NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

PRODUCTION FACTORY ILLUM.INATION

GRADUATION PROJECT
EE400

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Nicosia - 2008

ACKNOWLEDGMENTS

I dedicate my work and success to my father **Fawaz Amro,** my mother and my brothers who provided me.the encouragement enough to finish my studies.

Special thanks andtespects to my supervisor **Assoc.** Prof. **Dr. Kadri Bürüncük** for his help, advises, guiclingand effort in preparation of this project.

I anı very grateful to my teachers in Near East University and my lecturers who have brightened my mind with knowledge.

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ABSTRACT

The interior electrical installation of a preparation factory is going to be designed in this project with a brief description of the basic components of installation along with the illumination calculations.

The aim is to ınçet Jhe standard installation requirements and take into consideration the power consul1 1ptiğıısalpngwith.the decorative .side of installation.

INTRODUCTION

Lighting includes both artificial light sources such as lamps and natural illumination of interiors from daylight. Lighting represents a major component of energy consumption, accounting for a significant part of all energy consumed worldwide. Artificial lighting is provided today by electric lights, but previously by gas lighting, candles or oil lamps. Proper lighting can enhance task performance or aesthetics, while there can be energy wastage and adverse health effects of lighting. Indoor lighting is a form of fixture or fumishing, and a key part of interior design.

The Thesis consist of the introduction, four chapters and aconclusion.

Chapter 1 is côrıcemed in cables, explaining the different insulation materials used on cables and curreiıt carrying capacity of the conductors showing how heat plays a big role in the capacity of the current carried, then cable rating calculations is taken into concideration b)'/ğiving some examples to clearify the subject,iand finaly voltage drop of cables is ıtıentioned also showing by examples how it can be calculated.

Chapter 2 is splirted into two parts, the first part speaks about the basic requirments for circuit and shqwitıg hy figures how does typical arrangement fotfeeding final circuits in a domestic installation look like and an arrangement for maiıı;. and final circuits in a large installation as well, the second part is concemed in the di$triqution board and its components and specially the circuit breaker which is given the(biggest amount of explanation showing its parts.andkinds.

Chapter 3 studies sockets andJighting circuits explaining ring and radial circuits of sockets and when they are used .and showing both theoretical and practical circuits of lighting.

Chapter 4. is devoted ,to the iU:umination ~pd voltage-current calculations taking three different rooms of the plan as examples for illumination calculations to figure out how many lamps should be used in each room depending on its kind and other factors as well, and finally showing the list of prices for the components used in the project according to the EMO' s list of prices of the year 2007.

CHAPTERONE

CABLES

1.1. Cable Insulation Materials

Rubber

For many years wiring cables were insulated with vulcanised natura} rubber (VIR). Much cable of this type is still in service, although it is many years since it was last manufactured. the insulation is organic, it is subject to the normal ageing process, becoming hardiarid brittle. In this condition it will continue to give satisfactory service unless it is disturbed, when the rubber cracks and loses its insulating properties. It is advisable thatwi:ririğ of this type which is still in service should be replaced by a more modem cable•.Syıithetic rubber compounds are used widely forinsulation and sheathing of cables for flexible and for heavy duty applications. Many variations are possible, with conductor tempe:ratureratings from 60°C to 180°C, as well as;resistance to oil, ozone and ultra-violebfadiation depending on the formulation.

Paper

Dry paper is an excellent insulator but loses its insulating properties if it becomes wet. Dry paper is hygfoscopic, that is, it absorbs moisture from theCairnltmust be sealed to ensure that there is no contact with the air. Because of this, paper insulated cables are sheathed with impervious materials, lead being the most common, PILC (paper insulated.Iead covered) is traditionally used for heavy power work. The paper insulation is impregnatedr with oil .or non-draining compound to improve its long-term performance. Cables of -this kind need special jointing methods to ensure that the insulation remains sealed. This difficulty, as well as the weightof the cable, has led to the widespread use of p.v.c. and XLPE (thermosetting) insulated cables in place of paper insulated types.

P.V.C.

Polyvinyl chloride (p.v.c.) is now the most usual low voltage cable insulation. It is clean to handle and is reasonably resistant to oils and other chemicals. When p.v.c. bums, it emits dense smoke and corrosive hydrogen chloride gas. The physical characteristics of the material change with temperature: when cold it becomes hard and difficult to strip, and so BS 7671 specifies that it should not be worked at temperatures below 5°C. However a special p.v.c. is available which remains flexible at temperatures down to -20°c.

At high temperatures the material becomes soft so that conductors which are pressing on the insulation (e.g. at bends) will 'migrate' through it, sometimes moving to the edge of the insulation. Because of this property the temperature of general purpose P.V.C. must not be allowed to exceed 70°C, although versions which will operate safely at temperatures up to 85°C are also available. If p.v.c. is exposed to sunlight it may be degraded by u.ltra~violet radiation. If it is in contact with absorbent materials, the plasticiser mayl>elleached out' making the p.v.c. hard and brittle.

LSF **(Low smokeand fume)**

Materials which.have reduced smoke and corrosive gas emissions in fire compared with p.v.c. have beefriavailable for some years. They are norın.ally used as sheathing compounds over XLPE or LSF insulation, and can give considerable safety advantages in situations where rıumbers of people may have to be evacuatedjin the event of fire.

Thermosettiııg(XLPE)

Gross-linked polyethylene (XLPE) is a thermosetting compôund which has better electrical properties than p.v.c. and is therefore used for mediıım- and high-voltage applications. It has more resistance to deformation at higher teın.peratures than p.v.c., which it is gradually replacing. It is also replacing PILC -in some applications. Thermosetting insulation may be used safely with conductor temperatures up to 90°C thusincreasing the useful current rating, especially when ambient temperature is high. A LSF (low smoke and füme) type of thermosetting cable is available.

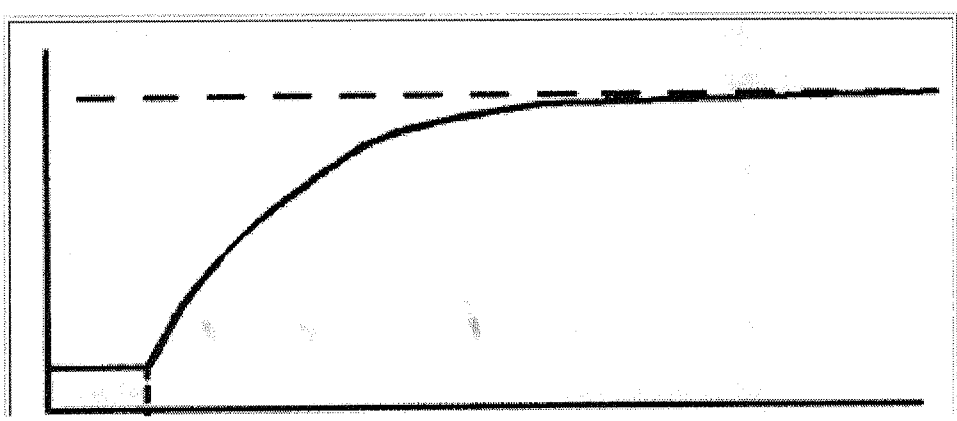
Mineral

Provided that it is kept dry, a mineral insulation such as magnesium oxide is an excellent insulator. Since it is hygroscopic (it absorbs moisture from the air) this insulationis kept seal6d withih a copper sfieath. The resulting cable is totally fireproof and will operate at temperatures of up to 250°C. It is also entirely inorganic and thus non-ageing. These cables have small diameters compared with altematives, great mechanical strength, are waterproof, resistant to radiation and electromagnetic pulses, are pliable and corrosion resistant. In cases where the copper sheath may corrode, the cable is used with an overall LSF covering, which reduces the temperature at which the cable may be allowed to operate. Since it is necessary to prevent the ingress of moisture, special seals are used to terminate cables.

