CODE OF PRACTICE FOR

Energy Efficiency of Electrical Installations

2005 EDITION

EMSD

Foreword

The Code of Practice for Energy Efficiency of Electrical Installations aims to set out the minimum requirements on energy efficiency of electrical installations in buildings. It forms a part of a set of comprehensive *Building Energy Codes* that addresses energy efficiency requirements on building services installations. Designers are encouraged to adopt a proactive approach to exceed the minimum requirements of this code.

This code was developed by the *Task Force on Electrical Energy Code* that was established under the *Energy Efficiency & Conservation Sub-committee* of the *Energy Advisory Committee*. The Task Force members include:-

Convenor :	Mr. Ronald S. Chin	(Electrical & Mechanical Services Department)
Members :	Mr. K.Y. Chung	(The Hong Kong Electric Co. Ltd.)
	Mr. Y.F. Kwok	(The Hong Kong Polytechnic University)
	Mr. W.K. Lam	(The Hong Kong E&M Contractors' Association Ltd.)
	Mr. Thomas K.S. Lam	(The Hong Kong Institution of Engineers)
	Mr. Bernard V. Lim	(The Hong Kong Institute of Architects)
	Mr. Y.F. So	(Hong Kong Electrical Contractors' Association Ltd.)
	Mr. Winston Tse	(China Light & Power Co. Ltd.)
	Mr. Martin Wu	(Electrical & Mechanical Services Department)

Secretary	(prior to Jan 1997)	: Mr. C.K. Lee (Electrical & Mechanical Services Department)
	(from Jan 1997)	: Mr. K.K. Lam (Electrical & Mechanical Services Department)

This Code was first published in 1998 by the Electrical & Mechanical Services Department.

The set of comprehensive *Building Energy Codes* cover this Code, the Codes of Practice for Energy Efficiency of Lighting Installations, Air Conditioning Installations, and Lift & Escalator Installations, and the Performance-based Building Energy Code.

The Building Energy Codes and Registration Scheme documents are available for free download at http://www.emsd.gov.hk/emsd/eng/pee/eersb.shtml
Enquiry: hkeersb@emsd.gov.hk

Amendment to 1999 Edition

To suit changes in technological advancement, there are the following amendments, which were agreed in meetings of ad-hoc code review task force with members from representative organizations in the building industry:

- Definition:- 'Local distribution board' added;
- Clause 4.6:- Requirement on domestic buildings revised;
- Clauses 5.1, 5.2 & 5.3:- Compliance with the other Codes of Practice are preferred (but not essential) requirements
- Clause 5.5:- Description added on required position of power factor improvement device;
- Clause 6.1:- Requirement on circuits serving lifts and escalators revised.

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1. SCOPE

1.1 The Code shall apply to all fixed electrical installations, other than those used as emergency systems, for all buildings except those specified in Clause 1.2, 1.3 and 1.4 below.

1.2 The following types of buildings are not covered in the Code:

(a) buildings with a total installed capacity of 100A or less, single or three-phase at nominal low voltage; and

(b) buildings used solely for public utility services such as power stations, electrical sub-stations, water supply pump houses, etc.

1.3 Buildings designed for special industrial process may be exempted partly or wholly from the Code subject to approval of the Authority.

1.4 Equipment owned by the public utility companies (e.g. HV/LV switchgear, transformers, cables, extract fans, etc.) and installed in consumers' substations will not be covered by the Code.

1.5 In case where the compliance of this Code is in conflict with the safety requirements of the relevant Ordinance, Supply Rules, or Regulations, the requirements of this Code shall be superseded. This Code shall not be used to circumvent any safety, health or environmental requirements.

2. DEFINITIONS

The expressions, which appear in this Code, are defined as follows:-

'Appliance' means an item of current using equipment other than a luminaire or an independent motor or motorised drive.

'Appliance, fixed' means an appliance, which is fastened to a support or otherwise secured at a specific location in normal use.

'Appliance, portable' means an appliance which is or can easily be moved from one place to another when in normal use and while connected to the supply.

'Building' means any building as defined in Building Ordinance Cap. 123.

'Circuit, feeder' means a circuit connected directly from the main LV switchboard to the major current-using equipment.

'Circuit, final' means a circuit connected from a local distribution board to a current-using equipment, or to a socket-outlet or socket-outlets or other outlet points for the connection of such equipment.

'Circuit, main' means a circuit connected from a distribution transformer to the main LV switchboard downstream of it.

'Circuit, sub-main' means a circuit connected from the main LV switchboard or a rising mains to a local distribution board.

'Communal installation' means an installation provided by the building owner as part of the services to the tenants or to comply with a particular statutory requirement.

'Distribution transformer' means an electromagnetic device used to step down electric voltage from high voltage distribution levels (e.g. 11kV) to the low voltage levels (e.g. 380V), rated from 200kVA, for power distribution in buildings.

'Effective current-carrying capacity' means the maximum current-carrying capacity of a cable that can be carried in specified conditions without the conductors exceeding the permissible limit of steady state temperature for the type of insulation concerned.

'Emergency system' means any statutory required system, which is installed for the purpose of fire services as defined in 'Code of Practice for the Minimum Fire Services Installations and Equipment' published by the Fire Services Department.

'Equipment' means any item for such purposes as generation, conversion, transmission, distribution, measurement or utilisation of electrical energy, such as luminaires, machines, transformers, apparatus, meters, protective devices, wiring materials, accessories and appliances.

'Harmonic' means a component frequency of a harmonic motion (as of an electromagnetic wave) that is an integral multiple of the fundamental frequency. For the power distribution system in Hong Kong, the fundamental frequency is 50 Hz.

'Installation' means the wiring installation together with any equipment connected or intended to be connected.

'Load factor' means the ratio of the average load of a building in kW, consumed during a designated period, to the peak or maximum load in kW, occurring in that same period.

'Local distribution board' means the distribution board for final circuits to current-using equipment, luminaires, or socket-outlets.

'Maximum demand' means the maximum power demand registered by a consumer in a stated period of time such as a month. The value is the average load over a designated interval of 30 minutes in kVA.

'Meter' means a measuring instrument and connected equipment designed to measure, register or indicate the value of voltage, current, power factor, electrical consumption or demand with respect of time, etc.

'Non-linear load' means any type of equipment that draws a nonsinusoidal current waveform when supplied by a sinusoidal voltage source.

'Power factor, displacement' of a circuit means the ratio of the active power of the fundamental wave, in watts, to the apparent power of the fundamental wave, in volt-amperes. Its value in the absence of harmonics coincides with the cosine of the phase angle between voltage and current.

'Power factor, total' of a circuit means the ratio of total active power of the fundamental wave, in watts, to the total apparent power that contains the fundamental and all harmonic components, in volt-amperes.

'Rated circuit current (at rated load condition)' means the magnitude of the maximum current (r.m.s. value for a.c.) to be carried by the circuit at its rated load condition in normal service.

'Total harmonic distortion (THD)' in the presence of several harmonics, is a ratio of the root-mean-square (r.m.s.) value of the harmonics to the r.m.s. value of the fundamental expressed in percentage. In equation form, the definition of %THD for current is:

$$\%THD = \frac{\sqrt{\sum_{h=2}^{\infty}(I_h)^2}}{I_1} \times 100$$

Where : I_1 = r.m.s. value of fundamental current
I_h = r.m.s. value of current of the hth harmonic order

'Variable speed drive (VSD)' means a motor accessory that enables the driven equipment to be operated over a range of speeds. Electronic types VSD include, but not limit to, current source inverter, cycloconverter, load-commutated inverter, pulse-width modulated, and voltage-source inverter.

'Voltage, nominal' means voltage by which an installation (or part of an installation) is designated. The following ranges of nominal voltage (r.m.s. values for a.c.) are defined:

- Extra Low	:	normally not exceeding 50V a.c. or 120V d.c., whether between conductors or to earth.
- Low	:	normally exceeding Extra Low voltage but not exceeding 1000V a.c. or 1500V d.c. between conductors, or 600V a.c. or 900V d.c. between conductors and earth.
- High	:	exceeding Low voltage.

3. GENERAL APPROACH

3.1 This Code sets out the minimum requirements for achieving energy efficient design of electrical installations in buildings without sacrificing the power quality, safety, health, comfort or productivity of occupants or the building function.

3.2 As the Code sets out only the minimum standards, designers are encouraged to design energy efficient electrical installations and select high efficiency equipment with energy efficiency standards above those stipulated in this Code.

3.3 The requirements for energy efficient design of electrical installations in buildings are classified in the Code into the following four categories:

(a) Minimising losses in the power distribution system.
(b) Reduction of losses and energy wastage in the utilisation of electrical power.
(c) Reduction of losses due to the associated power quality problems.
(d) Appropriate metering and energy monitoring facilities.

4. ENERGY EFFICIENCY REQUIREMENTS FOR POWER DISTRIBUTION IN BUILDINGS

4.1 High Voltage Distribution

High voltage distribution systems should be employed for high-rise buildings to suit the load centres at various locations. A high-rise building is defined as a building having more than 50 storeys or over 175m in height above ground level.

