MODULE – III

ESTIMATION OF INDUSTRIAL INSTALLATIONS

Earthing

It is the process of connecting non-current carrying parts of electrical apparatus such as metallic frame work, metallic covering of cable stay wires, earth terminal of socket etc… to the general mass of earth. Earthing is provided

- To ensure that no current carrying conductor rises to a potential with respect to general mass of earth than its designed insulation
- To avoid electric shock
- To avoid risk of fire due to earth leakage current through unwanted path

ISI Specification Regarding Earthing Of Electrical Installation

1. Distance of earth from the building

   An earthing electrode shall to be situated within a distance of 1.5m from the building whose installation system is being earthed.

2. Size of earth continuity conductor

   The conductor used to connect the metallic body of equipment to the earth is known as earth continuity conductor (ECC). The cross section of earth continuity conductor should be greater than 2.9mm^2 [14 SWG] or half of the installation conductor size.

3. Resistance of Earth

   In the case of resistance of earth there is no hard and fast rule. The main principle regarding earth resistance is that the earth resistance should be low enough to cause flow of current sufficient to operate the protective relays or blow fuses in the event of an earth fault. As a general rule the lower value of earth resistance better but the following values of earth resistance will be given satisfactory result.

Large power stations	– 0.5 Ω
Major power stations	– 1 Ω
Small substations	– 2 Ω
All other cases	– 8 Ω

Earth continuity inside an installation, ie, from the earth plate to any point in the installation - 1 Ω

4. Earth wire and earth electrode will be of same material.
5. Earth wire shall be taken through GI pipe of 13mm of diameter and 30 cm length, above and below ground surface to the earth electrode to protect it against mechanical damage.
6. It is not necessary that earth wire connected and earth electrode is run along the whole wiring system
7. The earthing electrode shall always be placed in vertical position inside the earth or pit. So that it may be in contact with all the different earth layers.

POINTS TO BE EARTHED

1. Earth pin of 3-pin lighting plug socket and 4-pin power plug sockets.
2. All metallic casing or metallic coverings of all electrical apparatus
3. Metal casing of portable apparatus such as heaters, refrigerators, soldering iron, electric drills…etc.
4. Frame of every generator, stationary motor, metallic parts of transformers…etc.
5. The neutral conductor of a 3-phase 4-wire system and the middle conductor of a 2-phase 3 wire system should be earthed not less than two separate and distinct connections with earth at the generating stations and at the substations
6. The case of a system comprising electric supply line having concentric cables, the external conductor of such cable should be earth by two separate and distinct collections with earth.
7. In a DC 3-wire system the middle conductor should be earthed at the generating stations.
8. Steel towers, line towers, tubular steel or rail poles carrying overhead conductors should be earthed. The continuous earth wire is provided and connected with earth at 4 point in every mile, the spacing between the points is being as nearly equi-distant as possible.
9. Stay wires provided for overhead line should be connected to earth by connecting at least one strand to the earth.

Factors Affecting the Earth Resistance

1. Condition of soil

2. Temperature of soil
3. Moisture of the soil
4. Size and spacing of earth electrode
5. Depth at which the electrode is embedded
6. Material of the conductor
7. Quality of coal and charcoal in the earth electrode pit

Types of Earthing

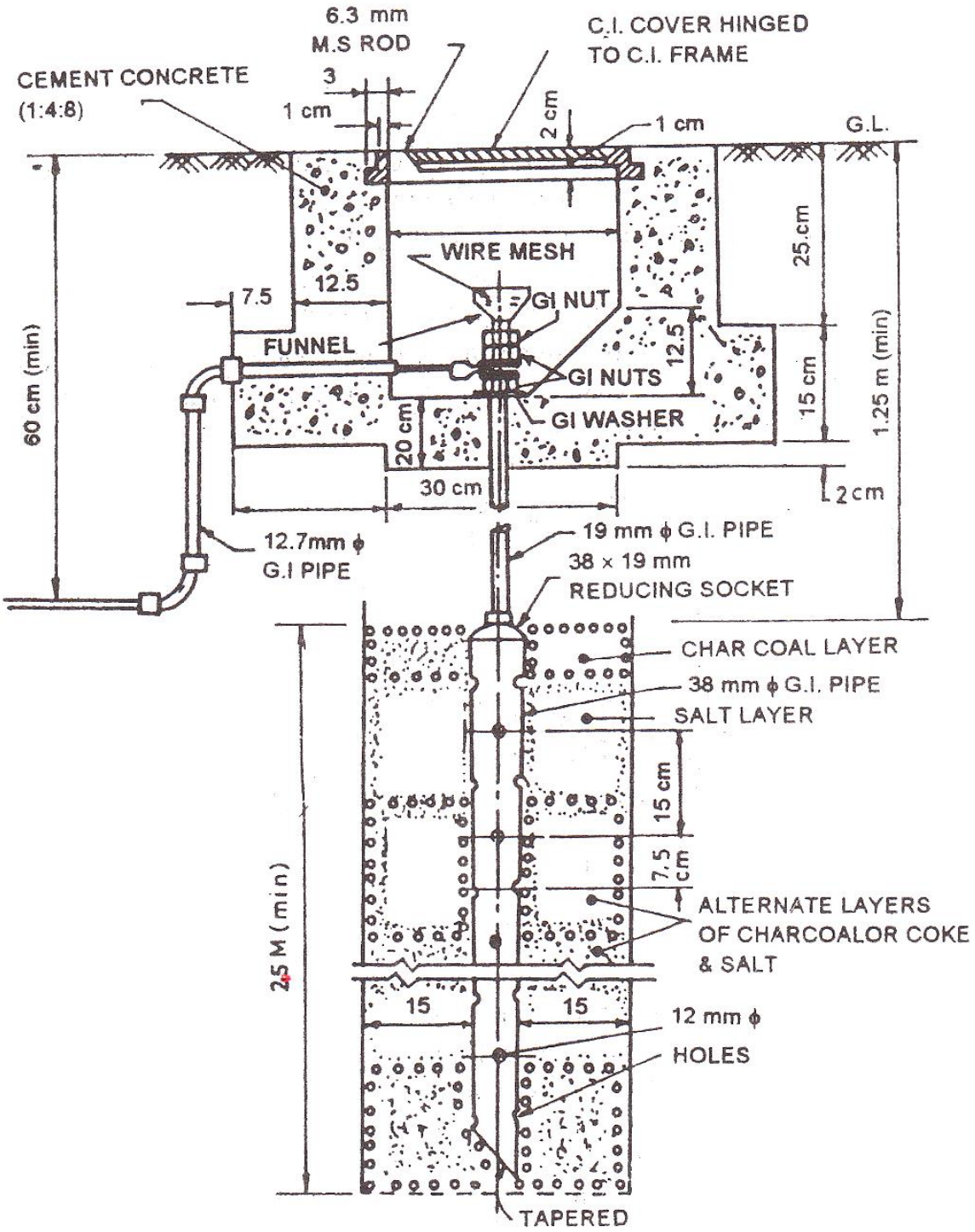
Various types of earthing are as follows