1.2. Current Carrying Capacity of Conductors

All cables have electrical resistance, so there must be an energy loss when they carry current. This loss appears as heat and the temperature of the cable rises. As it does so, the heat it loses to its surroundings by conduction, convection and radiation also increases. The rate of heat loss is a function of the difference in temperature between the conductor and the surroundings, so as the conductor temperature rises, so does its rate of beat loss. A cable carrying a steady current, which produces a fixed heating effect, will get hotter until it reaches the balance temperature where heat input is equal to heat loss {Fig 4.8}. The firnil temperature achieved by the cable will thus depend on the current carried, how easily heat is dissipated from the cable and the;temperature of the cable surroundings.

PVC. is probably the most usual form of insulation, and is very susceptible to damage by high tempefatures. it is very important that p.v.c. insulation should not be allowed normally to exceed 70°C, so the current ratings of cables are designed to ensure that this will not happen. Some special types of p.v.c. may be used l..ıp to 85°C. A conductor temperature as high as 160°C is permissible under very short .tirnefault conditions, on the assumption that when the fault is cleared the p.v.c. insulatiofi'will dissipate the heat without itself reaching a dangerous temperature.



Figl.1: Heat balance graph fora cable.

A different set of cable ratings will become necessary if the ability of a cable to shed its beat changes.

For example, if a mineral insulated cable has an overall sheath of LSF or p.v.c., the copper sheath temperature must not exceed 70°C, whilst if the copper sheath is hare and cannot be touched and is not in contact with materials which are combustible its temperature can be allowed to reach 150°C. Thus, a lmm2 light duty twin mineral insulated cable has a current rating of 18.5 A when it has an LSF or p.v.c. sheath, or 22 A if bare and not exposed to touch. It should be noticed that the cable volt drop will be higher if more cürrent is carried.

1.3. Cable Rating Calculation

The Regulations indicate the following symbols for use when selecting cables:

Iz	is the current carrying capacity of the cable in the situation where it is installed
It	is Jhe tabulated current for a single circuit at an arpbient temperature of 30°C
Ib	is the design current, the actual current to be carried by the cable
In	is the rating of the protecting fuse or circuit breaker
I2	is the operating current for the fuse or circuit breaker (the current at which the fuse blows or the circuit breaker opens)
Ca	is the correction factor for ambient temperature
Cg	is the correction factor for grouping
Ci	is the correction factor for thermal insulation.

The correction.factor for protection by a semi-enclosed (rewirable) fuse is not given a symbol but has a fixed value of 0.725.

Under all circumstances, the cable current carrying capacity must be equal to or greater than the circuit design current and the rating of the fuse or circuit breaker must be at least as big as the circuit design current. These requirements are common sense, because otherwise the cable would be overloaded or the fuse would blow when the load is switched an.

To ensure correct protection from overload, it is important that the protective device operating current (12) is not bigger than 1.45 times the current carrying capacity of the cable (iz). Additionally, the rating of the fuse or circuit breaker (ln) must not be greater than the cable current carrying capacity (Iz) It is important to appreciate that the operating current.of a protective device is always larger than its rated value. In the case ofa back-up fuse,which is not intended to provide overload protection, neither of these requirements applies.

To select a cable fora particular application, take the following steps:

1.-Calculate the e:,cpected (design) current in the circuit (Ib)

2.-Choose thetype and rating of protective device (fuse or circuit breaker) to be used (In)

3.-Divide the' < prötective device rated current by ambient temperature correction factôr (Ca) if ambient temperature differs from 30°€

4.-Further divitle by the grouping correction factor (Cg)

5.-Divide again by the thermal insulation correction factor (CI)

6.-Divide by the semi-enclosed fuse factor of 0.725 where applicaph~

7.-The result is the rated current of the cable required, whieh must be chosen from the appropriate tables (1.1 to 1.4).

Observe that one should divitle by the correction factors, whilst in the prevıous subsection we were multiplying them. The difference is that here we start with the design current of the circuit and adjust it to take account of factors which will derate the cable. Thus, the current carrying capacity of the cable will be equal to or greater than the design current.

(Tables 1.1 to 1.4) give curreiit ratings and'volt drops for some of the more commonly used cables and sizes. The Tables assume that the conductors and the insulation are operating at their maximum rated temperatures.

For example ifan immersion heater rated at 240 V, 3 kW is to be installed using twin with protective conductor p.v.c. insulated and sheathed cable. The circuit will be fed from a 15 A miniature circuit breaker type 2, and will be run for much of its 14 m length in a roof space which is thermally insulated with glass fiber. The roof space temperature is expected to rise to 50°C in summer, and where it leaves the consumer unit and passes through a 50 mm insulation-filled cavity, the cable will be bunched with seven others. To calculate the cross-sectional area of the required cable,

First calculate the design current Ib

$$I_b = \frac{p}{u} = \frac{3000\ A}{240} = 12.5\,A$$

The ambient temperature correction factor is found to be 0.71. The group correction factor is found as 0.52. (The circuit in question is bunched with seven others, making eight in all).

The thermal insulation correction factor is already taken ifıto account in the current rating table and need not be further considered. This is becaıise we can assume that the cable in the roofspace is in contact with the glass fibre but not~nclosed by it. What we must consider is the point where the bunched cables pass through the insulated cavity, we have a factor of 0.89.

The correction factors must now be considered to see if more tha.n one of them applies to the same part of the cable. The only place where this happens is in the insulated cavity behind the consumer unit. Factors of 0.52 (Cg) and 0..89 (CI) apply. The combined value of these (0.463), which is lower than the ambient temperature correction factor of 0.71, and will thus, be the figure to be applied. Hence the required current rating is calculated:-

$$I_z = \frac{in}{Cg \times Ci} = \frac{15\ A}{0.52 \times 0.89} = 32.4\,A$$

Table 1.1 - Current ratings and volt drops for unsheathed single core p.v.c. insulated cables

Cross sectional area	In conduit in thermal insulation	In conduit in thermal insulation	In conduit on wall	In conduit on wall	Clipped direct	Clipped direct	Volt drop	Volt drop
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)	(mV/A/m)	(mV/A/m)
-	2 cables	3 or 4 cables	2 cables	3 or 4 cables	2 cables	3 or 4 cables	2 cables	3 or 4 cables
1.0	11.0	10.5	13.5	12.0	15.5	14.0	44.0	38.0
1.5	14.5	13.5	17.5	15.5	20.0	18.0	29.0	25.0
2.5	19.5	18.0	24.0	21.0	27.0	25.0	18..0	15.0
4.0	26.0	24.0	32.0	28.0	37.0	33.0	11.0	9.5
6.0	34.0	31.0	41.0	36.0	47.0	43.0	7.3	6.4
10.0	46.0	42.0	57.0	50.0	65.0	59.0	4.4	3.8
16.0	61.0	56.0	76.0	68.0	87.0	79.0	2.8	2.4

