BANGLADESH RURAL ELECTRIFICATION BOARD
DHAKA, BANGLADESH

PBS INSTRUCTION 300-19

SUBJECT : WIRING SPECIFICATIONS AND RECOMMENDATIONS FOR PBS CONSUMERS.

Date of Approval : 04-10-1979
Date of Last Revision : 19-02-2020

WIRING STANDARDS FOR MEMBER OWNED WIRING INSTALLATIONS

Each Family dwelling compound shall be served by 1(one) KWH meter to be mounted on the outside wall of the house on the veranda or on a 7.62 M (25') pole set by the PBS. A shade must be mounted above the meter where there is no veranda. The thickness of the G.I. sheet shall be # 18 gauge & to be fixed as per drawing enclosed (Drawing No.1). The distance between the meter board and service mast must not exceed 3 meters and the service drop cable must be fixed on the wall with button & link clip.

The Service Entrance shall be in accordance with the standard set in Service Entrance section.

The main disconnect switch must be rated 15 Ampere capacity or larger and should permit manual operation. The energized component of the switch must be enclosed in a rain-tight enclosure if exposed to the weather.

The minimum of Two Branch Circuits are required for each compound. For larger electrical loads, switching and fusing equipment may be ganged together but shall not consist of more than 6(six) disconnect switches.

The electrical wiring installation shall be grounded with a approved driven ground rod connected to the neutral within the main disconnect switch.

The enclosure for the main disconnect switch and fuses shall be grounded to the system neutral.

Phase wires (ungrounded wires) within the compound must be fused at the load side of

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the disconnect switch. Fuse size shall not be larger than the rated capacity of the circuit conductors.

The neutral conductor (grounded wire) shall not be fused or switched and shall be continuous throughout the wiring network. Switching circuits shall be for phase wires only.

All electrical apparatus, switches, outlets and fixtures shall be designed for use on a 250 volt system.

All electrical equipment and junction boxes shall be mounted in their permanent position by use of not less than two screws or bolts.

Junction boxes shall generally be non-metallic and specifically for Kutcha houses. However, for permanent type building and with concealed wiring metallic junction boxes may be installed. But it should be bonded with the system ground.

Wire clips and nails shall be used to support all wiring conductors. They shall be placed at a distance no greater than 100 mm (4") apart in locations where the conductors are readily accessible.

In masonry constructed homes all insulated conductors shall be backed with wood strips (batten) of not less than 12.5 mm (1/2") thickness and 12.5 mm (1/2") width.

All installed conductors shall be insulated and of the type designed for use in locations exposed to heat and water. The black coloured insulated conductor is always the neutral.

The length of connected wire from junction box to light fixture mounted on that box shall be not less than 150 mm (6") and conductor insulation must extend through the opening in the junction box.

A drip loop must be formed in all cable or wire entering all vertically mounted apparatus. (disconnect switches, light switches, receptacles, meters, etc.).

All connections of conductors shall be of the twist splice type properly insulated with plastic tape.

A grounding conductor of sufficient size shall be used to bond motor frame, starters and main switch enclosures to the PBS system neutral and ground wire on the supply side of the service disconnect means.

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The ground wire conductor size shall be such that on occurrence of a fault of negligible impedance from a phase or non-earthed conductor to adjacent metal, a current corresponding to 3(three) times the rating of fuse or 1-1/2 (one and half) times the setting of the over-load circuit-breaker can flow through the ground wire. The grounding wire size may be determined from Table-2.

In addition to the above standards, all wiring shall be done in compliance with provisions of the Bangladesh Electrical Code or equivalent, if any.

METER POLES AND METER LOOPS

The PBS will own and install all meter poles. The wiring contractor doing work for the consumer must contact the local PBS for information concerning the type of meter loop that will be required and it's location.

Meter loops installed on meter poles shall have a fused disconnecting means between the meter and the consumer's load.

Single phase meter poles shall be installed and grouped together as much as practical to provide climbing space on the pole.

Meter loops shall be installed as per drawings before requesting inspection by the PBS. For information other than those listed, contact your local PBS.

Multiple load connections shall be made as per drawing . See Drawing No. 2. (Page 6).

The meter pole shall be the only PBS pole which shall be used jointly. Joint use may be permitted on other PBS poles by written permission of the PBS only.

All three phase meter loops for class 100 meters installed on poles shall be made up of GI pipe threaded and secured to a seven terminal meter socket on the meter board. See Drawing No. 3.

All class 20 instrument metering installations shall be made up of GI or PVC pipe threaded and secured to a thirteen terminal meter socket on the meter board.

Yard lights shall be placed so as not to interfere with overhead service conductors. Any switching devices shall be readily accessible.

OVERHEAD WIRING (600 VOLTS MAXIMUM)

Overhead service conductors shall have sufficient capacity to carry the load to all

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dwellings, public buildings or industrial applications. They shall have adequate mechanical strength and shall not be smaller than 2.0 mm^2 (3/.036). For installations to supply power for limited loads such as lighting circuits, they shall not be smaller than 1.5 mm^2 (3/.029).

No building shall be supplied through more than one service drop except for emergency electrical systems, or by special permission from the PBS. Multiple occupancy buildings shall be permitted to have two or more meters with sperate sets of service entrance conductors but shall be served from one service drop or lateral. See Drawing No. 4.

The following clearances shall be maintained:

3048 mm (10 Ft) above finished grade (earth)

3658 mm (12 Ft) above residential or commercial driveways not subject truck traffic.

4572 mm (15 Ft) above driveways subject to truck traffic.
5487 mm (18 Ft) above public streets or roads.

See Drawing No. 5.

Conductors shall be at least 2440 mm (8 Ft) above the nearest point of a building over which they pass and at least three feet distance from buildings by which they pass.

Overhead conductors terminating at buildings shall be properly secured at sufficient heights to maintain proper clearance throughout the service span. See Drawing No. 6.

If the building or home being served is not of sufficient height to allow proper clearance of overhead conductors, a mast type riser of such construction and so supported that it will with-stand the strain imposed by the service drop shall be used. See Drawing No. 7.

A bamboo pole 3658 mm (12 Ft) in length may be used as a mast provided it is seasoned and of sufficient diameter to withstand the strain of the conductor weight.

Masts for services must be 76 mm (3") diameter of larger.

All overhead conductors, other than service duplex, must be sheathed cable and supported with no. 14 (minimum) GI wire. It must be so constructed that the GI wire will carry the weight of the cable.

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All masts must be securely anchored with GI wire or other approved means. Jute rope is not acceptable. See Drawing No. 11.

Because of the different characteristics of copper and aluminium, devices such as pressure connectors and proper split bolt connectors shall be used when aluminium and copper are connected together.

The grounded neutral conductor of a secondary system shall be run to each building or other points to be served.

UNDER GROUND WIRING

Service lateral conductors shall be insulated for the applied voltage. Bare copper or Aluminum or Insulated stranded wire may be used in race-ways or direct burial for grounding of system neutral and/or equipment.

Underground service laterals shall have sufficient ampacity to carry the load. For limited loads such as a yard light circuit, they shall not be smaller than 1 mm^2 (1/.044). For other loads they shall not be smaller than 2 mm^2 (3/.036).

No building or other structure shall be supplied through more than one set of service laterals except for emergency electrical systems or by special permission from the PBS.

Underground Service lateral conductors shall be protected against physical damage by being installed:

1. In duct.
2. In rigid metal conduit made or material suitable for the condition.
3. In rigid non-metallic conduit.
4. By direct burial in the earth. Conductors buried directly in the earth, weather as single conductors, or as multi-conductor cable, shall be of a type approved for the purpose. Where necessary to prevent physical damage to the conductors from rocks, traffic, and other possible damage, direct buried conductors shall be provided with supplementary sleeve

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protection. Conductors under building shall be in a raceway that is extended beyond the outside walls of the building.

Direct buried cable, conduit, or other raceways approved for the purpose, shall be installed to meet the minimum cover requirements of the following table (Table-1):

Minimum Cover Requirements for 0-600 Volts, cover is defined as the distance between the top surface of direct buried cable, conduit, or other raceways approved for the purpose and the finished grade.

TABLE-1

WIRING METHOD	BURIAL MINIMUM (mm/In)
Direct Buried Cables	610 (24")
Rigid Metal Conduit	152 (6")
Rigid Non-metal Conduit Approved for direct Burial with out Concrete Encasement	458 (18")
Other Approved Raceways	458 (18")

When underground service conductors are installed up a pole, the mechanical protection shall be secured from a point at least 305 mm (12") underground to least 2438 mm (8') above the ground. See drawing No. 13.

Where entering a building, underground service conductors shall have mechanical protection from a point at least 305 mm (12") underground to the point of entrance on the building. See drawing No. 14.

Feeders or branch circuits installed underground shall have a fused disconnect means before entering the ground . See drawing No. 15.

Junction or splices may be made in approved boxes above ground on poles or on buildings. Boxes shall be 458 mm (18") above ground level. Junctions or splices may be made underground only if approved splice and insulating material are used.

The grounded (neutral) conductor shall be run in same protective conduit as ungrounded

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(hot) conductors.

Direct burial conductors shall be laid in trench loosely. To prevent conductor from becoming tight, the trench shall be filled from centre of run to both ends so conductor can follow the contour of the trench.

Do not install direct burial conductor in the same trench as water piping.

Connections in junction boxes shall be made by use of pressure or compression connectors of fittings suitable for of box assembly, connectors are to be properly taped or insulated.

