source since many specimens in reflected light work are very dark, metals, coal, etc. Since the illuminator uses a half silvered mirror 50% of the illuminating light is lost at that point.

## 2.1 Reflected Light Bright Field

Reflected light bright field is necessary for all the rest of the reflected light techniques. Bright field is used all by itself when ever the specimen has good contrast or a simple technique is needed. Simple bright field modules are small enough to mount on metal working machines and may have only one objective.

The basis of reflected light bright field is a good illuminator. Good illuminators have both field and condenser diaphragms. They act in a reflected illuminator as they do in a transmitted Kohler microscope.

## 2.2 Reflected Light Polarization

A reflected light polarizing module will include a polarizer located before the mirror and an analyser located after the mirror. While both may be rotatable to allow the most versatility usually only the analyser is rotatable. A well designed illuminator will allow the user to have either a very complex system with rotatable polarizer and analyser and to use wave plates or a very simple system with fixed polarizer and analyser. Wave plates and compensators should be easily interchangeable for a full range of polarizing techniques.

This technique is used throughout the materials area. A lot of things have birefringence and over the years we have learned to use this to identify materials. Anything with a crystalline structure may be a good candidate for this technique.

## **2.3 Reflected Light Fluorescence for Materials**

This technique works just like reflected light fluorescence for biological use however the specimen is usually a material like a semi-conductor wafer and the fluorochrome is something used in the manufacture of the material.

A good example of this is photo resist. This material is used in the production of semi-conductor chips. It must be thoroughly removed for the chip to work. It was discovered that this stuff fluoresced and soon fluorescent modules were being used in semi-conductor plants. Modern universal illuminators allow for rapid change over between fluorescence and all the other reflected light techniques.

Fluorescence is valuable only when there is a fluorochrome used in the material. Getting a fluorochrome into a material in a place that is of interest can be daunting to impossible. But were a fluorochrome exists and it is of interest this is an excellent technique.

The draw backs are the same with this technique as for biological fluorescence, light intensity. You need a lot in and you may not get a lot out. Typically a fluorescence equipped materials microscope will have a 75 watt or 150 watt Xenon light source. This light source provides dichroic illumination for bright field and other techniques and enough light for fluorescence.

These light sources may be way to bright for bright field and dark field. A universal illuminator should have a place for neutral density filters to reduce the intensity since these light sources can not be dimmed electronically. The best universal illuminators have built in neutral density filters that can be slipped in as needed.

A fluorescent equipped universal illuminator has three main filtering devices in it. The exciter filter takes the light from the light source and filters it to produce only the wavelengths needed to excite the specimen.

The next filtering device is both a filter and a mirror; a dichroic mirror. It reflects all light below a certain wavelength and transmits above that wavelength. This center point wave length must be between the excitation and emission point for the fluorochrome. It must be greater than the excitation wavelength so it will reflect the excitation light down and into the objective.

Dichroic mirrors act as filters by transmitting or reflecting unwanted light away. When the excitation light hits it any light that has to high a wavelength will be transmitted through the mirror and never reach the specimen.

At the specimen plane the excitation light triggers the fluorochrome to emit light. It will always be at a longer wave length than the excitation due to conservation of energy. The objective then gathers all the light allows it to and then the dichroic mirror passes the fluorescent light up to the barrier filter and reflects any excitation light back towards the light source.

The barrier filter screens out any left over exciter light and any fluorescent wavelengths that we don't want to see. The eyepieces then pass the image on to the user.

Obviously we must know the excitation and emission wavelength of the material we are working with. We must know these numbers to specify the filters we need to generate fluorescence. When we have this information then we can get the correct exciter, dichroic and barrier filter.

## **3. FLOURESCENT LAMP**

A fluorescent lamp or fluorescent tube is a gas-discharge lamp that uses electricity to excite mercury vapor in argon or neon gas, resulting in a plasma that produces shortwave ultraviolet light. This light then causes a phosphor to fluoresce, producing visible light.

Unlike incandescent lamps, fluorescent lamps always require a ballast to regulate the flow of power through the lamp. In common tube fixtures (typically 4 ft (122 cm) or 8 ft (244 cm) in length), the ballast is enclosed in the fixture. Compact fluorescent light bulbs may have a conventional ballast located in the fixture or they may have ballasts integrated in the bulbs, allowing them to be used in lampholders normally used for incandescent lamps.

## 3.1 Electrical Aspects of Operation

Fluorescent lamps are negative differential resistance devices, so as more current flows through them, the electrical resistance of the fluorescent lamp drops, allowing even more current to flow. Connected directly to a constant-voltage mains power line, a fluorescent lamp would rapidly self-destruct due to the uncontrolled current flow. To prevent this, fluorescent lamps must use an auxiliary device, a ballast, to regulate the current flow through the tube; and to provide a higher voltage for starting the lamp.

While the ballast could be (and occasionally is) as simple as a resistor, substantial power is wasted in a resistive ballast so ballasts usually use an inductor instead. For operation from AC mains voltage, the use of simple magnetic ballast is common. In countries that use 120 V AC mains, the mains voltage is insufficient to light large fluorescent lamps so the ballast for these larger fluorescent lamps is often a step-up autotransformer with substantial leakage inductance (so as to limit the current flow). Either form of inductive ballast may also include a capacitor for power factor correction.

In the past, fluorescent lamps were occasionally run directly from a DC supply of sufficient voltage to strike an arc. The ballast must have been resistive rather than reactive, leading to power losses in the ballast resistor (a resistive ballast would dissipate about as much power as the lamp). Also, when operated directly from DC, the

polarity of the supply to the lamp must be reversed every time the lamp is started; otherwise, the mercury accumulates at one end of the tube. Fluorescent lamps are essentially never operated directly from DC; instead, an inverter converts the DC into AC and provides the current-limiting function.

## 3.2 Advantages

Fluorescent lamps are more efficient than incandescent light bulbs of an equivalent brightness. This is because a greater proportion of the power used is converted to usable light and a smaller proportion is converted to heat, allowing fluorescent lamps to run cooler. A typical 100 Watt tungsten filament incandescent lamp may convert only 10% of its power input to visible white light, whereas typical fluorescent lamps convert about 22% of the power input to visible white light - see the table in the luminous efficacy article. Typically a fluorescent lamp will last between 10 to 20 times as long as an equivalent incandescent lamp when operated several hours at a time. Consumer experience suggests that the lifetime is much lower when operated for very short frequent intervals.

## 3.3 Disadvantages

#### 3.3.1 Health Issues

If a fluorescent lamp is broken, mercury can contaminate the surrounding environment. A 1987 report described a 23-month-old toddler hospitalized due to mercury poisoning traced to a carton of 8-foot fluorescent lamps that had broken. The glass was cleaned up and discarded, but the child often used the area for play.

Elimination of fluorescent lighting is appropriate for several conditions. In addition to causing headache and fatigue, and problems with light sensitivity, they are listed as problematic for individuals with epilepsy, lupus, chronic fatigue syndrome, and vertigo (related to cardiovascular problems, and several other disorders. Research on this is very limited.

#### 3.3.2 Ballasts

Fluorescent lamps require a ballast to stabilize the lamp and to provide the initial striking voltage required to start the arc discharge. This increases the cost of fluorescent light fixtures, though often one ballast is shared between two or more lamps. Electromagnetic ballasts with a minor fault can produce an audible humming or buzzing noise.

#### 3.3.3 Power Factor

Simple inductive fluorescent lamp ballasts have a power factor of less than unity. Inductive ballasts include power factor correction capacitors.

#### **3.3.4 Power Harmonics**

Fluorescent lamps are a non-linear load and generate harmonics on the electrical power supply. This can generate radio frequency noise in some cases. Suppression of harmonic generation is standard practice, but imperfect. Very good suppression is possible, but adds to the cost of the fluorescent fixtures.

#### 3.3.5 Optimum Operating Temperature

Fluorescent lamps operate best around room temperature (say, 20 °C or 68 °F). At much lower or higher temperatures, efficiency decreases and at low temperatures (below freezing) standard lamps may not start. Special lamps may be needed for reliable service outdoors in cold weather. A "cold start" electrical circuit was also developed in the mid-1970s.

#### 3.3.6 Dimming

Fluorescent light fixtures cannot be connected to a standard dimmer switch used for incandescent lamps. Two effects are responsible for this: the waveshape of the voltage emitted by a standard phase-control dimmer interacts badly with many ballasts and it becomes difficult to sustain an arc in the fluorescent tube at low power levels. Many installations require 4-pin fluorescent lamps and compatible dimming ballasts for successful fluorescent dimming.

#### 3.3.7 Reflector

Some lamps are designed with a reflector built inside the lamp. This is done by pouring an opaque coating into the lamp first, rotating the lamp to achieve the desired amount of coverage, then allowing it to dry before adding the traditional phosphors. With straight lamps, this is commonly poured in a fashion as to cover half the lamp as it is lying flat, with the lamp rated as to the amount of curvature that is covered in the opaque coating. A 180 degree lamp has 50% coverage, whereas a 210 degree lamp has 30 degrees more coverage. These are the most common type, although the reflector can vary from 120 degrees to well over 310 degrees. Lamps that have significantly more than 210 degrees of coverage are often referred to as "aperature lamps" as the amount of open area that light can escape is significantly less than the area that acts as an internal reflector. Often, a lamp is marked as a reflector lamp by adding the letter "R" in the model code, so a F##T##HO lamp with a reflector would be coded as "FR##T##HO". VHO lamps with reflectors may be coded as VHOR. No such designation exists for the amount of reflector degrees the lamp has.

## 4. **DISTRIBUTION BOARD**

A distribution board divides the electrical mains feed into various circuits, providing a fuse or circuit breaker for each circuit. They usually include a main switch, and often one or more Residual-current devices (RCD) or Residual Current Breakers with Overcurrent protection (RCBO).

## 4.1 Other Names

Distribution boards are also known as

- breaker panel
- fuse box
- fuse board
- circuit breaker panel
- consumer unit, or CU
- panelboard
- load center

#### **4.2 Breaker Arrangement**

Breakers are usually arranged in two columns. In a US-style board, breaker positions are numbered left-to-right, along each row from top to bottom. For 120/240 volts, hot wires (that which are live) are black and red (blue is used as the third leg of three-phase power [208Y/120 volts]) and white for neutral. For 480Y/277 volts (always three-phase) the hot wires are brown, orange and yellow and grey is the neutral. Green or bare wires are used as grounds in both configurations. The 208Y/120 volt and 480Y/277 volt systems are both wye systems. All three phases in these systems measure either 120 or 277 volts to the neutral and 208 or 480 volts to each other. Another common system seen in older buildings is the 240D/120 center tap delta system. In this system, two phases (phase A and phase C) measure 120 volts to the neutral. Phase B in this system is a high leg aka a "stinger" leg that measures 208 volts to the neutral. Every second and fifth slot in a panel fed with this system connects with the stinger leg and must not be used to supply 120 volt single phase loads. However the stinger can be used as part of a 240 volt single or three phase circuit. Most buildings with 240D/120 service don't feed all three phases into the lighting/small appliance panel. The two 120 volt to neutral phases are split out of the main supply entrance and feed a 120/240 single phase lighting/small appliance panel. The three phase in this system is only used for air

conditioning and other large motor loads. Almost all new buildings with three-phase service use the 208Y/120 volt system thus eliminating the stinger leg problem.

Illustration of breaker numbering in a North American type panelboard. Some labels are missing, and some lines have additional descriptive labels. The numbers on the toggles indicate the ampereage they will pass before tripping off and stopping all current. The top right breaker (Rated at 100 A) leads to a sub panel.

These breakers cycle through two or three phases, labelled as A, B, and C in the above diagram. This numbering system is universal across various competing manufacturers of breaker panels.

In a UK-style board, breaker positions are numbered top to bottom in the left hand column, then top to bottom in the right column. Each number is used to label one position on each phase, as below. It remains to be seen how the new wiring colours recently introduced in the UK will affect this labelling.

In both labelling styles the reason for the alternating pattern of phases is to allow for common trip breakers to have one pole on each phase.

In North America it is common to wire large heating equipment line-to-line. This takes two slots in the panel (two-pole) and gives a voltage of 240V if the supply system is split phase and 208 V if the supply system is three phase. This practice is much less common in countries that use a higher line-neutral voltage. Large motors, air conditioners, subpanels, etc., are typically three-phase (where available). Therefore a three-pole breaker is needed which takes three slots in the breaker panel.

A line can be seen directly exiting the box and running to a NEMA 5-15 electrical receptacle with something plugged into it.

#### 4.3 Inside a UK Distribution Board

The three incoming phase wires connect to the busbars via an isolator switch in the centre of the panel. On each side of the panel are two busbars, for neutral and earth. The incoming neutral connects to the lower busbar on the right side of the panel, which is in turn connected to the neutral busbar at the top left. The incoming earth wire connects to the lower busbar on the left side of the panel, which is in turn connected to the earth busbar at the top right. The cover has been removed from the lower-right neutral bar; the neutral bar on the left side has its cover in place.

Down the left side of the phase busbars are two two-pole RCBOs and two single-pole breakers, one unused. Down the right side of the busbars are a single-pole breaker, a two-pole RCBO and a three-pole breaker.

The two-pole RCBOs in the picture are not connected across two phases, but have supply-side neutral connections exiting behind the phase busbars.

It is likely that the manufacturer produces 18- and 24-position versions of this panel using the same chassis which explains why there appears to be so much unused space.

## 4.4 Manufacturer Differences

Most of the time, the panel and the breakers inserted into it must both be from the same company. Each company has one or more "systems", or kinds of breaker panels, that only accept breakers of that type. In Europe this is still the case, despite the adoption of a standard rail for mounting and a standard cut-out shape, as the positions of the busbar connections are not standardised.

It is commonly known in North America that Siemens and General Electric panels and breakers of the type shown in the above and below picture illustrations are seemingly interchangeable one-inch wide breakers. However, an installer must be cautious and abide by all equivalent regulations, as well as any state, federal, or local codes, when modifying systems or installing new overcurrent devices. A given manufacturer will often specify exactly what devices are permitted to be installed in their equipment. This is because these assemblies have been tested and approved for use by a recognized authority. Replacing or adding equipment which "just happens to fit" can result in unexpected or even dangerous conditions. Such installations should not be done without first consulting knowledgeable sources, including manufacturers.

Numerous older systems are still in use in older buildings and parts are still manufactured for these legacy applications, such as Zinsco and others.