Table 1.2 - Current ratings and volt drops for sheathed multi-côre p.v.c.-insulated cables

Cross sectional area	In conduit in thermal insulation	In conduit in thermal insulation	In conduit on wall	In conduit on wall	Clipped direct	Clipped direct	Volt drop	Volt drop
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)	(mV/A/m)	(mV/A/m)
-	2 core	3 or 4" core	2 core	3 or 4 core	2 core	3 or 4 core	2 core	3 or 4 core

1.0	11.0	10.0	13.0	11.5	15.0	13.5	44.0	38.0
1.5	14.0	13.0	16.5	15.0	19.5	17.5	29.0	25.0
2.5	18.5	17.5	23.0	20.0	27.0	24.0	18.0	15.0
4.0	25.0	23.0	30.0	27.0	36.0	32.0	11.0	9.5
6.0	32.0	29.0	38.0	34.0	46.0	41.0	7.3	6.4
10.0	43.0	39.0	52.0	46.0	63.0	57.0	4.4	3.8
16.0	57.0	52.0	69.0	62.0	85.0	76.0	2.8	2.4

From table 1.2, 6 mm? p.v.c. twin with protective conductor has a current rating of 32 A. This is not quife Iarge enough, so 10 mm2with a current rating öf 43 A is indicated. Not only would this add considerably to the costs, but would also result in difficulties due to terminating sucha large cable in the accessories.

A more sensible option would be to look for a method of redµcing the required cable size. For example, if the eight cables left the consumer unit in two bunches of four, this would result in a grouping factor of 0.65. Before applying this,iwe must check that the combined grouping and thermal insulation factors (0.65 x 0.89 = .0.58) are still less than the ambient temperature factor of 0.71, which is the case.

Table 1.3 - Current ratings of mineral insulated cables clipped direct

Cross-sectional area	Volt	p.v.c. sheath 2 x single or twin	p.v.c. Sheath 3 core	p.v.c. S_heath 3 x single or twin	Bare sheath 2 x single	Bare sheath 3 x single
(mm²)		(A)	(A)	(A)	(A)	(A)
1.0	500v	18.5	16.5	16.5	22.0	21.0
1.5	500v	24.0	21.0	21.0	28.0	27.0
2.5	500v	31.0	28.0	28.0	38.0	36.0

4.0	500v	42.0	37.0	37.0	51.0	47.0
1.0	750v	20.0	17.5	17.5	24.0	24.0
1.5	750v	25.0	22.0	22.0	31.0	30.0
2.5	750v	34.0	30.0	30.0	42.0	41.0
4.0	750v	45.0	40.0	40.0	55.0	53.0
6.0	750v	57.0	51.0	51.0	70.0	67.0
10.0	750v	78.0	69.0	69.0	96.0	91.0
16.0	750v	104.0	92.0	92.0	127.0	119.0

Note that in tables 1.3 and 1.4 P.V.C. Sheath means hare afld exposed to touch or having an over-all covering of p.v.c. or LSF and 'Bare' means}l::>ı.ıre and neither exposed to touch nor in coıιtact with combustible materials.

Table 1.4 - Volt drops for mineral insulated cables

Cross-sectional area	Single-phase p.v.c. Sheath	Single-phase bare	Three-phase p.v.c. Sheath	Three-phase bare
(mm^2)	(mV/A/m)	(mV/A/m)	(mV/A/m)	(mV/A/m)
1.0	42.0	47.0	36.0	40.0
1.5	28.0	31.0	24.0	27.0
2.5	17.0	19.0	14.0	16.0
4.0	10.0	12.0	9.1	10.0
6.0	7.0	7.8	6.0	6.8
10.0	4.2	4.7	3.6	4.1

16.0	2.6	3.0	2.3	2.6

This leads to a cable current rating of $\frac{15}{0.65 \times 0.89}$ A = 25.9 A

This is well below the rating for 6 rnrn2 of 32 A, so a cable of this size could be selected.

1.4. **Cable Voltage Drop**

All cables have resistance, and when current flows in thern this results in a volt drop. Hence, the voltağe at the load is lower than the supply voltage by the arnount of this volt drop.

The volt drop may be calculated using the basic Ohm's law formula	
U = **I** x **R**	
where	**U** is the cable volt drop (V)
	I is the circuit current (A), and
	R is the circuit resistance Ω(Ohms)

Unfortunately, this sirnple forrnula is seldorn of use in this case, because the cable resistance under load conditions is not easy to calculate.

To calculate the volt drop for a particular cable we use tables 1.1, 1.2 and 1.4. Each current rating table has an associated volt drop colurnn or table. For exarnple, rnulticore sheathed non-arrnored P.V.C. insulated cables are covered by table 1.2 for current ratings, and volt drops. The exception in the Regulations to this layout is for mineral insulated cables where there are separate volt drop tables for single- and three-phase operation, which are cornbined here as table 1.4.

To calculate the cable yolt drop:

1. Take the value frorn the volt drop table (rnV/Alın)
2. Multiply by the actual current in the cable (NOT the current rating)
3. Multiply by the length of run in metres
4. Divitle the result by one thousand (to convert rnillivolts to volts).

For example, if a 4 mm^2 p.v.c. sheathed circuit feeds a 6 kW shower and has a length of run of 16 m, we can find the volt drop thus:

From table 1.2, the volt drop figure for 4 mm^2 two-core cable is 11 mV/A/m.

Cable current is calculated from $I = \frac{P}{U} = \frac{6000}{240}\ A = 25\ A$

Volt drop is then $\frac{11 \times 25 \times 16}{1000}\ V = 4.4\ V$

Since the permissible volt drop is 4% of 240 V, which is 9.6 V, the cable in question meets volt drop requirements

CHAPTERTWO

BASIC REQUIRMENTS AND DISTRIBUTION BOARD

2.1. Basic Requirements for Circuits

The Regulations require that installations should be divided into circuits, the purposes being:

1. - to prevent da.nger in the event of a fault by ensuring that the fault current is no greater than necessary to operate the protective system. For example, a large three-phase motor must be connected to a single circuit because the load cannot be subdivided. If, however, a load .consisted of three hundred lamps, each rated at 100 W, it would be foolish to considet.putting all this load onto a single circuit. In the event ofa fault, the whole of the lighting would be lost, and the fault current needed to operate the protective device.fsingle-phase circuit current would be 125 Aııt 240 V) would be high enough to caüse a fire danger at the outlet where the fault; occurred. The correct approach wouldbe to divide the load into smaller circuits, each feeding, perhaps, ten lamps.

2. - to enable part of an installation to be switched off for maintenance or for testing without affecting the rest of the system.

3. - to prevent a fault on one circuit from resulting in the loss of the complete installation.