Direct burial underground service shall be grounded by an approved ground wire from the grounding bus in the service entrance equipment to an approved grounding electrode.

Underground grounded (neutral) conductors shall be sized in accordance with the maximum unbalanced condition, but shall be the same size as the undergrounded (hot) conductors in services up to 100 ampere capacity.

GI pipe and rigid plastic pipe may be used for complete runs of undergrounded services.

All cut ends of conduit shall be reamed to remove rough and sharp edges.

SERVICE ENTRANCES

In PBS wiring standard the Service Entrance will mean the conductor(s) connecting the Energy Meter and the Disconnect Switch installed in the consumer's installation.

Each family dwelling compound shall be served by one KWH meter either mounted on the house or on a 7.62 meter (25 Ft) pole set by PBS.

The length of Service Entrance wire from the KWH meter to the disconnect switch shall not exceed 3 meters (10'). Exception : When not feasible, written permission from PBS may be given to extend this length.

The Service Entrance shall be of PVC insulated type of adequate size but not less than 2 mm^2 (3/.036). The Service Entrance shall be :

a. Twin Core PVC, or

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b. Single Core PVC Insulated PVC Sheathed, or
c. unsheathed PVC cables in Conduits/ Pipes.

The Main Disconnect Switch must be rated 15 Amps or larger and shall permit manual operation. The energized component of the switch must be in a rain-tight enclosure if exposed the weather. Main disconnect switches may be of the following types :

a. Metallic case.
b. Cast steel body.
c. Ceramic construction.
d. Circuit breakers.

The electrical wiring installation shall be grounded with an approved driven ground rod connected to the main switch enclosure and bonded to the system neutral. See drawing No. 16.

The neutral conductor (grounded wire) shall not be fused or switched and shall be continuous through out the wiring net work.

All service equipment shall be designed for use on a 250 volt system.

Service entrance conductors shall be provided with a readily accessible fused main switch or circuit breaker rated no greater than full capacity of the service entrance conductors.

A building or other structure served shall be supplied by only one service except for emergency electrical systems or by special permission from the PBS.

Multiple occupancy buildings shall be served by one service drop with a meter for each apartment. See drawing No. 4.

For serving single phase one family dwelling the duplex may be securely anchored to the house if proper clearance can be maintained. Duplex service drop may be continued down the wall and connected directly to the line side of the meter. See drawing No. 6.

If proper clearance cannot be maintained, a service mast of bamboo 3658 mm (12') length x 76 mm (3") Diameter may be secured to the house. The service duplex may be anchored to the mast and continue to the line side of the meter. See drawing No. 7.

Care must be taken to adequately secure the mast to the building with GI wire. Jute rope is not acceptable.

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For longer life of service mast a treated wooden stub pole may be set in the ground with provisions for connecting the bamboo mast to the stub pole.

Service entrances in conduit shall be complete with weatherproof service head and arranged to drain. No splices shall be permitted in service entrance conductors.

150 mm (6") drip loops shall be provided between service head and overhead wiring. See drawing No. 18.

Service conductors shall be attached at their terminal points by pressure connectors clamps, or other approved means. No solder connections or twist joints permitted.

Bent pipe and threaded sweep Elbows are not recommended for use with conduit service entrances. BREB approved weather head shall be used. See drawing No. 18.

The consumer shall install the GI pipe, entrance conductor, and weather head. He will also install the main switch and driven ground. After all connections are completed, the PBS will connect the meter and run the service drop.

GROUNDING

Each account shall have a grounding electrode consisting of a Ground Rod 16 mm (5/8") ö x 1829 mm (6') with a 3048 mm (10') long 10 SWG G.I wire welded to the rod and the complete assembly will be galvanized or G.I. Pipe 19 mm (3/4") ö x 1829 mm (6') with a 3048 mm (10') long 10 SWG G.I Wire connected by grounding clamp or by making a hole on G.I Pipe to pass the G.I. wire through the hole and wrapping three layers of wire around the pipe. The wire will be made very tight by twisting the wire end with the help of pliers.

Alternately the ground can be made by a grounding plate of size 305x305x6.35 mm (12"x12"x1/4") G.I Plate with a G.I wire of size 10 SWG and 6096 mm (20') length welded at two points with the plate. The plate shall be buried at a depth of 2439 mm (8') below the ground level using appropriate digger.

The grounding conductor from the ground rod shall be connected to the system neutral at any accessible point from the load of the service drop to and including the grounding terminal or grounded bus of the service disconnect means.

For single phase services, the grounding conductor shall be connected from the ground to the main switch enclosure and bonded to the service neutral. See drawing No. 16.

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Care should be taken to make the service grounding conductor from main switch to load without splice. One splice may be allowed between grounding rod to maid disconnect.

If the grounding conductor must be spliced the extension wire must be of the same size and material. The correct splicing method must be used. See drawing No. 20.

Service grounding conductors shall be No.10 GI wire or equivalent and shall be securely fastened to the house or pole for mechanical protection.

Ground Rods/ Plates shall be placed 610 mm (2') out from the pole or building and 305 mm (12") from the surface of the earth to the top of the rod.

Ground Rods/ Plates and metallic piping systems shall be bonded together. In no instance shall local metallic piping systems be depended upon as the sole means of grounding the electrical system.

Ground electrode shall have a resistance to ground not to exceed 25 ohms. If resistance exceeds 25 ohms, two or more ground rods bonded together shall be used. This will be applicable for installations bonded with primary neutrals. However, installations having larger loads must have independent grounding arrangement irrespective of their bonding with the Primary Neutral. In such cases, the ground resistance shall not exceed 1(one) ohms as per provisions of the Electricity Rules, Bangladesh.

All equipment grounding conductors shall be connected to the grounded circuit system neutral) on the line side of the service disconnect means. A grounding connection shall not be made to any grounded circuit conductor on the load side of the service disconnect.

If metering is installed at the pole and load at consumer's end is connected by Duplex/ Quadruplex then two separate ground rods shall be used. One at the meter socket/ meter board location and the other at main switch, starter and motor location. Both the rods shall be supplied by the consumer.

EQUIPMENT GROUNDING

Fixed equipment such as metal enclosures for switching, motor starters, motor frames, and other noncurrent-carrying metal parts of equipment shall be grounded by a grounding Conductor. This conductor may be run in the same Raceway or cable as the circuit conductors and may be uninsulated. If the grounding conductor is insulated, the covering shall be green in colour. For Aluminum Wires protection against damage shall be ensured.

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Supplemental grounding electrodes (ground rods) shall be permitted to be added to the equipment grounding conductor, but the earth shall not be used as the sole equipment grounding conductor.

The grounded circuit neutral shall not be used for grounding noncurerent-carrying metal parts of equipment on the load side of the service disconnect means.

The equipment grounding conductor shall be connected to the grounded service neutral at or before the service entrance disconnecting means.

For minimum size conductors for grounding equipment see Table 2.

TABLE - 2

Rating of Overcurrent Device in the circuit ahead of Equipment. (AMPERE)	SIZE OF GROUNDING WIRE				
	Solid Cu		CopperWire mm^2 (BS)	Solid Al	
	AWG	ö mm		AWG	ö mm
15	14	1.63	2.5 (7/.029)	12	2.05
20	12	2.05	4 (7/.036)	10	2.59
30	10	2.59	6 (7/.044)	8	3.26
40	10	2.59	6 (7/.044)	8	3.26
60	10	2.59	6 (7/.044)	8	3.26
100	8	3.26	10 (7/.052)	6	4.67

RESIDENTIAL WIRING

Each family dwelling compound shall be served by one KWH meter either mounted on the house or on 7.62 Meter (25 Ft) pole set by PBS.

The Service Entrance length and Main Disconnect Switch Installations shall be according to PBS Standard.

For larger electrical loads, switching and fusing equipment may be ganged together but shall not consist of more than 6(six) disconnect switches. See drawing No. 21.

The electrical wiring installation shall be grounded with a 16 mm (5/8") ö x 1829 mm (6') driven Ground Rod or 19 mm (3/4") galvanized pipe of length 1829 mm (6') or by

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GI plate of size 305x305x6.35 mm (12"x12"x1/4") buried at a depth of 2439 mm (8') and connected to the neutral within the main disconnect switch or switches.

The enclosure for the main disconnect switch and fuses must be grounded to the system neutral. See drawing No. 21.

A minimum of two branch circuits are required for each compound. Branch circuits serving power outlet sockets shall provided for range, water heaters, air conditioners, electric clothes dryers, and water pumps.

Branch circuits serving lights only shall not be less than 1.5 mm^2 (3/.029).

One or more lights may be connected to a power circuit providing a lighting circuit is not conveniently nearby.

A power outlet socket may not be connected to a lighting circuit if the circuit is wired with 1.5 mm^2 (3/.029).
Phase wires (grounded wires) within the compound must be fused at the load side of the disconnect switch. Fuse size shall not be larger than the rated capacity of the circuit conductors.
The neutral conductor (grounded wire) shall not be fused or switched and shall be continuous throughout the wiring network. Switching circuits shall be phase wires only.

All electrical apparatus, switches, outlets, and fixtures shall be designed for use on a 250 volt system.

Lighting fixtures when installed on a wall shall have a minimum of one foot of clearance from the ceiling or any storage area where combustible material may be stored. See drawing No. 22.

Two and three way switches shall be so wired that only the hot wire is switched. The neutral shall not be switched.

All electrical equipment, light fixtures, mounting boards, and junction boxes shall be securely mounted in their permanent position by not less than two screws or bolts. See drawing No. 23

Boxes must be of sufficient size to provide free space for all conductors and proper connections.