#### 4.5 Location and Designation

For reasons of aesthetics and security, circuit breaker panels are often placed in outof-the-way closets, attics, garages, or basements, but sometimes they are also featured as part of the aesthetic elements of a building (as an art installation, for example) or where they can be easily accessed. However, current US building codes prohibit installing a panel in a bathroom (or similar room), in closets intended for clothing, or where there is insufficient space for a worker to access it. Specific situations, such as an installation outdoors, in a hazardous environment, or in other out-of-the-ordinary locations may require specialized equipment and more stringent installation practices.

In large buildings or facilities with higher electric power demand may have multiple circuit breaker panels. In this case, the panels are often indicated by letters of the alphabet. One case is The Decon Gallery, a modern building in downtown Toronto, which has 11 breaker panels designated "A", "B", "C", "D", and so on. A backstage outlet is therefore labeled "C27". In many such buildings, each outlet is on its own circuit breaker, and the outlets are labelled in the above specified manner to facilitate easy location of which breaker to shut off for servicing, rewiring, or the like.

In even larger buildings, such as schools, hospitals and sports/entertainment venues it is not uncommon to have scores of panels, specially designated for each building depending on how the architects and electrical engineers sub divide the building. They are commonly designated as either three-phase or single-phase and normal power or emergency power. In these set-ups they may also be designated for their use, such as distribution panels for supplying other panels, lighting panels for lights, power panels for equipment and receptacles and special uses for whatever type of building they are used in. It is also not uncommon for these panels to be located throughout the building in electric closets serving a section of the building.

In a theatre a specialty panel called a dimmer rack is used to feed stage lighting instruments. Instead of just circuit breakers, the rack has a solid state electronic dimmer with its own circuit breaker for each stage circuit. This is known as a dimmer-per-circuit arrangement. The dimmers are equally divided across the three incoming phases. In a 96 dimmer rack, there are 32 dimmers on phase A, 32 dimmers on phase B, and 32 on phase C to spread out the lighting load as equally as possible. In addition to the power feed from the supply transformer in the building, a control cable from the lighting desk carries information to the dimmers in a control protocol such as DMX-512.

Distribution boards may be surface-mounted on a wall or may be sunk in to the wall. The former arrangement allows for easier alteration or addition to wiring at a later date, but the latter arrangement may look neater, particularly in a residential situation. The other problem with recessing a distribution board into a wall is that if the wall is solid a lot of brick or block may need to be removed - for this reason recessed boards are generally only fitted on new-build projects when the required space can be built in to the wall

#### 5. MCCB

## 5.1 Application

The current limiting MCCB Superior series is suitable for circuit protection in individual enclosures, switchboards, lighting and power panels as well as motor-control centers. The MCCB is designed to protect systems against overload and short circuits up to 65kA with the full range of accessories.

## 5.2 Mechanism

The MCCB Superior series is designed to be trip-free. This applies when the breaker contacts open under overload and short circuit conditions and even if the breaker handle is held at the ON position. To eliminate single phasing, should an overload or short circuit occur on any one phase, a common trip mechanism will disconnect all phase contacts of a multipole breaker.

## 5.3 Material

The Superior series circuit breakers' housing is made of BMC material, which is unbreakable and has a very high dielectric strength, to ensure the highest level of insulation. The same material is also used to segregate the live parts in between the phases.

#### **5.4 Accessories**

To enhance the Superior series MCCB, internal and external modules can be fitted onto the breaker. They are as follows:

- shunt trip coil undervoltage release
- auxiliary switch alarm switch
- motorized switch rotary handle
- plug-in kit (draw-out unit)
- auxiliary & alarm switch

#### 5.5 The Technology of Tripping Devices

#### 5.5.1 MCCB Arc Chamber

The MCCB arc chamber is specially designed with an arc channel as a flow guide to improve the capability of extinguishing the arc and reducing the arc distance.

#### 5.5.2 MCCB Base

Mounting screws are used to insert thread nuts in the MCCB base. The cover can withstand high electromagnetic force during a short-circuit; this prevents the MCCB cover from tearing off. This is an improvement over self-taping screw of other models.

#### 5.5.3 Fixed Contact

The MCCB fixed contact does not have any mounting screws near the contact points. A steel screw can generate heat and the magnetic flux surrounding the conductor carrying the current can create a very high temperature. If a short-circuit occurs, it will cause the contact points to be welded or melted.

#### 5.5.4 Materials

The base and cover of the MCCB are made of a specially formulated material, i.e. bold moulded compound (BMC). It has a high-impact thermal strength, fire resistant and capable of withstanding high electromagnetic forces that occur during a short-circuit. Majority MCCB manufacturers in the market use pheonolic compounds with less electrical and mechanical strength.

#### 5.5.5 Repulsive Force

An electromagnetic repulsive force is where the force works between acurrent of the movable conductor and a current (I) in the reversed direction of the fixed conductor. This is an improvement of the electromagnetic force during breaking over other models.

#### 5.5.6 Time-Delay Operation

Time-delay operation occurs when an overcurrent heats and warps the bimetal to actuate the trip bar.

### **5.6 Proper MCCB for Protection**

It is very important to select and apply the right MCCB for a long lasting and rouble free operation in a power system. The right selection requires a detailed understanding of the complete system and other influencing factors. The factors for selecting a MCCB are as follows:

- 1) nominal current rating of the MCCB
- 2) fault current Icu, Ics
- 3) other accessories required
- 4) number of poles

## 5.6.1 Nominal Current

To determine the nominal current of a MCCB, it is dependent on the full load current rating of the load and the scope of load enhancement in future.

#### 5.6.2 Fault Current Icu, Ics

It is essential to calculate precisely the fault current that the MCCB will have to clear for a healthy and trouble-free life of the system down stream. The level of fault current at a specific point in a power system depends on following factors:

a) transformer size in KVA and the impedance

b) type of supply system

c) the distance between the transformer and the fault location

d ) size and material of conductors and devices in between the transformer and the fault location

e) the impedance up to the fault junction.

## 5.7 Internal Accessories

#### 5.7.1 Auxiliary Contact (AUX)

The auxiliary contact is used for remote signalling and control purposes. This consists of one or more than one potential free change-over contacts. It also acts as an indicator whether the circuit breaker's status is opened or closed.

Configurations: 1NO + 1NC

#### 5.7.2 Undervoltage Release (UVT)

The undervoltage release is used to trip the MCCB when there is a drop in voltage. The UVT can also be used for remote tripping and electrical interlocking purposes. The tripping threshold is 35% to 70% of the rated voltage. Pick-up voltage is 85% of the rated coil voltage. The operating voltage is AC 220V or 380V at 50/60Hz.

#### 5.7.3 Shunt Trip (ST)

The shunt release is used for remote tripping of the MCCB under abnormal conditions. The operating voltage is 70% to 110% of the rated voltage.

#### 5.7.4 Alarm Switch (AS)

When a tripping occurs in the MCCB, it is indicated by the alarm switch. The potential free change-over contacts can be utilized for indicative and circuit control purposes.

## **5.8 External Accessories**

#### **5.8.1 Insulation Barrier**

The insulation barrier should be utilized on the MCCB to facilitate termination of cable links. Used on the incoming side of the MCCB, it provides additional safety as it is made of superior insulating materials that have good mechanical and electrical properties. The insulation barrier prevents accidental contacts and flash-over between each phase and is highly recommended for the breakers especially during installation of a switchboard.

#### 5.8.2 Plug-in Kit (PIK)

The MCCB plug-in kit is designed to replace the standard terminal with a rear connection to improve the opening capability. Suitable for isolation, the plug-in kit has a better contact performance in the MCCB when there is less force and a low temperature. It is also important to note that the MCCB can be drawn out without disconnecting the incoming live cable.

#### 5.8.3 Rotary Handle (RH)

The MCCB toggle handle operating mechanism is used to facilitate the ON/OFF operation when the MCCB is installed in the cubicles of distribution boards. It is designed to be attached directly onto the MCCB and transform the toggle handle movement into a rotation switch to serve as position indicator switch.

#### 5.8.4 Motor Operating Mechanism (MOD)

The motor-operated mechanism enables the MCCB to be switched ON or OFF automatically. The MCCB should also be equipped with an alarm switch for automatic resetting purposes.

#### 5.9 Short-circuit & Short-circuit Current

#### 5.9.1 Short-Circuit in a Network

When a short-circuit in a network occurs, it will create a highly damaged and abnormal condition to the system, whereby the normal insulation of the system, be it the cables or equipment and load, are damaged. The function of the MCCB as a protection device, is to protect overloads and bring the effect of this faulty condition under control at a fast speed in order to reduce the damages. The LKE Superior series MCCB, with the right combination of accessories and proper selection to coordinate between the downstream and up-stream of the rated current and fault level, is one of the more reliable circuit breaker protection device available. It is important to understand the full load current and fault level to determine the rated current and short-circuit kA of the MCCB before selecting the right MCCB to protect the down-stream cable, equipment and load. The value of the short-circuit current at a fault-junction depends mainly on:

- the kVA of the supply source, (either a transformer or generator).
- the type of supply system.

#### 5.9.2 Types of Short-circuit

Before calculating the short-circuit current at any point of the network, one must be able to differentiate the various types of short-circuit. In a three-phase network, shortcircuits are generally classified as below, depending on the number of conductor affected and with or without fault-to-earth.

#### 5.9.3 Peak Value of the Short-circuit Current

When an R-L series circuit is closed with an A/C source, the current component results :

1) an A/C component with a phase shift with respect to the voltage

2) a D/C decaying component.

The arc component is superimposed on the D/C component. The initial peak value of the short-circuit current depends on the voltage at the instance of the breaker closing. The two extreme cases are:

a) when the breaker is closed at peak voltage, the D/C component is zero and the fault current is symmetrical or

b) when the breaker is closed at zero voltage, the D/C component is unbalanced

## 6. GROUND

In electrical engineering, the term ground or earth has several meanings depending on the specific application areas. Ground is the reference point in an electrical circuit from which other voltages are measured, a common return path for electric current (earth return or ground return), or a direct physical connection to the Earth.

Electrical circuits may be connected to ground (earth) for several reasons. In power circuits, a connection to ground is done for safety purposes to protect people from the effects of faulty insulation on electrically powered equipment. A connection to ground helps limit the voltage built up between power circuits and the earth, protecting circuit insulation from damage due to excessive voltage. Connections to ground may be used to limit the build-up of static electricity when handling flammable products or when repairing electronic devices. In some types of telegraph and power transmission circuits, the earth itself can be used as one conductor of the circuit, saving the cost of installing a separate run of wire as a return conductor. For measurement purposes, the Earth serves as a (reasonably) constant potential reference against which other potentials can be measured. An electrical ground system should have an appropriate current-carrying capability in order to serve as an adequate zero-voltage reference level.

#### 6.1 AC Power Wiring Installations

In a mains electricity (AC power) wiring installation, the ground is a wire with an electrical connection to earth. By connecting the cases of electrical equipment to earth, any insulation failure will result in current flowing to ground that would otherwise energize the case of the equipment. A proper bonding to earth will result in the circuit overcurrent protection operating to de-energize the faulty circuit. By bonding (interconnecting) all exposed non-current carrying metal objects together, any fault currents in the system will not produce dangerous voltages which could cause electric shock.

The power ground grounding wire is (directly or indirectly) connected to one or more earth electrodes. These may be located locally, be far away in the suppliers network or in many cases both. This grounding wire is usually but not always connected to the neutral wire at some point and they may even share a cable for part of the system under some conditions. A power ground serves to provide a return path for fault currents and therefore allows the fuse or breaker to disconnect the circuit. The power ground is also often bonded to the house's incoming pipework, and pipes and cables entering the bathroom are sometimes cross-bonded. This is done to try to reduce the voltage between objects that can be touched simultaneously. Filters also connect to the power ground, but this is mainly to stop the power ground carrying noise into the systems which the filters protect, rather than as a direct use of the power ground.

Permanently installed electrical equipment usually also has permanently connected grounding conductors. Portable electrical devices with metal cases may have them connected to earth ground by a pin in the interconnecting plug. (see Domestic AC power plugs and sockets). The size of power ground conductors is usually regulated by local or national wiring regulations

## 6.2 Lightning Protection

Lightning protection is a very specialised form of grounding used in an attempt to divert the huge currents from lightning strikes. A ground conductor on a lightning protection system is used to dissipate the strike into the earth. Lightning ground conductors must carry heavy currents for a short period of time. To limit inductance and the resulting voltage due to the fast pulse nature of lightning currents, lightning ground conductors may be wide flat strips of metal, usually run as directly as possible to electrodes in contact with the earth.

In overhead transmission lines, a ground conductor may also be the top most wire on pylons, poles, or towers. This ground conductor is intended to protect the power conductors from lightning strikes. These conductors are connected to earth either through the metal structure of a pole or tower, or by additional ground electrodes installed at regular intervals along the line. As a general rule, overhead power lines with voltages below 50 kV do not have a ground conductor, but most lines carrying more than 50kV do. Depending on local conditions and reliability requirements, an over head transmission line may have two overhead ground conductors. In such cases the pylons are either equipped with an additional crossbeam above the conductors, with two tops in form of a letter "V" or the ground conductors are mounted on the top of the topmost crossbeam. In some parts of the world, the ground conductor cable is used to support fibreoptic cables for data transmission .

## 7. VOLTAGE DROP

Voltage drop is the reduction in voltage in an electrical circuit between the source and load. In electrical wiring national and local electrical codes may set guidelines for maximum voltage drop allowed in a circuit, to ensure reasonable efficiency of distribution and proper operation of electrical equipment (the maximum permitted voltage drop varies from one country to another)

Voltage drop may be neglected when the impedance of the interconnecting conductors is small relative to the other components of the circuit.

For example, an electric space heater may very well have a resistance of ten ohms, and the wires which supply it may have a resistance of 0.2 ohms, about 2% of the total circuit resistance. This means that 2% of the supplied voltage is actually being lost by the wire itself.

Excessive voltage drop will result in unsatisfactory operation of electrical equipment, and represents energy wasted in the wiring system. Voltage drop can also cause damage to electrical motors.

In electronic design and power transmission, various techniques are used to compensate for the effect of voltage drop on long circuits or where voltage levels must be accurately maintained. The simplest way to reduce voltage drop is to increase the diameter of the cable between the source and the load which lowers the overall resistance.

#### 7.1 Voltage Drop in Direct Current Circuits

A current flowing through the non-zero resistance of a practical conductor necessarily produces a voltage across that conductor. The dc resistance of the conductor depends upon the conductor's length, cross-sectional area, type of material, and temperature. The local voltages along the long line decrease gradually from the source to the load

If the voltage between the conductor and a fixed reference point is measured at many points along the conductor, the measured voltage will decrease gradually toward the load. As the current passes through a longer and longer conductor, more and more of the voltage is "lost" (unavailable to the load), due to the voltage drop developed across the resistance of the conductor. In this diagram the voltage drop along the conductor is represented by the shaded area.