4.2 Minimum Transformer Efficiency

The privately owned distribution transformers should be selected to optimise the combination of no-load, part-load and full-load losses without compromising operational and reliability requirements of the electrical system. The transformer should be tested in accordance with relevant IEC standards and should have a minimum efficiency shown in Table 4.1 at the test conditions of full load, free of harmonics and at unity power factor.

Table 4.1: Minimum Transformer Efficiency

Transformer Capacity	Minimum Efficiency
$<$ 1000kVA	98%
$\geq$ 1000kVA	99%

4.3 Locations of Distribution Transformers and Main LV Switchboards

The locations of distribution transformers and main LV switchboards should preferably be sited at their load centres.

4.4 Main Circuits

The copper loss of every main circuit connecting the distribution transformer and the main incoming circuit breaker of a LV switchboard should be minimised by means of either:

(a) locating the transformer room and the main switchroom immediately adjacent to, above or below each other, or

(b) restricting its copper loss to not exceeding 0.5% of the total active power transmitted along the circuit conductors at rated circuit current.

The effective current-carrying capacity of neutral conductors should have ratings not less than those for the corresponding phase conductors.

4.5 Feeder Circuits

The maximum copper loss in every feeder circuit should not exceed 2.5% of the total active power transmitted along the circuit conductors at rated circuit current. This requirement does not apply to circuits used for compensation of reactive and distortion power.

4.6 Sub-main Circuits

The maximum copper loss in every sub-main circuit, including the rising mains, should not exceed 1.5% of the total active power transmitted along the circuit conductors at rated circuit current. For Domestic buildings only, the maximum copper loss could exceed 1.5% but not exceed 2.5%.

4.7 Final Circuits

The maximum copper loss for every single-phase or three-phase final circuit over 32A should not exceed 1% of the total active power transmitted along the circuit conductors at rated circuit current.

Note: Table 4.2A & 4.2B are given in the following pages to provide guidance for preliminary selection of appropriate cable size for main, feeder, sub-main and final circuits based on the maximum allowable resistance value for a certain percentage copper loss.

TABLE 4.2A
Multicore Armoured and Non-armoured Cables (Copper Conductor)
Conductor Resistance at 50 Hz Single-phase or Three-phase a.c.
(Based on BS7671:1992 The Regulations for Electrical Installations, Table 4D2B, 4D4B, 4E2B & 4E4B)

Conductor cross-sectional area (mm^2)	Conductor resistance for PVC and XLPE cable in milliohm per metre (mΩ/m)	
	PVC cable at max. conductor operating temperature of 70°C	XLPE cable at max. conductor operating temperature of 90°C
1.5	14.5	15.5
2.5	9	9.5
4	5.5	6
6	3.65	3.95
10	2.2	2.35
16	1.4	1.45
25	0.875	0.925
35	0.625	0.675
50	0.465	0.495
70	0.315	0.335
95	0.235	0.25
120	0.19	0.2
150	0.15	0.16
185	0.125	0.13
240	0.095	0.1
300	0.0775	0.08
400	0.0575	0.065

TABLE 4.2B
Single-core PVC/XLPE Non-armoured Cables, with or without sheath (Copper Conductor)
Conductor Resistance at 50 Hz Single-phase or Three-phase a.c.
(Based on BS7671:1992, Table 4D1B & 4E1B)

Conductor cross-sectional area (mm^2)	Conductor resistance for PVC and XLPE cable in milliohm per metre ($m\Omega/m$)			
	PVC cable at max. conductor operating temperature of 70°C		XLPE cable at max. conductor operating temperature of 90°C	
	Enclosed in conduit/trunking	Clipped direct or on tray, touching	Enclosed in conduit/trunking	Clipped direct or on tray, touching
1.5	14.5	14.5	15.5	15.5
2.5	9	9	9.5	9.5
4	5.5	5.5	6	6
6	3.65	3.65	3.95	3.95
10	2.2	2.2	2.35	2.35
16	1.4	1.4	1.45	1.45
25	0.9	0.875	0.925	0.925
35	0.65	0.625	0.675	0.675
50	0.475	0.465	0.5	0.495
70	0.325	0.315	0.35	0.34
95	0.245	0.235	0.255	0.245
120	0.195	0.185	0.205	0.195
150	0.155	0.15	0.165	0.16
185	0.125	0.12	0.135	0.13
240	0.0975	0.0925	0.105	0.1
300	0.08	0.075	0.0875	0.08
400	0.065	0.06	0.07	0.065
500	0.055	0.049	0.06	0.0525
630	0.047	0.0405	0.05	0.043
800	-	0.034	-	0.036
1000	-	0.0295	-	0.0315

5. REQUIREMENTS FOR EFFICIENT UTILISATION OF POWER

5.1 Lamps and Luminaires

All lamps and luminaires forming part of an electrical installation in a building should preferably comply with the latest edition of the Code of Practice for Energy Efficiency of Lighting Installations.

5.2 Air Conditioning Installations

All air conditioning units and plants drawing electrical power from the power distribution system should preferably comply with the latest edition of the Code of Practice for Energy Efficiency of Air Conditioning Installations. Any motor control centre (MCC) or motor for air conditioning installations, having an output power of 5kW or greater, with or without variable speed drives, should also be equipped, if necessary, with appropriate power factor correction or harmonic filtering devices to improve the power factor to a minimum of 0.85 and restrict the total harmonic distortion (THD) of current to the value as shown in Table 6.1.

5.3 Vertical Transportation

All electrically driven equipment and motors forming part of a vertical transportation system should preferably comply with the latest edition of the Code of Practice for Energy Efficiency of Lift and Escalator Installations.

5.4 Motors and Drives

5.4.1 Motor Efficiency

Except for motors which are components of package equipment, any polyphase induction motor having an output power of 5kW or greater that is expected to operate more than 1,000 hours per year should use "high-efficient" motors tested to relevant international standards such as IEEE 112-1991 or IEC 34-2. The nominal full-load motor efficiency shall be no less than those shown in Table 5.1 below.

Table 5.1: Minimum Acceptable Nominal Full-Load Motor Efficiency for Single-Speed Polyphase Motors

Motor Rated Output (P)	Minimum Rated Efficiency (%)
5kW≤P<7.5kW	84.0
7.5kW≤P<15kW	85.5
15kW≤P<37kW	88.5
37kW≤P<75kW	90.0
75kW≤P<90kW	91.5
P≥90kW	92.0

5.4.2 Motor Sizing

Every motor having an output power of 5kW or greater should be sized by not more than 125% of the anticipated system load unless the load characteristic requires specially high starting torque or frequent starting. If a standard rated motor is not available within the desired size range, the next larger standard size may be used.

5.4.3 Variable Speed Drives (VSDs)

A variable speed drive (VSD) should be employed for motor in a variable flow application. Any motor control centre (MCC) with VSDs should also be equipped, if necessary, with appropriate power factor correction or harmonic reduction devices to improve the power factor to a minimum of 0.85 and restrict the THD current to the value as shown in Table 6.1.

5.4.4 Power Transfer Devices

Power transfer devices used for motors having an output power of 5kW or greater, and to change continually the rotational speed, torque, and direction, should be avoided. Directly connected motors running at the appropriate speed via variable speed drives should be used as far as practicable. If the use of belts is unavoidable, synchronous belts- having teeth that fit into grooves on a driven sprocket to prevent slip losses - should be employed to provide a higher efficiency over friction belts.

5.5 Power Factor Improvement

The total power factor for any circuit should not be less than 0.85. Design calculations are required to demonstrate adequate provision of power factor correction equipment to achieve the minimum circuit power factor of 0.85. If the quantity and nature of inductive loads and/or non-linear loads to be installed in the building cannot be assessed initially, appropriate power factor correction devices shall be provided at a later date after occupation.

The correction device should be installed at the source motor control centre or distribution board just upstream of the circuit in question. However for Sub-circuits feeding Local distribution board, group compensation is allowed should there be space or other constraints that cause impracticality in installing the correction device at the Local distribution board. Under such circumstance, the correction device could be installed at the next upstream Sub-main or Main whereby no such constraints exist.

5.6 Other Good Practice

5.6.1 Office Equipment

Office consumers should be encouraged to select and purchase office machinery/equipment, e.g. personal computers, monitors, printers, photocopiers, facsimile machines etc., complete with ‘power management’ or ‘energy saving’ feature which power down unnecessary components within the equipment but maintaining essential function or memory when the equipment are idle or after a user-specified inactivity period.

5.6.2 Electrical Appliances

Consumers should be encouraged to select and purchase energy efficient electrical appliances such as refrigerators, room coolers, washing machines, etc. which are registered under the Energy Efficiency Labelling Scheme (EELS) with good energy efficiency grade 3 or better.

5.6.3 Demand Side Management (DSM)

The Demand Side Management (DSM) programmes developed by the utility companies have tried to change consumers' electricity usage behaviour to achieve a more efficient use of electric energy and a more desirable building load factor, which is beneficial to both consumers and the utility companies. Designers are encouraged to incorporate into their design all latest DSM programmes available in order to reduce the building maximum demand and the electrical energy consumption. DSM Energy Efficiency Programmes include utilities' special ice-storage air-conditioning tariff and time-of-use tariff, rebates offered to participants to purchase energy efficient electrical appliances/installations (e.g. refrigerators, air-conditioners, compact fluorescent lamps, electronic ballasts, HVAC systems) etc.