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Junction boxes shall generally be non-metallic specifically for Kutcha houses. For permanent house with concealed wiring may have metallic junction boxes. Metallic junction boxes shall be grounded.

Wire clips and nails shall be used to support all exposed wiring. They shall be placed at a distance not greater than 100 mm (4") apart in locations where the conductors are readily accessible.
On masonry surface all conductors shall be backed with wood strips (batten) of not less than 12.5 mm (1/2") thickness and 12.5 mm (1/2") width.

The length of connected wire from the junction box to the light fixture mounted on the box shall be not less than 150 mm (6") and the conductor insulation must extend through the opening in the junction box. See drawing No. 23.
All insulated conductors shall have insulation of the type designed for locations exposed to heat and water.

The black coloured insulated conductor is always the neutral.

Concealed wiring within walls or ceiling be installed in an approved raceway. The raceway shall be of metallic or PVC tubing and shall be continuous between cabinets, boxes, fittings, or other enclosures.

Conductors shall be continuous and no splices will be made within the raceway itself.

The number of conductors installed in a single conduit shall not exceed the figure in Table 3 and Table 4 for different sizes of conduit or tubing. For Determining number of cables in a conduit, the Cable area shall be 53% of the conduit cross section for single cable, 31% for two cables and 40% for other numbers. (Ref NEC-1985).

For determining the connected load following assumptions will be made :-

- Average 70 Watts Shall be considered for each holder points, ceiling rose, 2-pin socket outlets; However, it is general assumption that One should calculate the load on actual basis.
- Average 500 Watts for each 3-pin socket; However, it is general assumption that One should calculate the load on actual basis.
- Actual load for other appliances.

However, for loads above 2 KW, a Diversity Factor of 1.33 shall be considered for determining the Load.

After the load is calculated, the cable for different section may be selected by following the steps as described in a separate section of this Instruction.

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CONCEALED WIRING

For concealed wiring the conduit system must be completely erected before drawing in of cables. For capacities of conduit see Table-80 (A & B). However, for short and straight runs, e.g. for switch drops, it is admissible to install number of cables moderately in excess of those stated in the Tables.

All conduits must be protected against the entry of dust and water, however, the system should provide drainage outlets at the lowest level to prevent the collection of condensation. The concealed conduits shall be self-ventilating.

All conduit systems must be properly supported. In the case of rigid PVC conduits, allowance must also be made for longitudinal expansion.

The inner radius of a conduit bend must lever be smaller than 2.5 times the outer diameter of the conduit.

It should be ensured that luminaries installed over plastic boxes do not develop excess heat (for PVC maximum 60° C allowable), at the same time the weight of the fixture should be within supporting capacity of the boxes, specifically for the plastic boxes.

If the concealed wiring uses metallic conduits, earth continuity conductors shall be installed all through, and the integrated system shall separately earthed.

End of lengths of conduit shall be reamed, and if possible be fitted with bushes, to avoid abrasion of cables.

There shall be adequate junction boxes with cover in order to facilitate inspection as well as replacement of cables.

The conduits shall be so placed in the walls, floors and ceiling that adequate covering (minimum 19 mm i.e, 3/4") over them is maintained.

The Phase and Neutral shall be of different colour, so that they are easily identified. As a standard practice RED colour should be used for Phase and BLACK colour for Neutral conductors.

INDUSTRIAL WIRING

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Other than the general electrification, special attention shall be given to the following points for industrial power uses.

Switch boards with exposed parts shall be located permanently in dry positions. It should be so located that the possibility of damage from equipment, door-window shutters or other process is reduced to a minimum.

A minimum clearance of 915 mm (3') is maintained from top of switch board to non-fireproof ceiling. This would reduce the chances of fire hazard originated from accidental flushes at the switch board.

All panel boards shall have a rating not less than the minimum feeder capacity required for the load.

Bare Busbars shall be permitted if they are rigidly mounted. Exposed blades of knife switches shall be dead when they are in open position.

Instruments, pilot lights, PT etc. of control panels shall be supplied by a circuit that is protected by standard over current devices rated 15A or less.

Terminals of motors and controllers shall be suitably marked or coloured where necessary to indicate the proper connections.

Protection to be taken against liquids such as dripping or spreading oil, water or other injurious liquids unless the motor is designed for that environment or purpose.

Motor terminal housing shall be of metal construction. Motors shall be located so that adequate ventilation is provided and so that maintenance, such as lubrication of bearings and replacement of brushes can be readily accomplished.

Lamps for machinery shall be mounted on the machine else they shall be placed on fixed or moveable stand by using flexible conduits when the supplying wires run over floor. Bulk load switching by using circuit breakers, MCB, MCCB or main switches should be avoided. In such situations, magnetic contact switches are recommended.

If the Industrial premises contains trusses, they shall be adequately earthed. Similarly, the overhead crane rails shall be earthed.

If a sub-station is required for supplying a industry, the same shall be fenced with a danger plate on it. Fire-fighting equipment shall be provided in such sub-stations. For

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indoor sub-station it is recommended that the consumer provides dry type transformers. For stand by generators, the change over switch shall be standard cabinet type and mounted on floor, wall or column permanently. An instruction plate describing the sequence of change over shall be placed beside the change over switch.

Cables connecting different motors/ machines shall not be placed over floor. These shall run either through trenches, ducts or through conduits buried under floor or through conduits clipped on walls. Flexible conduits shall be used from the control board/ panel to the controller and upto motor terminals.

All motors, equipment, machine shall be grounded as per standard of this instruction.

All motors shall have either direct-on-line or Wye-Delta controllers as per requirement by their ratings. Manual type starter should be avoided as far as possible.

Industries containing heat zones, shall have appropriate type of conduits and cables shall be used.

The cables terminating on the bus-bars must have terminal sockets. The original insulation at these terminal shall be removed and replaced with heat resistant insulating tapes.

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WIRING METHODS

All conductors and electrical equipment shall be protected against corrosion and mechanical injury where subject to such damage.

All raceways, cables, switchgear, and equipment shall be securely fastened in place and connected to boxes, fittings and devices.

At least 150 mm (6") of free conductor shall be left at each outlet, switch point or junction, for making attachment to equipment or circuit extensions.

A box shall be installed at each light, outlet socket, switch or junction point of the conductor. See drawing No. 23.

The number of conductors in raceways shall comply with conduit Table No. 3 and Table No. 4.

When metal raceways are used, all conductors shall be so run as to prevent heating by induction.

Nonmetallic sheathed PVC cable may be used for both exposed and concealed work. It may be run inside or outside of buildings. It may be run underground or in air voids in masonry block or brick walls where such walls are constructed with air voids. It shall not be installed where exposed to destructive liquids, fumes, or vapours; nor shall it be imbedded in masonry, concrete, or plaster. Care must be taken at all times to provide protection against mechanical damage.

Nonmetallic sheathed PVC cable may be used underground, including direct burial in the soil, as feeder or branch circuit cable when provided with overcurrent protection not in excess of the rated current carrying capacity of the individual conductors. See Chapter 3, undergroundwiring.

Revision:				
BANGLADESH RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-17	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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TABLE 3

MAXIMUM NUMBER OF PVC INSULATED CABLES IN A CONDUIT

WIRE SIZE (BRITISH)	CONDUIT, PIPE OR TUBING						
	12.5 mm 1/2"	19 mm 3/4"	25 mm 1"	32 mm 1-1/4"	38 mm 1-1/2"	50 mm 2"	63.5 mm 2-1/2"
1/.044	6	13	24	37	54	96	151
3/.029	4	10	18	28	41	73	114
3/.036	3	8	14	23	33	59	92
7/.029	3	7	13	20	29	52	82
7/.036	2	5	9	14	20	37	57
7/.044	1	4	7	11	16	29	45
7/.052	1	3	5	9	13	23	37
7/.064	1	2	4	7	10	17	28
19/.044	-	1	3	5	7	13	21
19/.052	-	1	2	4	6	10	17
19/.064	-	-	1	3	4	7	12

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TABLE 4

MAXIMUM NUMBER OF PVC INSULATED CABLES IN A CONDUIT

WIRE SIZE (METRIC)	CONDUIT, PIPE OR TUBING						
	12.5 mm 1/2"	19 mm 3/4"	25 mm 1"	32 mm 1-1/4"	38 mm 1-1/2"	50 mm 2"	63.5 mm 2-1/2"
1 mm^2	6	13	24	38	55	98	154
1.5 mm^2	5	11	20	31	45	81	127
2.5 mm^2	3	7	12	19	28	50	78
4 mm^2	2	5	9	15	21	38	60
6 mm^2	1	4	7	11	17	30	47
10 mm^2	1	2	4	7	10	19	30
16 mm^2	-	1	3	5	7	13	21
25 mm^2	-	1	2	3	5	90	14
35 mm^2	-	1	1	2	4	7	11
50 mm^2	-	-	1	2	2	5	8

MOTORS AND CONTROLLERS

Before installing motors of five (5) horsepower or larger, the installer shall consult with the local PBS for requirements.

For motors rated less than five (5) horsepower, a general use switch having an ampere rating two times the full load current rating of the motor may be used as a controller. (Exception) When single phase motors are used with external starting capacitors the switch for starting must be so designed to disconnect the starting winding after the motor has reached running speed.

A motor controller includes any switch or device normally used to start and stop a motor.

The controller shall have a horsepower rating not lower than the horsepower rating of the motor.