1. Pipe earthing
2. Strip or wire earthing
3. Rod earthing
4. Plate earthing

1. Pipe Earthing

In this method of earthing a 38mm internal diameter, perforated galvanized pipe of length 2.5m is placed vertically in a permanently wet soil. The inclination should not be more than 30^0 from the vertical. The pipe is surrounded by the pieces of coke charcoal and salt in alternate layers of about 15cm around the pipe, is used to decrease the earth's resistance. Another pipe of 19mm diameter length 1.25 is connected to the buried pipe through reducing socket. At the top of the 19mm pipe a funnel is fitted and is fastened in a cement concrete work. For a effective earthing water should be poured, 2- 4 buckets especially in summer. The earth wire is carried in a GI pipe of 12.7mm diameter and at a depth of 60cm from the ground level. A cast iron cover is hinged in a small masonry work on the top of the earthing to facilitate identification and periodical checking.

Explain the Pipe earthing with a neat diagram and list out the materials required for each work

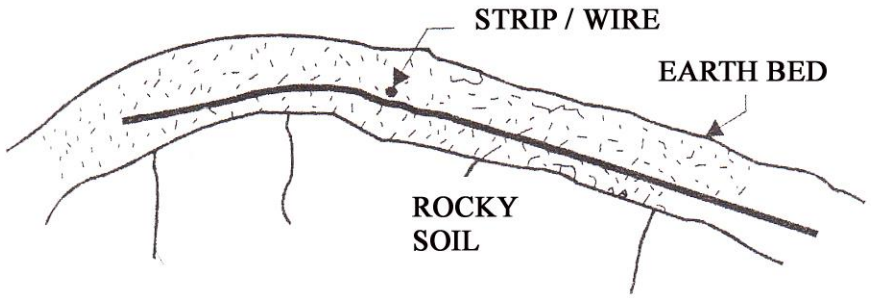


No	Specification of Material	Qty	RATE		Cost	Remarks
			Rs	Per		
1 2	38mmGI pipe (perforated) GI wire (8SWG)					

3	12.7mm GI pipe					
4	19mm GI pipe					
5	GI(38x19mm) reducing socket					
6	GI nut,bolt, washers, checknut					
7	GI bend 12.7mm					
8	GI lugs					
9	Cast iron frame with hinges					
10	Cast iron cover 30cmX30cm					
11	Funnel with wire mesh					
12	Charcol or cock					
13	Salt					
14	Cement					
15	Caution plate					

2. Strip or Wire Earthing

In this method, a metal strip or wire is used as earthing electrode. This type of earthing is used where soil is rocky. In this system 25x4 mm GI strip or 25x1.6 mm Cu strip is buried in horizontal trenches of minimum depth of 0.5m. The length of strip wire is not less than 15m. Sometimes one strip or wire is layed in parallel or radial trenches.