### 7.2 Voltage Drop in Alternating Current Circuits

In alternating current circuits, additional opposition to current flow occurs due to the interaction between electric and magnetic fields and the current within the conductor; this opposition is called "impedance". The impedance in an alternating current circuit depends on the spacing and dimensions of the conductors, the frequency of the current, and the magnetic permeability of the conductor and its surroundings. The voltage drop in an AC circuit is the product of the current and the impedance (Z) of the circuit. Electrical impedance, like resistance, is expressed in ohms. Electrical impedance is the vector sum of electrical resistance, capacitive reactance, and inductive reactance. The voltage drop occurring in an alternating current circuit is the product of the current and impedance of the circuit. It is expressed by the formula E = IZ, analogous to Ohm's law for direct current circuits.

#### 7.3 Voltage Drop in Household Wiring

The majority of circuits wired within a residential building usually are not long enough or high current enough to make voltage drop a factor in selection of wiring. However this is a necessary factor in cable choice in a percentage of cases. In the case of very long circuits, for example, connecting a home to a separate building on the same property, it is often necessary to increase the size of conductors over the minimum requirement for the circuit current rating. It is also normal for a percentage of UK domestic circuits to require cable size increase to meet voltage drop specs in the UK wiring regulations.

Some wiring codes or regulations set an upper limit to the allowable voltage drop in a branch circuit. In the United States, the 2005 National Electrical Code (NEC) recommends no more than a 5% voltage drop for residential applications at the outlet. UK regulations limit voltage drop to 4% of supply voltage.

Voltage drop of a branch circuit is readily calculated, or less accurately it can be measured by observing the voltage before and after applying a load to the circuit. Excessive voltage drop on a residential branch circuit may be a sign of insufficiently sized wiring or of other faults within the wiring system, such as high resistance connections.

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## 8. POWER FACTOR CORRECTION

Power factor correction (PFC) is the process of adjusting the characteristics of electric loads that create a power factor that is less than 1. Power factor correction may be applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network; or, correction may be installed by individual electrical customers to reduce the costs charged to them by their electricity supplier. A high power factor is generally desirable in a transmission system to reduce transmission losses and improve voltage regulation at the load.

#### 8.1 Linear Loads

Electrical loads consuming alternating current power consume both real power, which does useful work, and reactive power, which dissipates no energy in the load and which returns to the source on each alternating current cycle. The vector sum of real and reactive power is the apparent power. The ratio of real power to apparent power is the power factor, a number between 0 and 1 inclusive. The presence of reactive power causes the real power to be less than the apparent power, and so, the electric load has a power factor of less than 1.

The reactive power increases the current flowing between the power source and the load, which increases the power losses through transmission and distribution lines. This results in additional costs for power companies. Therefore, power companies require their customers, especially those with large loads, to maintain their power factors above a specified amount (usually 0.90 or higher) or be subject to additional charges. Electricity utilities measure reactive power used by high demand customers and charge higher rates accordingly. Some consumers install power factor correction schemes at their factories to cut down on these higher costs.

Electrical engineers involved with the generation, transmission, distribution and consumption of electrical power have an interest in the power factor of loads because power factors affect efficiencies and costs for both the electrical power industry and the consumers. In addition to the increased operating costs, reactive power can require the use of wiring, switches, circuit breakers, transformers and transmission lines with higher current capacities.

Power factor correction brings the power factor of an AC power circuit closer to 1 by supplying reactive power of opposite sign, adding capacitors or inductors which act to cancel the inductive or capacitive effects of the load, respectively. For example, the inductive effect of motor loads may be offset by locally connected capacitors. Sometimes, when the power factor is leading due to capacitive loading, inductors (also known as *reactors* in this context) are used to correct the power factor. In the electricity industry, inductors are said to consume reactive power and capacitors are said to supply it, even though the reactive power is actually just moving back and forth between each AC cycle.

## 8.2 Non-linear Loads

Non-linear loads create harmonic currents in addition to the original AC current. Addition of linear components such as capacitors and inductors cannot cancel these harmonic currents, so other methods such as filters or active power factor correction are required to smooth out their current demand over each cycle of alternating current and so reduce the generated harmonic currents.

## **8.3 Switched-mode Power Supplies**

A typical switched-mode power supply first makes a DC bus, using a bridge rectifier or similar circuit. The output voltage is then derived from this DC bus. The problem with this is that the rectifier is a non-linear device, so the input current is highly non-linear. That means that the input current has energy at harmonics of the frequency of the voltage.

This presents a particular problem for the power companies, because they cannot compensate for the harmonic current by adding simple capacitors or inductors, as they could for the reactive power drawn by a linear load. Many jurisdictions are beginning to legally require power factor correction for all power supplies above a certain power level.

The simplest way to control the harmonic current is to use a filter: it is possible to design a filter that passes current only at line frequency (e.g. 50 or 60 Hz). This filter reduces the harmonic current, which means that the non-linear device now looks like a linear load. At this point the power factor can be brought to near unity, using capacitors

or inductors as required. This filter requires large-value high-current inductors, however, which are bulky and expensive.

It is also possible to perform active PFC. In this case, a boost converter is inserted between the bridge rectifier and the main input capacitors. The boost converter attempts to maintain a constant DC bus voltage on its output while drawing a current that is always in phase with and at the same frequency as the line voltage. Another switchmode converter inside the power supply produces the desired output voltage from the DC bus. This approach requires additional semiconductor switches and control electronics, but permits cheaper and smaller passive components. It is frequently used in practice. Due to their very wide input voltage range, many power supplies with active PFC can automatically adjust to operate on AC power from about 100 V (Japan) to 240 V (UK). That feature is particularly welcome in power supplies for laptops and cell phones.

## 8.4 Passive PFC

This is a simple way of correcting the nonlinearity of a load by using capacitor banks. It is not as effective as active PFC. Switching the capacitors into or out of the circuit causes harmonics, which is why active PFC or a synchronous motor is preferred.

## 8.5 Active PFC

An Active Power Factor Corrector (active PFC) is a power electronic system that controls the amount of power drawn by a load in order to obtain a Power factor as close as possible to unity. In most applications, the active PFC controls the input current of the load so that the current waveform is proportional to the mains voltage waveform (a sinewave).

Some types of active PFC are

- 1. Boost
- 2. Buck
- 3. Buck-boost

Active power factor correctors can be single-stage or multi-stage. Active PFC is the most effective and can produce a PFC of 0.99 (99%).



Figure 1-Internal View of a Compensation Board (in real life)

Figure 2-as Autocad View



Figure 3-Different View of a Compensation Board

| COMPENSAT<br>CONTUCTOR<br>TS 3629<br>IEC 60947-4<br>TS EN 60947 | TON<br>RS<br>-1<br>7-4-1 |           |           |           |           |           |           |              |
|---|--------------------------|-----------|-----------|-----------|-----------|-----------|-----------|--------------|
| TYPE OF CONTUCTOR   |                          | FC12DK    | FC18DK    | FC25DK    | FC32DK    | FC65DK    | FC95DK    | FC150DK      |
| Usage class   |                          | 8         | 15        | 23        | 29        | 43        | 72        | 101          |
| Saturetion current (lth)  |                          | 25        | 32        | 40        | 50        | 80        | 125       | 200          |
| Crossectional connection area<br>(mm^2)                         |                          | 4         | 6         | 10        | 10        | 25        | 50        | 95           |
| Saturated conductor   | 220/240 V                | 3         | 6         | 7         | 10        | 15        | 30        | 40           |
| power ( kVAr)   | 380/415 V                | 5         | 10        | 15        | 20        | 30        | 50        | 70           |
| Satureated isola  | tor voltage V            | 690       | 690       | 690       | 690       | 690       | 690       | 690          |
| Saturated resist  | current kV               | 8         | 8         | 8         | 8         | 8         | 8         | 8            |
| Electrical life tim   | e (open - close)         | 200.000   | 200.000   | 200.000   | 200.000   | 200.000   | 200.000   | 200.000      |
| No. of assistant  | conductors               | 1NA + 1NK | 1NA + 1NK | INA + 1NK | INA + 1NK | 2NA + 1NK | 2NA + 1NK | 1NA veya 1NK |
| Weight kg   |                          | 0,39      | 0,40      | 0,58      | 0,60      | 1,36      | 1,58      | 2,65         |

Figure 4-Table of Contuctors

| CORES AND<br>CROSS- |                 | THICKNESS          | THICKNESS OF<br>BEDDING |        | STEEL<br>WIRE ARMOUR | THICKNESS<br>OF | OUTER<br>DIAMETER | RESISTANCE  |           | CURRENT<br>CAPACITY | CABLE<br>WEIGHT |
|---------------------|-----------------|--------------------|-------------------------|--------|----------------------|-----------------|-------------------|-------------|-----------|---------------------|-----------------|
| \$EC                | CTIONAL<br>AREA | CORE<br>INSULATION | EXTRUDED                | LAPPED | WIRE DIAMETER        | OVERSHEATH      | APPROX.           | DC AT 20° C | REACTANCE | IN AIR<br>At 20° C  | APPROX.         |
|                     | mm <sup>2</sup> | mm                 | mm                      | mm     | nım                  | mm              | mm                | Ohm/km      | Ohm/km    | A                   | kg/km           |
| 2 x                 | 1.5 *           | 0.8                | 0.8                     | -      | 0.9                  | 13              | 12.5              | 12 10       | 0 105     | 23                  | 340             |
| 2 x                 | 2.5 *           | 0.7                | 0.8                     | ~      | 0.9                  | 1.4             | 14.0              | 7.280       | 0.101     | 30                  | 420             |
| 2 x                 | 4 ==            | 0.8                | 0.8                     | -      | 0.9                  | 1.4             | 16.0              | 4.810       | 0.097     | 41                  | 550             |
| 2 x                 | 8 "             | 0.8                | 0.8                     |        | 0.9                  | 1.5             | 17.0              | 3.080       | 0.091     | 53                  | 650             |
| 2 x                 | 10 **           | 1.0                | 0.8                     | -      | 1.25                 | 1.6             | 20.5              | 1.830       | 0.089     | 74                  | 890             |
| 2 x                 | 18 **           | 1.0                | 0.8                     | 0.8    | 1.25                 | 1.6             | 22.0              | 1.150       | 0.080     | 120                 | 1.080           |
| 2 x                 | 25 **           | 1.2                | 1.0                     | 0.8    | 1.8                  | 1.7             | 28.5              | 0.727       | 0.079     | 160                 | 1 610           |
| 2 x                 | 35 **           | 1.2                | 1.0                     | 0.8    | 1.8                  | 1,8             | 27.5              | 0.524       | 0.077     | 200                 | 1 970           |
| 2 x                 | 50 **           | 1.4                | 1.0                     | 0.8    | 1.8                  | 1.9             | 32.0              | 0.387       | 0.076     | 240                 | 2 480           |
| 3 x                 | 1.5 ×           | 0.8                | 0.8                     | 0.8    | 0.9                  | 1.4             | 12.3              | 12.10       | 0.105     | 23                  | 310             |
| 3 x                 | 2.5 *           | 0.7                | 0.8                     | 0.8    | 0.9                  | 1.4             | 13.8              | 7.280       | 0.101     | 30                  | 390             |
| 3 x                 | 4 78            | 0.8                | 0.8                     | 0.8    | 0.9                  | 1.4             | 15.8              | 4.810       | 0.097     | 41                  | 520             |
| 3 x                 | 8 **            | 0.8                | 0.8                     | 0.8    | 1.25                 | 1.5             | 18.0              | 3.080       | 0.091     | 53                  | 730             |
| 3 x                 | 10 **           | 1.0                | 0.8                     | 0.8    | 1.25                 | 1.8             | 21.0              | 1.830       | 0.089     | 74                  | 1 010           |
| 3 x                 | 18 **           | 1.0                | 0.8                     | 0.8    | 1.25                 | 1.6             | 24.0              | 1.150       | 0.080.0   | 105                 | 1 200           |
| 3 x                 | 25 **           | 1.2                | 1.0                     | 0.8    | 1.6                  | 1.7             | 29.0              | 0.727       | 0.079     | 140                 | 1 820           |
| 3 x                 | 35 ***          | 1.2                | 1.0                     | 0.8    | 1.8                  | 1.8             | 27.5              | 0.524       | 0.077     | 170                 | 2 050           |
| 3 x                 | 50              | 1.4                | 1.0                     | 0.8    | 1.8                  | 1.9             | 30.5              | 0.387       | 0.078     | 205                 | 2 580           |
| 3 x                 | 70              | 1.4                | 1.2                     | 0.8    | 2.0                  | 2.0             | 35.0              | 0.268       | 0.075     | 260                 | 3 590           |
| 3 x                 | <b>\$</b> 5     | 1.8                | 1.2                     | 0.8    | 2.0                  | 2.1             | 39.5              | 0.193       | 0.073     | 320                 | 4 710           |
| 3 x                 | 120             | 1.8                | 1.2                     | 0.8    | 2.0                  | 2.2             | 42.0              | 0.153       | 0.073     | 370                 | 5 590           |
| 3 x                 | 150             | 1.8                | 1.4                     | 0.8    | 2.5                  | 2.4             | 47.5              | 0.124       | 0.073     | 430                 | 7 110           |
| 4 x                 | 1.5 *           | 0.8                | 0.8                     |        | 0.9                  | 1.4             | 13.0              | 12.10       | 0.105     | 23                  | 350             |
| 4 x                 | 2.5 *           | 0.7                | 0.8                     |        | 0.9                  | 1.4             | 14.5              | 7.280       | 0.101     | 30                  | 440             |
| 4 x                 | 4 **            | 0.8                | 0.8                     | •      | 1.25                 | 1.5             | 17.8              | 4.610       | 0.097     | 41                  | 710             |
| 4 x                 | 8 12            | 0.8                | 0.8                     | -      | 1.25                 | 1.5             | 19.0              | 3.080       | 0.091     | 53                  | 850             |
| 4 x                 | 10 **           | 1.0                | 0.8                     | •      | 1.25                 | 1.6             | 23.0              | 1.830       | 0.089     | 74                  | 1 200           |
| 4 x                 | 18 "            | 1.0                | 0.8                     | 0.8    | 1.8                  | 1.7             | 28.5              | 1.150       | 0.080     | 105                 | 1 810           |
| 4 x                 | 25 "            | 1.2                | 1.0                     | 0.8    | 1.8                  | 1.8             | 31.5              | 0.727       | 0.079     | 140                 | 2 440           |
| 4 x                 | 35 xex          | 1.2                | 1.0                     | 0.8    | 1.8                  | 1.8             | 30.5              | 0.524       | 0.077     | 170                 | 2 530           |
| 4 x                 | 50              | 1,4                | 1.0                     | 0.8    | 2.0                  | 2.0             | 35.5              | 0.387       | 0.078     | 205                 | 3 480           |
| 4 x                 | 70              | 1.4                | 1.2                     | 0.8    | 2.0                  | 2.1             | 39.0              | 0.268       | 0.075     | 260                 | 4 470           |
| 4 x                 | 85              | 1.8                | 1.2                     | 0.8    | 2.0                  | 2.2             | 44.5              | 0.193       | 0.073     | 320                 | 5 900           |
| 4 x                 | 120             | 1.8                | 1.2                     | 0.8    | 2.0                  | 2.4             | 49.5              | 0.153       | 0.073     | 370                 | 7 540           |
| 4 x                 | 150             | 1.8                | 1.4                     | 0.8    | 2.5                  | 2.5             | 53.5              | 0.124       | 0.073     | 430                 | 8 970           |