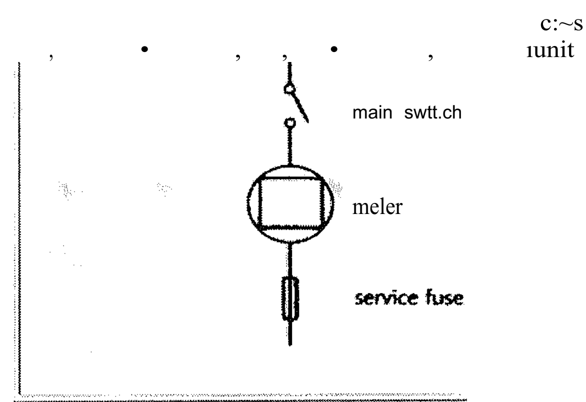


Fig 2.1 Typical arrangement for feeding final circuits in a domestic installation

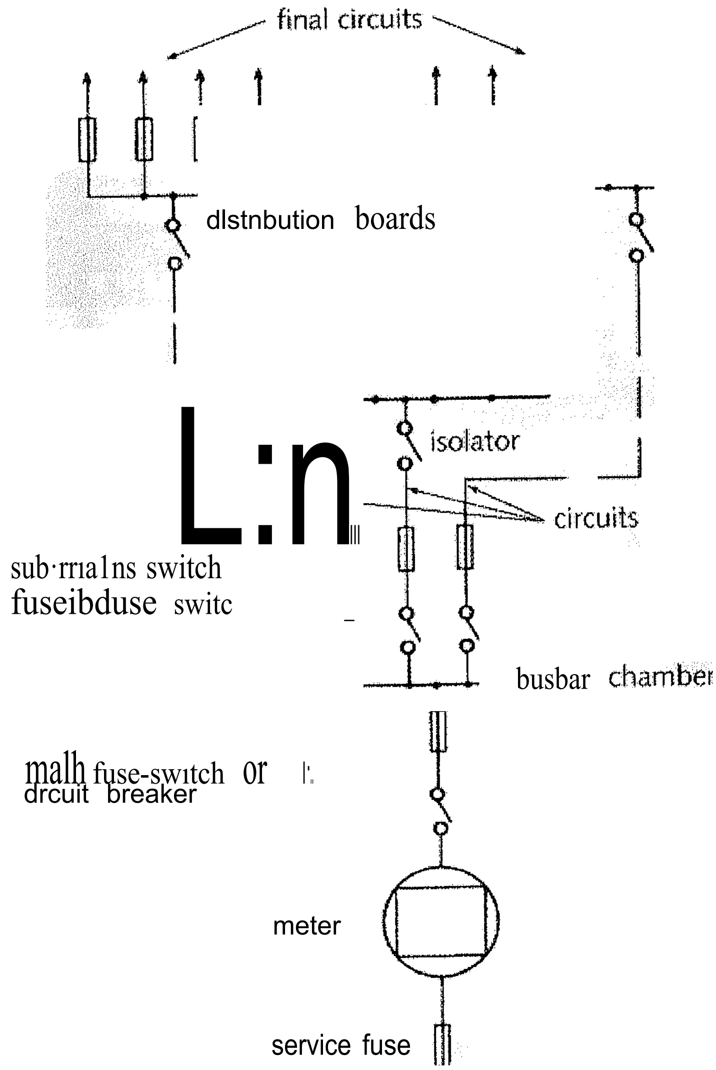


Fig 2.2 An arrangement for main and final circuits in a large installation

A durable notice giving details of all the circuits fed is required to be posted in or near each distribution board. The data required is the equipment served by each circuit, its rating, its design current and its breaking capacity. When the occupancy of the premises changes, the new occupier must be provided with full details of the installation.

2.2. DlstribüfibnBoard

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-currerıt devices (RCD).

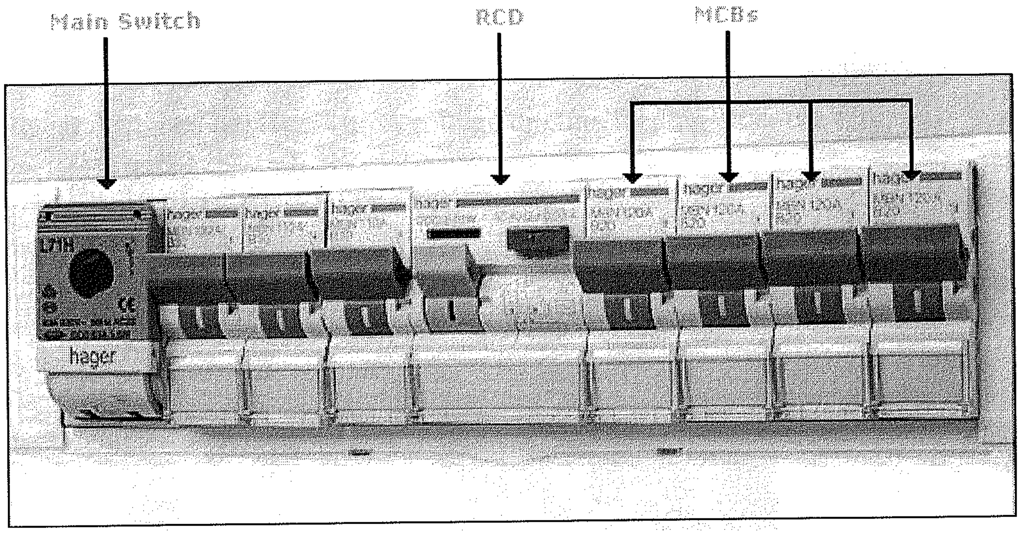


Figure 2.3: Typical Distribution Board- MCB Type

2.2.1. Main'Swtteh

The main switch-allows you to tum off the electricity supply to the electrical installation. Note that sorne electrical installations may have more thaı:i"öne main switch. For example, if the house is heated by electric storage heaters, i[will probably have a separate main switch and consumer unit arranged to supply them.

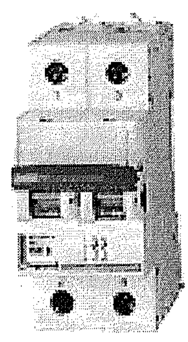


Figure 2.4: Main Switch

2.2.2.Circuit Breaker

A circuit breaker is an autornatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city.

2.2.2.1. Parts of circuit breakers

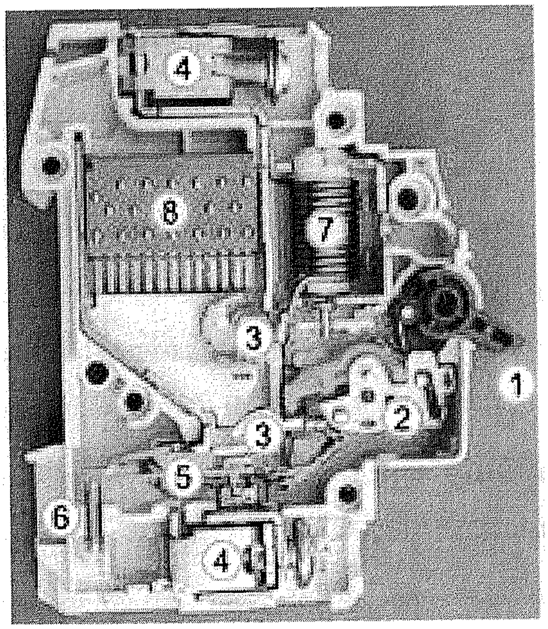


Figure 2.5: Photo of inside ofa circuit breaker

The 10 ampere DIN fail mounted thermal-magnetic miniature cifcllit breaker is the most common style in modem domestic consumer units and ·cömi.netcia.l electrical distribution boards throughout Europe. The design includes the follôwing components:

I .Actuator lever - used to manually trip and reset the circuit breaker. Also indicates the status of the circuit breaker (On or Off/tripped). Most breakers are designed so they can still trip even if the lever is held or locked in the on position. This is sometimes referred to as "free trip" or "positive trip" operation.