Each motors shall be provided with overcurrent protection.

This device is intended to protect the motor and motor control apparatus against excessive heating due to motor overloads and failure to start.

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Overload devices shall be set to trip or rated at not more than the following percent of the motor nameplate full-load current rating. Motors with a marked service factor not less than:

1.15 (marked Service Factor)	- 125%
Motors with a marked temperature rise not over 40 degree C	- 125%
All other Motors	- 115%

Where fuses are used for motor running protection, a fuse shall be inserted in each ungrounded conductor and sized according to the above paragraph.

A motor running overload device that can restart a motor automatically after shutdown shall not be installed if it's automatic restarting can result in injury to persons.

Every motor shall be installed with an individual accessible disconnect means.

The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.

Where an installation consists of a single motor, the service switch may serve as the disconnecting means.

The disconnecting means shall be a motor-circuit switch rated in horsepower or a circuit breaker.
Where a motor is connected to a branch circuit by means of an attached plug and receptacle the running current shall not exceed ten (10) amperes.

Conductors of motor control circuits shall be protected against over-current in accordance with their ampacities. See Table No. 5A & 5B for conductor ampacity.

Mechanical protection of motor circuit conductors shall be provided where damage would constitute a hazard.

Physical protection can be supplied by direct burial in the earth, rigid metal conduit, or PVC conduit. See drawing No. 24.

Enclosure for motor controllers and disconnect means shall not be used as junction

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boxes or for raceways for conductors feeding through.

Where wires pass through openings in meter bases, main switch enclosures, controller enclosures, or junction boxes, a bushing shall be used to protect the conductors from the sharp edges of the opening.

Branch circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating.

Conductors supplying 2(two) or more motors shall have an ampacity equal to the sum of the full-load current rating of all the motors plus 25 percent of the highest rated motor in the group. Multiply the largest single motor ampere rating determined by 1.25. add all other motor ampere ratings and select the conductor ampacity for this total ampere rating. See Table No. 5A & 5B.

Compensator or reduced voltage starting equipment should be used on all twenty-five horsepower or larger motors. Exception to the requirement of compensator starters will be made for motors which are run continuously for long periods of time. Example : Irrigation pumps.

Voltage drop shall not exceed 2.5 percent computed from the service entrance to the point use. When computing, all loads on the circuit must be considered.

Motor maintenance should be considered when locations are selected for installation.

A motor and its driven machinery shall be within sight and maximum of 15.24 meter (50 feet) from the point of its starter. See drawing No. 24.

Pump motors such lowlift pumps and tubewells installed in locations subjected to flood waters should be connected for easy and simple removal.

The meter and main switch should be mounted in a location above the high water level. See drawing No. 25.

The service cable shall be disconnected at the main switch for removal of motor and controller with out requiring the removal of the meter or main switch.

A grounding conductor of sufficient size shall be used to bond the motor frame, starter, main switch enclosures and ground rod to the PBS system neutral on the supply side of the service disconnecting means.

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Supplementary grounding shall be permitted to add to the equipment grounding conductors but the earth shall not be used as the sole equipment grounding conductor. See drawing No. 26.

For single phase service and motor installation. See drawing No. 31 and drawing No. 32.

For single phase motor starter wiring connection. See drawing No. 33.

For Direct on line motor starter see drawing No. 34 and for star-delta automatic motor starter see drawing No. 29.

TABLE - 5A

CURRENT RATING OF COPPER CONDUCTORS

Single Core, PVC Insulated, Nonsheathed
in Amperes

Conductor Size British Sizes	Overall Dia mm	Bunched & Unenclosed		Bunched in Conduits	
		2 cables 1-phase	3 or 4 Cables, 3-phase	2 cables 1-phase	3 or 4 Cables, 3-phase
1/.044	3.03	13	12	11	9
3/.029	3.48	16	14	13	11
3/.036	3.88	20	18	16	14
7/.029	4.11	25	23	21	18
7/.036	4.90	33	30	28	23
7/.044	5.51	41	37	34	28
7/.052	6.12	52	46	43	36
7/.064	7.03	67	60	56	48
19/.044	8.00	79	71	66	56
19/.052	9.00	94	84	77	65
19/.064	10.55	125	115	105	88

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TABLE - 5B

CURRENT RATING OF COPPER CONDUCTORS

Single Core, PVC Insulated, Nonsheathed
in Amperes (30° C Ambient)

Conductor Size Metric Sizes	Overall Dia mm	Bunched & Unenclosed		Bunched in Conduits	
		2 cables 1-phase	3 or 4 Cables, 3-phase	2 cables 1-phase	3 or 4 Cables, 3-phase
1 mm^2	3.00	13	12	11	9
1.5 mm^2	3.30	16	15	13	11
2.5 mm^2	4.20	23	20	18	16
4 mm^2	4.80	30	27	24	22
6 mm^2	5.40	38	34	31	28
10 mm^2	6.80	51	46	42	39
16 mm^2	8.00	68	61	56	50
25 mm^2	9.80	89	80	73	66
35 mm^2	11.00	109	98	90	80

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TABLE - 6

FULL LOAD CURRENT FOR ELECTRIC MOTORS

Approximate Figures in Amperes for Standard Type Motors

H.P	Typical Efficiency Values	Typical P.F Value	1- Phase	Three Phase	
			230 Volts	230 Volts	400 Volts
0.25	0.60	0.68	1.99	1.15	0.66
0.50	0.63	0.70	3.68	2.13	1.22
0.75	0.68	0.72	4.97	2.87	1.65
1	0.70	0.74	6.26	3.62	2.08
1.5	0.74	0.77	8.54	4.94	2.84
2	0.76	0.80	10.67	6.17	3.55
3	0.76	0.81	15.81	9.14	5.25
5	0.78	0.82	25.36	14.66	8.43
7.5	0.81	0.83	36.18	20.92	12.03
10	0.83	0.85	45.97	26.57	15.28
15	0.85	0.87	-	38.03	21.87
20	0.86	0.87	-	50.12	28.82
25	0.86	0.87	-	62.65	36.02
30	0.87	0.88	-	73.47	42.24
40	0.87	0.88	-	97.95	56.32
50	0.87	0.88	-	122.44	70.40
60	0.87	0.89	-	145.28	83.54
75	0.87	0.89	-	181.60	104.42
100	0.88	0.89	-	239.38	137.64

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SELECTION OF CABLE

The most important factor when choosing a cable is the temperature attained by its insulation. If the temperature exceeds the design value, premature failure may result. Additionally corrosion of the metallic sheath, conduits and enclosure may occur.

Type of cable should be selected such that it meets the exact requirement and suitable for its purpose. As for example :-

a) In damp or corrosive situations, corrosion-resisting cables and accessories shall be selected.
b) In concrete ducts which are likely to be rough enough to damage insulation, nonsheathed cables must not be used.
c) For direct burial underground, the type of cable shall be sheathed and protected.
d) For exposed wiring, cables should be protected from mechanical damage. For concealed wiring with conduits, non-sheathed cable may be selected.
e) Flexible cords should not be used for fixed wiring.

All cables have resistance and heat is produced in them when they carry current. In selecting cables, current carrying capacity is of prime importance. The current due to load, should be within safe ampacity of the cable. Rating factors as recommended in different Standard and also by the manufacturer shall be applied in determining the current carrying capacity of cables. Deviations like ambient conditions, grouping/ bunching, installation methods etc. should be taken into account and rating factors shall be taken from recommended values. PVC Insulated cable ratings manufactured in our country are based on 35° C Ambient and 70° C maximum temperature.

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STEPS IN SELECTING CABLES

The steps to be followed when determining the cable to be used in a particular case may be outlined as follows :-

a) Calculate the design current for the circuit/ load.
b) Choose the type and rating of the over current protective device to be used.
c) Divide the protective device current rating by the ambient temperature correction factor.
d) Further divide by the grouping correction factor.
e) Divide again by the thermal insulation correction factor if appropriate.
f) The result is the current rating of the cable which must be chosen from a suitable table.

It is to be noted that, the current carrying capacity of a cable is dependent on the type of protective device, and the correction factor for such devices can be obtained from any standard table. The correction factors as set in B.S are given below :

NORMAL CONDITIONS

The basis of the current ratings of cables of the Manufacturer in our country for normal ambient temperature of 35 C and for normal laying conditions as follows:

A. For group of unenclosed systems of single core cables:

1) The horizontal clearance between the systems is not more than 150 mm (6") and not less than six times the individual cable diameter or one time the overall width of the individual system.
2) The vertical clearance between the systems is not less than 150 mm (6").
3) If the number of system is more than four, they are installed in a horizontal plane.

B. For group of unenclosed multicore cables:

1) The horizontal clearance between cables is not more than 150 (6") mm and not less than six times the individual cable diameter.

2) The vertical clearance between cables is not less than 150 mm (6").

3) If the number of cable is more than four, they are installed in a horizontal plane.

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DEVIATED CONDITIONS

If the actual conditions of the installations are not same as normal conditions, the current rating values given in Standard Wire Tables are to be multiplied with the rating factors as given below:

TABLE - 7A

Rating Factor for Variation of Ambient Temperature

Ambient Temp Deg C	25	30	35	40	45	50	55	60
Rating Factors for cables having excess current protection, which will operate within four hours at 1.5 times of the designed load current.	1.13	1.06	1	0.93	0.84	0.76	0.65	0.53
Rating Factors for cables having no excess current protection as above.	1.05	1.03	1	0.97	0.94	0.91	0.79	0.65

TABLE - 7B

Group Rating Factor for Single-core Cables in Three-phase System in Air

Number of Systems	2	3	4	5	6	8	10
Rating Factor	0.80	0.69	0.62	0.59	0.55	0.51	0.48

TABLE - 7C

Group Rating Factor for Multi-core Cables in Air

Number of Systems	2	3	4	5	6	8	10
Rating Factor	0.80	0.70	0.65	0.60	0.57	0.52	0.48

Cable sizes as determined above shall be checked against permissible voltage drop. Calculation method for VD has been given in the following section.