6. ENERGY EFFICIENCY REQUIREMENTS FOR POWER QUALITY

6.1 Maximum Total Harmonic Distortion (THD) of Current on LV Circuits

The total harmonic distortion (THD) of current for any circuit should not exceed the appropriate figures in Table 6.1. According to the quantity and nature of the known non-linear equipment to be installed in the building, design calculations are required to demonstrate sufficient provision of appropriate harmonic reduction devices to restrict harmonic currents of the non-linear loads at the harmonic sources, such that the maximum THD of circuit currents, at rated load conditions, shall be limited to those figures as shown in Table 6.1 below.

Table 6.1: Maximum THD of current in percentage of fundamental

Circuit Current at Rated Load Condition 'I' at 380V/220V	Maximum Total Harmonic Distortion (THD) of Current
I<40A	20.0%
40A≤I<400A	15.0%
400A≤I<800A	12.0%
800A≤I<2000A	8.0%
I≥2000A	5.0%

In case of motor circuits using VSDs, group compensation at the sub-main panel or MCC is allowed, provided that the maximum allowable fifth harmonic current distortion at the VSD input terminals during operation within the variable speed range is less than 35%.

If the quantity and nature of non-linear equipment to be installed in the building cannot be assessed initially, appropriate harmonic reduction devices shall be provided at a later date after occupation.

For lift & escalator installations complying with the *Code of Practice for Energy Efficiency of Lift and Escalator Installations*, *in particular clause 4.5 or clause 5.3 as appropriate*, the THD of the circuit of a single lift/escalator or a bank of lifts/escalators would not be further subject to requirements of Table 6.1.

6.2 Balancing of Single-phase Loads

All single-phase loads, especially those with non-linear characteristics, in an electrical installation with a three-phase supply should be evenly and reasonably distributed among the phases. Such provisions are required to be demonstrated in the design for all three-phase 4-wire circuits exceeding 100A with single-phase loads.

The maximum unbalanced single-phase loads distribution, in term of percentage current unbalance shall not exceed 10%. The percentage current unbalance can be determined by the following expression:

$$I_u = (I_d \times 100) / I_a$$

Where I_u = percentage current unbalance
I_d = maximum current deviation from the average current
I_a = average current among three phases

7 REQUIREMENTS FOR METERING AND MONITORING FACILITIES

7.1 Main Circuits

All main incoming circuits exceeding 400A (3-phase 380V) current rating should be incorporated with metering devices, or provisions for the ready connection of such devices, for measuring voltages (all phase-to-phase and phase-to-neutral), currents (all lines and neutral currents) and power factor, and for recording total energy consumption (kWh) and maximum demand (kVA).

7.2 Sub-main and Feeder Circuits

All sub-main distribution and individual feeder circuits exceeding 200A (3-phase 380V) current rating should be complete with metering devices, or provisions for the ready connection of such devices, to measure currents (3 phases and neutral) and record energy consumption in kWh for energy monitoring and audit purposes. This requirement does not apply to circuits used for compensation of reactive and distortion power.

8 SUBMISSION OF INFORMATION

Relevant information, drawings and calculations for the buildings should be submitted on the following standard forms set out in the schedule of this Code:

(a) FORM EL-1: Electrical Installations Summary

(b) FORM EL-2 Electrical Power Distribution Worksheet

(c) FORM EL-3 Electrical Power Utilisation Worksheet

(d) FORM EL-4 Electrical Power Quality Worksheet

(e) FORM EL-5 Electrical Metering & Monitoring Worksheet

SCHEDULE OF FORMS

Job Ref. No. ________________

Electrical Installations Summary	FORM EL-1

Part (A) : General Information of Electrical Installations

Project/Building* Name : ______________________________	
Project/Building* Address : ______________________________	
Type of Building : Domestic/Commercial/Industrial/Hotel/Others* ____________	
Electrical Installation Works : Expected Commencement Date : ____________ Expected Completion Date : ____________	
No. of Storeys : ____________	Building Height : ________m
Gross Floor Area : ____________m^2	
Usable Floor Area : ____________ m^2	
Building Demand Assessment (kVA) :	
Landlord's Demand : ____________kVA	
Tenants' Demand : ____________kVA	
Total Demand : ____________kVA	
Total Load Density : ____________kVA/ m^2 usable floor area excluding plantrooms	

Part (B) : Attached Electrical Forms

Electrical Forms	No. of Sheets
☐ Form EL-2 (Power Distribution Worksheet)	
☐ Form EL-3 (Power Utilisation Worksheet)	
☐ Form EL-4 (Power Quality Worksheet)	
☐ Form EL-5 (Metering & Monitoring Worksheet)	

Note : All clauses quoted in the above forms are corresponding to the clauses of Code of Practice for Energy Efficiency of Electrical Installations.

* - delete as appropriate
☐ - tick where appropriate

Part (C) : List of Attached Drawings

Drawing No.	Revision No.	Drawing Title	No. of Copies

Sheet (   ) of (   )

Job Ref. No. _______________

Electrical Power Distribution Worksheet	FORM EL-2

A. High Voltage Distribution (Clause 4.1)

The building has more than 50 storeys or over 175m in height above ground? ☐ Yes ☐ No	
Voltage level :________kV System designed and installed by: ☐ Utility Company ☐ Private Consultants and Contractors	

B. Minimum Transformer Efficiency (Clause 4.2)

Any privately owned distribution transformers used in the building?	
☐ Yes Transformer Rated Capacity : __________kVA 1-phase/3-phase* No. of Transformers : __________ Efficiency at Full Load : __________%	☐ No

C. Location of Distribution Transformers & Main LV Switchboards (Clause 4.3)

The distribution transformers and main LV switchboards are at their load centres?	
☐ Yes Locations : ________________________ ________________________	☐ No Locations : ________________________ ________________________

D. Main Circuits (Clause 4.4)

The transformer rooms and main LV switchrooms are adjacent to each other?	
☐ Yes ☐ No Maximum length of main circuits : ______m	
Maximum power losses using the type and size of conductors below if the main circuit(s) is/are not provided by the utility company:	
☐ Cable Material : Copper/Aluminium* Design Current (I_b) : ____________A Cable Type : ____________ Conductors Size : ____________mm^2 Cable Length : ____________m Power Loss : ____________kW Percentage Power Loss : __________%	☐ Busbar/Busduct* Material : Copper/Aluminium* Design Current (I_b) : ____________A Busduct Rating : ____________A Busduct Length : ____________m Power Loss : ____________kW Percentage Power Loss : __________%

Sheet ( ) of ( )

E. Feeder and Sub-main Circuits (Clause 4.5 & 4.6)

Designed operating temperature of feeder and sub-main circuit conductors : _______°C

Schedule of Copper Losses for Dedicated Feeder & Sub-main Distribution Circuits (Note: circuits for Emergency Systems can be excluded):

Circuit Ref. (F=Feeder S=Sub-main)	Cable Type	Conductor Size (mm^2)	Circuit Length (m)	Design Current I_b (A)	Design p.f.	Active Power (W)	Copper Loss (W)	Copper Loss (%)

Sheet (   ) of (   )

F. Final Circuits (Clause 4.7)

Are there any final circuits having a rating over 32A (single-phase or three-phase)?

☐ No
☐ Yes (Schedule of copper losses of these final circuits is listed as follows)

Schedule of Copper Losses for Final Circuits having a rating over 32A :

Circuit Ref.	Cable Type	Conductor Size (mm^2)	Circuit Length (m)	Design Current I_b (A)	Design p.f.	Active Power (W)	Copper Loss (W)	Copper Loss (%)

Sheet ( ) of ( )

Job Ref. No. ________________

Electrical Power Utilisation Worksheet	FORM EL-3

A. Lamps and Luminaires (Clause 5.1)

Do the lighting installations comply with the Code of Practice for Energy Efficiency of Lighting Installations?	
☐ Yes	☐ No — Building/indoor space is for : ☐ Domestic ☐ Medical ☐ Industrial ☐ Others ______________

B. Air Conditioning Installations (Clause 5.2)

Do the air conditioning installations comply with the Code of Practice for Energy Efficiency of Air Conditioning Installations?	
☐ Yes	☐ No — Building is for : ☐ Domestic ☐ Medical ☐ Industrial ☐ Others ______________

C. Vertical Transportation (Clause 5.3)

Do the vertical transportation systems comply with the Code of Practice for Energy Efficiency of Lift & Escalator Installations?	
☐ Yes	☐ No

D. Power Factor Improvement (Clause 5.5)

Anticipated total apparent power (S) for communal installations : ______________kVA

Anticipated total active power (P) for communal installations : ______________kW

Anticipated initial power factor before correction : ______________

Design power factor after correction : ______________

Type of power factor correction equipment used : ___________________________

Rating of power factor correction equipment used : ________________ kvar

Location of power factor correction equipment : _____________________________

Other provisions for future use :

1. ______________________________________
2. ______________________________________
3. ______________________________________

Sheet ( ) of ( )

E. Motors and Drives (Clause 5.4)

Are there any motors or driving systems having an output rating of 5kW or greater?
☐ No ☐ Yes (Schedule of motors used is listed in the following table)