2.Actuator mechanism - forces the contacts together or apart.

3.Contacts - Allow current toflow when t9uching and break the flow of current when moved apart.

4.Terminals

5.Bimetallic strip

6.Calibration screw - allows the manufacturer to precisely adjust the trip current of the device after assembly.

7 .Solenoid.

8.Arc divider / extinguisher.

2.2.2.2. Circüit-Breaker Types

There are many different technologies used in circuit breakers and they do not always fall into distirıctcategories. Types that are common in domestic, commercial and light industrial applieatiöns at low voltage (Iess than 1000 V) include:

- MCB (Miniature Circuit Breaker)-rated current not more than 100 A. Trip characteristics normally not adjustable. Thermal or' thermal-magnetic operation. Breaketssillüstrated above are in this category.
- MCCB (Moulded Case Circuit Breaker)-rated current.np to 1000 A. Thermal or therırtif-rnagnetic operation. Trip current may be acljtrstab1e.

Electric power systems require the breaking of higher currents at higher voltages. Examples of high-voltage AC circuit breakers are:

- Vacuum circuit breaker=-With rated current up to 3000 A, these breakers interrupt the current by creating and extinguishing the ar.CiriKyacuum container. These can only be practically applied for voltages up to abôüt35,000 V, which corresponds roughly.to the medium-voltage range of power systems. Vacuum circuitl)reakers tend to have longer life expectancies betwccn' overhaul than do air circuifbreakers.
- Air circuit breaker=-Rated current up to 10,000 A. Trip characteristics are often fully adjustable including configurable trip thresholds and delays. Usually electronically controlled, though some models are microprocessor controlled via an integral electronic trip unit. Often used for main power distribution in large industrial plant, where the breakers are arranged in draw-out enclosures for ease of maintenance.

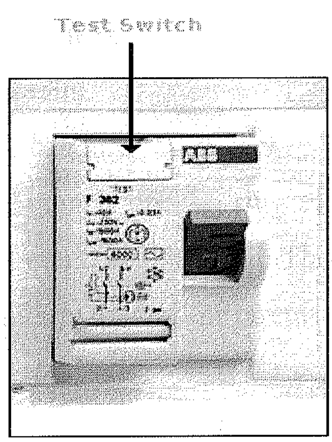
2.2.3. Residual Current Devices (RCDs)

RCDs guard against serious electric shock in the event of atı electrical fault. They detect 'leaking' electricity from a circuit (which can occur when a cable is damaged for example) and respond by disconnecting the electricity supply from the circuit.

Most modern homes have an RCD fitted in their distribution/ fuse board, but older homes may need to install one. RCDs are also available to fit at a socket outlet as a plug- in item. Ph:ığs 'which incorporate an RCD should be used for tools and outdoor equipment if there<isno RCD fitted at:the tlistribution board.

2.2.3.1. To TesfRCD

it is crucial to .checkwhether the RCD is working correctly. To perform this check we press the test buttqn marked 'T' or 'Test' on the RCD fitted artlı~ distribution/ fuse board, all RCDs have öne. If it is working correctly, the power to all socket circuits will immediately S\Yitch off. If the RCD fails to trip have it replaced immediately by a registered electrical contractor. Remember reset the RCD aftert~sting to restore power!



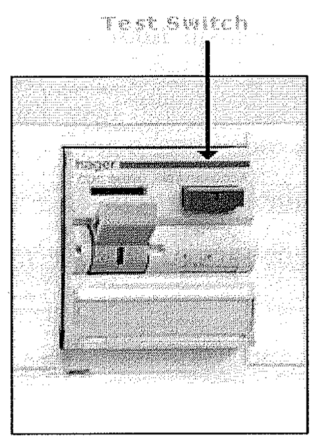


Figure 2.6: Residual Current Devices' test buttons.

CHAPTER THREE

SOCKETS AND LIGHTING CIRCUITS

3.1. Socket Outlet Circuits

There are two main types of circuits used in connecting sockets. Those are: ring circuits and radial circuits.

3.1.1 Ring Circııit

Most modem Sôcketcircuits are ring circuits or ring mains as they are sometimes referred to. AS we>see in figtfre 3.1 cables leaves the consumer:uııit aıid travels to each socket on the rriaiıi!aıidwhen it reaches the last socket it then retums to the consumer unit, thus creating a ring. The advantage of this system is that power can reach the sockets in the circuit from both directions, which reduces the power load on the cables.

A ring circuit caııiserve an area up to 110 square meters (120 square yards), 2.5mm2 cable is used tO'\yirethe circuit and the circuit hasa 30amp fuse or 32amp MCB on the consumer unit. Itis usual for a house to have one ring circuit upstairs .and one ring circuit downstairs.

Ring circuits can have extra sockets added to them by adding a 'spur' onto a ring circuit. A spur is a branch off the ring circuit, usually from an existing circuit, although a junction box could also be used. Theoretically as many spurs as sockets could be added, but the maximum load of the circuit (30/32amp) still exists.

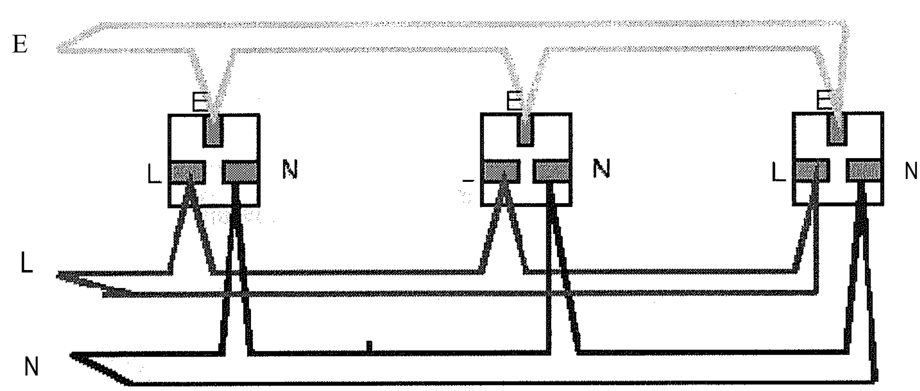


Figure 3.1 Connection ofa ring power circuit

3.1.2 **Radial** Circuit

With radial circuits as shown in figure 3.2 the cable comes from the consumer unit and travels to each socket, similar to the ring circuit. However, when the circuit reaches the last socket the cable ends, whereas a ring main travels back to the consumer unit. Radial circuits can therefore only serve a smaller area. Using 2.5mm2 cable combined with a 20amp fuse/MCB an area of 20 square meters (24 square yards) is permissible. For 4mm2 cable cômbined with a 32amp MCB or a 30amp cartridge fuse (a re--Wirable fuse is not allowedran area of 50 square.rneters (60 square yards) is permissible.

In a similar wa.y/tg ting circuits spurs can be added at points along the radial circuit if required. High pdViTered appliances (cookers / showers) must have their own radial circuit.