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Example : For 30 HP Motor

Full Load Ampere	= 42.24 A
Over current Protection	= By Fuse
Ambient Temperature	= 30 °C (Cable in air) Take 35 °C if in conduit)
Rating Factor for Temp.	= 1.03
Group Rating Factor	= 0.69
Cable Ampacity required	= 42.24÷(1.03x0.69) = 59.4 A
From Table-5A, the size	= 7/.064
(Bunched and unenclosed, 3-Phase I	= 60A)
or From Table-5B, the size	= 16 mm^2

Then, **3-Phase Voltage Drop = 1.37 V** [Using Eqn. of following section]

Taking 50' length between Main switch and Motor terminal
Allowable Drop = 2.5% of 400 V = 10 V
Hence the Selection is OK.

VOLTAGE DROP CALCULATIONS

All cables have resistance, and when current flows in them this results in volt drop. If the resistance of the cable is known the voltage drop can be calculated from V=IR. Alternatively, if the conductivity and cross-sectional area are known, the volt drop can also be calculated. The second method is convenient for metric sizes. In practice, calculation of resistance is difficult because of the increase in its value as the cable becomes hot when carrying current. In addition, for large cables, the impedance will need to be considered rather than the resistance.
When the resistance of the conductor is known, the Voltage Drop can be calculated by using the following formulae.

$$1\text{-}\phi \text{ Volt Drop to Neutral} = \frac{\text{Amp}\times\text{Length}\times 2\times(\text{R Per 1000 Ft})}{1000}$$

$$3\text{-}\phi \text{ Volt Drop} = \frac{1.73\times\text{Amp}\times\text{Length}\times(\text{R Per 1000 Ft})}{1000}$$

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But if the resistance in not known but the cross-sectional area and conductivity (Lamda) known (copper = 56 m/ohm.mm^2, Aluminum = 34 m/ohm.mm^2) then VD can be calculated as follows :

For Single Phase System (2 wire)

$$e = \frac{2\times Amp\times Length\times \cos\phi}{\lambda.Area}$$

$$= \frac{2\times Length\times Watt}{\lambda.Area.\ Volt}$$

For Three Phase System :

$$e = \frac{\sqrt{3}\times Amp\times Length\times \cos\phi}{\lambda.Area}$$

$$= \frac{Length\times Watt}{\lambda.Area.\ Volt}$$

The Area shall be in mm^2, Length in Meter, Voltage means Phase to Neutral Volts and Watt is Per Phase Watts. Then (e) will be the Voltage drop in volts.

If conductivity and area is known, the resistance of a copper cable can be determined by using the following equation.

R = Length ÷ {conductivity x Area in mm^2} ohm
R = 304.878 ÷ (56 x Area in mm^2) ohm
R = 5.4443 ÷ (Area in mm^2) ohm

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The following table gives the D.C resistance at 20° C of some common size of cables. (Aluminum Wires except AWG Sizes are of theoretical interest and not being produced in our country) :

TABLE - 8

Metric Size	R per 1000'		British Size	R per 1000'		AWG Size	R per 1000'	
	AL	CU		AL	CU		AL	CU
1 mm^2	8.92	5.444	1/.044	9.202	5.613	6	0.674	0.410
1.5 mm^2	5.95	3.6292.	3/.029	6.918	4.2202.806	4	0.423	0.259
2.5 mm^2	3.57	178	3/.036	4.600	1.877	3	0.336	0.205
4 mm^2	2.23	1.361	7/.029	3.077	1.204	2	0.266	0.162
6 mm^2	1.49	0.907	7/.036	1.973	0.844	1	0.211	0.129
10 mm^2	0.89	0.544	7/.044	1.383	0.582	1/0	0.168	0.102
16 mm^2	0.56	0.340	7/.052	0.954	0.375	2/0	0.134	0.081
25 mm^2	0.36	0.218	7/.064	0.615	0.281	3/0	0.105	0.064
35 mm^2	0.25	0.155	19/.044	0.461	0.211	4/0	0.084	0.051
50 mm^2	0.18	0.109	19/.052	0.346	0.141			
			19/.064	0.231				

For other Temperature use Temperature Resistance co-efficient as follows:

Copper	0.00393 per Deg C
Aluminum	0.00403 per Deg C

When calculating wire size for motors use nameplate amperes or if this is not available refer to table 91 for approximate full load amperes. A one motor circuit shall have a capacity of 125% of the motor's full load current. If the circuit feeds two or more motors the capacity shall be 125% of the total full load amperes for all the motors. Care must be taken to ensure adequate voltage at the motor. Use the above formulas to determine the voltage drop. A voltage that is 10% below the nominal rating will produce the following effects on induction motors.

Torque	Decreases 19%
Full load speed	Decreases 1.5%
Full load efficiency	Decreases 2 points
Full load current	Increases 11%
Temperature rise	Increases 6 to 7 degree C
Over load capacity	Decreases 19%

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Voltage at the customers meter must be assumed to be the lowest allowable voltage at the meter. This would be 218.5 volts on single phase and 379 volts on three phase.

STANDBY POWER GENERATOR SYSTEM

Standby power systems are generally installed to provide and emergency source of electric energy to serve loads such as refrigeration, communications, or industrial processes that, when stopped during power outage could cause interruption of the process or damage to the product.

The transfer switch, if exposed to the weather, must be rain-tight and must be of the same capacity or larger as the meter loop and main switch.

Transfer switches and wiring associated with the stand-by system shall be provided with suitably rated protective devices.

Standby generators or any other alternate source of electrical power must be isolated from the main power source through a double throw transfer switch, See drawing No. 35.

STATIC PHASE CONVERTER

The installation of any phase converter should be made by a competent electrician. The unit should be mounted upright in a vertical position and fastened securely to a firm support. Indoor installations are preferable but not always practical.

Before connecting the phase converter, establish that the frequency is 50 hertz and the supply voltage matches the converter rating.

A single-phase supply shall be connected through a fuse disconnect switch using fuses designed for motor starting and rated at 125% of the single-phase rating of the converter.

A magnetic starter with overload protection in each phase is required for adequate motor protection.

Motors installed with phase converters must be metered on the single phase input side of the phase converter.

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Multi-speed motors may cause an application problem when using a static phase converter.

An installation where several motors are being operated requires further knowledge of the use of static converters.

The motor currents of each phase should be checked with a clamp-on ammeter and balanced if necessary. The motor must be loaded before taking the readings.

If the load changes by more than 10%, the static converter must be rebalanced for optimum operation.

There will be some motor phase current unbalance on varying load conditions, however there need be no cause for concern unless these currents exceed the nameplate rating of the phase current balance to the three-phase motor is critical. It is recommended that the phase currents be within 5% balance.

The percentage of unbalance is to be computed by the following formula:

$$\%\ \text{CURRENT UNBALANCE} = \frac{\text{Maxm Current Diff from-Avg}}{\text{Average Current}} \times 100$$

$$\text{AVERAGE CURRENT} = \frac{\text{Phase 1} + \text{Phase 2} + \text{Phase 3}}{3}$$

The straight capacitor type static phase converter is not recommended for the submersible pump motor. The auto transformer-capacitor type can be used very successfully.

The submersible pump motor will have a "maximum current rating" which includes the service factor amps of the motor maximum rating. Therefore, the installation must be evaluated differently than the above ground motor be greater and the KVA requirements will be greater. The submersible pump motor manufacturer furnishes a chart indicating the proper size of wire that must be used for the specific setting of the submersible pump motor. These recommendations should be followed exactly.

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BALANCING INSTRUCTIONS FOR ADD-A-PHASE CONVERTER

"A" PHASE TOO HIGH :	Too much capacitance in the circuit. Disconnect the oil capacitors one at a time until the current reading in "A" phase is the same as the reading in "B" and "C" phase, or the nameplate rating of the motor.
"A" PHASE TOO LOW :	Too little capacitance in the circuit. Capacitors one at a time until the current reading in "A" phase is the same as the reading in "B" and "C" phases. Capacitors can be disconnected from, or connected into, the circuit by disconnecting or connecting one of the terminals on the oil running capacitors. Extra capacitors can be added for balancing.
"B" PHASE TOO HIGH :	Transformer Tap "X" lead should be moved to number on the transformer.
"B" PHASE TOO LOW :	Transformer Tap "X" lead should be moved to higher number on the transformer.
"C" PHASE TOO HIGH :	Indicates motor is overloaded with respect adjustment of the ADD-A-PHASE. Add all oil running capacitors to the circuit and move the transformer tap "X" lead to a number tap. If "A" or "B" phase currents are now high, follow steps 1 or 2 respectively. If "C" phase is still high the next larger size motor and ADD-A-PHASE should be applied to the load or reduce the load.

Revision:				
BANGLADESH RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-33	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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WIRE SIZES FOR ADD-A-PHASE CONVERTER

The wiring from the converter to the motor must be of correct size for proper starting torque and for prevention of excess current due to low voltage.