Figure 5-Current Carrying Capacity of Cable

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### 9. CALCULATIONS

#### 9.1 Illumination Calculations

 $H = h_1 - (h_2 + h_3)$ 

 $h_1 =$ Hight of room

 $h_2$  =Hight of work plane

 $h_3$  =Hanging distance of armature

$$K = \frac{A \times B}{(A+B) \times H}$$

A =Width of the room B = Length of the room

$$\phi t = \frac{E_o \times S}{M \times n}$$

 $\phi t$  =Total light flux

 $E_o$  = Average illumination level (standard)

S = Area of the surface

M = Dirty factor

 $\eta$  =Multiplication factor(usage factor)

$$N = \frac{\phi_T}{\phi_A \times Z}$$

N =Number of armature

 $\phi_A$  =Flux of the lamp

Z = Number of lamp in the armature

**Basement Floor** 

Г

BANK SAFE(200 lux)

| H = 3.5 - (1 + 0.5) = 2m   |
|--|
| $K = \frac{78.12}{(9.3 + 8.4) \times 2} = 2.2$                       |
| 2 0.51   |
| 2.2 η<br>2.5 0.56  |
| $\eta = 0.51 + \frac{2.22 - 2}{2.5 - 2} \times (0.56 - 0.51) = 0.53$ |
| $\phi t = \frac{78.12 \times 200}{0.85 \times 0.53} = 34681.4$       |
| $N = \frac{34681.4}{1000 \times 4} = 8.7 \cong 9$                    |

CUSTOMER SAFE ROOM(150 lux)

| H = 3.5 - (1 + 0.5) = 2m   |  |
|--|--|
| $K = \frac{36}{(4+9) \times 2} = 1.384$                                    |  |
| 1.25 0.41  |  |
| 1.384 $\eta$   |  |
| 1.5 0.45   |  |
| $\eta = 0.41 + \frac{1.5 - 1.25}{1.5 - 1.25} \times (0.45 - 0.41) = 0.431$ |  |
| $\phi t = \frac{36 \times 150}{0.85 \times 0.431} = 13921$                 |  |
| $N = \frac{13921}{1000 \times 4} = 3.4 \cong 3$                            |  |

BANK ARCHIVE(50 lux)

| H = 3.5 - (1 + 0.5) = 2m                                       |
|--|
| $K = \frac{111.65}{(7.7 + 14.5) \times 2} = 2.5$               |
| $\eta = 0.56$  |
| $\phi t = \frac{111.65 \times 50}{0.85 \times 0.56} = 11727.9$ |
| $N = \frac{11727.9}{1000 \times 2} = 5.8 \cong 6$              |

## STORAGE ARCHIVE(100 lux)

| H = 3.5 - (1 + 0.5) = 2m   |
|--|
| $K = \frac{58.5}{(9+6.5)\times2} = 1.887$                                |
| 1.5 0.45   |
| $   \begin{array}{cccc}     1.887 & \eta \\     2 & 0.51   \end{array} $ |
| $\eta = 0.45 + \frac{1.887 - 1.5}{2 - 1.5} \times (0.51 - 0.45) = 0.50$  |
| $\phi t = \frac{58.5 \times 100}{0.85 \times 0.50} = 13882.3$            |
| $N = \frac{13882.3}{1000 \times 4} = 3.5 \cong 4$                        |

### SAFE TRUCK AREA(150 lux)

|   | H = 3.5 - (1 + 0.5) = 2m                                       |  |
|---|--|--|
| - | $K = \frac{68.25}{(9.75+7) \times 2} = 2.03 \approx 2$         |  |
|   | $\eta = 0.51$  |  |
|   | $\phi t = \frac{68.25 \times 150}{0.85 \times 0.51} = 23615.9$ |  |
|   | $N = \frac{23615.9}{1000 \times 4} = 5.9 \cong 6$              |  |

### MECHANICAL-ELECTRICAL SERVISE(100 lux)

| - | H = 3.5 - (1 + 0.5) = 2m   |  |
|---|--|--|
|   | $K = \frac{84}{(12+7) \times 2} = 2.21$                              |  |
|   | 2 0.51<br>2.21 η<br>2.5 0.56   |  |
|   | $\eta = 0.51 + \frac{2.21 - 2}{2.5 - 2} \times (0.56 - 0.51) = 0.53$ |  |
|   | $\phi t = \frac{84 \times 100}{0.85 \times 0.53} = 18645.9$          |  |
|   | $N = \frac{18645.9}{1000 \times 4} = 4.6 \cong 5$                    |  |

OFFICE CIRCULATION AREA(150 lux)

| <br>H = 3.5 - (1 + 0.5) = 2m   |  |
|--|--|
| $K = \frac{17.5}{(7+2.5) \times 2} = 0.92$                             |  |
| 0.8 0.31   |  |
| 0.92 η<br>1 0.36   |  |
| $\eta = 0.31 + \frac{0.92 - 0.8}{1 - 0.8} \times (0.36 - 0.31) = 0.34$ |  |
| $\phi t = \frac{17.5 \times 150}{0.85 \times 0.34} = 9083.04$          |  |
| $N = \frac{9083.04}{1000 \times 4} = 2.27 \cong 2$                     |  |

## OFFICE CIRCULATION AREA(100 lux)

| H = 3.5 - (1 + 0.5) = 2m  |
|---|
| $K = \frac{23.52}{(4.8 + 4.9) \times 2} = 1.21$                                     |
| 1 0.36  |
| $1.21  \eta$  |
| <br>1.25 0.41   |
| $\eta = 0.36 + \frac{1.21 - 1}{1.25 - 1} \times (0.41 - 0.36) = 0.402 \approx 0.40$ |
| $\phi t = \frac{23.52 \times 100}{0.85 \times 0.40} = 6917.6$                       |
| $N = \frac{6917.6}{1000 \times 4} = 1.7 \cong 2$                                    |

## **Ground Floor**

#### KITCHEN(150 lux)

|      | H = 3.5 - (1 + 0.5) = 2m                                      |  |
|------|---|--|
| 8    | $K = \frac{(1.6) \times (2.7)}{(1.6 + 2.7) \times 2} = 0.5$   |  |
| - ka | Since 0.5<0.6<br>$\eta = 0.24$                                |  |
|      | $\phi t = \frac{4.32 \times 150}{0.85 \times 0.24} = 3000 lm$ |  |
|      | $N = \frac{3000}{1000 \times 4} = 0.75 \cong 1$               |  |

SERVICE HALL(150 lux)

H = 3.5 - (1 + 0.5) = 2m

 $K = \frac{4.25}{(4.2) \times 2} = 0.5$  $\eta = 0.24$  (because of the same situation)

 $\phi t = \frac{4.25 \times 150}{0.85 \times 0.24} = 2951.4 lm$ 

 $N = \frac{2951.4}{1000 \times 4} = 0.72 \cong 1$ 

## EMPLOYEE CIRCULATION AREA(150 lux)

| H = 3.5 - (1 + 0.5) = 2m                                     |
|--|
| $K = \frac{12.4}{(7.3) \times 2} = 0.85$                     |
| $ \begin{array}{cccccccccccccccccccccccccccccccccccc$        |
| $\eta = 31 + \frac{36 - 31}{1 - 0.8} (0.85 - 0.8) = 0.323$   |
| $\phi t = \frac{12.4 \times 150}{0.85 \times 0.32} = 6458lm$ |
| $N = \frac{6458}{1000 \times 4} = 1.6 \cong 2$               |
| HEAD CASHER(150 lux)   |
| H = 3.5 - (1 + 0.5) = 2m                                     |
| $K = \frac{11.5}{(7.1) \times 2} = 0.8$                      |
| $\eta=0.31$ from the table                                   |
| $\phi t = \frac{11.5 \times 150}{0.85 \times 0.31} = 6183m$  |

 $N = \frac{6183}{1000 \times 4} = 1.5 \cong 2$ 

| H = 3.5 - (1 + 0.5) = 2m   |
|--|
| $K = \frac{15}{(9.8) \times 2} = 0.77$                                   |
| $\begin{array}{ccc} 0.6 & 0.24 \\ 0.77 & \eta \\ 0.8 & 0.31 \end{array}$ |
| $\eta = 24 + \frac{31 - 24}{0.8 - 0.6} \times (0.77 - 0.6) = 0.29$       |
| $\phi t = \frac{15 \times 150}{0.85 \times 0.3} = 8333lm$                |
| $N = \frac{8333}{1000 \times 4} = 2.08 \cong 2$                          |
| OPEN OFFICE (150 lux)  |
| H = 3.5 - (1 + 0.5) = 2m   |
| $K = \frac{105}{(7+15) \times 2} = 2.4$                                  |
| $\begin{array}{cccc} 2 & 0.51 \\ 2.4 & \eta \\ 2.5 & 0.56 \end{array}$   |
| $\eta = 51 + \frac{56 - 51}{2.5 - 2} \times (2.4 - 2) = 0.56$            |
| $\phi t = \frac{105 \times 150}{0.85 \times 0.56} = 31250 lm$            |
| $N = \frac{31250}{1000 \times 4} = 7.8 \cong 8$                          |

WAITING AREA(150 lux)

| H = 3.5 - (1 + 0.5) = 2m  |
|---|
| $K = \frac{14}{(8) \times 2} = 0.88$                                    |
| $\begin{array}{cccc} 0.8 & 0.31 \\ 0.88 & \eta \\ 1 & 0.36 \end{array}$ |
| $\eta = 31 + \frac{36 - 31}{1 - 0.8} \times (0.88 - 0.8) = 0.33$        |
| $\phi t = \frac{14 \times 150}{0.85 \times 0.33} = 7070 lm$             |
| $N = \frac{7070}{1000 \times 4} = 1.76 \cong 2$                         |
| LOOBY(150 lux)  |
| H = 3.5 - (1 + 0.5) = 2m  |
| $K = \frac{16.3}{(9.6) \times 2} = 0.85$                                |
| $\begin{array}{cccc} 0.8 & 0.31 \\ 0.85 & \eta \\ 1 & 0.36 \end{array}$ |
| $\eta = 31 + \frac{36 - 31}{1 - 0.8} \times (0.85 - 0.8) = 0.31$        |
| $\phi t = \frac{16.3 \times 150}{0.85 \times 0.31} = 8232lm$            |
| $N = \frac{8232}{1000 \times 4} = 2.05 \cong 2$                         |

### CUSTOMER CIRCUATION AREA(150lux)

| H = 3.5 - (1 + 0.5) = 2m  |  |
|---|--|
| $K = \frac{23.9}{(9.8) \times 2} = 1.2$                                 |  |
| $\begin{array}{cccc} 1 & 0.36 \\ 1.2 & \eta \\ 1.25 & 0.41 \end{array}$ |  |
| $\eta = 36 + \frac{41 - 36}{1.25 - 1} \times (1.2 - 1) = 0.4$           |  |
| $\phi t = \frac{23.9 \times 150}{0.85 \times 0.4} = 9958lm$             |  |
| $N = \frac{9958}{1000 \times 4} = 2.4 \cong 2$                          |  |

### BANK ENTERANCE(150lux)

| H = 3.5 - (1 + 0.5) = 2m  |  |
|---|--|
| $K = \frac{170}{(31.1) \times 2} = 2.7$                         |  |
| 2.5 56<br>2.7 $\eta$<br>3 59                                    |  |
| $\eta = 56 + \frac{59 - 56}{3 - 2.5} \times (2.7 - 2.5) = 0.57$ |  |
| $\phi t = \frac{170 \times 150}{0.85 \times 0.57} = 49707 lm$   |  |
| $N = \frac{49707}{1000 \times 4} = 12.4 \cong 12$               |  |

WAITING AREA(130 LUX)

|   | H = 3.5 - (1 + 0.5) = 2m   |
|---|--|
| 1 | $K = \frac{53.3}{(15) \times 2} = 1.84$                          |
|   | $\begin{array}{cccccccccccccccccccccccccccccccccccc$             |
|   | $\eta = 45 + \frac{51 - 45}{2 - 1.5} \times (1.84 - 1.5) = 0.49$ |
|   | $\phi t = \frac{55.3 \times 150}{0.85 \times 0.49} = 19196 lm$   |
|   | $N = \frac{19196}{1000 \times 4} = 4.8 \cong 5$                  |

#### CREDIT OFFICER

| H = 3.5 - (1 + 0.5) = 2m  |
|---|
| $K = \frac{21.5}{(9.3) \times 2} = 1.15$                        |
| 1. 45<br>1.15 $\eta$<br>1.25 41                                 |
| $\eta = 36 + \frac{41 - 36}{1.25 - 1} \times (1.15 - 1) = 0.39$ |
| $\phi t = \frac{21.5 \times 150}{0.85 \times 0.39} = 9728lm$    |
| $N = \frac{9728}{1000 \times 4} = 2.4 \cong 2$                  |

|   | H = 3.5 - (1 + 0.5) = 2m   |  |
|---|--|--|
|   | $K = \frac{12.25}{(7.4) \times 2} = 0.83$                          |  |
| 4 | $\begin{array}{ccc} 0.8 & 31 \\ 0.83 & \eta \\ 1 & 36 \end{array}$ |  |
|   | $\eta = 31 + \frac{36 - 31}{1 - 0.8} \times (0.83 - 0.8) = 0.31$   |  |
|   | $\phi t = \frac{12.25 \times 150}{0.85 \times 0.31} = 4841 lm$     |  |
|   | $N = \frac{4841}{1000 \times 4} = 1.74 \cong 2$                    |  |