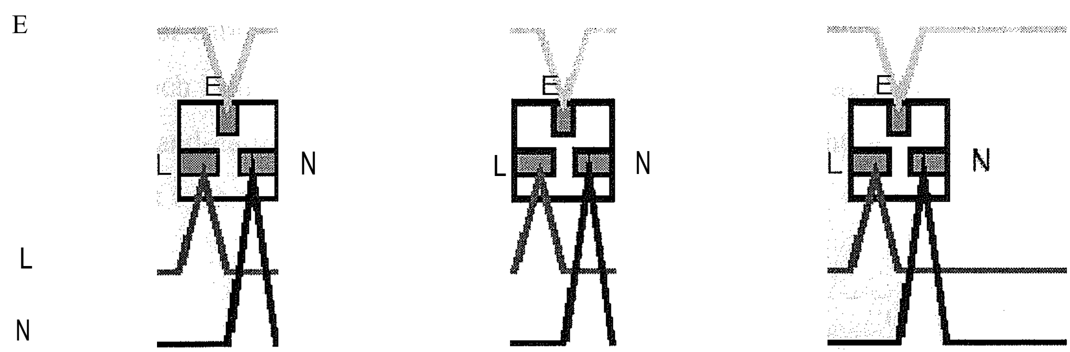


Figure 3 .2 connection of a radial power

3.2 **Lighting** Cireuits

Lighting circuits may include' fixed lighting units, like ceiling 'pendants and uplighters, and outlets for flexible lighting systems (like track lighting). These circuits are often more complicated to construct, because they include a switch. In theory, the wiring ofa lighting circuit can be viewed as figure 3.3.

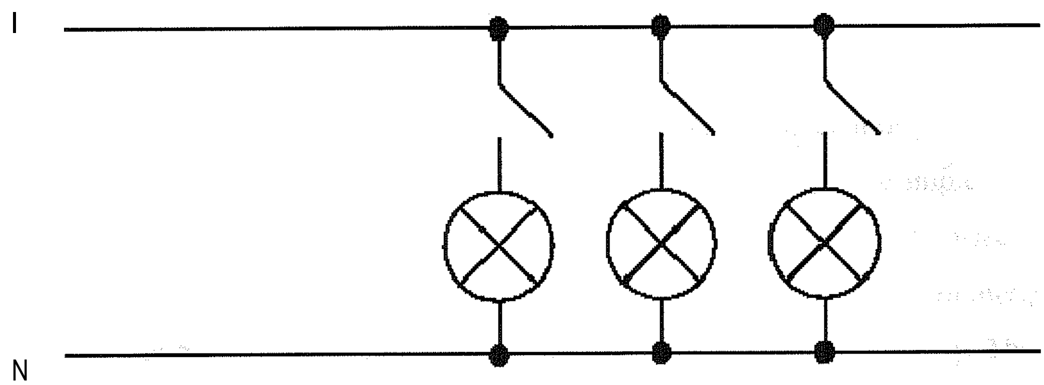


Figure 3.3 A theoretical lighting circuit with switches

As can be seell frorn the figure, the switch is on the live and not on the neutral part of the circuit. This ensures that the light fitting is safe when the switch is off (so, for example, the bulb can be changed without risk of electrocution).

In practice it wôuld be very difficult to wire a lighting circuit like figure 3.3, because the live and neutralcables are separate. In addition, an earth collllection is needed at each switch, and each 'light fitting, for safety reasons (not shown oridiagram). Normally we use two-core-and-earth cable for domestic wiring, so by convention the wiring of a lighting circuit is as shown in figure 3.4.

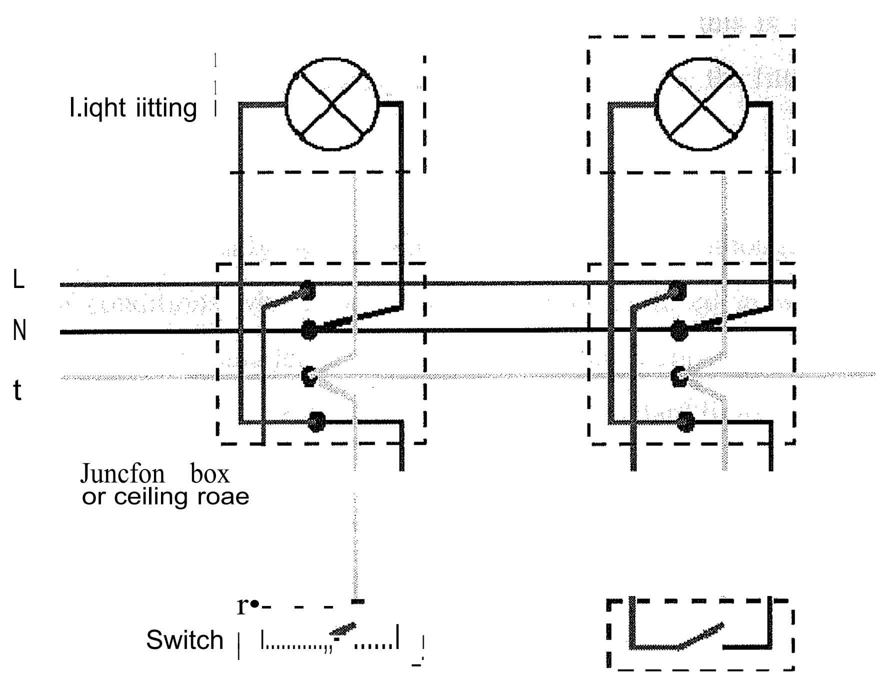


Figure 3.4 A more practical lighting circuit

Apart from only showing two lights rather than three, this configuration is identical to figure 3.3, although it looks more complex. This additional complexity is to ensure that all connections can be made with two-core-and-earth cable. The central point for each light fitting is a junction box with four terminals. There are two ways to implement this junction box. First, a specific four-terminal lighting junction box can be used. The junction box will normally be concealed in a ceiling or floor void. Second, an integrated ceiling rose can be used, where the terminal blocks are part of the rose body. The rose connects the petjdant lamp holder, and hides all the connections. For simplicity, the rose will often be supplied with exactly the right number of terminals to accommodate all the cable connectiögs; ;Fhat is,. there will be two blocks of three terminals, one block of two, and one block qffour (for the earth wires).

üne importanf pôi:rıt to note about the standard lighting circuit is that when the switch is on, both wires(red and black) to the switch are live. If this situation (a black live wire) is found to beiµnpalatable, one can buy a two-core-and-eaıth cable with two red conductors. Altematively - at much lower cost - a small red marker (e.g., red insulating tape) could be wrapped around the black wire wherever it is visible.

When integrated ceiling roses are used throughout a circuit, this is called a "loop-in' configuration. Note, again, that the only connections are inside the fittings; there are no concealed junction boxes.

Lighting circuits are usually wired with 1.5 mrrr' cable, although 1 mm2 is not uncommon. In conditions where the cable is entirely enclosed in wall plaster, at 30 degrees Celsius even the smaller of these two cables has a current carrying capacity of .11 amps: still well below the likely load imposed by a standard lighting circuit (11 amps will support more than twenty 100-watt light bulbs). However, if the cable run is long, it is more likely to exceed the maximum voltage drop regulation. In a worst-case configuration (a long cable with maximum allowable current drawn at the far end) it tums out that a 1 mm2 cable can be about 35 meters long before this happens. If the cable is longer than that, a larger cable is needed.