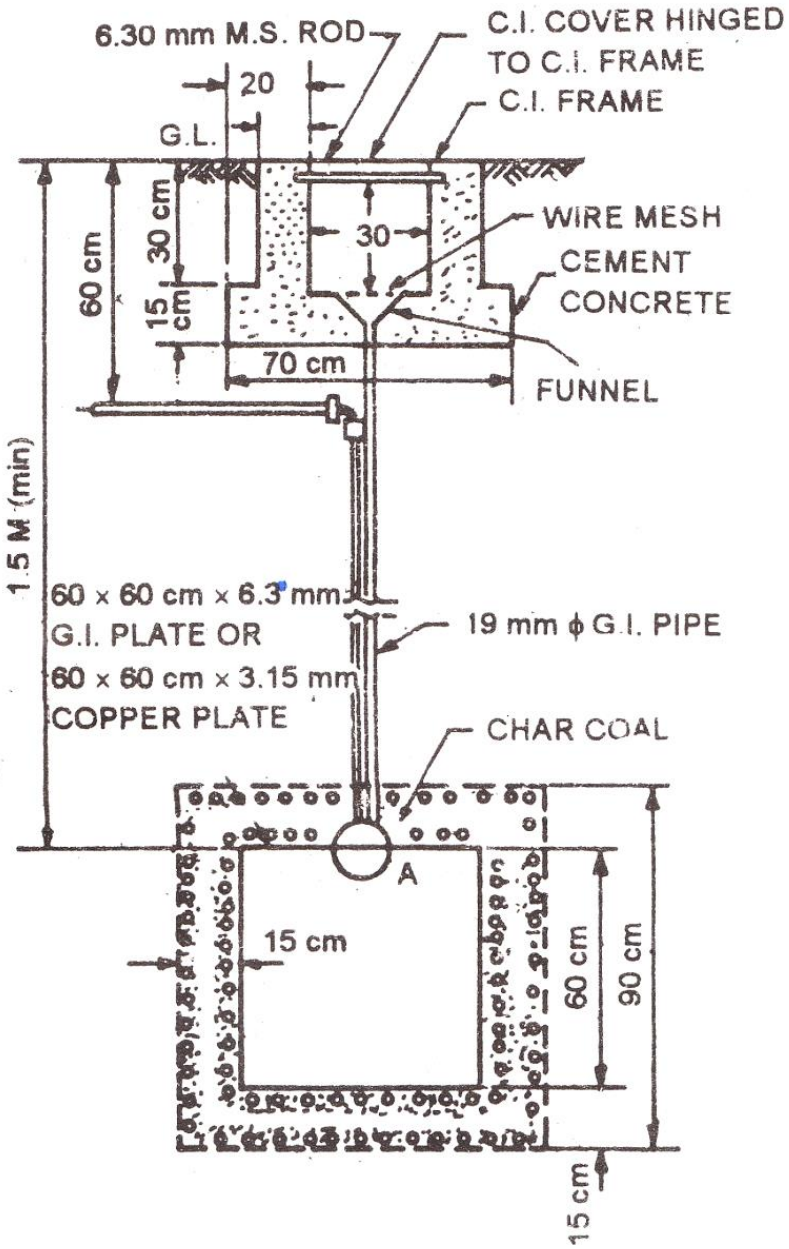
3. Rod Earthing

This method of earthing is simple, cheap and does not need earth excavation. It is suitable for the areas which are having loose soil condition or sanding. In this system of earthing a 16mm diameter GI solid rod of length not less than 2.5m driven vertically into the ground.

4. Plate Earthing

In this type of earthing, a copper plate of 60cm X 60cm X 6.3mm is used as an earth electrode. Plate electrode should be buried with its face vertical such that top edge is at a depth of not less than 1.5m below the surface of the ground. The electrode is surrounded by alternate layers of broken pieces of coke coal and salt. The earth wire is connected to the GI electrode. A cast iron tower is provided at the top of the earthing when resistance of one plate earthing is higher than the required value more than one plate should be earthed and connected together.-

Explain the plate earthing with a neat diagram and list out the materials required for each work



No	Specification of Material	Qty	RATE		Cost	Remarks
			Rs	Per		

1	GI plate 60cmX60cmX6.3mm					
2	GI wire (8SWG)					
3	12.7mm GI pipe					
4	19mm GI pipe					
5	GI nut,bolt, washers, checknut	6 sets				
6	GI bend 12.7mm					
7	GI lugs					
8	Cast iron frame with hinges					
9	Cast iron cover 30cmX30cm					
10	Funnel with wire mesh					
11	Charcol or cock	20kg				
12	Salt	20kg				
13	Cement					
14	Caution plate					

ESTIMATION OF CONTROL PANEL

Sl no	Materials Required
1	Incoming Service wires
2	Energy meter
3	Voltmeter
4	Ammeter
5	Bus-bars
6	Pilot lamps
7	IC main switch/ circuit breakers
8	Sub circuit cutout or MCB'S
9	Interconnecting wires
10	Closed Container
11	Danger plate
12	Nails and Screws
13	Insulation tape
14	Wooden gutties
15	Sand, cement... etc

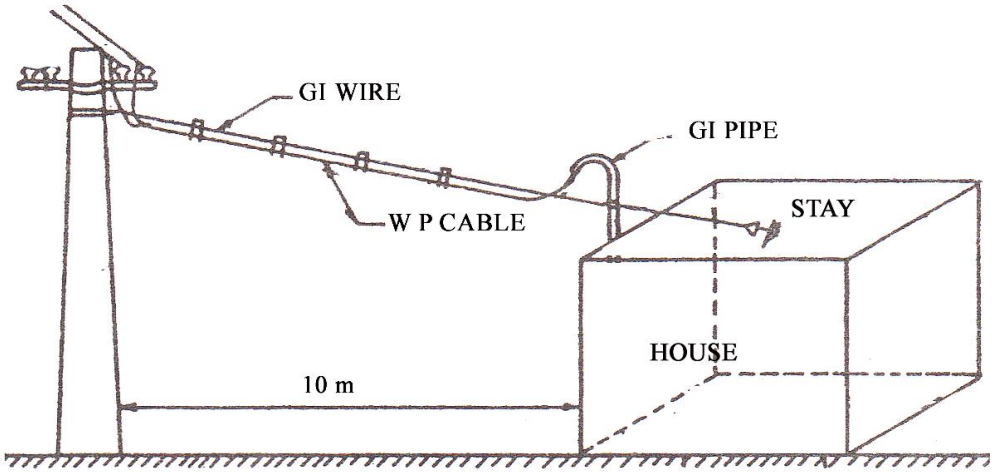
CURRENT CARRYING CAPACITY OF CABLES

Area	Copper	Aluminium
0.5	4A	
0.75mm^2	7A	
1 mm^2	11A	
1.5 mm^2		12A
2 mm^2	17A	
2.5 mm^2		16A