#### COUNTER-BACK WORKING SPACE(150 lux)

H = 3.5 - (1 + 0.5) = 2m

$$K = \frac{85.8}{(5.8 + 14.8) \times 2} = 2$$

 $\eta = 0.51$  exact value from the table

$$\phi t = \frac{85.8 \times 150}{0.85 \times 0.51} = 29688lm$$

$$N = \frac{29688}{1000 \times 4} = 7.4 \cong 8$$

|   | H = 3.5 - (1 + 0.5) = 2m   |  |
|---|--|--|
| 4 | $K = \frac{14.8}{(8.2) \times 2} = 0.9$                            |  |
|   | $\begin{array}{cccc} 0.8 & 31 \\ 0.9 & \eta \\ 1 & 36 \end{array}$ |  |
|   | $\eta = 31 + \frac{36 - 31}{1 - 0.8} \times (0.9 - 0.8) = 0.33$    |  |
|   | $\phi t = \frac{14.8 \times 150}{0.85 \times 0.33} = 7681 lm$      |  |
|   | $N = \frac{7681}{1000 \times 4} = 1.9 \cong 2$                     |  |

#### IN FRONT OF THE BRANCH MANAGER(150 lux)

| H = 3.5 - (1 + 0.5) = 2m                                       |
|--|
| $K = \frac{7.41}{(7) \times 2} = 0.6$                          |
| $\eta=0.24$  |
| $\phi t = \frac{7.41 \times 150}{0.85 \times 0.24} = 5448.5lm$ |
| $N = \frac{5448.5}{1000 \times 4} = 1.3 \cong 1$               |

### SECURITY CHECK POINT(150lux)

|    | H = 3.5 - (1 + 0.5) = 2m   |  |
|----|--|--|
| /  | $K = \frac{26.5}{(10.3) \times 2} = 1.28$                            |  |
| ÷. | $\begin{array}{cccccccccccccccccccccccccccccccccccc$                 |  |
|    | $\eta = 41 + \frac{45 - 41}{1.5 - 1.25} \times (1.28 - 1.25) = 0.41$ |  |
|    | $\phi t = \frac{26.5 \times 150}{0.85 \times 0.41} = 11134lm$        |  |
|    | $N = \frac{11134}{1000 \times 4} = 2.8 \cong 3$                      |  |

#### SECRETARY

| H = 3.5 - (1 + 0.5) = 2m                                     |  |
|--|--|
| $K = \frac{4.8}{(4.6) \times 2} = 0.6$                       |  |
| $\eta = 0.24$  |  |
| $\phi t = \frac{4.8 \times 150}{0.85 \times 0.24} = 3529 lm$ |  |
| $N = \frac{3529}{1000 \times 4} = 0.88 \cong 1$              |  |

| H = 3.5 - (1 + 0.5) = 2m                                       |
|--|
| $K = \frac{8.58}{(7.9) \times 2} = 0.54$                       |
| N = 1 since the room dimensions too small                      |
| WC (150 lux)   |
| H = 3.5 - (1 + 0.5) = 2m                                       |
| $K = \frac{21}{(9.2) \times 2} = 1.1$                          |
| $ \begin{array}{cccccccccccccccccccccccccccccccccccc$          |
| $\eta = 36 + \frac{41 - 36}{1.25 - 1} \times (1.1 - 1) = 0.38$ |
| $\phi t = \frac{21 \times 150}{0.85 \times 0.38} = 9752 lm$    |
| $N = \frac{9752}{1000 \times 4} = 13$                          |

**First Floor** 

#### KITCHEN(150 lux)

$$H = 3.5 - (1 + 0.5) = 2m$$

$$K = \frac{4.32}{(4.3) \times 2} = 0.5$$

N = 1 since the room dimensions are too small

#### SERVICE HALL(150 lux)

| H = 3.5 - (1 + 0.5) = 2m   |
|--|
| $K = \frac{4.25}{(4.2) \times 2} = 0.65$                             |
| $\begin{array}{ccc} 0.6 & 24 \\ 0.65 & \eta \\ 0.8 & 31 \end{array}$ |
| $\eta = 24 + \frac{31 - 24}{0.8 - 0.6} \times (0.65 - 0.6) = 0.25$   |
| $\phi t = \frac{4.25 \times 150}{0.85 \times 0.26} = 2884.6lm$       |
| $N = \frac{2884.6}{1000 \times 4} = 0.72 \cong 1$                    |

### EMPLOYEE CIRCULATION AREA(150 lux

|     | H = 3.5 - (1 + 0.5) = 2m  |
|-----|---|
| ÷   | $K = \frac{12.9}{(7.4) \times 2} = 0.87$                            |
| -b. | $\begin{array}{cccc} 0.8 & 31 \\ 0.87 & \eta \\ 1 & 36 \end{array}$ |
|     | $\eta = 31 + \frac{36 - 31}{1 - 0.8} \times (0.87 - 0.8) = 0.32$    |
|     | $\phi t = \frac{12.9 \times 150}{0.85 \times 0.33} = 6898lm$        |
|     | $N = \frac{6898}{1000 \times 4} = 1.7 \cong 2$                      |

### OPEN OFFICE ENTERANCE(150 lux)

| H = 3.5 - (1 + 0.5) = 2m                                     |
|--|
| $K = \frac{4.37}{(4.2) \times 2} = 0.6$                      |
| $\eta=0.24$  |
| $\phi t = \frac{4.37 \times 150}{0.85 \times 0.24} = 3213lm$ |
| $N = \frac{3213}{1000 \times 4} = 0.8 \cong 1$               |

LOOBY

|    | H = 3.5 - (1 + 0.5) = 2m                                      |  |
|----|---|--|
| ê. | $K = \frac{23.8}{(9.8) \times 2} = 1.2$                       |  |
| 5  | $ \begin{array}{cccccccccccccccccccccccccccccccccccc$         |  |
|    | $\eta = 36 + \frac{41 - 36}{1.25 - 1} \times (1.2 - 1) = 0.4$ |  |
|    | $\phi t = \frac{23.8 \times 150}{0.85 \times 0.4} = 10500 lm$ |  |
|    | $N = \frac{10500}{1000 \times 4} = 2.6 \cong 3$               |  |

### CUSTOMER CIRCULATION

| H = 3.5 - (1 + 0.5) = 2m  |  |
|---|--|
| $K = \frac{29.3}{(11) \times 2} = 1.3$                              |  |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$                |  |
| $\eta = 41 + \frac{45 - 41}{1.5 - 1.25} \times (1.3 - 1.25) = 0.41$ |  |
| $\phi t = \frac{29.3 \times 150}{0.85 \times 0.41} = 12311 lm$      |  |
| $N = \frac{12311}{1000 \times 4} = 3.07 \cong 3$                    |  |

### CUSTOMERT SERVICE (150 lux)

|   | H = 3.5 - (1 + 0.5) = 2m   |
|---|--|
| ÷ | $K = \frac{115}{57.6} = 1.9$                                       |
| 2 | $\begin{array}{cccc} 1.5 & 45 \\ 1.9 & \eta \\ 2 & 51 \end{array}$ |
|   | $\eta = 45 + \frac{51 - 45}{2 - 1.5} \times (1.9 - 1.5) = 0.49$    |
|   | $\phi t = \frac{115 \times 150}{0.85 \times 0.49} = 41416lm$       |
|   | $N = \frac{41416}{1000 \times 4} = 10.4 \cong 10$                  |

OPEN OFFICE(150L ux)

| H = 3.5 - (1 + 0.5) = 2m                                      |
|---|
| $K = \frac{97.2}{46.8} = 2$                                   |
| $\eta=0.51$   |
| $\phi t = \frac{97.2 \times 150}{0.85 \times 0.51} = 33633lm$ |
| $N = \frac{33633}{1000 \times 4} = 8.4 \cong 8$               |

## OFFICE CIRCULATION AREA(150 lux)

|   | H = 3.5 - (1 + 0.5) = 2m  |  |
|---|---|--|
| 4 | $K = \frac{16.3}{(9) \times 2} = 0.9$                             |  |
|   | $\begin{array}{ccc} 0.8 & 31 \\ 0.9 & \eta \\ 1 & 36 \end{array}$ |  |
|   | $\eta = 31 + \frac{36 - 31}{1 - 0.8} \times (0.9 - 0.8) = 0.33$   |  |
|   | $\phi t = \frac{16.3 \times 150}{0.85 \times 0.34} = 8460 lm$     |  |
|   | $N = \frac{8460}{1000 \times 4} = 2.1 \cong 2$                    |  |

### DEPARTMENT MANAGER(150 lux

| H = 3.5 - (1 + 0.5) = 2m   |
|--|
| $K = \frac{26.8}{21.2} = 1.26$   |
| $\begin{array}{cccc} 1.25 & 41 \\ 1.26 & \eta \\ 1.5 & 45 \end{array}$ |
| $\eta = 41 + \frac{45 - 41}{1.5 - 1.25} \times (1.26 - 1.25) = 0.41$   |
| $\phi t = \frac{26.8 \times 150}{0.85 \times 0.41} = 11535lm$          |
| $N = \frac{11535}{1000 \times 4} = 2.8 \cong 3$                        |

#### COUNTER BACK WORKING SPACE

| H=3.5                         | 5 - (1 + 0.5) = 2m                                    |
|-------------------------------|---|
| K                             | $=\frac{60}{53}=1.13$                                 |
|                               | $ \begin{array}{cccccccccccccccccccccccccccccccccccc$ |
| $\eta = 36 + \frac{41}{1.25}$ | $\frac{-36}{5-1} \times (1.13 - 1) = 0.38$            |
| $\phi t = \frac{60}{0.8}$     | $\frac{0 \times 150}{5 \times 0.39} = 27149lm$        |
| $N = \frac{1}{1}$             | $\frac{27149}{000 \times 4} = 6.7 \cong 7$            |

### SECRETARTY &WAITING AREA(150lux)

ſ

| H = 3.5 - (1 + 0.5) = 2m                                      |
|---|
| $K = \frac{10.1}{13.6} = 0.6$                                 |
| $\eta = 0.24$   |
| $\phi t = \frac{10.1 \times 150}{0.85 \times 0.24} = 7426 lm$ |
| $N = \frac{7426}{1000 \times 4} = 1.8 \cong 2$                |

4×(OPEN OFFICE) (150 lux)

| H = 3.5 - (1 + 0.5) = 2m                                   |
|--|
| $K = \frac{6}{10} = 0.6$                                   |
| $\eta = 0.24$  |
| $\phi t = \frac{6 \times 150}{0.85 \times 0.24} = 4411 lm$ |
| $N = \frac{4411}{1000 \times 4} = 1.1 \cong 1$             |

#### OFFICE CIRCULATION

| H = 3.5 - (1 + 0.5) = 2m   |
|--|
| $K = \frac{27.6}{28.6} = 0.97$                                     |
| $\begin{array}{ccc} 0.8 & 31 \\ 0.97 & \eta \\ 1 & 36 \end{array}$ |
| $\eta = 31 + \frac{36 - 31}{1 - 0.8} \times (0.97 - 0.8) = 0.35$   |
| $\phi t = \frac{27.6 \times 150}{0.85 \times 0.35} = 13915lm$      |
| $N = \frac{13915}{1000 \times 4} = 3.4 \cong 37$                   |

50

|   | H = 3.5 - (1 + 0.5) = 2m                                       |
|---|--|
|   | $K = \frac{21.6}{18.6} = 1.2$                                  |
| 4 | $ \begin{array}{cccccccccccccccccccccccccccccccccccc$          |
|   | $\eta = 36 + \frac{41 - 36}{1.25 - 1} \times (1.2 - 1) = 0.40$ |
|   | $\phi t = \frac{21.6 \times 150}{0.85 \times 0.4} = 27149 lm$  |
|   | $N = \frac{9529}{700 \times 1} = 13$                           |

**Second Floor** 

#### OPEN OFFICE (150 LX)

| H = 3.5 - (1 + 0.5) = 2  |
|--|
| $K = \frac{260}{(20+13) \times 2} = 3.94$                                      |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$                           |
| $\eta = 0.59 + \frac{3.94 - 3}{4 - 3} \times (0.63 - 0.59) = 0.627 \cong 0.63$ |
| $\varphi t = \frac{260 \times 150}{0.85 \times 0.63} = 72829$                  |
| $N = \frac{72829}{1000 \times 4} = 18.2 \cong 20$                              |
| $K = \frac{33.75}{(7.5 + 4.5) \times 2} = 1.4$                                 |
| $\begin{array}{cccc} 1.25 & 0.41 \\ 1.4 & \eta \\ 1.5 & 0.45 \end{array}$      |
| $\eta = 0.41 + \frac{1.4 - 1.25}{1.5 - 1.25} \times (0.45 - 0.41) = 0.434$     |
| $\varphi t = \frac{33.75 \times 150}{0.85 \times 0.434} = 13723.2$             |
| $N = \frac{13723.2}{1000 \times 4} = 3.43 \cong 3$                             |

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## CUSTOMER CIRCULATION AREA (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{16.75}{(6.7 + 2.5) \times 2} = 0.91$                                     |
| $\begin{array}{ccc} 0.8 & 0.31 \\ 0.91 & \eta \\ 1 & 0.36 \end{array}$              |
| $\eta = 0.31 + \frac{0.91 - 0.8}{1 - 0.8} \times (0.36 - 0.31) = 0.3375 \cong 0.34$ |
| $\varphi t = \frac{16.75 \times 150}{0.85 \times 0.34} = 8693.8$                    |
| $N = \frac{8693.8}{1000 \times 4} = 2.2 \cong 2$                                    |
| $K = \frac{7.2}{(3.6+2) \times 2} = 0.64$   |
| $\begin{array}{cccc} 0.6 & 0.24 \\ 0.64 & \eta \\ 0.8 & 0.31 \end{array}$           |
| $\eta = 0.24 + \frac{0.64 - 0.6}{0.8 - 0.6} \times (0.31 - 0.24) = 0.254$           |
| $\varphi t = \frac{7.2 \times 150}{0.85 \times 0.254} = 5002.3$                     |
| $N = \frac{5002.3}{1000 \times 4} = 1.25 \cong 1$                                   |

|  | VERSITY   |
|--|-----------|
| SECRETARY / WAITING AREA (150 LX)                                      | BRAR      |
| H = 3.5 - (1 + 0.5) = 2  | A LON ISS |
| $K = \frac{25}{(5.8 + 4.3) \times 2} = 1.24 \cong 1.25$                |           |
| $\eta = 1.25$  |           |
| $\varphi t = \frac{25 \times 150}{0.85 \times 0.41} = 10760.4$         |           |
| $N = \frac{10760.4}{1000 \times 4} = 2.7 \cong 3$                      |           |
| $K = \frac{50}{(25+2) \times 2} = 0.93$                                |           |
| $\begin{array}{ccc} 0.8 & 0.31 \\ 0.93 & \eta \\ 1 & 0.36 \end{array}$ |           |
| $\eta = 0.31 + \frac{0.93 - 0.8}{1 - 0.8} \times (0.36 - 0.31) = 0.34$ |           |
| $\varphi t = \frac{50 \times 150}{0.85 \times 0.34} = 25951.5$         |           |
| $N = \frac{25951.5}{1000 \times 4} = 6.48 \cong 6$                     |           |