Motor Reference	Anticipated System Load (kW)	Motor Rating (kW)	Full Load Motor Efficiency (%)	Percentage Motor Rating to System Load (%)	VSD Type & Rating	Type of Power Transfer Devices	No. of Identical Motors

Sheet (   ) of (   )

Job Ref. No. ________________

Electrical Power Quality Worksheet	FORM EL-4

A. Maximum Total Harmonic Distortion (THD) of Current (Clause 6.1)

Are there any non-linear electrical loads in the communal installations?
☐ No (Other than fluorescent luminaires with conventional controlgear) ☐ Yes (Schedule of non-linear loads is listed as follows)

Type of Non-linear Load	Circuit Ref.	Rating (kVA)	Load Current (A)	Anticipated THD Current (%)	Harmonic Reduction Devices (if any)	Final THD Current (%)

Sheet (   ) of (   )

B. Balancing of Single-phase Loads (Clause 6.2)

Are there any single-phase electrical loads (communal installations) connected in the three-phase four-wire power distribution system?
☐ No ☐ Yes (Schedule of load currents in each phase is listed as follows)

Sub-main Circuit Ref. (with 1-phase loads)	Design Current in Red Phase I_R (A)	Design Current in Yellow Phase I_Y (A)	Design Current in Blue Phase I_B (A)	Average Current I_a (A)	Max. Deviation from Average I_d (A)	% Current Unbalance $Iu = (I_d \times 100) \div I_a$ (%)

Sheet (   ) of (   )

Job Ref. No. ________________

Electrical Metering and Monitoring Worksheet	FORM EL-5

A. Main Circuits (Clause 7.1)

Does the rating of any main incoming circuit exceed 400A, three-phase?	
☐ Yes Ammeter to read: ☐ Red Phase Current (I_R) ☐ Yellow Phase Current (I_Y) ☐ Blue Phase Current (I_B) ☐ Neutral Current (I_N) Voltmeter to read: ☐ Red to Yellow Line Voltage (V_{RY}) ☐ Yellow to Blue Line Voltage (V_{YB}) ☐ Blue to Red Line Voltage (V_{BR}) ☐ Red Phase to Neutral Voltage (V_{RN}) ☐ Yellow Phase to Neutral Voltage (V_{YN}) ☐ Blue Phase to Neutral Voltage (V_{BN}) ☐ Power Factor Meter ☐ kWh Energy Meter ☐ Maximum Demand Meter (kVA) ☐ Other metering provisions/facilities : ____________________ ____________________ ____________________ ____________________	☐ No

B. Sub-main and Feeder Circuits (Clause 7.2)

Does the rating of any sub-main/feeder circuit exceed 200A, three-phase?	
☐ Yes Ammeter to read : ☐ Red Phase Current (I_R) ☐ Yellow Phase Current (I_Y) ☐ Blue Phase Current (I_B) ☐ Neutral Current (I_N) ☐ kWh Energy Meter ☐ Other metering provisions/facilities : ____________________ ____________________ ____________________ ____________________	☐ No

Sheet ( ) of ( )

APPENDICES

Appendix A

Explanatory Notes and Sample Calculations

A1 Cable Sizing (Conventional Method)

The relationship among circuit design current (I_b), nominal rating of protective device (I_n) and effective current-carrying capacity of conductor (I_z) for an electrical circuit can be expressed as follows:

Co-ordination among I_b, I_n & I_z: $I_b \le I_n \le I_z$

Calculated minimum tabulated value of current: $I_{t(min)} = I_n \times \frac{1}{C_a} \times \frac{1}{C_g} \times \frac{1}{C_i}$

Effective current-carrying capacity : $I_z = I_t \times C_a \times C_g \times C_i$

where I_t = the value of current tabulated in Appendix 4 of BS7671:1992, The Requirements for Electrical Installations

C_a = Correction factor for ambient temperature

C_g = Correction factor for grouping

C_i = Correction factor for thermal insulation

Assumption: The supply voltages and load currents are sinusoidal and balanced among the three phases in a 3-phase 4-wire power distribution system.

A2 Power Factor and Losses due to Harmonic Distortion in Circuits with Non-linear Loads

Non-linear loads: all equipment working on the basis of phase control or arcing phenomena, e.g. electronic power supplies, thyristor equipment, welding machines, induction or arc furnaces, discharge lamps, etc. are non-linear loads. Harmonics increase power losses in distribution systems and equipment due to extra harmonic currents, eddy currents, hysterisis, skin and proximity effect.

Total Power Factor & Displacement Power Factor

Consider a circuit with non-linear loads current I, which is the r.m.s. values of fundamental (I_1) and all harmonic components (I_2, I_3, I_4, ...), an expression of the power factor could be found as follows:

Assumption: The circuit is fed from a line voltage having a low value of distortion and only the fundamental sinusoidal value U_1 is significant:

Apparent Power: $S = UI$

$$S^2 = (UI)^2 = U_1^2(I_1^2 + I_2^2 + I_3^2 + I_4^2 + \ldots)$$
$$= U_1^2 I_1^2 \cos^2\theta + U_1^2 I_1^2 \sin^2\theta + U_1^2(I_2^2 + I_3^2 + I_4^2 + \ldots)$$

According to this expression in the distorted circuit, the apparent power contained three major components:

1. Active Power in kW $P = U_1 I_1 \cos\theta$
   (This is the effective useful power)

2. Reactive Power in kvar $Q_1 = U_1 I_1 \sin\theta$
   (This is the fluctuating power due to the fundamental component and coincides with the conventional concept of reactive power in an inductive circuit consumed and returned to the network during the creation of magnetic fields)

3. Distortion Power in kvad $D^2 = U_1^2.(I_2^2 + I_3^2 + I_4^2 + ...)$
   (This power appears only in distorted circuits and its physical meaning is that of a fluctuating power due to the presence of harmonic currents)

The relationship among these three power components could further be shown in the following power triangles :

1. Fundamental Components: $S_1^2 = P^2 + Q_1^2$
   (Note : Displacement Power Factor, $\cos\theta = P/S_1$)

2. Fluctuating Power: $Q_T^2 = Q_1^2 + D^2$

3. Power Triangle in Distorted Circuit: $S^2 = Q_T^2 + P^2$
   (Note : Total Power Factor, $\cos\gamma = P/S$, is always smaller than the Displacement Power Factor, $\cos\theta$, and could be improved by either reducing the amount of harmonic distortion power (kvad) or reactive power (kvar))

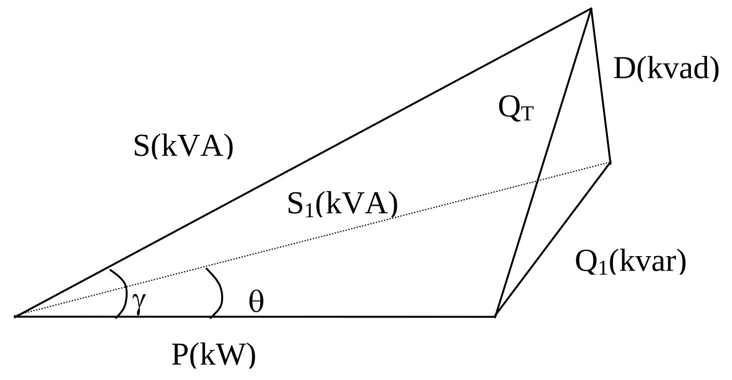


Fig. A1- Power Triangles for Apparent Power, Active Power, Reactive Power & Distortion Power

The expression only gives an approximate formula without any voltage distortion caused by voltage drop in line impedance. These harmonic voltages will also give active and reactive components of power but the active power is generally wasted as heat dissipation in conductors and loads themselves.

A3 Copper Loss Calculation

A3.1 For a 3-phase balanced and linear circuit:

Apparent power transmitted along the circuit conductors in VA, $S = \sqrt{3} U_L I_b$
Active power transmitted along the circuit conductors in W, $P = \sqrt{3} U_L I_b \cos\theta$
Total copper losses in conductors in W, $P_{copper} = 3 \times I_b^{\ 2} \times r \times L$
where U_L = Line to line voltage, 380V
I_b = Design current of the circuit in ampere
$\cos\theta$ = Power factor of the circuit
r = a.c. resistance per metre at the conductor operating temperature
L = Length of the cable in metre

Percentage copper loss with respect to the total active power transmitted,

$$\% \text{ loss} = \frac{3 \times I_b^{\ 2} \times r \times L}{\sqrt{3} U_L I_b \cos\theta}$$

$$\text{Therefore, max. r (m}\Omega\text{/m)} = \frac{\text{max.}\%loss \times U_L \times \cos\theta \times 1000}{\sqrt{3} \times I_b \times L}$$

Appropriate conductor size could then be selected from Table 4.2A and 4.2B

Correction for copper loss calculation due to various conductor operating temperature could be carried out as follows:

Conductor operating temperature at design current I_b is given by:

$$t_1 = t_a + \frac{I_b^{\ 2}}{I_t^{\ 2}}\left(t_p - 30\right)$$

where t_a = actual or expected ambient temperature
t_p = maximum permitted conductor operating temperature
ambient temperature = 30°C