3 mm^2	22A	
4 mm^2	25A	23A
4.5 mm^2	26A	
6 mm^2		30A

ESTIMATION FOR 1- PHASE SERVICE CONNECTION

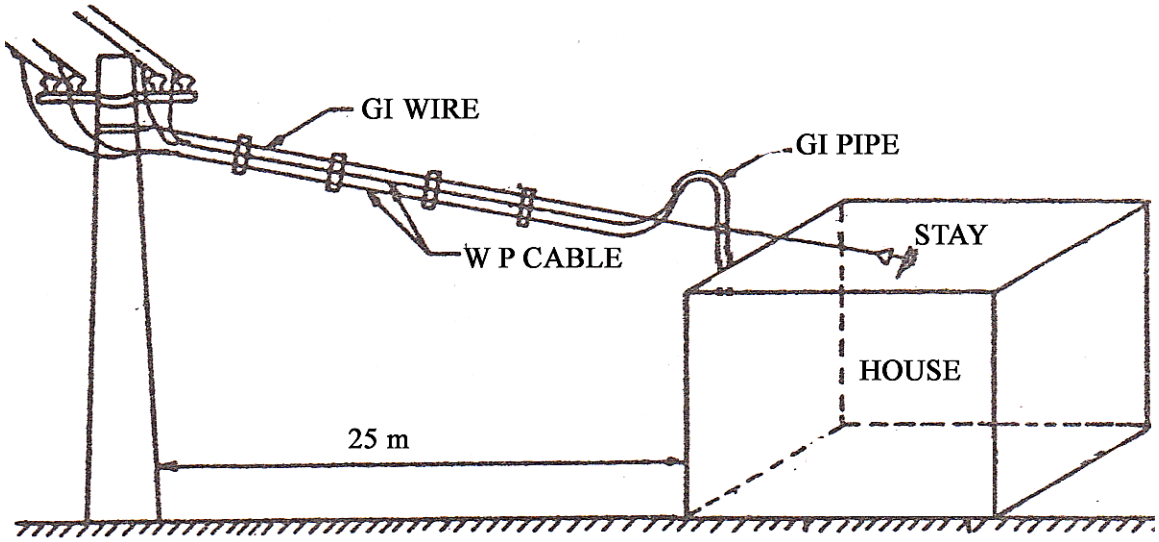
Estimate the cost of material required for giving service connection from a nearby LT pole at 10m.



No	Specification of Material	Qty	RATE		Cost	Remarks
			Rs	Per		
1	1 phase energy meter	1				Supplied by KSEB
2	16 A fuse unit	1		Each		
3	7/20 WP twin core cable	15m		M		Service wire
4	GI wire for supporting cable	25m		Kg		10m ≈1kg
5	Link clips	1box		Box		
6	Insulation tape	1		Each		
7	GI Pipe 18mm dia	1m		M		On roof
8	Neutral link	1		each		
9	Cement	1kg		Kg		Fitting MB &GI pipe
10	Sand	LS		-		
11	Wooden board 10” X 10”	1		Each		
12	Nails and Screws	LS		-		
13	Wooden gutties	4		Dozen		
14	Labour charge			-		

ESTIMATION FOR 3- PHASE SERVICE CONNECTION

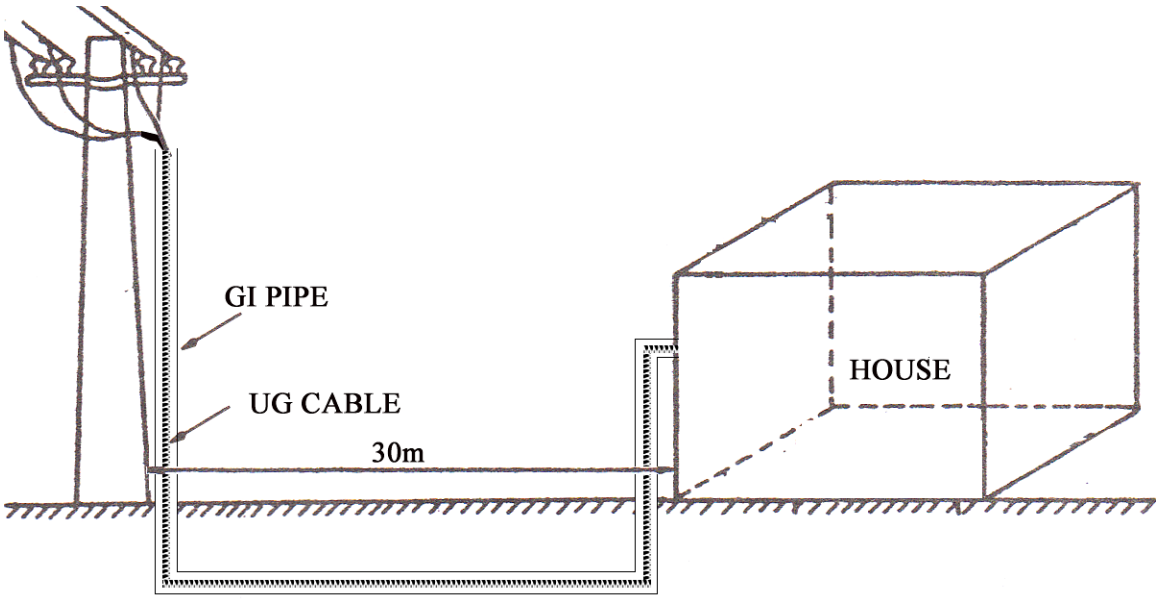
Estimate the cost of material required for giving service connection from a nearby LT pole at 25m.