VICE PRESIDENT (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{36.75}{(7.5 + 4.9) \times 2} = 1.48 \cong 1.5$         |
| $\eta=0.45$   |
| $\varphi t = \frac{36.75 \times 150}{0.85 \times 0.45} = 14411.8$ |
| $N = \frac{14411.8}{1000 \times 4} = 3.6 \cong 4$                 |

#### PRESIDENT (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{41.25}{(7.5 + 5.5) \times 2} = 1.59$                         |
| $\begin{array}{cccc} 1.5 & 0.45 \\ 1.59 & \eta \\ 2 & 0.51 \end{array}$ |
| $\eta = 0.45 + \frac{1.59 - 1.5}{2 - 1.5} \times (0.51 - 0.45) = 0.46$  |
| $\varphi t = \frac{41.25 \times 150}{0.85 \times 0.46} = 15824.8$       |
| $N = \frac{15824.8}{1000 \times 4} = 3.96 \cong 4$                      |

REGIONAL MANAGER (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{23.22}{(5.4 + 4.3) \times 2} = 1.2$                          |
| $\begin{array}{cccc} 1 & 0.36 \\ 1.2 & \eta \\ 1.25 & 0.41 \end{array}$ |
| $\eta = 0.36 + \frac{1.2 - 1}{1.25 - 1} \times (0.41 - 0.36) = 0.4$     |
| $\varphi t = \frac{23.22 \times 150}{0.85 \times 0.4} = 10244$          |
| $N = \frac{10244}{1000 \times 4} = 2.56 \cong 3$                        |

### DEPARTMENT MANAGER (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{41.44}{(7.4 + 5.6) \times 2} = 1.594 \cong 2$        |
| $\eta = 2$  |
| $\varphi t = \frac{41.44 \times 150}{0.85 \times 0.51} = 14339$ |
| $N = \frac{14339}{1000 \times 4} = 3.59 \cong 4$                |

MEETING ROOM (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{43}{(6.9 + 6.5) \times 2} = 1.6$                           |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$                  |
| $\eta = 0.45 + \frac{1.6 - 1.5}{2 - 1.5} \times (0.51 - 0.45) = 0.46$ |
| $\varphi t = \frac{43 \times 150}{0.85 \times 0.46} = 16496.2$        |
| $N = \frac{16496.2}{1000 \times 4} = 4.12 \cong 4$                    |

OFFICE CIRCULATION AREA (150 LX)

| H = 3.5 - (1 + 0.5) = 2  |
|--|
| $K = \frac{16.25}{(6.5 + 2.5) \times 2} = 0.9$                         |
| $\begin{array}{ccc} 0.8 & 0.31 \\ 0.9 & \eta \\ 1 & 0.36 \end{array}$  |
| $\eta = 0.31 + \frac{0.9 - 0.8}{1 - 0.8} \times (0.36 - 0.31) = 0.335$ |
| $\varphi t = \frac{16.25 \times 150}{0.85 \times 0.335} = 8560$        |
| $N = \frac{8560}{1000 \times 4} = 2.14 \cong 2$                        |

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LOBBY / WAITING AREA (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |  |
|---|--|
| $K = \frac{30.25}{(5.5 + 5.5) \times 2} = 1.375$                            |  |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$                        |  |
| $\eta = 0.41 + \frac{1.375 - 1.25}{1.5 - 1.25} \times (0.45 - 0.41) = 0.43$ |  |
| $\varphi t = \frac{30.25 \times 150}{0.85 \times 0.43} = 12414.5$           |  |
| $N = \frac{12414.5}{1000 \times 4} = 3.1 \cong 3$                           |  |

# Third Fourth, Fifth and Sixth Floors

| OFFICE-1(150 lux)   |
|---|
| H = 3.5 - (1 + 0.5) = 2   |
| $K = \frac{71.5}{(6.5 + 11) \times 2} = 2.04 \approx 2$                           |
| $\eta=0.51$   |
| $\phi t = \frac{71.5 \times 150}{0.85 \times 0.51} = 24740.4$                     |
| $N = \frac{24740.4}{1000 \times 4} = 6.1 \cong 6$                                 |
| $K = \frac{80}{(10+8) \times 2} = 2.22$   |
| $\begin{array}{cccc} 2 & 0.51 \\ 2.22 & \eta \\ 3 & 0.59 \end{array}$             |
| $\eta = 0.51 + \frac{2.22 - 2}{3 - 2} \times (0.59 - 0.51) = 0.5276 \approx 0.53$ |
| $\phi t = \frac{80 \times 150}{0.85 \times 0.53} = 25157$                         |
| $N = \frac{25157}{1000 \times 4} = 6.2 \cong 6$                                   |
| 6 + 6 = 12  |

OFFICE-2(150 lux)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{14.04}{(2.7 + 5.2) \times 2} = 0.888$                                      |
| $\begin{array}{cccc} 0.8 & 0.31 \\ 0.888 & \eta \\ 1 & 0.36 \end{array}$              |
| $\eta = 0.31 + \frac{0.888 - 0.8}{1 - 0.8} \times (0.36 - 0.31) = 0.332 \approx 0.33$ |
| $\phi t = \frac{14.04 \times 150}{0.85 \times 0.33} = 7508$                           |
| $N = \frac{7508}{1000 \times 4} = 1.877 \cong 2$                                      |
| $K = \frac{120}{(10+12) \times 2} = 2.72$   |
| $\begin{array}{cccc} 2.5 & 0.56 \\ 2.72 & \eta \\ 3 & 0.59 \end{array}$               |
| $\eta = 0.56 + \frac{2.72 - 2.5}{3 - 2.5} \times (0.59 - 0.56) = 0.573 \approx 0.57$  |
| $\phi t = \frac{120 \times 150}{0.85 \times 0.57} = 37151.7$                          |
| $N = \frac{37151.7}{1000 \times 4} = 9.2 \cong 9$                                     |
| 9 + 2 = 11  |

OFFICE-3(150 lux)

| H = 3.5 - (1 + 0.5) = 2                                       |
|---|
| $K = \frac{150}{(15+10) \times 2} = 3$                        |
| $\eta = 0.59$   |
| $\phi t = \frac{150 \times 150}{0.85 \times 0.59} = 44865.40$ |
| $N = \frac{44865.40}{1000 \times 4} = 11.2 \cong 11$          |

OFFICE-4(150 lux)

| H = 3.5 - (1 + 0.5) = 2  |
|--|
| $K = \frac{165}{(15+11) \times 2} = 3.2$   |
| $\begin{array}{cccc} 3 & 0.59 \\ 3.2 & \eta \\ 4 & 0.63 \end{array}$             |
| $\eta = 0.59 + \frac{23.2 - 3}{4 - 3} \times (0.63 - 0.59) = 0.598 \approx 0.60$ |
| $\phi t = \frac{165 \times 150}{0.85 \times 0.60} = 48529.4$                     |
| $N = \frac{48529.4}{1000 \times 4} = 12.1 \cong 12$                              |

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OFFICE CIRCULATION AREA(E>150 lux)

| H = 3.5 - (1 + 0.5) = 2  |
|--|
| $K = \frac{30}{(12+2.5)\times 2} = 1.03 \cong 1$                           |
| $\eta = 0.36$  |
| $\phi t = \frac{30 \times 150}{0.85 \times 0.36} = 14070.5$                |
| $N = \frac{14070.5}{1000 \times 4} = 3.7$                                  |
| 5 armatures are used according to lifts and stairs                         |
| WAITING AREA (150 lux)   |
| H = 3.5 - (1 + 0.5) = 2  |
| $K = \frac{22.3}{(5.25 + 4.25) \times 2} = 1.17$                           |
| $\begin{array}{cccc} 1.0 & 0.36 \\ 1.17 & \eta \\ 1.25 & 0.41 \end{array}$ |
| $\eta = 0.36 + \frac{1.17 - 1}{1.25 - 1} \times (0.41 - 0.36) = 0.394$     |
| $\phi t = \frac{22.3 \times 150}{0.85 \times 0.394} = 9980$                |
| $N = \frac{9980}{1000 \times 4} = 2.4 \cong 2$                             |

ENTRANCE HALL(100<E<150 lux)

| H = 3.5 - (1 + 0.5) = 2  |  |
|--|--|
| $K = \frac{60}{(4+15) \times 2} = 1.6$                                 |  |
| $ \begin{array}{cccccccccccccccccccccccccccccccccccc$                  |  |
| $\eta = 0.45 + \frac{1.6 - 1.5}{2 - 1.5} \times (0.51 - 0.45) = 0.462$ |  |
| $\phi t = \frac{60 \times 150}{0.85 \times 0.462} = 22918.2$           |  |
| $N = \frac{22918.2}{1000 \times 4} = 5.7$                              |  |
| $\phi t = \frac{60 \times 100}{0.85 \times 0.462} = 15278.8$           |  |
| $N = \frac{15278.8}{1000 \times 4} = 3.8$                              |  |
| 5 armatures are used according to hall                                 |  |

THE REAL PROPERTY OF THE REAL

## **Seventh Floor**

### OFFICE'S ENTERANCE HALL (150 LX)

|             | H = 3.5 - (1 + 0.5) = 2  |
|-------------|--|
|             | $K = \frac{54.6}{(13+4.2)\times 2} = 1.59$                       |
|             | $\begin{array}{cccccccccccccccccccccccccccccccccccc$             |
| $\eta = 0.$ | $45 + \frac{1.59 - 1.5}{2 - 1.5} \times (0.51 - 0.45) = 0.46$    |
|             | $\varphi t = \frac{54.6 \times 150}{0.85 \times 0.46} = 20946.3$ |
|             | $N = \frac{20946.3}{1000 \times 4} = 5.24 \cong 5$               |
|             | $K = \frac{21.84}{(5.2 + 4.2) \times 2} = 1.16$                  |
|             | $\begin{array}{cccccccccccccccccccccccccccccccccccc$             |
| $\eta = 0$  | $36 + \frac{1.16 - 1}{1.25 - 1} \times (0.41 - 0.36) = 0.39$     |
|             | $\varphi t = \frac{21.84 \times 150}{0.85 \times 0.39} = 9882.4$ |
| v.          | $N = \frac{9882.4}{1000 \times 4} = 2.47 \cong 2$                |
OFFICE CIRCULATION AREA (150 LX)

|   | H = 3.5 - (1 + 0.5) = 2  |  |
|---|--|--|
|   | $K = \frac{29.4}{(11.75 + 2.5) \times 2} = 1$                    |  |
|   | $\eta = 0.36$  |  |
| 5 | $\varphi t = \frac{29.4 \times 150}{0.85 \times 0.36} = 14411.8$ |  |
|   | $N = \frac{14411.8}{1000 \times 4} = 3.6 \cong 4$                |  |

OFFICE AREA (150 LX)

| H = 3.5 - (1 + 0.5) = 2   |
|---|
| $K = \frac{168.3}{(15.3 + 11) \times 2} = 3.2$                                |
| $\begin{array}{cccc} 3 & 0.59 \\ 3.2 & \eta \\ 4 & 0.63 \end{array}$          |
| $\eta = 0.59 + \frac{3.2 - 3}{4 - 3} \times (0.63 - 0.59) = 0.598 \cong 0.60$ |
| $\varphi t = \frac{168.3 \times 150}{0.85 \times 0.60} = 49500$               |
| $N = \frac{49500}{1000 \times 4} = 12.37 \cong 13$                            |

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OFFICE AREA (150 LX)

| H = 3.5 - (1 + 0.5) = 2  |
|--|
| $K = \frac{79.4}{(9.8 + 8.1) \times 2} = 2.2$                          |
| $\begin{array}{cccc} 2 & 0.51 \\ 2.2 & \eta \\ 2.5 & 0.56 \end{array}$ |
| $\eta = 0.51 + \frac{2.2 - 2}{2.5 - 2} \times (0.56 - 0.51) = 0.53$    |
| $\varphi t = \frac{79.4 \times 150}{0.85 \times 0.53} = 26437.3$       |
| $N = \frac{26437.3}{1000 \times 4} = 6.6 \cong 8$                      |
| $K = \frac{25}{(5+5) \times 2} = 1.25$                                 |
| $\eta=0.41$  |
| $\varphi t = \frac{25 \times 150}{0.85 \times 0.41} = 10760.4$         |
| $N = \frac{10760.4}{1000 \times 4} = 2.7 \cong 2$                      |

OFFICE AREA (150 LX)

| H = 3.5 - (1 + 0.5) = 2  |
|--|
| $K = \frac{42.25}{(6.5 + 6.5) \times 2} = 1.63$                        |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$                   |
| $\eta = 0.45 + \frac{1.63 - 1.5}{2 - 1.5} \times (0.51 - 0.45) = 0.47$ |
| $\varphi t = \frac{42.25 \times 150}{0.85 \times 0.47} = 15863.6$      |
| $N = \frac{15863.6}{1000 \times 4} = 3.97 \cong 4$                     |
| RECEPTION / WAITING AREA (150 LX)                                      |
| H = 3.5 - (1 + 0.5) = 2  |
| $K = \frac{13.5}{(5+2.7) \times 2} = 0.88$                             |
| $\begin{array}{ccc} 0.8 & 0.31 \\ 0.88 & \eta \\ 1 & 0.36 \end{array}$ |
| $\eta = 0.31 + \frac{0.88 - 0.8}{1 - 0.8} \times (0.36 - 0.31) = 0.33$ |
| $\varphi t = \frac{13.5 \times 150}{0.85 \times 0.33} = 7219.3$        |
| $N = \frac{7219.3}{1000 \times 4} = 1.8 \cong 2$                       |

ſ

| H = 3.5 - (1 + 0.5) = 2  |
|--|
| $K = \frac{138}{(12.5 + 11) \times 2} = 2.94$                                      |
| $\begin{array}{cccc} 2.5 & 0.56 \\ 2.94 & \eta \\ 3 & 0.59 \end{array}$            |
| $\eta = 0.56 + \frac{2.94 - 2.5}{3 - 2.5} \times (0.59 - 0.56) = 0.586 \cong 0.59$ |
| $\varphi t = \frac{138 \times 150}{0.85 \times 0.59} = 41276.2$                    |
| $N = \frac{41276.2}{1000 \times 4} = 10.3 \cong 10$                                |
| $K = \frac{13.5}{(5+2.7)\times 2} = 0.88$  |
| $\begin{array}{cccc} 0.8 & 0.31 \\ 0.88 & \eta \\ 1 & 0.36 \end{array}$            |
| $\eta = 0.31 + \frac{0.88 - 0.8}{1 - 0.8} \times (0.36 - 0.31) = 0.33$             |
| $\varphi t = \frac{13.5 \times 150}{0.85 \times 0.33} = 7219.3$                    |
| $N = \frac{7219.3}{1000 \times 4} = 1.8 \cong 2$                                   |