To determine the minimum wire size to be used from converter to motor, first take the full load amperes of the motor nameplate x 125% (if nameplate current is not available refer to Table-6). after current has been established refer to Table No. 5 for wire size.

To determine the minimum wire size from power source to converter, take the full load amperes (as above) x 125% x 2 and refer to table No. 5A & 5B for wire size. It is possible for the single phase current to be two times the full load current of the three phase motor.

ROTARY PHASE CONVERTER

SELECTION OF ROTARY UNIT AND CAPACITORS

One rotary converter can operate several motors at the time under varying load conditions. the horsepower rating of the largest motor to be operated determines the minimum rating of the rotary unit. If only one motor is to be operated determines the minimum ratings of the rotary unit. If only one motor is to be operated, the horsepower of the rotary base should be same as the load motor horsepower. Over sizing the rotary unit, in most installations, would not be an advantage and would result in a slight loss in efficiency. Under sizing would limit the load applied to the load motor and possible damage could occur to the motor.

Capacitors providing running current for the manufactured phase must be of continuous run type. For 230 volt system a rule of thumb is to install 40 mfd per horsepower. this should provide adequate current for motors operating close to full load conditions. If reduced load condition occur, one or more capacitors are disconnected for better current balance. The voltage rating of the capacitors must be equal or higher than the operating voltage on the single phase system. For 400 volt systems, about 25 mfd per horsepower should be adequate.

Rotary base units specially designed for Rotary Phase Converters will starts with run capacitors only. Using a standard motor for a rotary base in a converter often requires additional capacitors for starting and bringing the rotary unit up to speed. For lower cost investment and less maintenance, a simple switch or breaker may be used to switch a small bank of electrolytic capacitors from the run capacitor circuit after the rotary unit is up to speed.

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INSTALLATION

These Converter like any piece of electrical equipment, are installed and serviced by trained and experienced personnel. Many of the problems with have been due to improper installations. Incorrect connections of wires to the converter, loose connections, undersized wiring, or poor workmanship are some of the examples of improper installations.

The size of wire can be determined by referring to Table - 9. Although this instruction refers to static type phase converters, the same charts applies for Rotary Converters as well. Full load current for electric motors and current ratings conductors are also available in the PBS Instruction. It is desirable to install the Rotary Converter as near as practical to the load motor. If distance of 7.62 M (25 ft) or more separates the load motor from the converter, voltage drop within the conductor shall be considered when selecting wire size.

A single phase switch is suitable for energizing the rotary base unit. The phase current requirements of the three phase load motor are not the same as the phase current of the single phase service. Three phase load current multiplied by the square root of 3 (i.e., 1.732) will equal the single phase current. With the ground wye system of the PBSs, the neutral is maintained at ground potential. The Code does not permit switching the neutral. All poles if more than one, in the rotary base unit switch, may be paralleled for added current carrying capacity.

The three conductors are feeding out from the Rotary Phase Converter are considered three phase conductors and are to be treated as three phase. The manufactured phase becomes "A" phase. The phase conductor of the single phase source is now "B" phase. The single neutral is now "C" phase. A three phase magnetic starter with thermal overload protection in each line is required. the holding coil of the magnetic starter must be connected across "B" and "C" phase. Do not connect the coil to "A" phase (manufactured phase). Wye start delta run starting is not to be used for soft start. The Rotary converter provides soft starting by nature of the design. Across the line starting is recommended for starting the load motor.

ROTARY CONVERTER OPERATION

"A", "B" and "C" phase should be tagged or colour coded for convenient identification. Provisions for the use of a clip on ampere meter to measure and balance phase currents are necessary.

The Rotary Converter must be fully up to speed before the load is applied.

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a) If starting capacitors are required for starting the rotary base unit, switch the bank of the electrolytic to the on position.

Note: Some rotary base units will start and come up to speed without start caps. It will be worth a try of step b) to see if the rotary base will start and come up to speed without start caps.

b) Energize the rotary base switch for staring the rotary unit. The rotary unit should come up to speed within a few seconds when the switch is energized. The direction of rotation of the rotary unit is insignificant in operating the load motor.

c) Immediate switch off the start capacitors after the rotary base unit reaches full speed. Any delay will over heat the start capacitors and possibly do damage.

d) Without further delay, energize the load motor with the magnetic starter. The load motor should come up to speed normal steps may be taken to reverse the rotation. Reserve any two phases on the load side of the starter or at the motor terminals. As previously stated, it is not good for the rotary base unit to run idle for more than a few minutes. Circulating current within the rotary base will raise the temperature of the unit.

e) Current balance cannot be obtained unless the motor load applied. A clip on ampere meter should be used to measure the phase current between the load motor and motor starter.

BALANCING PROCEDURE

If "A" phase is high than "B" phase, disconnect run capacitors in the converter one at a time until "A" and "B" are balanced or in close range of balance. If "A" phase is low, connect additional capacitors until a balance is achieved between "A" and "B". Since there are no taps on the rotary base unit, "C" phase current can only be changed by the load applied to the motor.

Power Factor correction capacitors should not be used at the load motor. The rotary based capacitors installed for providing current for "A" phase will achieve the desired power factor level required by the PBS. Any additional capacitors installed at the motor will create a current unbalance between "B" and "C" phase.

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METER INSTALLATIONS FOR SEASONAL IRRIGATION LOADS

The following practice shall be for low lift pumps, deep tube wells, and shallow tube wells. For other than exceptional cases all service drops and single phase meters shall remain in place after the seasonal load is disconnected. The three phase meters shall be removed from the meter socket for disconnect.

Steps shall be taken to insure quality workmanship as well as an expedient method for connecting and disconnecting.

The meter and disconnect device shall be installed on a permanent structure above the highest flood level. See drawing No. 41, 42, 43, 44, 45, 46 & 47.

The meter and disconnect device shall be installed in an accessible location for convenience of the PBS and consumer.

Service conductors shall be sized for motor loads in accordance to motor and conductor Table No. 5A, 5B and Table-6.

The pump motor should not be more than 23 Meters (75') in distance from the meter installation. If greater distance is required, voltage drop shall be considered when calculating conductor size.

The main switch should be installed on the consumer side near the meter. Exception: If the main switch is installed on the pump motor assembly by the manufacturer, fuse cut-outs may be used at the meter for disconnecting the consumers conductor.

Provisions shall be made to protect main switch & fuse cut-out from rain.

Meter sockets and main switch enclosures mounted on pole or pole structure shall be grounded to pole ground.

The consumer may remove his conductors, main switch, and other equipment after the meter is disconnected if he desires.

All PBS equipment will remain in place when disconnect is given. Exception: Three phase meters will be removed ad taken to PBS stores.

Revision:				
BANGLADESH RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-37	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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METER DISCONNECTS AND RECONNECTS-FOR AUTHORIZED BREB/PBS PERSONNEL ONLY !

Steps for disconnecting Single phase meter.

1. Break seal and remove terminal cover on bottom of meter.
2. Using and insulated screwdriver loosen terminal screws on load side only and remove consumer's conductors.
3. Insert plastic plug manufactured for this purpose, in phase terminal # 4 only and tighten screw with insulated screwdriver. DO NOT REMOVE LINE SIDE CONDUCTORS. Exception: Plastic Plug not necessary with side entrance terminal cover.
4. Replace terminal cover and reseal.
   The PBS meter and equipment will remain in place for future use.

Steps for reconnecting Single phase meter.

1. Break seal and remove terminal cover on bottom of meter.
2. Using an insulated screwdriver loosen terminal screws on load side and remove plastic plug.
3. Connect consumer's conductors and securely tighten terminal screws.
4. Replace terminal cover and reseal.

Steps for disconnecting Conventional three phase meter.

1. Break seal and remove cover and meter.
2. Disconnect consumer's conductors if consumer plans to remove his wiring.
3. Install blank cover plate.
4. Replace socket cover and reseal.

The PBS equipment, other than the meter, will remain in place for future use.

Steps for Reconnecting Conventional three phase meter.

1. Break seal and remove blank cover plate.
2. Reconnect consumer's conductors if they were disconnected previously.
3. Insert meter in socket.
4. Replace cover and reseal.

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-38	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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WIRING STANDARD FOR POWER FACTOR CORRECTION

CAPACITORS ON THREE-PHASE LOADS

All new three-phase consumers with inductive loads are required to install capacitors in order to improve the expected power factor. The capacitors must be installed as a part of the electrical equipment and the wiring and equipment installation must be approved by the PBS wiring inspector before the PBS energy meter is set and energized. The required capacitance to be determined by MS Department.

The capacitors shall be located on the electrical panel board near the motor starter and connected phase to phase on the load side of the starter.

When using a wye(Y)start and delta(Δ) run starter the capacitors will not remain electrically connected across the motor windings when the motor is not be energized. An electrical circuit for discharging the capacitors must be included for personnel safety, See drawing No. 37.

Compliance with this instruction shall not be regarded as an exemption from the power factor penalties as set forth in the rate schedule. The PBS will retain the right to measure the consumer power factor at any time after energization.

Minimum Requirement of Capacitors for the improvement of Power Factor for running Three-Phase and Single-Phase Installation may be determined from the Table-11 in the following pages.

WARNING

Capacitors will retain charges that will cause serious electrical shock to personnel if contact with capacitor circuits are made. Provisions must be made for discharging the capacitors when the motor is not in use. A simple and inexpensive way to do this is to install two low wattage (0-5 Watts) light bulbs in series to neutral in each phase. These bulbs must remain in the circuit at all times. The bulbs will provide an electrical path for discharging the capacitors when the motor switch is off. If any of the bulbs are burned out or removed from their sockets the capacitors will not discharge when the motor switch is off and dangerous conditions will again exist.