No	Specification of Material	Qty	RATE		Cost	Remarks
			Rs	Per		
1	3 phase energy meter	1				Supplied by KSEB
2	16 A fuse unit	3		Each		
3	7/20 WP 3.5 core cable	35m		M		Service wire
4	GI wire for supporting cable	40m		Kg		10m ≈1kg
5	Link clips	1box		Box		
6	Insulation tape	2		Each		
7	GI Pipe 18mm dia	1m		M		On roof
8	Neutral link	1		each		
9	Cement	1kg		Kg		Fitting MB &GI pipe
10	Sand	LS		-		
11	Wooden board 10” X 12”	1		Each		
12	Nails and Screws	LS		-		
13	Wooden gutties	4		Dozen		
14	Labour charge			-		

ESTIMATION FOR 1- PHASE AND 3- PHASE SERVICE CONNECTION USING UNDER GROUND CABLE

Estimate the cost of material required for giving1-phase and 3 phase service connection from a nearby LT pole at 30m.



No	Specification of Material	Qty	RATE		Cost	Remarks
			Rs	Per		
1	3 phase energy meter	1				Supplied by KSEB
2	1 phase energy meter					Supplied by KSEB
3	16 A fuse unit	3		Each		
4	7/20 UP 3 core cable	45m		M		Under ground
5	7/20 WP twin core cable	45m		m		1 phase
6	GI pipe 25mm dia	45m		Kg		10m ≈1kg
7	Link clips	1box		Box		
8	Insulation tape	2		Each		
9	MS frame	1		each		To fix energy meter
10	Neutral link	1		each		
11	Cement	1kg		Kg		Fitting MB &GI pipe
12	Sand	LS		-		
13	Clamp to fix GI pipe	1		Each		To LT pole
14	Nails and Screws	LS		-		
16	25mm couplings	2 no				
17	25mm bends	2 no		-		
18	Bricks	200 no	**6**	each	**1200**	To lay over GI pipe
19	Labour charge					
			TOTAL			

STARTERS SUITABLE FOR DIFFERENT TYPES OF MOTORS

Sl No.	Type of Motor	Type of starter	Remarks

1	Induction motor – Upto 3HP	Direct on Line (DOL)	In industry
2	Induction motor – Upto 7.5HP	Direct on Line (DOL)	In Agricultural
3	Induction motor – Upto 15HP	Star Delta	
4	Induction motor beyond 15 HP	Auto Transformer	
5	Slip ring Induction motor	Rotor rheostat starter	
6	DC Shunt Motor	3-point Starter	
7	DC Series Motor	2- point or face plate starter	
8	DC Compound Motor	4- point starter	

Estimate the quantity of material for wiring of agricultural pump set motor 400V , 5kW, 50Hz, 3phase using star delta starter, ICTP switch and indicating lamps. The supply to the pump is to be taken from an over head, LT pole 15m away from pump shed (5mX3m). Use conduit wiring for motor connection.

Solution

Assumptions:

1. The efficiency of the pump set motor is 85% at a PF of 0.8

2. The Switch board, starter are fixed 1.5m above the floor level

3. The height of the horizontal run is 2.5 m

4. The cost of service wire and motor is not included in the estimate

5. The motor shall be installed on suitable foundation, 0.2 metre above the floor level

6. The conductors from starter to motor terminal run at depth of 0.2m under the floor level.

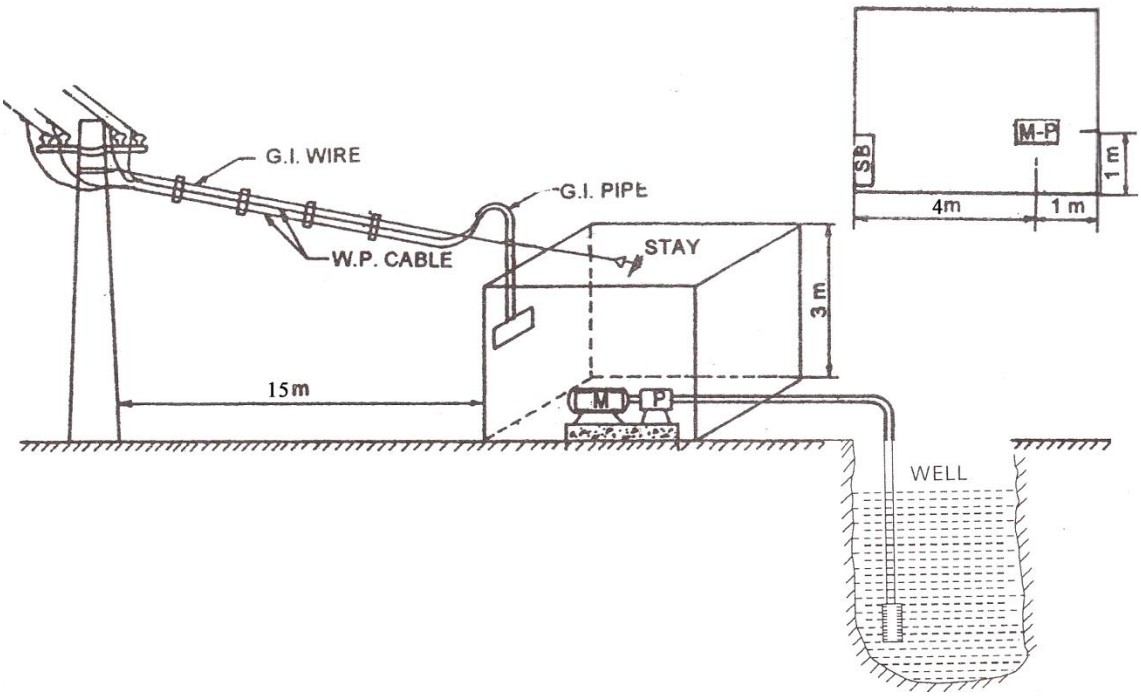
a) Selection of cable and ICTP rating:

Full load current of the motor = $\frac{Rating}{\sqrt{3}\times VL\ cos\emptyset\times\eta}$ = $\frac{5\times1000}{\sqrt{3}\times400\times0.8\times0.85}$ = 10.61A

The starting current of the motor = 2X 10.61 = 21.22 A

Hence 3.0 mm^2 copper conductor cable of current carrying capacity 22A can be used

A 32A, 500V, ICTPN Switch with fuses may be used.



b) Size of Conduit

25.4 mm metal conduit is required from panel or switch board to motor base and flexible conduit of 25.4mm size is sufficient from motor base to motor terminals, since 6 cables are to be run through the conduit.

c) Length of Conduit

Length on the roof = 1.5 m

Length from SB to Motor base (1+4+2.5+1) = 8.5 m

Total length of conduit = 1.5+8.5 = 10m

10% for wastage and connection = 10X 0.10 = 1m

The total length of conduit required = 10+1 = 11m

Flexible conduit from motor base to motor terminals = 0.75m ≈ 1m

d) Length of Cable (single core copper)

Length from ICTPN to Starter (0.5 x 3) = 1.5 m

From starter to motor terminals (1+4+2.5+1+0.75) x 6 = 55.5 m

10% wastage and end connections = 55.5 x 0.10 = 5.55 ≈ 6m

Total length of cable required = 55.5 + 6 = 61.5 ≈ 62m

1.0mm^2 copper wire for lamps and Neutral = 2 m

e***) Length of Earth Wire***

According to IE rules, the motor frame, motor switch, motor starter, main switch are to be earthed by means of two separate and direct connections. Hence two separate earth electrodes will be provided for earthing purposes.

Length of earth wire required

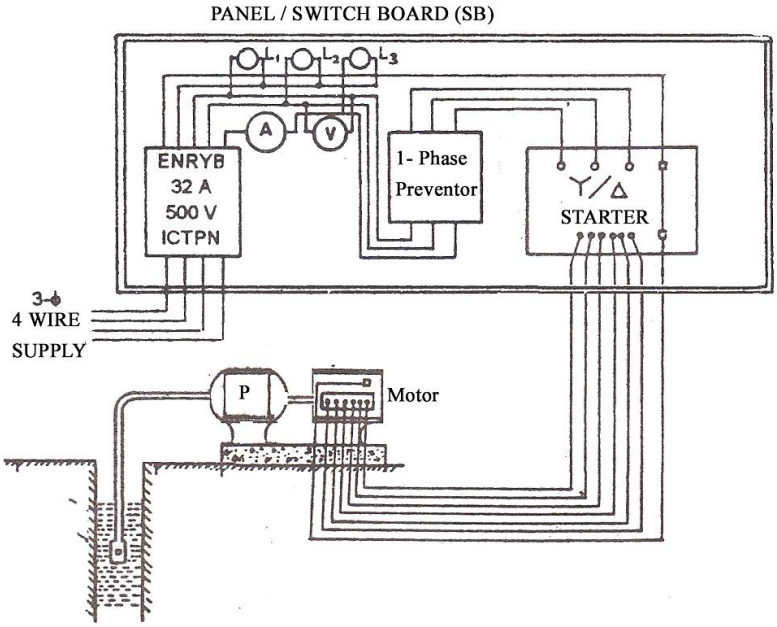
= 2 x length of conduit including length of flexible conduit