# 9.2 Power Calculations

| TABLE                   |        |  |               |        | BASEMENT   | FLOOR  |
|-------------------------|--------|--|---------------|--------|--|--|
| NAME<br>OF THE<br>BOARD | POWER  | CURRENT  | USED<br>CABLE | SWITCH | EXPLANATION  | INDIVIDUAL<br>POWERS   |
| ADP                     | 739326 | $I = \frac{739326}{\sqrt{3} \times 380 \times 0.95} = 1183A$ |               |        | TDPB-1         TDPB-2         TDPZ-1         TDPZ-2         TDP1         TDP2         TDP3         TDP4         TDP5         TDP6         TDP7 | 13128W         9600W         38512W         12466W         34086W         27774W         32298W         32298W         32298W         32298W         32298W         32298W         32298W         32298W         32298W         32298W |
|                         |        | L  |               | Т      | TOTAL  | 739326W  |

| TABLE                   |       |  |                                 |        | BASEMENT FLOOR       |                      |
|-------------------------|-------|--|---------------------------------|--------|----------------------|----------------------|
| OF THE<br>BOARD         | POWER | CURRENT  | USED<br>CABLE                   | SWITCH | EXPLANATION          | INDIVIDUAL<br>POWERS |
|                         |       |  |                                 |        | CENTRAL AIRCONDITION | 400000W              |
|                         |       | $\frac{445700}{\times 380 \times 0.95} = 713A$ | 5 <i>mm</i> <sup>2</sup> (810A) | 750 A  | HYDROFOR             | 6000W                |
|                         | N     |  |                                 |        | LIFT1                | 7500W                |
|                         |       |  |                                 |        | LIFT2                | 7500W                |
| Ģ                       | 0     |  |                                 |        | LIFT3                | 7500W                |
| d                       | 570   |  |                                 |        | LIFT4                | 7500W                |
| D                       |       |  |                                 |        | LIFT5                | 7500W                |
| $\left[ \dashv \right]$ | 4     |  |                                 | 3X     | RESERVE OF $3\phi$   | 2200W                |
|                         | 4     | $l = \frac{1}{\sqrt{3}}$                       | 2× 18                           |        |                      |                      |
| T                       |       |  |                                 |        | OTAL                 | 445700W              |

| TABLE                   |        |   |                                   |               | BASEMENT FLOOR  |  |
|-------------------------|--------|---|-----------------------------------|---------------|---|--|
| NAME<br>OF THE<br>BOARD | POWER  | CURRENT   | USED<br>CABLE                     | SWITCH        | EXPLANATION   | INDIVIDUAL<br>POWERS   |
| TDPB-1                  | 13128W | $I = \frac{13128}{\sqrt{3} \times 380 \times 0.95} = 21A$ | 6 <i>mm</i> <sup>2</sup> NYA(47A) | (30mA) 3×32 A | 27 ARMATURE(4×18W)=108LAMP<br>9 ARMATURE(2×18W)=18LAMP<br>10 SPOT LAMP(1×18W)<br>7 DOUBLE SOCKET (14 SINGLE)<br>STAIR ILLUMINATION<br>AIR CONDITION FEEDER(2000W)<br>RESERVE OF ILLUMINATIONS<br>RESERVE OF SOCKETS<br>RESERVE OF $3\phi$ | 108×18W=1944W<br>18×18W=324W<br>10×18W=180W<br>14×300W=4200W<br>8×60=480W<br>1×2000W=2000W<br>300W<br>1500W<br>2200W |
| Т                       |        |   |                                   |               | TOTAL   | 13128W   |

| TABLE                   |        |                                       |               |        | BASEMENT F                  | LOOR                 |
|-------------------------|--------|---------------------------------------|---------------|--------|-----------------------------|----------------------|
| NAME<br>OF THE<br>BOARD | POWER  | CURRENT                               | USED<br>CABLE | SWITCH | EXPLANATION                 | INDIVIDUAL<br>POWERS |
|                         |        | 4                                     |               |        | 19 ARMATURE(4×18W)=76 LAMP  | 76×18W=1368W         |
|                         |        | $\frac{1}{0.95} = 15.3$               | A(47A)        | 3×32 A | 2 SPOT LAMP(1×18W)          | $2 \times 18W = 36W$ |
|                         |        |                                       |               |        | 7 DOUBLE SOCKET (14 SINGLE) | 14×300W=4200W        |
| B-2                     | $\geq$ |                                       |               |        | RESERVE OF ILLUMINATIONS    | 300W                 |
|                         |        |                                       |               |        | RESERVE OF SOCKETS          | 1500W                |
| Π                       | 8      |                                       | XV            |        | RESERVE OF $3\phi$          | 2200W                |
| TD                      | )96    | $I = \frac{960}{\sqrt{3} \times 380}$ | $6mm^2$ N     | (30mA  |                             |                      |
| -                       |        |                                       | ·             | Т      | TOTAL                       | 9600W                |

| TABLE                   |         |   |                |            | GROUND FL  | OOR  |
|-------------------------|---------|---|----------------|------------|--|--|
| NAME<br>OF THE<br>BOARD | POWER   | CURRENT   | USED<br>CABLE  | SWITCH     | EXPLANATION  | INDIVIDUAL<br>POWERS   |
| TDPZ-1                  | 38512 W | $\frac{38512}{\overline{3} \times 380 \times 0.95} = 61.7A$ | $nm^2NYA(65A)$ | 0mA) 3×63A | 4/ARMATURE(4×18W)=188 LAMP<br>4 ARMATURE(2×18W)=8LAMP<br>13 SPOT LAMP(1×18W)<br>23 DOUBLE SOCKET (46SINGLE)<br>2 COOKER (3000W)<br>2 SINGLE SOCKET -COOKER (300W)<br>2EXTERIOR ILLAIR CIRCULATION<br>1 DETECOR<br>RESERVE OF ILLUMINATIONS | 188×18W=3384W<br>8×18W=144W<br>13×18W=234W<br>46×300W=13800W<br>2×300W=6000W<br>2×300W=600W<br>2×5000W=10000W<br>1×350W=350W<br>300W |
|                         |         |   | 10n            | (3(<br>т   | RESERVE OF SOCKETS<br>RESERVE OF $3\phi$<br>OTAL   | 1500W<br>2200W<br>38512W   |

| TABLE                   |         |   |                 |               | GROUND FL   | OOR   |
|-------------------------|---------|---|-----------------|---------------|---|---|
| NAME<br>OF THE<br>BOARD | POWER   | CURRENT   | USED<br>CABLE   | SWITCH        | EXPLANATION   | INDIVIDUAL<br>POWERS  |
| TDPZ-2                  | 12466 W | $I = \frac{12466}{\sqrt{3} \times 380 \times 0.95} = 20A$ | $6mm^2NYA(47A)$ | (30mA) 3×32 A | 8 ARMATURE(4×18W)=32 LAMP<br>3 DOUBLE SOCKET (6 SINGLE)<br>1 EXTERIOR ILLAIR CIRCULATION<br>1 DETECOR<br>STAIR ILLUMINATION<br>AIR CONDITION FEEDER(2000W)<br>RESERVE OF ILLUMINATIONS<br>RESERVE OF SOCKETS<br>RESERVE OF 3φ | 32×18W=576W<br>6×300W=1800W<br>1×5000W=5000W<br>1×350W=350W<br>9×60=540W<br>1×2000W=2000W<br>300W<br>1500W<br>2200W |
| T                       |         |   |                 |               | OTAL  | 12466W  |

| TABLE                   |       |  |               |          | FIRST FLOOR                     |                      |  |
|-------------------------|-------|--|---------------|----------|---------------------------------|----------------------|--|
| NAME<br>OF THE<br>BOARD | POWER | CURRENT  | USED<br>CABLE | SWITCH   | EXPLANATION                     | INDIVIDUAL<br>POWERS |  |
|                         |       | $\frac{34086}{\times 380 \times 0.95} = 48.2A$ | 2NYA(65A)     |          | 52ARMATURE(4×18W)=208 LAMP      | 208×18W=3744W        |  |
|                         | Λ     |  |               | 4) 3×63A | 3 ARMATURE(2×18W)=6LAMP         | 6×18W=108W           |  |
|                         |       |  |               |          | 13 SPOT LAMP(1×18W)             | 13×18W =234W         |  |
| DP1                     |       |  |               |          | 29 DOUBLE SOCKET (58SINGLE)     | 58×300W=17400W       |  |
|                         |       |  |               |          | 2 COOKER (3000W)                | 2×3000W=6000W        |  |
|                         | 34086 |  |               |          | 2 SINGLE SOCKET -COOKER (300W)  | 2×300W=600W          |  |
|                         |       |  |               |          | AIR CONDITION FEEDER(2000W)     | 1×2000W=2000W        |  |
|                         |       |  | u,            | 'n       | <b>RESERVE OF ILLUMINATIONS</b> | 300W                 |  |
|                         | 0.7   | m  | uu            | 0        | RESERVE OF SOCKETS              | 1500W                |  |
|                         |       |  | 6             | $\odot$  | RESERVE OF $3\phi$              | 2200W                |  |
|                         |       | -  |               |          |                                 |                      |  |
| Т                       |       |  |               |          | OTAL                            | 34086W               |  |

| TDP2NAME<br>OF THE<br>BOARDNAME<br>OF THE<br>BOARD $27774$ OF THE<br>BOARD $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 44.47A$ POWERPOWER $\frac{27774}{\sqrt{3} \times 380 \times 0.95} = 44.47A$ POWER $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 44.47A$ CURRENT $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 44.47A$ CURRENT $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 44.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 44.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 44.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ USED $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ SWITCH $1 = \frac{27774}{\sqrt{3} \times 380 \times 0.95} = 844.47A$ SWITCH | SECOND FLOOR                                 |                   |               |                                 |                                |                      |  |  |
|--|--|-------------------|---------------|---------------------------------|--------------------------------|----------------------|--|--|
| NAME<br>OF THE<br>BOARD  | POWER  | CURRENT           | USED<br>CABLE | SWITCH                          | EXPLANATION                    | INDIVIDUAL<br>POWERS |  |  |
|  |  |                   | -             |                                 | 70ARMATURE(4×18W)=280 LAMP     | 280×18W=5040W        |  |  |
|  |  | 7A                |               |                                 | 13 SPOT LAMP(1×18W)            | 13×18W =234W         |  |  |
|  |  | 4.4               | 2A            | A.                              | 22 DOUBLE SOCKET (44SINGLE)    | 44×300W=13200W       |  |  |
| TDP2 OF THE<br>OF THE<br>BOARD<br>27774 W POWER POWER  |  | (0;               | 63            | 1 COOKER (3000W)                | 1×3000W=3000W                  |                      |  |  |
| 5  | TDP2 OF THE<br>BOARD BOARD BOARD POWER POWER | 95                | A(            | ×                               | 1 SINGLE SOCKET -COOKER (300W) | 1×300W=300W          |  |  |
| TDP2 OF THE<br>OF THE<br>BOARD<br>27774 POWER  | - V  | X                 | 3             | AIR CONDITION FEEDER(2000W)     | 1×2000W=2000W                  |                      |  |  |
|  | 30 >   | Z                 | A             | <b>RESERVE OF ILLUMINATIONS</b> | 300W                           |                      |  |  |
|  | 5  | 27                | n,            | 'n                              | RESERVE OF SOCKETS             | 1500W                |  |  |
|  |  | Îm                | uu            | 0                               | RESERVE OF $3\phi$             | 2200W                |  |  |
|  |  | $I = \frac{1}{2}$ | $10\eta$      | (3                              |                                |                      |  |  |
|  |  |                   |               | Т                               | OTAL                           | 27774W               |  |  |

| TDP3NAME<br>OF THE<br>BOARDNAME<br>OF THE<br>BOARD12298 WPOWER12298 WPOWER12298 WPOWER $(2298 W)$ POWER $(2380 \times 0.95)$ $(218E)$ $(2380 \times 0.95)$ <th></th> <th colspan="8">THIRD FLOOR</th> |         |   |                            |               | THIRD FLOOR  |  |  |  |  |  |  |  |
|--|---------|---|----------------------------|---------------|--|--|--|--|--|--|--|--|
| NAME<br>OF THE<br>BOARD  | POWER   | CURRENT   | USED<br>CABLE              | SWITCH        | EXPLANATION  | INDIVIDUAL<br>POWERS   |  |  |  |  |  |  |
| TDP3   | 32298 W | $I = \frac{32298}{\sqrt{3} \times 380 \times 0.95} = 51.7A$ | 16mm <sup>2</sup> NYA(87A) | (30mA) 3×63 A | 59 ARMATURE(4×18W)=236 LAMP<br>25 SPOT LAMP(1×18W)<br>14 DOUBLE SOCKET (28 SINGLE)<br>4 COOKER (3000W)<br>4 SINGLE SOCKET -COOKER (300W)<br>AIR CONDITION FEEDER(2000W)<br>RESERVE OF ILLUMINATIONS<br>RESERVE OF SOCKETS<br>RESERVE OF 3φ | 236×18W=4248W<br>25×18W=450W<br>28×300W=8400W<br>4×300W=1200W<br>4×300W=1200W<br>1×2000W=2000W<br>300W<br>1500W<br>2200W |  |  |  |  |  |  |
|  |         |   |                            | Т             | OTAL   | 32298W   |  |  |  |  |  |  |

|                         | T       | ABL   | E                          |               | FOURTH FLOOR   |   |  |  |  |  |  |
|-------------------------|---------|---|----------------------------|---------------|--|---|--|--|--|--|--|
| NAME<br>OF THE<br>BOARD | POWER   | CURRENT   | USED<br>CABLE              | SWITCH        | EXPLANATION  | INDIVIDUAL<br>POWERS  |  |  |  |  |  |
| TDP4                    | 32298 W | $I = \frac{32298}{\sqrt{3} \times 380 \times 0.95} = 51.7A$ | 16mm <sup>2</sup> NYA(87A) | (30mA) 3×63 A | 59 ARMATURE(4×18W)=236 LAMP<br>25 SPOT LAMP(1×18W)<br>14 DOUBLE SOCKET (28 SINGLE)<br>4 COOKER (3000W)<br>4 SINGLE SOCKET -COOKER (300W)<br>AIR CONDITION FEEDER(2000W)<br>RESERVE OF ILLUMINATIONS<br>RESERVE OF SOCKETS<br>RESERVE OF 3φ | 236×18W=4248W<br>25×18W=450W<br>28×300W=8400W<br>4×300W=12000W<br>1×2000W=2000W<br>300W<br>1500W<br>2200W |  |  |  |  |  |
|                         |         |   |                            | I             | TOTAL  | 32298W  |  |  |  |  |  |