Exception: Capacitors connected to the motor side of conventional magnetic starters will discharge through the field windings of the motor.

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-39	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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SPECIFICATIONS FOR ELECTRIC SERVICES TO WEEKLY/SEMI-WEEKLY CONVENED HAT-BAZARS.

The following specifications for extension of Electric service facilities to weekly/ semi-weekly convened Hat-Bazars (i.e. the Hats and Bazars where many consumers require electric service connections only one or two days a week) will be applicable, provided the respective Hat-Bazar Committee enters into a written agreement with the Palli Bidyut Samity as per following guidelines and specifications:

I. GUIDELINES:

a. The Hat Bazar committee shall be responsible for the safety of the users of electricity in the respective Bazar.

b. The Hat-Bazar committee shall be responsible for collecting money from the individual shop owners and users and shall pay the Electricity consumption Bill to the PBS.

c. The Hat-Bazar Committee hired electricians under the supervision of a PBS Lineman, shall be engaged to install facilities that will safely allow safe operation, connection and disconnection of lights by the Bazar personnel on a daily basis and accurate metering and billing by the PBS on a monthly basis.

II. SPECIFICATIONS:

1. METERING DETAILS:

a. A class 50 single phase PBS meter will be pole mounted and enclosed in a grounded steel box, like irrigation units. If available a socket type single phase meter may be used.

b. The bottom edge of the box or socket will be at least 4 meter (13') above ground.

c. The service wire to the meter pole may be # 3 or # 6 duplex depending on its length and the number of user poles to be served.

2. MAIN SWITCH DETAILS:

a. The main switch will be sized for the load with the minimum size of 30 amps and will be mounted directly under the meter.

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-40	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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b. All wires must enter or leave through the bottom of the switch enclosure.

c. Top and sides of enclosure must be solid without openings except for door on the front.

d. Wiring will be # 6 duplex (Switch terminals must be made for aluminium).

e. Switch body (and metal enclosure) is to be permanently grounded.

f. There should be a continuous # 6 neutral.

g. Minimum clearance from the ground to the bottom of the box will be 3.7 Meter (12').

3. USER POLE DETAILS:

a. User poles will be 7.62 M (25 feet) class 7 or 25 feet poles received from broken poles, and located in the centre of shop rows to avoid path crossings when possible (see sample design).

b. User poles will be so located that no twin-core-service drops will cross any road where motorized vehicles/ automobiles may ply.

c. All # 6 splices must be done with compression or split bolt connectors (no wrapping is acceptable) and properly insulated with tape.

d. A maximum of 10 poles will be allowed under each meter.

e. Poles will usually be spaced 9.2 Meter (30') apart, but this will depend on the layout of the Bazar.

f. GI ground wire to be spliced as per BREB approved method.

4. USER ENCLOSER DETAILS:

a. Enclosure must be made of galvanized steel (with solid grounding) or wood (painted inside and outside) with minimum inside dimensions of 254 x 305 mm (10"x12").

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-41	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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b. Top and sides of the enclosure must be solid without opening except for door on the front.

c. One 10 amp circuit breaker plus 10 (ten) convenience outlets and mounting board, minimum size 203 x 254 mm (8"x10") will be mounted securely inside enclosure.

d. The enclosure box will be so mounted that the bottom will be at least 3.35 Meter (11') above ground.

e. All wires will enter or leave the enclosure through the bottom.

f. # 6 duplex phase wire will terminate at the breaker.

g. # 6 neutral wire will be solidly connected to the pole ground.

5. USER WIRING DETAILS:

a. Individual users will connect to the sockets installed within the user enclosure by means of 1.5 mm^2 (3/.029) twin core or sheathed single core copper wire and standard 5 amp 2 pin plugs.

b. Each socket service user wire will be suspended by a GI messenger wire (# 12 minimum size).

c. Metal hooks will be driven into the pole beside or just below the enclosure for attachment and support of messenger wire loops.

d. The messenger wire will also be securely fastened to the users shop structure.

e. The user conductor should be slack at each end and looped into the bottom of the user enclosure.

f. When any foot-path is crossed by user wires, minimum 3.048 Meter clearance to ground must be maintained.

g. During wet and rainy conditions, all wiring terminals mast be covered and kept dry, the person (s) responsible for making the connections will ensure this before plugging anything in.

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-42	6(02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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III. SUMMARY OF REQUIRED FACILITIES AND OWNERSHIP:

1. PBS SUPPLIED MATERIAL & EQUIPMENT:

a. 7.62 Meter (25 feet) class 7 poles, or 7.62 M poles received from broken poles.
b. Single phase meter.
c. Duplex service wire (# 6) and attachment hardware.

2. BAZAR COMMITTEE SUPPLIED MATERIAL & EQUIPMENT:

a. Main switch (minimum 30m amp, maximum 100 amp) with rain tight enclosure.
b. One rain tight enclosure for breaker and user points on each pole (steel with ground or painted wood).
c. One circuit breaker per user pole.
d. All house-wiring materials for providing convenience outlets to socket services on each user pole.
e. One 1829 mm (6') grounding rod per user pole plus GI wire to extend ground into the enclosure.
f. One rain tight enclosure for breaker and user points on each pole.
g. Metal hooks on each pole for attaching messenger wires.

3. SHOP-KEEPER/USER SUPPLIED MATERIAL & EQUIPMENT:

a. 1.5 mm^2 (3/.029) conductor from pole to shop.
b. 12 GI messenger wire.

c. 5 amp 2 pin plug.
d. Lighting socket and bulb.
e. If need arises, use bamboo or other overhead support for user wire (to maintain 3048 mm (10') clearance over paths).

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INSULATION RESISTANCE

An insulator is a material which has a very high resistivity in comparison with a good conductor of electricity. For this reason conductors which have to be maintained at a reasonable potential with respect to earth are either entire sheathed in insulating materials (cables) or are supported by insulators (OH line). Even so, there is always a certain amount of leakage to earth.

The insulating resistance is the resistance to true leakage current. In insulated cables, the useful current flows axially along the core, whereas the leakage current flows radially from the core to sheath. It therefore, follows that the Insulation Resistance of a cable is inversely proportional to its length, whereas the conductor resistance is directly proportional to the length. Again with the increase of cross sectional area of the insulation the Insulation resistance increases, on the contrary the resistance of a conductor decreases with the increase of cross-sectional area.

Bangladesh Electricity Rules indicates that, the leakage current in any conductor shall not exceed (1/5000)th times the maximum current flowing through it.

Theory of Insulation Resistance provided method for determining the same by utilizing the resistivity of the insulating materials. The insulation resistance is given by the following equation :

$$R_t = \frac{2.303\rho}{2\pi l} \text{Log}_1 \frac{R}{r}$$

$$= K.\text{Log}_{10} \frac{R}{r} \qquad (l=1 \text{ Meter})$$

For PVC which is Widely used Cable Insulation for wiring cables, the conductivity is 2 x 10^{12} Ohm-cm i.e, 2 x 10^4 Megohm-m. Using this value for a length of 1 Meter K is found to be 7330. According to NEMA Publication WC-7, the value of K should not be less than 10,000 Megohm per 1000' for XLPE Insulations.

INSPECTION OF WIRING INSTALLATIONS

The following test and check shall be conducted during inspection of an electrical Installation on completion of wiring:

1. Continuity of wiring.

2. Testing of polarity of single phase switches to ascertain that they are installed on phase conductors.

3. Insulation resistance test between conductors, conductor to earth.

4. Earth resistance test. (For industrial consumer only)

During the inspection the wiring inspector shall ensure that:

a) The wiring has been made using standard materials as approved by BREB/PBS.

b) Main switches has been installed properly as approved by BREB.

c) Earth wire has been connected properly with the main switch and other metallic parts.

d) In case of industries, motor starter were applicable has been installed properly.

e) Meter board and service entrance arrangements have been made as per PBS wiring regulations.

f) Earthing rod has been driven properly into the ground.

g) Power factor improvement equipment has properly been installed by inductive load consumers, in applicable cases.

h) Changeover switch has properly been installed for consumer having standby Generators.

i) A Clear space of minimum 915 mm (3') in width has been kept in front of the main switches.

If there are any attachment or bare connections at the back of the switchboard, the space (if any) behind the switchboard shall be either less than 229 mm (9")

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or more than 762 mm (30") in wide measured from the further outstanding part of any attachment or conductor.

j) The operating switches and sockets have been installed at a standard height not less than 1220 mm (4'). These shall be placed such that opening of door or window shutters do not damage them.

ACCEPTABLE TEST RESULTS

As a standard practice in this sub-continent, if the insulation resistance shall be (50 ÷ Nos. of points.) Mega-Ohms. However, if the insulation resistance is found above 1(one) mega-ohms for the whole wiring installation of a residential building, the result shall be acceptable. But under no circumstances, a service shall be energized, if the test result shows values less than 0.5 Meg-ohms.

When megger testing is carried prior to fixing of light, fan and other loads, the conductor (phase) to conductor (phase/neutral) insulation resistance should not be less than 50% of conductor to earth Insulation resistance values.

Bangladesh Electricity Rules indicates that the maximum leakage current shall not exceed (1/5000)th times the Maximum Current of the installation. The other results shall be checked with this value when the connected load is reasonably less.