The resistance of a copper conductor R_t at temperature t_1 is given by:

$$R_t = R_{20}\left[1 + \alpha_{20}\left(t_1 - 20\right)\right]$$

where R_{20} = conductor resistance at 20°C
α_{20} = the temperature coefficient of resistance of copper at 20°C (0.00393/°C)

or alternatively,

$$R_t = R_0\left(1 + \alpha_0 t_1\right)$$

where R_0 = conductor resistance at 0°C

α_0 = the temperature coefficient of resistance of copper at 0°C (0.00428/°C)

Therefore ratio, $$\frac{R_t}{R_p} = \frac{1+\alpha_0 t_1}{1+\alpha_0 t_p} \approx \frac{230+t_1}{230+t_p}$$

A3.2 For a 3-phase non-linear circuit having known harmonic current I_b & THD :

Apparent power transmitted along the circuit conductors in VA,

$$S = \sqrt{3} U_L I_b$$

where $$I_b = \sqrt{\sum_{h=1}^{\infty} I_h^2} = \sqrt{I_1^2 + I_2^2 + I_3^2 + ...}$$

From definition: $$THD = \frac{\sqrt{\sum_{h=2}^{\infty} (I_h)^2}}{I_1}$$

Therefore, $$I_b = I_1 \sqrt{1+THD^2}$$

And, fundamental current $$I_1 = \frac{I_b}{\sqrt{1+THD^2}}$$

Assuming voltage distortion is small, $U_L = U_1$, and active power transmitted along the circuit conductors in W is given by:

$$P = \sqrt{3} U_L I_1 \cos\theta$$

where U_L = Supply line voltage at 380V

I_1 = Fundamental phase current of the circuit in ampere

$\cos\theta$ = Displacement power factor of the circuit

And, Total Power Factor = $$\frac{P}{S} = \frac{\cos\theta}{\sqrt{1+THD^2}}$$

Assuming the skin and proximity effects are small, total copper losses in conductors including neutral in W is given by:

$$P_{copper} = (3 \times I_b^2 + I_N^2) \times r \times L$$

where I_N = Neutral current of the circuit in ampere

$$= 3 \times \sqrt{I_3^2 + I_6^2 + I_9^2 + \ldots\ldots}$$

I_b = Design rms phase current of the circuit in ampere

r = a.c. resistance per metre at the conductor operating temperature

L = Length of the cable in metre

Percentage copper loss with respect to the total active power transmitted,

$$\% \text{ loss} = \frac{(3 \times I_b^{\,2} + I_N^{\,2}) \times r \times L}{\sqrt{3} U_L I_1 \cos\theta}$$

$$\text{Therefore, max. r (m}\Omega\text{/m)} = \frac{max.\%loss \times \sqrt{3} \times U_L \times I_1 \times \cos\theta \times 1000}{(3 \times I_b^{\,2} + I_N) \times L}$$

Appropriate conductor size could then be selected from Table 4.2A and 4.2B

Correction for copper loss calculation due to various conductor operating temperature could be carried out as follows:

Conductor operating temperature at phase current I_b & neutral current I_N is given by:

$$t_1 = t_a + \frac{(3I_b + I_N)^2}{(3I_t)^2}\left(t_p - 30\right)$$

where t_a = actual or expected ambient temperature

t_p = maximum permitted conductor operating temperature

The resistance of a copper conductor R_t at temperature t_1 is given by:

$$R_t = R_0\left(1 + \alpha_0 t_1\right)$$

where R_0 = conductor resistance at 0°C

α_0 = the temperature coefficient of resistance of copper at 0°C (0.00428/°C)

Therefore ratio, $$\frac{R_t}{R_p} = \frac{1 + \alpha_0 t_1}{1 + \alpha_0 t_p} \approx \frac{230 + t_1}{230 + t_p}$$

A4 Sample Calculations for Cable Sizing

A 3-phase sub-main circuit having a design fundamental current of 100A is to be wired with 4/C PVC/SWA/PVC cable on a dedicated cable tray. Assuming an ambient temperature of 30°C and a circuit length of 40m, calculate an appropriate cable size for the following conditions:

(a) Undistorted balanced condition using traditional method ($cos\theta$ = 0.85);
(b) Undistorted balanced condition with a maximum copper loss of 1.5% ($cos\theta$ = 0.85);
(c) Distorted balanced condition with I_3=33A & I_5=20A (THD 38.6%) and a maximum copper loss of 1.5% ($cos\theta$ = 0.85); and
(d) Circuit to feed AHU variable speed drives with full load and full speed harmonic current I_5=70A, I_7=50A & I_{11}=15A (THD 87%) and a maximum copper loss of 1.5% ($cos\theta$ = 1)

Case (a): Undistorted balanced condition using conventional method:

I_b = 100A I_n = 100A I_t(min) = 100A

Refer to BS7671:1992, The Requirements for Electrical Installations,
Table 4D4A 25mm^2 4/C PVC/SWA/PVC cable I_t = 110A
Table 4D4B r = 1.5mV/A/m x = 0.145mV/A/m (negligible)

Conductor operating temperature t_1 = 30 + 100^2 / 110^2 x (70-30) = 63°C
Ratio of conductor resistance at 63°C to 70°C = (230+63)/(230+70)= 0.98

Voltage drop = 1.5mV/A/m x 0.85 x 0.98 x 100A x 40m = 5V (1.3%)

Active power transferred (P) = √3 x 380V x 100A x 0.85 = 56kW

Total copper losses in conductors
= 3 x 100^2 A^2 x 0.0015Ω/m / √3 x 0.98 x 40m
= 1.02kW (1.82%)
(Cable size selected is not acceptable if the maximum allowable copper loss is 1.5%)

Case (b): Maximum copper loss method using Table 4.2A in the Code for initial assessment of an approximate conductor size required by calculating the max. conductor resistance at 1.5% power loss:

$$\text{max. r (m}\Omega\text{/m)} = \frac{\max.\%loss \times U_L \times \cos\theta \times 1000}{\sqrt{3} \times I_b \times L}$$

$$= \frac{0.015 \times 380V \times 0.85 \times 1000}{\sqrt{3} \times 100A \times 40m}$$

= 0.7 mΩ/m

From Table 4.2A 35 mm^2 4/C PVC/SWA/PVC cable having a conductor resistance of 0.625 mΩ/m is required.

Refer to BS7671:1992, The Requirements for Electrical Installations,
Table 4D4A 35mm^2 4/C PVC/SWA/PVC cable I_t = 135A
Table 4D4B r = 1.1mV/A/m x = 0.145mV/A/m

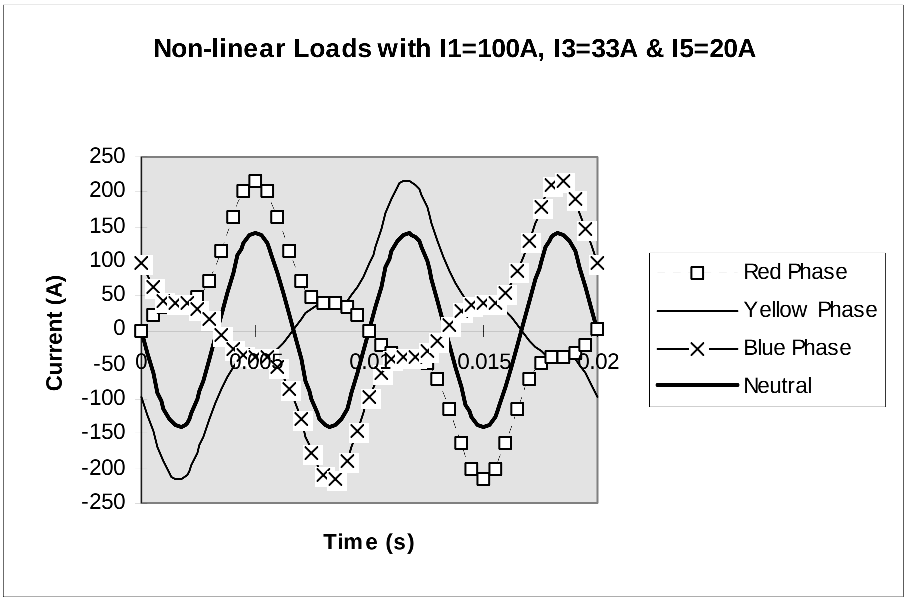
Conductor operating temperature $t_1 = 30 + 100^2 / 135^2 \times (70-30) = 52°C$
Ratio of conductor resistance at 52°C to 70°C = (230+52)/(230+70) = 0.94

Voltage drop = 1.1mV/A/m x 0.85 x 0.94 x 100A x 40m = 3.5V (0.92%)

Total copper losses in conductors = $3 \times 100^2 \times 0.0011 / \sqrt{3} \times 0.94 \times 40$ = 716W (1.28%)
(Cable size selected is acceptable, i.e. power loss < 1.5%, under undistorted and balanced conditions)

Case (c): Distorted balanced condition with I_3=33A & I_5=20A (THD 38.6%) and a maximum copper loss of 1.5%:

Fundamental current I_1 = 100A, harmonic currents I_3 = 33A & I_5=20A
THD = $\sqrt{(33^2 + 20^2)}/ 100$ = 38.6%
$I_{rms} = I_1 \sqrt{(1+THD^2)} = 100A\sqrt{(1+0.386^2)}$ = 107.2A
Neutral current (rms) I_N = 3x33A = 99A