= 2 x (12) = 24

10% wastage and connections= 24 x 0.10 = 2.4m

Total length of earth wire required = 24 + 2.4 = 26.4 ≈ 27 m

Wiring Diagram

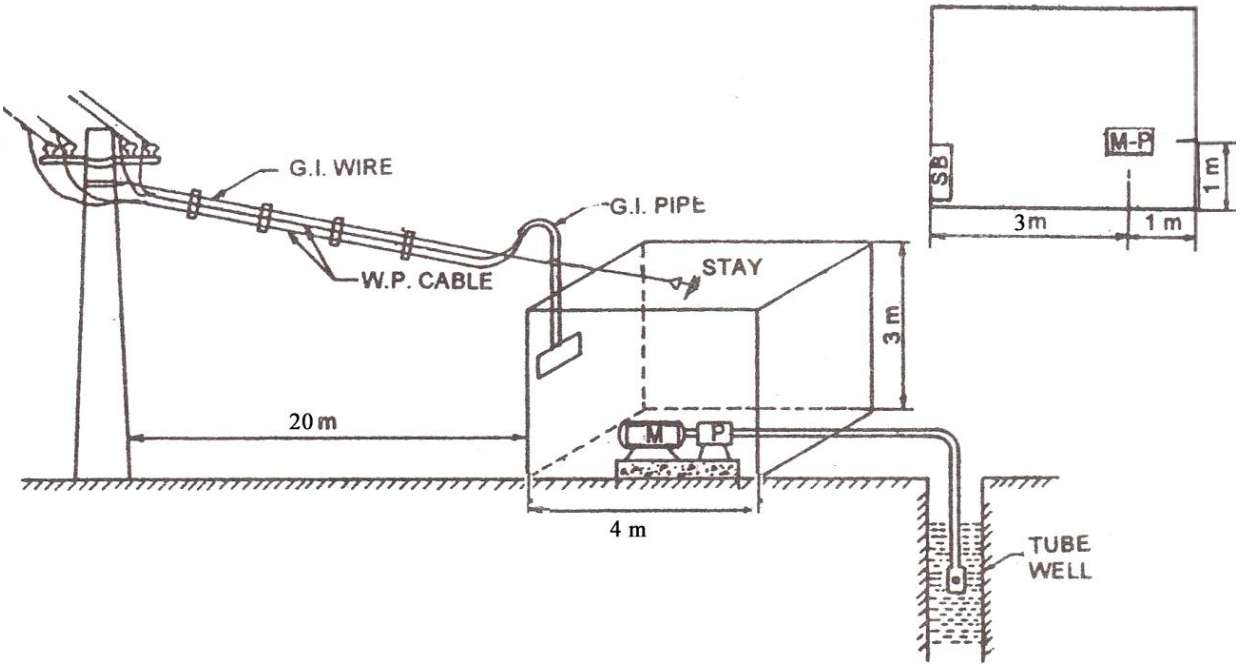


ESTIMATION

Sl No.	Material with Specification	Qty	Rate	Per	Cost	Remark
1	32 A 400V,ICTPN switch with fuses	1 No.		Each		
2	Star-Delta Starter, 16A, 500V	1 No.		Each		
3	I- phase preventer	1 No.		Each		
4	25.4mm conduit			M		
5	25.4mm flexible conduit			M		
6	25.4mm conduit bends			No		
7	25.4mm conduit coupler			No		
8	25.4mm saddles			No		
9	$3mm^2$ copper cable			M		
10	1 mm^2 copper cable			M		
11	Panel board with angle Iron frame	1 No.		Each		
12	Earthing set (complete set)	2 No.		Each		
13	Earth wire (GI 8 SWG)	27m				
14	Lugs for connecting leads to motor	6 No.				
15	Lamps	3 No.		each		
16	Batten holders	3 No.		each		
17	Switches	3 No.		each		
18	Ammeter (0-30 A)	1 No.		each		
19	Voltmeter (0- 500V)	1 No.		each		
20	Nails and Screws	0.5kg		kg		
21	Cement	2 kg		kg		
22	Sand	0.5sack		sack		
23	Danger Plate	1 No.		each		
24	Shock treatment chart	1 No.		each		

Estimate the quantity of material required for giving connection to a tube well having 7.5 HP, 400V, 3 phase induction motor. The height of the control room is 3.0 m. the distance between the LT pole and motor room is 20 m.

Solution



Assumptions:

1. The efficiency of the pump set motor is 85% at a PF of 0.8

2. The Switch board, starter are fixed 1.5m above the floor level

3. The height of the horizontal run is 2.5 m

4. The cost of service wire and motor is not included in the estimate

5. The motor shall be installed on suitable foundation, 0.2 metre above the floor level

6. The conductors from starter run at depth of 0.2m under the floor level.

a) Selection of cable and ICTP rating:

Full load current of the motor = $\frac{HP \times 735.5}{\sqrt{3} \times VL\ cos\emptyset \times \eta}$ = = A

The starting current of the motor = 1.5 X = A

Hence …… mm^2 copper conductor cable of current carrying capacity ……A can be used

A 32A, 500V, ICTPN Switch with fuses may be used.

b) Size of Conduit

25.4 mm metal conduit is required from panel or switch board to motor base and flexible conduit of 25.4mm size is sufficient from motor base to motor terminals, since 6 cables are to be run through the conduit.

c) Length of Conduit

Length on the roof = …….. m

Length from SB to Motor base (…+…+…+…) = ……..m

Total length of conduit = …+… = ……..m

10% for wastage and connection = …X 0.10 = ……..m

The total length of conduit required = …+… = ……..m

Flexible conduit from motor base to motor terminals = 0.75m ≈ 1m

d) Length of Cable (single core copper)

Length from ICTPN to Starter (0.5 x 3) = 1.5 m

From starter to motor terminals (… +… +…+…+…) x 6 = ……..m

10% wastage and end connections = 55.5 x 0.10 = ……..≈ ……..m

Total length of cable required = 55.5 + 9 = ……..≈ ……..m

1.0 mm^2 copper wire for lamps and Neutral = 2 m

e***) Length of Earth Wire***

According to IE rules, the motor frame, motor switch, motor starter, main switch are to be earthed by means of two separate and direct connections. Hence two separate earth electrodes will be provided for earthing purposes.

Length of earth wire required

= 2 x length of conduit including length of flexible conduit

= 2 x ….. = …..

10% wastage and connections= ….. x 0.10 = …..m

Total length of earth wire required = ….. + 2.4….. = ….. m

Wiring Diagram

ESTIMATION

Sl No.	Material with Specification	Qty	Rate	Per	Cost	Remark

Power Circuit Wiring

Power-circuits can be divided into two main categories

i) Power circuits for heaters, coolers, refrigerators, air conditioners…etc.

ii) Power-circuits for motors, generators…etc.

i) Wiring of Heaters, coolers…etc is done on the same pattern as for light and fan sub-circuits wiring. The difference is that in each **light and fan sub-circuit** the load is restricted to **800watts** and number of **points to 10** but in a **power sub circuit** the load is normally restricted to **3000watts** and number of **points to 2** on each sub circuit.

ii) Wiring of motor circuits, generator.

For internal wiring for supply to a motor use PVC cable of suitable size, depending upon the rating of the motor. The conduit employed for this purpose is of two types namely

i) **Rigid Heavy Gauge conduit** and ii) **Flexible conduit**.