The minimum Insulation Resistance of an Electrical Equipment such as Motor, transformers etc. may be taken as the value recommended by AIEE Standard 43. As per this standard for machine upto 999 KVA,

$$R_i = KV + 1 \text{ Megohms. (Temp upto 75 Deg C)}$$

and for higher size machines at 40° C,

$$R_i = \{ 2.5 \times (KV + 3.6) \times (8 + rpm^{0.5})\} \div (KVA^{0.5} - 16) \text{ Megohms}$$

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TABLE - 9

MOTOR					AMPERE		MINIMUM CONDUCTOR		PUMP				
HP	φ	Volt	Amp	Phase Converter on 1-φ Line	Motor Switch Cap.	Fuse Cap.	To	Size mm^2	Size Suction and Delivery	Capacity CUSEC	Total Head Feet	1500 RPM CODE NO	Use
5	1	230	26		30	30	M	4	4" x 4"	3/4	30'-35'	61101	STW/ LLP.
	3	230		x	30	30	C M	4 4					
	3	400	8		15	15	M	2.5					
7.5	1	230	36		60	50	M	10	4" x 4"	1	30'-35'	61151	LLP
	3	230	21	x	60	40	C M	10 4					
	3	400	12		15	15	M	2.5					
10	1	230	46	x	60	60	M	16	5" x 5"	1.5	20'-30'	61251	LLP
	3	230	27		60	60	C M	16 4					
	3	400	15		30	20	M	2.5					

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-47	6(02-2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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MOTOR					AMPERE		MINIMUM CONDUCTOR		PUMP				
HP	φ	Volt	Amp	Phase Converter on 1-φ Line	Motor Switch Cap.	Fuse Cap.	To	Size mm^2	Size Suction and Delivery	Capacity CUSEC	Total Head Feet	1500 RPM CODE NO	Use
15	3	230	38	x	100	80	C M	16 10	6" x 6"	2	30'-40'	61301	LLP
	3	400	22		30	30	M	4					
20	3	230	50	x	100	100	C M	25 16					DTW
	3	400	29		60	40	M	10					
25	3	230	63	x	150	125	C M	35 25					DTW
	3	400	36		60	40	M	10					
30	3	230	73	x	150	150	C M	35 35					DTW
	3	400	42		60	50	M	16					

M = Motor. STW = Shallow Tube Well.
C = Converter. DTW = Deep Tube Well.
LLP = Low Lift Pump.

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-48	6(02-2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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TABLE - 10

SELECTION OF SOME COMMON KWH METERS FOR VARIOUS MOTOR RATINGS

HP	φ	Volt	Phase Converter on 1-φ Line	Demand Register	Instrument	Meter Class	Meter Class
5	1 3 1	230 230 400	x			10(30) 10(30) 100	50 50 100
7.5	1 3 3	230 230 400	x			50 50 100	 100
10	1 3 3	230 230 400	x			50 50 100	60(150) 60(150) 100
15	3 3	230 400	x			60(150) 100	 100
20	3 3	230 400	x			60(150) 100	 100
25	3 3	230 400	x			60(150) 100	 100
30	3 3	230 400	x	 x		60(150) 100	 100
40-70	3	400		x		100	100
70-400	3	400		x	400:5 CT	20	20
400-600	3	400		x	600:5 CT	20	20
600-1500	3	400		x	50:5 CT 6350:240 PT	20	20

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-49	6(02-2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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TABLE – 11

CAPACITOR SIZE:

KVAR of Capacitors = Load in KW multiplied by factor given in Table to improve from existing P.F. to proposed P.F.

Existing Power Factor	Proposed Power Factor				
	1.0	0.95	0.90	0.85	0.80
1	2	3	4	5	6
0.20	4.899	4.570	4.415	4.279	4.149
0.21	4.656	4.327	4.171	4.036	3.906
0.22	4.433	4.104	3.949	3.813	3.683
0.23	4.231	3.002	3.747	3.611	3.481
0.24	4.045	3.716	3.561	3.425	3.295
0.25	3.873	3.544	3.389	3.253	3.123
0.26	3.714	3.385	3.229	3.094	2.964
0.27	3.566	3.238	3.082	2.946	2.816
0.28	3.429	3.100	2.944	2.809	2.679
0.29	3.300	2.971	2.816	2.680	2.550
0.30	3.180	2.851	2.696	2.560	2.430
0.31	3.067	2.738	2.583	2.447	2.317
0.32	2.961	2.632	2.476	2.341	2.214
0.33	2.861	2.532	2.376	2.241	2.111
0.34	2.766	2.437	2.282	2.146	2.046
0.35	2.676	2.347	2.192	2.056	1.926
0.36	2.592	2.263	2.107	1.872	1.842
0.37	2.511	2.182	2.027	1.891	1.761
0.38	2.434	2.105	2.950	1.814	1.684
0.39	2.361	2.032	2.877	1.741	1.611
0.40	2.291	1.963	1.807	1.671	1.541
0.41	2.225	1.896	1.740	1.605	1.475
0.42	2.161	1.832	1.676	1.541	1.410
0.43	2.100	1.771	1.615	1.480	1.349
0.44	2.041	1.712	1.557	1.421	1.291
0.45	1.985	1.656	1.501	1.365	1.235
0.46	1.930	1.602	1.446	1.310	1.180
0.47	1.877	1.548	1.392	1.257	1.128
0.48	1.828	1.499	1.343	1.208	1.077
0.49	1.779	1.450	1.295	1.159	1.029

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-50	6 (02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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৬২১ তম বোর্ড সভায় অনুমোদন সিদ্ধান্ত নং ১৭৭০০

(Kamrul Ahsan Molla)
Asst. Secy. (Board), BREB.

TABLE-11 (Continued)

Existing Power Factor	Proposed Power Factor				
	1.0	0.95	0.90	0.85	0.80
1	2	3	4	5	6
0.50	1.732	1.403	1.248	1.112	0.982
0.51	1.687	1.358	1.202	1.067	0.936
0.52	1.643	1.314	1.158	1.023	0.892
0.53	1.600	1.271	1.116	0.980	0.850
0.54	1.559	1.230	1.074	0.939	0.808
0.55	1.518	1.189	1.034	0.898	0.768
0.56	1.479	1.150	1.995	0.859	0.729
0.57	1.442	1.113	1.957	0.822	0.691
0.58	1.405	1.076	1.920	0.785	0.654
0.59	1.368	1.040	1.884	0.748	0.618
0.60	1.333	1.004	0.849	0.713	0.582
0.61	1.299	1.970	0.815	0.679	0.549
0.62	1.266	1.937	0.781	0.646	0.515
0.63	1.233	1.904	0.748	0.613	0.482
0.64	1.201	1.872	0.716	0.581	0.450
0.65	1.169	0.840	0.685	0.549	0.419
0.66	1.138	0.810	0.654	0.518	0.388
0.67	1.108	0.779	0.624	0.488	0.358
0.68	1.078	0.750	0.594	0.458	0.328
0.69	1.049	0.720	0.565	0.429	0.298
0.70	1.020	0.691	0.536	0.400	0.270
0.71	0.992	0.663	0.507	0.372	0.241
0.72	0.964	0.635	0.480	0.344	0.214
0.73	0.936	0.608	0.452	0.316	0.186
0.74	0.909	0.580	0.426	0.289	0.158
0.75	0.882	0.553	0.398	0.262	0.132
0.76	0.855	0.527	0.371	0.235	0.105
0.77	0.829	0.500	0.344	0.209	0.078
0.78	0.802	0.474	0.318	0.182	0.052
0.79	0.776	0.447	0.292	0.156	0.026
0.80	0.750	0.421	0.266	0.130	--
0.81	0.724	0.395	0.240	0.104	--
0.82	0.698	0.369	0.214	0.078	--
0.83	0.672	0.343	0.188	0.052	--
0.84	0.646	0.317	0.162	0.026	--

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-51	6 (02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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৬২১ তম বোর্ড সভায় অনুমোদিত সিদ্ধান্ত নং ১৭৭০০

(Kamrul Ahsan Molla)
Asst. Secy. (Boards), BREB

TABLE-11 (Continued)

Existing Power Factor	Proposed Power Factor				
	1.0	0.95	0.90	0.85	0.80
1	2	3	4	5	6
0.85	0.620	0.291	0.136	--	--
0.86	0.593	0.265	0.109	--	--
0.87	0.567	0.238	0.082	--	--
0.88	0.540	0.211	0.056	--	--
0.89	0.512	0.183	0.028	--	--
0.90	0.484	0.155	--	--	--
0.91	0.456	0.127	--	--	--
0.92	0.426	0.097	--	--	--
0.93	0.395	0.066	--	--	--
0.94	0.363	0.034	--	--	--
0.95	0.329	--	--	--	--
0.96	0.292	--	--	--	--
0.97	0.251	--	--	--	--
0.98	0.203	--	--	--	--
0.99	0.142	--	--	--	--
1.00	--	--	--	--	--

Revision:

RURAL ELECTRIFICATION BOARD				
PBS Instruction 300-19 : WIRING SPECIFICATIONS FOR PBS CONSUMER				
Original Date	Reviewed by	Approved by	Section & Page	Rev. No
04/10/79	BREB	BREB Board	300-19-52	6 (02/2020)
Revision Dates: 03/05/83, 12/09/85, 31/10/96, 24/12/2013, 04/05/2014, 19/02/2020				

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৬২১ তম বোর্ড সভায় গৃহীত সিদ্ধান্ত নং ১৭৭০০

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