From case (b) above 35mm^2 4/C PVC/SWA/PVC cable was selected

Refer to BS7671:1992, The Requirements for Electrical Installations,
Table 4D4A 35mm^2 4/C PVC/SWA/PVC cable I_t = 135A
Table 4D4B r = 1.1mV/A/m x = 0.145mV/A/m

Conductor operating temperature, t_1 = 30 + $(3x107.2+99)^2$ / $(3x135)^2$ x (70-30) = 73°C (Note: conductor operating temperature would be 73°C at this condition which is over the maximum of 70°C for PVC insulated cable)

Ratio of conductor resistance at 73°C to 70°C = (230+73)/(230+70) = 1.01(over temperature)

Total copper losses in conductors (assuming skin & proximity effects are negligible for harmonic currents) = (3 x 107.2^2 + 99^2) x 0.000635 x 1.01 x 40
= 1.14kW

Active power, P = √3 x 380V x 100A x 0.85 = 56kW
% copper loss = 1.14kW/ 56kW x 100 = 2% (over 1.5% allowed)

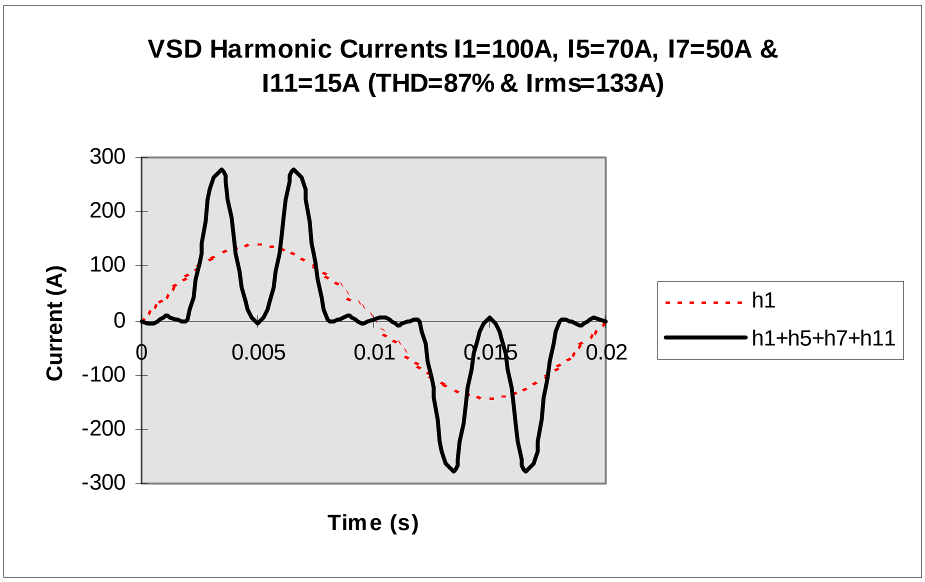
Try next cable size: $50mm^2$ 4/C PVC/SWA/PVC cable

Refer to BS7671:1992, The Requirements for Electrical Installations,
Table 4D4A $50mm^2$ 4/C PVC/SWA/PVC cable I_t = 163A
Table 4D4B r = 0.8mV/A/m x = 0.14mV/A/m

Conductor operating temperature, t_1 = 30 + $(3x107.2+99)^2$ / $(3x163)^2$ x (70-30) = 59.6°C
Ratio of conductor resistance at 59.6°C to 70°C = (230+59.6)/(230+70) = 0.965

Total copper losses in conductors = (3 x 107.2^2 + 99^2) x 0.0008/√3 x 0.965 x 40
= 789W
% copper loss = 0.789kW/ 56kW x 100 = 1.4% (<1.5% OK)

Case (d): Circuit to feed AHU various speed drives with full load and full speed harmonic current I_5=70A, I_7=50A & I_{11}=15A (THD 87%) and a maximum copper loss of 1.5% ($cos\theta$ = 1)



Fundamental current, I_1 = 100A
Harmonic currents, I_5= 70A, I_7= 50A & I_{11}=15A

THD = $\sqrt{(70^2 + 50^2 + 15^2)}$/ 100 = 87.3%
$I_{rms} = I_1 \sqrt{(1+THD^2)} = 100A\sqrt{(1+0.873^2)} = 133A$

New design current, $I_b = I_{rms}$ =133A
New rating of protective device, I_n = 160A
Minimum current-carrying capacity of conductors, I_t(min) = 160A

Max. conductor resistance, r $= \dfrac{\max.\%loss \times U_L \times I_1 \times \cos\theta \times 1000}{\sqrt{3} \times I_b^{\,2} \times L}$

$$= \frac{1.5\%loss \times 380 \times 100 \times 1 \times 1000}{\sqrt{3} \times 133^2 \times 40}$$

= 0.465 mΩ/m

From Table 4.2A 50 mm^2 4/C PVC/SWA/PVC cable having a conductor resistance of 0.465 mΩ/m is required.

Refer to BS7671:1992, The Requirements for Electrical Installations,
Table 4D4A 50mm^2 4/C PVC/SWA/PVC cable I_t = 163A
Table 4D4B r = 0.8mV/A/m x = 0.14mV/A/m z = 0.81mV/A/m

Conductor operating temperature t_1 = 30 + 133^2 / 163^2 x (70-30) = 57°C
Ratio of conductor resistance at 57°C to 70°C = (230+57)/(230+70)= 0.956

Voltage drop = 0.8mV/A/m x 0.956 x 133A x 40m = 4V (1.07%)

Active power drawn (P) = √3 x 380V x 100A = 65.8kW

Total copper losses in conductors (assuming skin & proximity effects are negligible for harmonic currents)
= 3 x 133^2 A^2 x 0.0008Ω/m / √3 x 0.956 x 40m
= 0.94kW (1.4%) (<1.5% OK)

A5 Power Loss Calculations for Main Circuits

The proposed wiring systems used for a main circuit feeding from a 1500kVA 11kV/380V 3-phase distribution transformer to a main LV switchboard having a circuit length of 20m are as follows :

1. 2500A 4-wire copper insulated busduct system
2. $3x630mm^2$ 1/C XLPE copper cables for each phase and neutral in cable trench
3. $3x960mm^2$ 1/C XLPE aluminium cables for each phase and neutral in cable trench

Assuming a balanced and undistorted full load design current of 2280A at a power factor of 0.85, calculate the power losses in transferring the power in each case.

Total active power transferred = 1500kVA x 0.85 = 1275kW

Case (1) : 2500A 4-wire copper busduct system

Resistance per conductor, r = 0.0177mΩ/m at 80°C (Based on data provided by a busduct manufacturer)
Total power losses = $3 \times 2280^2 A^2 \times 0.0000177\Omega/m \times 20m$ = 5.52kW (0.433%)

Case (2) : $3x630mm^2$ 1/C XLPE copper cables for each phase and neutral in cable trench

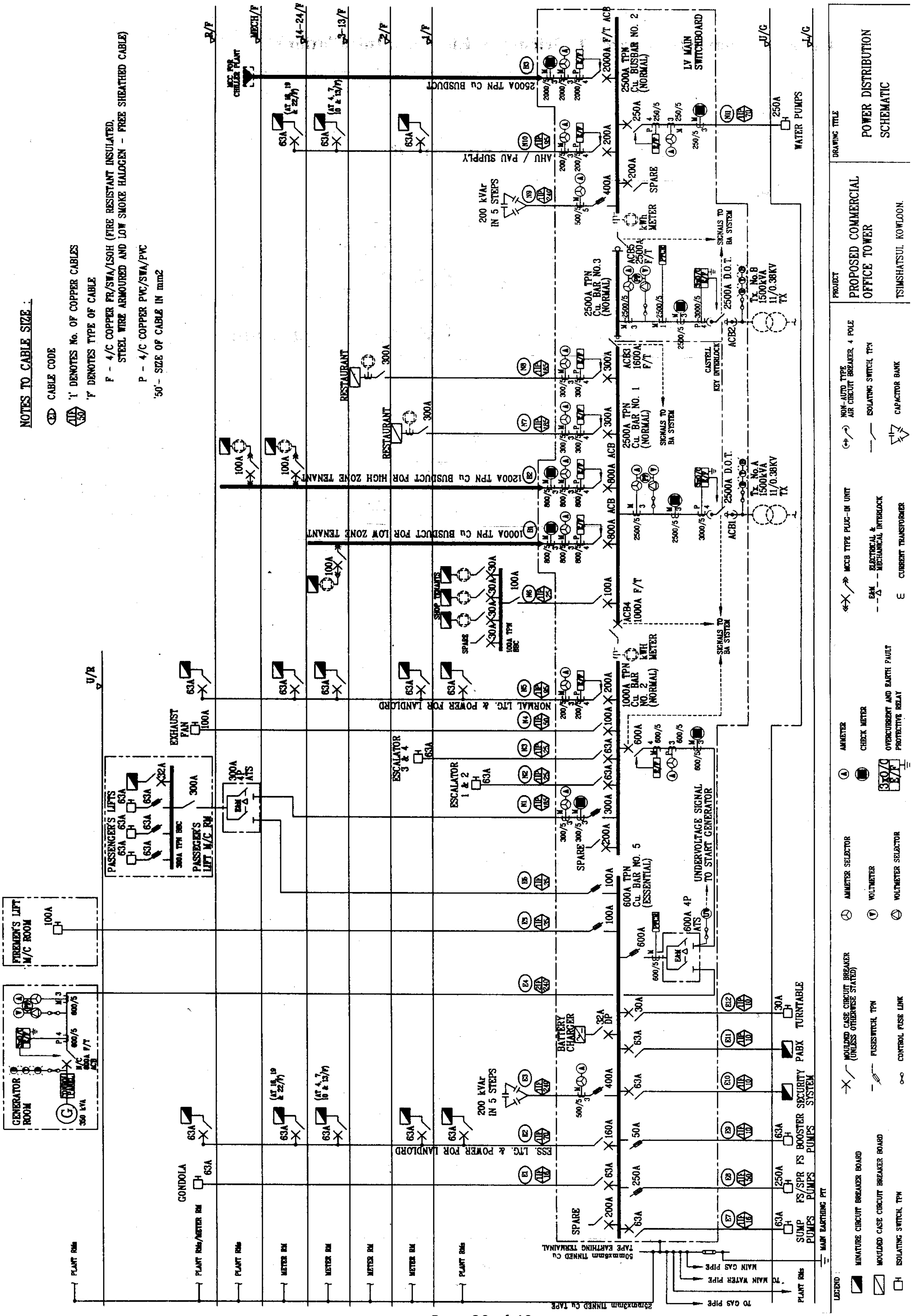
Resistance per conductor (Table 4E1B) = $0.074/\sqrt{3}$ = 0.043 mΩ/m (at 90°C)
Effective resistance per phase with 3 conductors in parallel = 0.043/3 mΩ/m = 0.0143 mΩ/m
Total power losses = $3 \times 2280^2 A^2 \times 0.0000143\Omega/m \times 20m$ = 4.46kW (0.35%)