Circuits and sub circuits to 400V motors must **be provided with fuses** on all poles i.e**. on both poles in case of DC** supply and **on all three phase in case of 3-phase ac** supply. Circuits supplying **single phase motors shall not be provided with fuse on the Neutral.**

IMPORTANT POINTS ABOUT MOTOR INSTALLATION WIRING

1. Looping of conductors and use of the joints shall not be allowed.
2. The length of flexible conduit used for connections between the terminal boxes of motors and starters shall not exceed 1.25m
3. Every motor, regardless of its size shall be provided with a switch fuse placed near it.
4. In addition to switch fuse all motors shall be provided with suitable means for starting and stopping (starters) placed at convenient places. T starters are used to limit the starting current to a desirable value
5. The current ratings of cables for supply to motor may be used upon the normal full load current of motor but the rating of the fuse should be based upon the starting current i.e. fuse should be capable of carrying the starting current of the motor. In no case the rating of fuse should be greater than twice the rating of cables so for deciding the rating of fuse and cables.
6. The conduit used in power wiring shall be electrically continuous throughout and connected to toe frame of motor. The frame of the motor shall be earthed by the owner by two separate and distinct connections to earth.
7. The wire used for earthing conductor shall be of copper or GI.
8. while deciding the current rating of a main switch controlling a group of motors, starting current of one motor (of highest rating) plus full load current of remaining motors shall be considered.

In a flour-mill(5x4) one 10 HP 440V, 3 phase , 50Hz squirrel cage induction motor is to be installed. Prepare the estimate of the quantity of material required and cost with its wiring diagram.

Solution

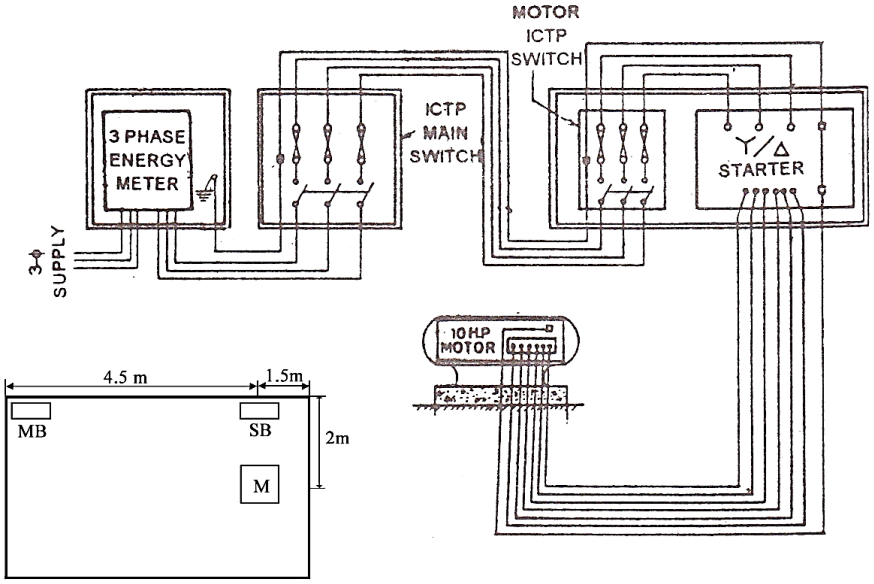
Assumptions

1. The efficiency of the pump set motor is 85% at a PF of 0.8
2. Height of the main switch, motor switch and starter will be 1.5metre from ground level.

3. Height of the horizontal run from ground level will be 3.0m

4. The conductors from starter run at depth of 0.2m under the floor level.

5. The motor shall be installed on suitable foundation, 0.2 metre above the floor level



a) Selection of cable and ICTP rating:

Full load current of the motor = $\frac{HP\times735.5}{\sqrt{3}\times VL\ cos\emptyset\times\eta}$ = $\frac{10\times735.5}{\sqrt{3}\times440\times0.8\times0.85}$

= 14.19A

The starting current of the motor = 1.5 X 14.19 = 21.28 A

Hence 4.0 mm^2 copper conductor cable of current carrying capacity 25 A can be used

A 32A, 500V, ICTPN Switch with fuses may be used.

b) Size of Conduit

19 mm metal conduit is required from meter to switch board, and25.4mm is used from starter to motor base and flexible conduit of 25.4mm size is sufficient from motor base to motor terminals, since 6 cables are to be run through the conduit.

c) Length of Conduit

Length on the roof = 1 m

Length from MB to SB (1.5+4.5+1.5) (19 mm) = 7.5 m

Length from SB to Motor base (1.5+0.2+2+0.2) (25.4 mm) = 3.9 m ≈ 4m

Total length of conduit = 7.5+ 4 = 11.5 m

10% for wastage and connection = 11.5 X 0.10 = 1.15 m

The total length of conduit required = 11.5+1.15 = 12.65 ≈ 13m

Flexible conduit from motor base to motor terminals (25.4 mm) = 0.75m ≈ 1m

d) Length of Cable (single core copper)

Length from ICTPN to SB(1.5+4.5+1.5) x 3 = 22.5 m

From starter to motor terminals (1.5 +0.2 +2+0.2) x 6 = 23.4 m

from motor base to motor terminals = (0.2 x6) = 1.2 m

10% wastage and end connections = 46.7 x 0.10 = 4.67 ≈ 5 m

Total length of cable required = 46.7 + 5 = 61.7 .≈ 62 m

1.0 mm^2 copper wire for lamps and Neutral = 2 m

e***) Length of Earth Wire***

According to IE rules, the motor frame, motor switch, motor starter, main switch are to be earthed by means of two separate and direct connections. Hence two separate earth electrodes will be provided for earthing purposes.

Length of earth wire required

= 2 x length of conduit including length of flexible conduit

= 2 x 13 = 26

10% wastage and connections= 26x 0.10 = 2.6 m

Total length of earth wire required = 26+ 2.6 = 28.6 ≈ 29 m