Lighting circuits are not normally wired as a ring system, because the total current requirement rarely even approaches the capacity of the cable.

CHAPTER FOUR

ILLUMINATION AND VOLTAGE-CURRENT CALCULATIONS

4.1. Average Lighting Calculations

At working plane the luminance at the related with dimension of the room and position of the lamps with maintenance of the lamp can be calculated by

$$\phi_{Total} = \frac{A \cdot M \cdot E_{av}}{\eta}$$

Where; ϕ_{total} = the total luminance flux

E_{av} = average luminance

η = utilization factor

A = the area of working place

M = maintenance factor

$$K = \frac{ab}{H(a+b)}$$

Where; K = Room Index,

a = the length of the working plane,

b = width of the working plane,

H = distance between lamps and working plane

$H = h-(h1+h2)$

h = height of the room

h1 = height of working plane (like tables)

h2 = hanging distance of the lamp.

η can be found by using (Table 4.1) depending on the color of the wall, ground and ceiling and the calculated room index.

4.1.1. Lighting Calculation for Done Production Store

a= 11.45 m

b= 8.55 m

A= a x b = 98m2

H = h-(hl+h2) = 4-(0+0) = 4m

$K = \frac{a.b}{H(a+b)}$ = (8.55xl 1.45)/4(8.55+ 11.45) =l.22

To find the value of η

Consider that th.e<color of the Ceiling is light color (0.8), walls are light dark (0.5) and the surface is bright color (0.3).

Using linear iritefpôlation,

Index	Efficiency
$x_1 = 1$	$y_1 = 0.36$
$x_2 = 1.22$	$y_2 = ?$
$x_3 = 1.25$	$y_3 = 0.41$

$$y_2 = y_1 + \frac{x_2 - x_1}{x_3 - x_1}(y_3 - y_1)$$

$$y_2 = 0.36 + \frac{1.22-1}{1.25-1}(0.41-0.36) = 0.404$$

η= 0.404

E = 50 lux (selected according to electrical installation standards fora store).

M = 1.25

$\phi_{total} = \frac{A.M.E_{Av}}{\eta}$ = (98x50x 1.25)/0.404= 15160 lumen.

0L= 2350 lumen (selected according to electrical installation standards using 36 W fluorescent lamps).

n = rfuotal = 15160/2350 = 6.45 (put 6 lamps)
r/J1

4.1.2. Lighting Calculation **for Cooking Area**

a= 11.45 m

b= 14.32 m

A= a x b =163.9n'i2

ah
K=H(a+b) .45x14.32) / (3.15 (ll.45+14.32)) =2.0

To find the vahteiof lJ

Consider that the color of the Ceiling is light color (0.8), walls are light dark (0.5) and the surface is bright color (0.3).

7]=0.51

M =1.25.

E = 125 lux (selected according to electrical installation standards for kitchens).

r/JTo1a1 = A.M -EAv = (163.9xl.25x125)/0.51=50214 lumen
lJ

0L = 2350 x 2 = 4700 lumen (selected according to electrical installation standards using 36 W füıotescent lamps).

n = r/Jıo1a1 =50214/4700=10.68 (put 10 lamps)
r/J1

4.1.3. Lighting Calculation for Dinning **Room**

a=4.1 m

b=5.2 m

A=4.lx5.2 =21.32 m2

K= tb \ = (4.lx5.2)/ (3.15(4.1+5.2)) =0.73
H a+b

Using linear interpolation,

Index	Efficiency
$x_1 = 0.6$	$y_1 = 0.24$
$x_2 = 0.73$	$y_2 = ?$
$x_3 = 0.8$	$y_3 = 0.31$

$$y_2 = y_1 + \frac{x_2 - x_1}{x_3 - x_1}(y_3 - y_1)$$

$$y_2 = 0.24 + \frac{0.73 - 0.6}{0.8 - 0.6}(0.31 - 0.24) = 0.285$$

$\eta = 0.285$

$M = 1.25$

E = 50 lux (selected according to electrical installation standards for dinning rooms).

$$\Phi_{total} = \frac{A \cdot M \cdot E_{Av}}{\eta} = (21.32 \times 1.25 \times 50) / 0.285 = 4675 \text{ lumen}$$

Φ_L = 2350 lumen (selected according to electrical installation standards using 36 W fluorescent lamps).

$$n = \frac{\Phi_{total}}{\Phi_L} = (4675/2350) = 1.9 \text{ (put 2 lamps)}$$

Table 4.1: Room efficiency

Ceiling	0.80				0.50				0.30	
Wall	0.50		0.30		0.50		0.30		0.10	0.30
Ground	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10
$K = \frac{AxB}{(A+B)xH}$	Room efficiency (η)									
0.60	0.24	0.23	0.18	0.18	0.20	0.19	0.15	0.15	0.12	0.15
0.80	0.31	0.29	0.24	0.23	0.25	0.24	0.20	0.19	0.16	0.17
1.00	0.36	0.33	0.29	0.28	0.29	0.28	0.24	0.23	0.20	0.20
1.25	0.41	0.38	0.34	0.32	0.33	0.31	0.28	0.27	0.24	0.24
1.50	0.45	0.41	0.38	0.36	0.36	0.34	0.32	0.30	0.27	0.26
2.00	0.51	0.46	0.45	0.41	0.41	0.38	0.37	0.35	0.31	0.30
2.50	0.56	0.49	0.50	0.45	0.45	0.41	0.41	0.38	0.35	0.34
3.00	0	0.52	0.54	0.48	0.47	0.43	0.43	0.40	0.38	0.36
4.00	0.63	0.55	0.58	0.51	0.50	0.46	0.47	0.44	0.41	0.39
5.00	0.66	0.57	0.62	0.54	0.53	0.48	0.50	0.46	0.44	0.40

4.2. Voltage-Current Calculations

4.2.1. Maximum demand

Maximum demand (often referred to as MD) is the largest current normally carried by circuits, switches and protective devices; it does not include the levels of current flowing under overload or short circuit conditions, Assessment of maximum demand is sometimes straightforward. For example, the maximum demand ofa 240 V single-phase 8 kW shower heater can be calculated by dividing the power (8 kW) by the voltage (240 V) to give a current of 33.3 A. This calculation assumes a power factor of unity, which is a reasonable assumption for such a purely resistive load.

There are times, hôwever, when' assessment of maximum demand is less obvious. For example, if a ring .circuit feeds fifteen 13 A sockets, the maximum demand clearly should not be 15 x 13 = 195 A, if only because the circuit protection will not be rated at more than 32 A. Some 13 A sockets may feed table lamps with 60 W lamps fitted, whilst others may feed 3 kW washing machines; others again may not be loaded at all.

Lighting circuits pose a special problem when determining MD. Eachlaınp-hôlder must be assumed to carry the current required by the connected load, subject to a minimum loading of 100 W per 1ampholder (a demand of 0.42 A per Iampholder- at 240 V). Discharge lamps are particularly difficult to assess, and current cannot be calculated simply by dividinglamp power by supply voltage. The reasons for this are:

1. Control geaflôssesfesult in additional current,

2. The power faetor' is usually less than unity so current is greater, and

3. Chokes and öther control gear usually distort the waveform of the current so that it contains harmoııics which are additional to the fundamental supply current.