Case (3) : $3x960mm^2$ 1/C XLPE aluminium cables for each phase and neutral

Resistance per conductor (Table 4L1B) = $0.082/\sqrt{3}$ = 0.0473 mΩ/m (at 90°C)
Effective resistance per phase with 3 conductors in parallel = 0.0473/3 mΩ/m
= 0.0158mΩ/m
Total power losses = $3 \times 2280^2 A^2 \times 0.0000158\Omega/m \times 20m$ = 4.93kW (0.387%)

Appendix B

Case Study
for a
Typical Commercial Building in Hong Kong



NOTES TO CABLE SIZE :
CABLE CODE
'1' DENOTES No. OF COPPER CABLES
'F' DENOTES TYPE OF CABLE
F - 4/C COPPER FR/SWA/LSOH (FIRE RESISTANT INSULATED, STEEL WIRE ARMOURED AND LOW SMOKE HALOGEN - FREE SHEATHED CABLE)
P - 4/C COPPER PVC/SWA/PVC
'50' - SIZE OF CABLE IN mm2
2500A TPN Cu BUSDUCT
1200A TPN Cu BUSDUCT FOR HIGH ZONE TENANT
1000A TPN Cu BUSDUCT FOR LOW ZONE TENANT
NORMAL LTG. & POWER FOR LANDLORD
ESS. LTG. & POWER FOR LANDLORD
AHU / PAU SUPPLY
200 kVAr IN 5 STEPS
RESTAURANT
SHOP TENANTS
ESCALATOR 1 & 2
ESCALATOR 3 & 4
EXHAUST FAN
PASSENGER'S LIFTS
PASSENGER'S LIFT M/C RM
FIREMEN'S LIFT M/C ROOM
GENERATOR ROOM
GONDOLA
BATTERY CHARGER
SPARE
2500A TPN Cu. BUSBAR NO. 2 (NORMAL)
2500A TPN Cu. BAR NO. 3 (NORMAL)
2500A TPN Cu. BAR NO. 1 (NORMAL)
1000A TPN Cu. BAR NO. 2 (NORMAL)
600A TPN Cu. BAR NO. 5 (ESSENTIAL)
LV MAIN SWITCHBOARD
Tx. No.A 1500kVA 11/0.38KV TX
Tx. No.B 1500kVA 11/0.38KV TX
SIGNALS TO BA SYSTEM
UNDERVOLTAGE SIGNAL TO START GENERATOR
CASTELL KEY INTERLOCK
WATER PUMPS
SUMP PUMPS
FS/SPR PUMPS
FS BOOSTER PUMPS
SECURITY SYSTEM
PABX
TURNTABLE
MAIN EARTHING PIT
TO GAS PIPE
TO MAIN WATER PIPE
MAIN GAS PIPE
PLANT Rm
METER Rm
R/F
MECH/F
14-24/F
3-13/F
2/F
1/F
U/R
U/G
L/G
LEGEND :
MINIATURE CIRCUIT BREAKER BOARD
MOULDED CASE CIRCUIT BREAKER BOARD
ISOLATING SWITCH, TPN
MOULDED CASE CIRCUIT BREAKER (UNLESS OTHERWISE STATED)
FUSESWITCH, TPN
CONTROL FUSE LINK
AMMETER SELECTOR
VOLTMETER
VOLTMETER SELECTOR
AMMETER
CHECK METER
OVERCURRENT AND EARTH FAULT PROTECTIVE RELAY
MCCB TYPE PLUG-IN UNIT
ELECTRICAL & MECHANICAL INTERLOCK
CURRENT TRANSFORMER
NON-AUTO TYPE AIR CIRCUIT BREAKER, 4 POLE
ISOLATING SWITCH, TPN
CAPACITOR BANK
PROJECT
PROPOSED COMMERCIAL OFFICE TOWER
TSIMSHATSUI, KOWLOON.
DRAWING TITLE
POWER DISTRIBUTION SCHEMATIC

Job Ref. No. ________________

Electrical Installations Summary	FORM EL-1

Part (A) : General Information of Electrical Installations

Project/Building* Name : Typical Commercial Building	
Project/Building* Address : x x Road, Kowloon	
Type of Building : ~~Domestic~~/Commercial/~~Industrial~~/~~Hotel~~/~~Others~~* _______________	
Electrical Installation Works : Expected Commencement Date : xx / x / 1997 Expected Completion Date : xx / x / 1999	
No. of Storeys : 25 .	Building Height : 95 m
Gross Floor Area : 12,000 m^2	
Usable Floor Area : 10,000 m^2	
Building Demand Assessment (kVA) : 2500kVA	
Landlord's Demand : 1400 kVA	
Tenants' Demand : 1100 kVA	
Total Demand : 2500 kVA	
Total Load Density : 0.25 kVA/ m^2 usable floor area	

Part (B) : Attached Electrical Forms

Electrical Forms	No. of Sheets
☑ Form EL-2 (Power Distribution Worksheet)	3
☑ Form EL-3 (Power Utilisation Worksheet)	2
☑ Form EL-4 (Power Quality Worksheet)	2
☑ Form EL-5 (Metering & Monitoring Worksheet)	1

Note : All clauses quoted in the above forms are corresponding to the clauses of the Code of Practice for Energy Efficiency of Electrical Installations.

* - delete as appropriate
☐ - tick where appropriate

Part (C) : List of Attached Drawings

Drawing No.	Revision No.	Drawing Title	No. of Copies
TCB/EL/01	C	Power Distribution Schematic	2
TCB/El/02	C	Lower Ground Floor Power Distribution Layout	2
TCB/EL/03	C	Upper Ground Floor Power Distribution Layout	2
TCB/EL/04	C	1/F & 2/F Typical Power Distribution Layout	2
TCB/EL/05	C	12/F Typical Office Floor Electrical Services Layout	2
TCB/EL/06	C	Mechanical/Roof Floor Electrical Services Layout	2

Sheet (   ) of (   )

Job Ref. No. _______________

Electrical Power Distribution Worksheet	FORM EL-2

A. High Voltage Distribution (Clause 4.1)

The building has more than 50 storeys or over 175m in height above ground? ☐ Yes ☑ No	
Voltage level :_________kV System designed and installed by : ☐ Utility Company ☐ Private Consultants and Contractors	

B. Minimum Transformer Efficiency (Clause 4.2)

Any privately owned distribution transformers used in the building?	
☐ Yes Transformer Rated Capacity : ___________kVA 1-phase/3-phase* No. of Transformers : ___________ Efficiency at Full Load : ___________%	☑ No

C. Location of Distribution Transformers & Main LV Switchboards (Clause 4.3)

The distribution transformers and main LV switchboards are at their load centres?	
☐ Yes Locations : __________________________ __________________________	☑ No Locations : _Upper Ground Level_____. _______________________

D. Main Circuits (Clause 4.4)

The transformer rooms and main LV switchrooms are adjacent to each other?	
☑ Yes ☐ No Maximum length of main circuits : ____10___m	
Maximum power losses using the type and size of conductors below if the main circuit(s) is/are not provided by the utility company:	
☐ Cable Material : Copper/Aluminium* Design Current (I_b) : _____________A Cable Type : _____________ Conductors Size : _____________mm^2 Cable Length : _____________m Power Loss : _____________kW Percentage Power Loss : ____________%	☐ Busbar/Busduct* Material : Copper/Aluminium* Design Current (I_b) : _____________A Busduct Rating : _____________A Busduct Length : _____________m Power Loss : _____________kW Percentage Power Loss : ____________%