| DP5 DP1<br>DP5 DF1HE<br>OFTHE BOARD 0FTHE BOARD $OFTHE BOARD OFTHE BOARD OFTHE BOARD OFTHE BOARD OFTHE BOARD OFTHE BOARD OFTHE BOARD OFTHEOFTHE BOARD OFTHEOFTHE BOARD OFTHEOFTHE BOARD OFTHEOOFTHEOOTTHEOOT$ |         |   |                            |              | FIFTH FLOOR  |   |  |  |  |  |  |  |
|---|---------|---|----------------------------|--------------|--|---|--|--|--|--|--|--|
| NAME<br>OF THE<br>BOARD   | POWER   | CURRENT   | USED<br>CABLE              | SWITCH       | EXPLANATION  | INDIVIDUAL<br>POWERS  |  |  |  |  |  |  |
| TDP5  | 32298 W | $I = \frac{32298}{\sqrt{3} \times 380 \times 0.95} = 51.7A$ | 16mm <sup>2</sup> NYA(87A) | (30mA) 3×63A | 59 ARMATURE(4×18W)=236 LAMP<br>25 SPOT LAMP(1×18W)<br>14 DOUBLE SOCKET (28 SINGLE)<br>4 COOKER (3000W)<br>4 SINGLE SOCKET -COOKER (300W)<br>AIR CONDITION FEEDER(2000W)<br>RESERVE OF ILLUMINATIONS<br>RESERVE OF SOCKETS<br>RESERVE OF 3φ | 236×18W=4248W<br>25×18W =450W<br>28×300W=8400W<br>4×300W=1200W<br>1×2000W=2000W<br>300W<br>1500W<br>2200W |  |  |  |  |  |  |
|   |         |   |                            | Т            | OTAL   | 32298W  |  |  |  |  |  |  |

| DP6NAME<br>OF THE<br>BOARD $098$ OF THE<br>BOARD $298$ W $000 \text{ CB}$ POWER $000 \text{ CB}$ POWER $000 \text{ CB}$ USED <td< th=""><th colspan="8">SIXTH FLOOR</th></td<> |                |         |               |        | SIXTH FLOOR                     |                      |  |  |  |  |  |  |
|--|----------------|---------|---------------|--------|---------------------------------|----------------------|--|--|--|--|--|--|
| NAME<br>OF THE<br>BOARD  | POWER          | CURRENT | USED<br>CABLE | SWITCH | EXPLANATION                     | INDIVIDUAL<br>POWERS |  |  |  |  |  |  |
|  |                | A       |               |        | 59 ARMATURE(4×18W)=236 LAMP     | 236×18W=4248W        |  |  |  |  |  |  |
|  |                | 1.7     | Á             | A      | 25 SPOT LAMP(1×18W)             | 25×18W =450W         |  |  |  |  |  |  |
|  | F              | L N     | 87            | 3      | 14 DOUBLE SOCKET (28 SINGLE)    | 28×300W=8400W        |  |  |  |  |  |  |
| 10   | $\geq$         | 32      |               | Ô      | 4 COOKER (3000W)                | 4×3000W=12000W       |  |  |  |  |  |  |
| P(   | $\infty$       | 0.0     | Υ             | 3      | 4 SINGLE SOCKET -COOKER (300W)  | 4×300W=1200W         |  |  |  |  |  |  |
| Q  | 67             | 863 X   | Z             |        | AIR CONDITION FEEDER(2000W)     | 1×2000W=2000W        |  |  |  |  |  |  |
| F  | 23             | 322     | 12            | ٩      | <b>RESERVE OF ILLUMINATIONS</b> | 300W                 |  |  |  |  |  |  |
|  | $\mathfrak{c}$ | ×       | un            | Lu (   | RESERVE OF SOCKETS              | 1500W                |  |  |  |  |  |  |
|  |                |         | <i>n</i>      | 30     | RESERVE OF $3\phi$              | 2200W                |  |  |  |  |  |  |
|  |                | =       | 1(            | .)     |                                 |                      |  |  |  |  |  |  |
|  |                |         |               | Т      | OTAL                            | 32298W               |  |  |  |  |  |  |

|                         | T       | ABL   | E                           |              | SEVENTH FL   | OOR  |
|-------------------------|---------|---|-----------------------------|--------------|--|--|
| NAME<br>OF THE<br>BOARD | POWER   | CURRENT   | USED<br>CABLE               | SWITCH       | EXPLANATION  | INDIVIDUAL<br>POWERS   |
| TDP7                    | 32868 W | $I = \frac{32868}{\sqrt{3} \times 380 \times 0.95} = 52.6A$ | 25mm <sup>2</sup> NYA(115A) | (30mA) 3×80A | 57ARMATURE(4×18W)=228 LAMP<br>28 SPOT LAMP(1×18W)<br>20 DOUBLE SOCKET (40SINGLE)<br>3 COOKER (3000W)<br>3 SINGLE SOCKET -COOKER (300W)<br>AIR CONDITION FEEDER(2000W)<br>TERRACE OF ILLUMINATIONS<br>RESERVE OF ILLUMINATIONS<br>RESERVE OF SOCKETS<br>RESERVE OF 3φ | 228×18W=4104W<br>28×18W=504W<br>40×300W=12000W<br>3×300W=9000W<br>3×300W=900W<br>1×2000W=2000W<br>6×60W=360W<br>300W<br>1500W<br>2200W |
|                         |         |   |                             | T            | OTAL   | 32868W   |

## Current&Voltage-drop&Compensation Calculations

TADP = 293.6 kW

TDP-G = 445.7 kW

In TADP board has (each floor 2 kW airconditon feeder  $\times$  9 = 18 kW)

INSTALLED POWER 293.6 kw – 18 kW = 275 626 W

275 626 W %60 = 165 376 W

165 376 W + 18 000 W = 183 376 W for <u>TADP Board</u>

445 700 W %100 = 445 700 W for <u>TDP-G Board</u>

<u>DEMAND POWER</u> 445 700 + 183 376 = 629 076 W

#### 9.3 Current Calculation

For ADP  $I = \frac{P}{\sqrt{3} \times U \times \cos \phi} = \frac{626\ 076}{\sqrt{3} \times 380 \times 0.95} = 1006\ A < 1215\ A$ 

| CIRCUITS | VOLT    | FORMULAS  | RESULTS               |
|----------|---------|---|-----------------------|
| 3 PHASE  |         | $\%e = \frac{100LN}{KSU^2} = \frac{10^5 L N(kW)}{56 S(380)^2}$          | $0.0124 \frac{LN}{S}$ |
| 1 PHASE  | 220/380 | $\% e = \frac{200 LN}{KSU^2} = \frac{2 \times 10^5 LN(kW)}{56S(220)^2}$ | $0.074 \frac{LN}{S}$  |
| 2 PHASE  |         | $\% e = \frac{100LN}{KSU^2} = \frac{15.10^4 LN(kW)}{56S(220)^2}$        | $0.056 \frac{LN}{S}$  |
| 3 PHASE  |         | $\% e = \frac{100LN}{KSU^2} = \frac{10^5 LN (kW)}{56S(42)^2}$           | $1\frac{LN}{S}$       |
| 1 PHASE  | 24/42   | $\% e = \frac{100LN}{KSU^2} = \frac{2.10^5 LN (kW)}{56S(24)^2}$         | $6.2\frac{LN}{S}$     |

| %e=VOLTAGE DROP(%)  | S=CONDUCTO   | <b>PR CROSSECTION</b> ( $mm^2$ )              |
|---------------------|--------------|---|
| N=POWER(kW)         | K=CONDUCTI   | VITY COEFFICIENT( $m/\Omega mm^2$ )           |
| U=VOLTAGE(volt)     | K (Cu) COND. | COEFFICIENT (56 m/ $\Omega$ mm <sup>2</sup> ) |
| L=LINE DISTANCE (m) | K (Al) COND. | COEFFICIENT(35 m/ $\Omega$ mm <sup>2</sup> )  |

100 100 100

# 9.4 Voltage-Drop Calculation

Voltage Drop Between Trasformer and ADP Board

Used cable:  $3 \times (3 \times 185 \ mm^2)$ NYY for Phase

Distance: 70 m

 $\% e1 = 1.24 \times 10^{-5} \frac{P \times L}{q}$ 

 $\% e1 = 1.24 \times 10^{-5} \frac{629\,076 \times 70}{3 \times 185} = \% 0.98$ 

Voltage Drop Between ADP and TDP-G Board

Used cable:  $3 \times (2 \times 185 \ mm^2)$ NYY for Phase

Distance: 5 m

 $\% e^{2}=1.24 \times 10^{-5} \frac{P \times L}{q}$ 

 $\% e^{2} = 1.24 \times 10^{-5} \frac{445\ 700 \times 5}{2 \times 185} = \% 0.075$ 

Voltage Drop Between TDP-G and TDP-K Board

Used cable:  $3 \times (2 \times 150 \text{ mm}^2)$ NYY for Phase

Distance: 55 m

 $\% e^{3}=1.24 \times 10^{-5} \frac{P \times L}{q}$  $\% e^{3}=1.24 \times 10^{-5} \frac{400\ 000 \times 55}{2 \times 150} = \% 0.91$ 

Total Voltage Drop

% e1 + % e2 + % e3 = % 0.98 + % 0.075 + % 0.91 = % 1.97

% 1.97 < % 3

so all the cross section areas are convenient

## 9.5 Compensation Calculations

For the buildings in project dagree we must consider  $\cos \phi_1 as 0.70$ .

<u>DEMAND POWER</u> = 445 700 + 183 376 = 629 076 W

 $\cos \phi_1 = 0.70$   $\cos \phi_2 = 0.95$   $\cos^{-1} 0.7 = 45.57$   $\cos^{-1} 0.95 = 18.19$   $\tan 18.19 = 0.33$   $\tan 45.57 = 1.02$  1.02 - 0.33 = 0.69CAPACITOR POWER = 629 076 × 0.69 = 434 062 Var = 434 kVAr CHOOSEN COMPENSATION GROUP = 430 kVAr  $1 \times 10$  kVAr CONSTANT  $5 \times 20$  kVAr AUTO

 $2 \times 10$  kVAr AUTO  $6 \times 50$  kVAr AUTO

|             |               |               |              |              |              |             |               |              |              |                 |                 |             | RD               |           |               |           | NC               |          |               |           |           |             |  |
|-------------|---------------|---------------|--------------|--------------|--------------|-------------|---------------|--------------|--------------|-----------------|-----------------|-------------|------------------|-----------|---------------|-----------|------------------|----------|---------------|-----------|-----------|-------------|--|
| EXPLANATION | (18W)ARMATURE | (18W)ARMATURE | (1×18W) SPOT | OUBLE SOCKET | INGLE SOCKET | DATA SOCKET | EPHONE SOCKET | OUBLE SWITCH | INGLE SWITCH | CONDITION BOARD | TRIBUTION BOARD | OW ARMATURE | DISTRIBUTION BOA | GENERATOR | NERATOR BOARD | COOCER    | L AIR CIRCULATIC | DETECTOR | VO WAY SWITCH | FOTOCELL  | MCCB+     | NORMAL MCCB |  |
|             | (4×           | (2×           |              | Δ            | S            |             | TEL           | Δ            | 5            | AIRC            | DIS             | 9           | MAIN [           |           | GE            |           | EXT. II          |          | Υ             |           |           |             |  |
| CODE        | A-14.15       | A-14.4        | A-6.5        | C-1.2        |              | D-16.4      | D-1.4         |              |              | C-2.10          | 1-1.7           | A-4.1       | H-3.27           | L-1.5     | L-2.8         | C-2.4     | A-7              |          |               | C-2.20    | A-2.4     | A- 2.3      |  |
| LIST PRICE  | 252 YTL       | 192 YTL       | 102 YTL      | 80 YTL       |              | 290 YTL     | 680 YTL       |              |              | 118 YTL         | 238 YTL         | 95 YTL      | 11735 YTL        | 4200 YTL  | 3800 YTL      | 146 YTL   | 65 YTL           |          |               | 375 YTL   | 203 YTL   | 180 YTL     |  |
| PIECE       | 516           | 16            | 179          | 159          | 16           | 141         | 141           | 31           | 132          | 6               | 11              | 23          | 1                | 1         | 1             | 26        | m                | 2        | 2             | m         | 20        | 20          |  |
| PRICE       | 130 032 YTL   | 3 072 YTL     | 18 258 YTL   | 12 720 YTL   |              | 40 890 YTL  | 95 880 YTL    |              |              | 1 062 YTL       | 2 618 YTL       | 2 185 YTL   | 11 735 YTL       | 4 200 YTL | 3 800 YTL     | 3 796 YTL | 195 YTL          |          |               | 1 125 YTL | 4 060 YTL | 3 600 YTL   |  |

## 9.6 Total Price

TOTAL PRICE =345 000 YTL

#### **CONCLUSION**

For an electrical engineer, drawing electrical installation projects is the part of the job, but not all the electrical engineers have the signature authority for the electrical installation projects. So the related lectures were choosen first then to gain more experiance and intensify the knowledge seen in the lectures with the real operation, the project were choosen about the design of electrical installation.

Making the electrical installation project means, taking big responsibilites.Because if an error occurs in the future, the first person that they will judge is the electrical engineer who made or signed the project. And the designer have to be very careful while choosing the armatures, sockets, cables and so on because in a big project, a small mistake while choosing the equipment can cause a big cost and quality difference.Sometimes it costs peoples lifes.

In this project the Turkey standards were applied for the electrical values, but for the symbols the British Standards were prefered.Because of protecting the real power and to decrease the cost in the bill, also a compensation system were built with measuring and calculating the necessary formulas. The errors reduced in calculating and the design kept in most suitable form.

## REFERENCE

http://www.lke-electric.com (from that address you can find MCCB) http://en.wikipedia.org/wiki/Florescent\_lamp http://en.wikipedia.org/wiki/Ground\_%28electricity%29 http://en.wikipedia.org/wiki/Voltage\_drop http://en.wikipedia.org/wiki/Distribution\_board http://www.blackwell-synergy.com/doi/pdf/10.111/j.1467-8659.2006.00816.x http://www.cielobuio.org/cielobuio/europe/lightingplans.doc http://www.evkelektrik.com/teknik/birim-olcu.pdf