So long as thçrpf)yverfactor of a discharge lighting circuit js not less than 0.85, the current demandfor the circuit can be calculated from:

$$\text{current (A)} = \frac{\text{larhp böwer (W}\} \times 1.8}{\text{süpply voltage (V)}}$$

For example, the steady state current demand of a 240 V circuit supplying ten 65 W fluorescent lamps would be:

$$I = \frac{10 \times 65 \times 1.8 \text{ A}}{240} = 4.88\text{A}$$

Switches fôr cifcuits feedinğ discharge lamps must be rated at twice the current they are required to cafry, ünless they have been specially constructed to withstand the severe arcing resulting from the Switching of such inductive and capacitive loads.

4.2.2. Diversity

A domestic ring circuit typically feeds a large number of 13 A sockets hut is usually protected by a fuse or circuit breaker rated at 30 A or 32 A. This means that if sockets were feeding 13 A loads, more than two of them in use at the same time would overload the circuit and it.would be disconnected by its protective device.

In practice, the chances of all domestic ring sockets feeding loads taking 13 A are small. Whilst there maybe a 3 kW washing machine in the kitchen, a 3 kW heater in the living room and another in the bedroom, the chance of all three being in use at the same time is remote. If they are all connected at the same time, this could be seen as a failure of the designer when assessing the installation requirements; the installation should have two ring circuits to feed the parts of the house in question.

Most sockets, then, will feed smaller loads such as table lamps, vacuunı cleaner, television or audio machines and so on. The chances of all the sockets beirıg used simultaneously is remote in the extreme provided that the number of sockets (arıd ring circuits) installedsis large enough. The condition that only a few sockets will be iffıise at the same time, arıd;that the loads they feed will be small is called diversity.

By making allôwarıce for reasonable diversity, the number of circuits and their rating can be reducı::ci, with a consequent financial saving, but without reducing the effectiveness Ofthe installation. However, if diversity is over-estimated, the normal current demandswill exceed the ratings of the protective devices, which will disconnect the circuits ~rrı.ôt\a/welcome prospect for the user of the installation! Overheating may also result frorrıôverloading which exceeds the rating of the protective device, but does not reach its operating current in a reasonably short time. The Regulations require that circuit design-sheiıld prevent the occurrence of small overloads of long duration.

The sensible application of diversity to the design of an installation calls for experience and a detailed knowledge of the intended use of the installation. Future possible increase in load should also be taken into account. Diversity relies on a number of factors which can only be properly assessed in the light of detailed knowledge of the type of installation, the industrial process concemed where this applies, and the habits and practices of the users.

4.2.3. Voltage Calculation Formula

-For three phase (220/380 v)

$$\&[\%] = \frac{100 x L x P}{x x\, q x\, V^2} = \frac{L x P(KW) x 10^5}{56 x\, q x\, (380)}$$

$$\&\% = 0.0124 \frac{L x p}{q} < 1.5$$

-For single phase (220 v)

$$c[\%] = \frac{200 \times L \times P}{\chi \times q \times V^2} = \frac{2.10^5 \times L \times P(KW)}{56 \times q \times (220)^2}$$

$$c\% = 0.074 \frac{L \times p}{q} < 1.5$$

Where

c[%] = voltage c~lculation (percent)

P = power (KW),

L = distance of the line (m),

V = voltağe(380 volt) in 3 phase and (220)in one phase .

q = conductive cross section (mm-)

χ = conduqtiyecoefficient where z(cu) =56 mi Omm2, ,t(Al) =35nı/Qmm2

4.2.4. CurrentCalculation Formula

-For three phase

$$I = \frac{p}{V \times COS\varphi \times \sqrt{3}}$$

-For one phase

$$I = \frac{p}{V \times COS\varphi}$$

Where

V = voltage (380 volt) in3phase and (220) in one phase.

P = power (KW),

I = current.

4.3. Cost Calculations

The cost calculations of the project are shown in table 4.2

Table 4.2: Cost calculations.

CODE*	Com_e_onent	Price per piece	Quantity	Price
A-4	Duvar Globu Tesisatı:	60.00	10	600.00
A-3	Tavan Globu Tesisatı:	60.00	2	120.00
A-12.2	1x36/40 W Floresen Tesisatı:	93.00	28	2,604.00
A-12.5	2x36/40 W Floresen Tesisatı:	127.00	76	9,652.00
A-14.15	Reflöktörlü 4x18/20 W Gömme Floresen Lamba tesisatı:	252.00	50	12,600.00
A-17.2	1x36/40W W/Proff floresen lamba teslsatn	312.00	21	624.00
C-1.1	1x13 Ame_OPri:z tesisatı	67.00	76	5,092.00
C-1.2	2x13 Am_e_. Priz tesisatı.	80.00	28	2,240.00
C-2.4	Cooker Kontrol Tesisatı	146.00	1	146.00
F-5.2	Üç Faz3X:32APriz Tesisatı	72.00	18	1,296.00
H-3.10	(3X6) Xe>II~ 400 Amp TP N E Busburlı Ana Da_ğıtım."Ti!!)losu	5,288.00	1	5,288.00
H-1.8	(3x12) Yôllü - 3x200 Amp Bus-Bur'lı Dağıtım tablosu	1,350.00	2	2,700.00
H-1.6	(3x6) Yollu• .. 3x200 Amp Bus-Bur'lı Dağıtım tablosu	1,200.00	2	2,400.00
H-1.7	(3x8) Yollu - 3x200 Amp Bus-Bur'lı Dağıtım tablosu	1,262.00	1	1,262.00
1-1.6	(1x8) Yollu Daijıtım Tablosu	216.00	1	216.00
H-2.1	MCB 1 Faz 45 Am_e_ere kadar	30.00	50	1,500.00
H-2.5	MCB 3 Faz 45 Am_e_ere Kadar	105.00	18	1,890.00
H-4.1	MCCB 1x63 Am_e_.'e kadar 15kA	109.00	1	109.00
H-4.4	MCCB 3x100 Am_e_.'e kadar 15kA	189.00	2	378.00
H-4.3	MCCB 3x63 Am_e_.'.e kadar 15kA	181.00	3	543.00
H-4.7	MCCB 3x400 Am_e_.'e kadar 25kA	1,474.00	1	1,474.00
H-4.19	MCCB 4x400 Am_e_.'e kadar 25kA	2,060.00	1	2,060.00
H-5.8	(4x60) Amper Kollu Sigortalı Kesici Tesisatı	451.80	31	1,355.40
H-5.9	(4x100) Amper Kollu Sigortalı Kesici Tesisatı	706.80	~	1,413.60
E-2.1	Akım Otomatiği (C/0) 30/45/60 Amp.	102.00		102.00
G-6	Merkezi To_e_raklama:	2,700.00	1	2,700.00
		Total Cost		60,365.00

* The code is according to EMO' s list of prices.

CONCLUSION

The interior electrical installation of a production factory was designed in this project. Electrical installation is a very wide field and there are many ways to meet the standard installation requirements. That's why different electrical engineers can have different designs for the same project. It is in a way limited to the designer's creativity.

The best design-would definitely be the one that meets the standard electrical installation requirements at the lowest cost, taking into consideration the power consumptiorı-anôflts decorative side of installation.

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