Sheet (   ) of (   )

E. Feeder and Sub-main Circuits (Clause 4.5 & 4.6)

Designed operating temperature of feeder and sub-main circuit conductors : 70 °C

Schedule of Copper Losses for Dedicated Feeder & Sub-main Distribution Circuits (Note: circuits for Emergency Systems can be excluded):

Circuit Ref. (F=Feeder S=Sub-main)	Cable Type	Conductor Size (mm^2)	Circuit Length (m)	Design Current I_b (A)	Design p.f.	Active Power (kW)	Copper Loss (kW)	Copper Loss (%)
N1 (F) (Lifts)	4/C PVC/SWA/PVC	185	110	150	0.85	84	0.9	1.07
N2 (F) (Escalators)	4/C PVC/SWA/PVC	25	25	63	0.85	3.5	0.26	0.73
N3 (F) (Escalators)	4/C PVC/SWA/PVC	25	30	63	0.85	3.5	0.31	0.88
N4 (F) (Ex. fan)	4/C PVC/SWA/PVC	50	100	65	0.85	36	0.59	1.61
N5 (S) (Landlord)	4/C PVC/SWA/PVC	95	110/2	140	0.85	78	0.77	0.98
N6 (S) (Shops)	4/C PVC/SWA/PVC	25	10	80	0.85	44.8	0.17	0.35
N7 (S) (Restaurant)	4/C PVC/SWA/PVC	185	75	250	0.85	140	1.7	1.22
N8 (S) (Restaurant)	4/C PVC/SWA/PVC	185	80	250	0.85	140	1.82	1.3
N10 (S) (AHU riser)	4/C PVC/SWA/PVC	95	110/2	150	0.85	84	0.88	1.05
N11 (F) (Pumps)	4/C PVC/SWA/PVC	70	20	200	0.85	112	0.76	0.68
B1 (S)(Riser 1)	1000A Busduct		47	630	0.85	353	3.5	0.99
B2 (S)(Riser 2)	1200A Busduct		89	630	0.85	353	4.7	1.35
B3 (F) (Chillers)	2500A Busduct		110	1700	0.85	950	16.9	1.77
E1 (F) (Gondola)	4/C FR/SWA/LSOH	16	110	20	0.85	11	0.19	1.7
E2 (S) (Landlord)	4/C FR/SWA/LSOH	70	55	80	0.85	44.8	0.36	0.8
E4 (mains) (Generator)	4/C FR/SWA/LSOH	2x240	110	450	0.85	252	3.4	1.34
E6 (Homing)	4/C FR/SWA/LSOH	35	110	46	0.85	25.7	0.46	1.8
E7 (Sump pump)	4/C FR/SWA/LSOH	16	50	45	0.85	25.2	0.44	1.74
E10 (Security)	4/C FR/SWA/LSOH	10	50	20	0.85	11	0.14	1.2
E11 (PABX)	4/C FR/SWA/LSOH	10	50	20	0.85	11	0.14	1.2
E12 (Turntable)	4/C FR/SWA/LSOH	10	40	20	0.85	11	0.11	1

Sheet ( ) of ( )

F. Final Circuits (Clause 4.7)

Are there any final circuits having a rating over 32A (single-phase or three-phase)?

☐ No
☑ Yes (Schedule of copper losses of these final circuits is listed as follows)

Schedule of Copper Losses for Final Circuits having a rating over 32A :

Circuit Ref.	Cable Type	Cable Size (mm^2)	Circuit Length (m)	Design Current I_b (A)	Design p.f.	Active Power (W)	Copper Loss (W)	Copper Loss (%)
LD/1 (heater)	4x1/C PVC	25	40	55	1	36kW	346W	0.96

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Job Ref. No. ________________

Electrical Power Utilisation Worksheet	FORM EL-3

A. Lamps and Luminaires (Clause 5.1)

Do the lighting installations comply with the Code of Practice for Energy Efficiency of Lighting Installations?	
☑ Yes	☐ No Building/indoor space is for : ☐ Domestic ☐ Medical ☐ Industrial ☐ Others ________________

B. Air Conditioning Installations (Clause 5.2)

Do the air conditioning installations comply with the Code of Practice for Energy Efficiency of Air Conditioning Installations?	
☑ Yes	☐ No Building is for : ☐ Domestic ☐ Medical ☐ Industrial ☐ Others ________________

C. Vertical Transportation (Clause 5.3)

Do the vertical transportation systems comply with the Code of Practice for Energy Efficiency of Lifts & Escalators?	
☑ Yes	☐ No

D. Power Factor Improvement (Clause 5.5)

Anticipated total apparent power (S) for communal installations : 1,300 kVA

Anticipated total active power (P) for communal installations : 1,040 kW

Anticipated initial power factor before correction : 0.8 .

Design power factor after correction : 0.88 .

Type of power factor correction equipment used : capacitor banks .

Rating of power factor correction equipment used : 200 kvar

Location of power factor correction equipment : Main LV Switchroom .

Other provisions for future use :
1. 200A spare fuse-switch for future harmonic filter
2. ________________
3. ________________

Sheet ( ) of ( )

E. Motors and Drives (Clause 5.4)

Are there any motors or driving systems having an output rating of 5kW or greater?

☐ No
☑ Yes (Schedule of motors used is listed in the following table)

Motor Reference	Anticipated System Load (kW)	Motor Rating (kW)	Full Load Motor Efficiency (%)	Percentage Motor Rating to System Load (%)	VSD Type & Rating	Type of Power Transfer Devices	No. of Identical Motors
Flush Water Pump	10	11	89	110	N/A	direct	1
Potable Water Pump	7	7.5	87	107	N/A	direct	1
Primary Chilled Water Pumps	10	11	89	110	N/A	direct	4
Secondary Chilled Water Pumps	27	30	90	115	PWM 30kVA	direct	4
Booster Pump	5	5.5	86	110	N/A	direct	1
Chiller Motor	600	630	96	107	N/A	direct	4
PAU	14	15	90	107	PWM 15kVA	Synchronous belt	3
VAV AHU	9	11	89	122	PWM 11kVA	Synchronous belt	30

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Job Ref. No. ________________

Electrical Power Quality Worksheet	FORM EL-4

A. Maximum Total Harmonic Distortion (THD) of Current (Clause 6.1)

Are there any non-linear electrical loads in the communal installations?
☐ No (Other than fluorescent luminaires with conventional controlgear) ☑ Yes (Schedule of non-linear loads is listed as follows)

Type of Non-linear Load	Circuit Ref.	Rating (kVA)	Load Current (A)	Anticipated THD Current (%)	Harmonic Reduction Devices (if any)	Final THD Current (%)
VSD (PWM)	SCWP	30	46	80	Passive Filters at MCC	15 at MCC
VSD (PWM)	PAU	15	23	80	Broad-band Filter	15
VSD (PWM)	VAV	11	17	80	Line Reactor	20

Sheet (   ) of (   )

B. Balancing of Single-phase Loads (Clause 6.2)

Are there any single-phase electrical loads (communal installations) connected in the three-phase four-wire power distribution system?
☐ No ☑ Yes (Schedule of load currents in each phase is listed as follows)

Sub-main Circuit Ref. (with 1-phase loads)	Design Current in Red Phase I_R (A)	Design Current in Yellow Phase I_Y (A)	Design Current in Blue Phase I_B (A)	Average Current I_a (A)	Max. Deviation from Average I_d (A)	% Current Unbalance $Iu=(I_d \times 100) \div I_a$ (%)
N5	150	140	130	140	10	7.1%
N7	250	240	230	240	10	4.2%
N8	230	240	250	240	10	4.2%
B1	600	630	615	615	15	2.4%
B2	630	600	615	615	15	2.4%
E2	85	80	75	80	5	6.25%

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Job Ref. No. ________________

Electrical Metering and Monitoring Worksheet	FORM EL-5

A. Main Circuits (Clause 7.1)

Does the rating of any main incoming circuit exceed 400A, three-phase?	
☑ Yes Ammeter to read : ☑ Red Phase Current (I_R) ☑ Yellow Phase Current (I_Y) ☑ Blue Phase Current (I_B) ☑ Neutral Current (I_N) Voltmeter to read : ☑ Red to Yellow Line Voltage (V_{RY}) ☑ Yellow to Blue Line Voltage (V_{YB}) ☑ Blue to Red Line Voltage (V_{BR}) ☑ Red Phase to Neutral Voltage (V_{RN}) ☑ Yellow Phase to Neutral Voltage (V_{YN}) ☑ Blue Phase to Neutral Voltage (V_{BN}) ☑ Power Factor Meter ☑ kWh Energy Meter ☑ Maximum Demand Meter (kVA) ☐ Other metering provisions/facilities : ____________________ ____________________ ____________________ ____________________	☐ No

B. Sub-main and Feeder Circuits (Clause 7.2)

Does the rating of any sub-main/feeder circuit exceed 200A, three-phase?	
☑ Yes Ammeter to read : ☑ Red Phase Current (I_R) ☑ Yellow Phase Current (I_Y) ☑ Blue Phase Current (I_B) ☑ Neutral Current (I_N) ☑ kWh Energy Meter ☐ Other metering provisions/facilities : ____________________ ____________________ ____________________ ____________________	☐ No

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