Trinidad and tobago electrical regulations

The Trinidad and Tobago Electricity Commission (T&TEC) is responsible for the distribution and transmission of electrical energy around the country. The electrical power comes from three main power stations which are Port of Spain (308MW station, Point Lisas (634MW) station and Penal (236MW) station. It is through this system the commission provides electrical power to its customers and meters this energy in order to obtain revenue. However the system is also one of the most vulnerable parts of that company's infrastructure, as they are prone to damage in a myriad of different scenarios. These reasons have caused power companies such as T&TEC to lay down some of the strict standards, which we will now be examined in detail. Since this report is concerned with industrial wiring systems, mainly three-phase AC voltage will be addressed. The energy that they supply is only single or three phase with frequency of 60 hertz.

TRANSMISSION SYSTEMS

Characteristic of Supply

T&TEC supplies energy with the following declared voltages and characteristics:

Single phase, 2 wires, 115 volts used for installation with loads up to a maximum of 30 amperes (A).

Single phase, 3 wire, and 115/230 volts for installation with loads up to a maximum of 200 amperes (A).

Three phase, 4 wire, 115/230 volts from a delta-connected source for installations with combined lighting and power loads up to a maximum demand of 199KVA. Voltage of 230 across phase wires, 115 between either

of two phase wires and earthed neutral, and 200 volts between this third phase wire and neutral. (This third 200V phase wire must be positively identified with the color blue throughout the installation or by whatever means of identification is required by the codes in force.

Three phase, 4 wire, 230/400 volts from a star connected source for installation with combined lighting and power loads up to a maximum of 350KVA.

One of the following high voltages depending on the maximum demand of the load, location of the installation and the voltage available at the location:

Table : High voltage supply

3 phase

3 wire

6. 6KV

3 phase

3 or 4 wire

12KV

3 phase

3 wire

33KV

3 phase

3 wire

66KV

3 phase

3 wire

132KV

*Accordingly the Commission should be consulted before the consumer makes plans for an installation to be supplied at high voltage.

Consumers requiring supplies with utilization voltages other than the Commission’s standard voltages as discussed above from (a) to (e) will be supplied at one of the commissions high voltages declared in (e) and are required to provide their own transformers. The Electricity Supply rules made under Section 15 of the Electricity (Inspection) Act Chapter 54. 72 provides for variation of 6 percent above or below the declared voltages.

As a result a few guide lines are to be followed:

1. The point of supply must be near the face of a building and at the commissions’ distribution pole.

2. When the appropriate voltage supply is available, the point of supply for an installation supplied at 115/230 or 230/400 volts, must be at the Commission’s distribution pole

3. If a transformer must be installed to supply the 115/230 or 230/400 volt then the transformer has to be the point of supply.

4. The point of supply for a consumer’s installation supplied which is at high voltage will either be the consumer’s terminals which is connects to the service line or the terminal of the commission’s disconnecting means.

Provided that the consumer has consulted the commission to determine the location of the point of supply (the point at which T&TEC supplies energy) for the new installation, the commission shall provide only one service line to supply a building. The service lines are any electrical conductors through which energy may be supplied or is intended to be a supplied by the commission. These conductors are runs from the distribution main or directly from the premises of the Commission. See figure below.

Fig. 1 Typical Overhead Service Line with Consumer’s Entrance cable on Consumer’s building

Figure : typical overhead service line with consumer’s entrance cable on private pole

POSITIONING OF SERVICE LINE

The position of the weather- head or gland at the point of entrance must be placed at a minimum distance of 15cm away from the bash board and not in the direct path of water flow from rooftops and guttering.

It must be note also that the Commission only provides one service line to supply a building.

The customer’s point of entrance must not be located directly above a building extension or split roof.

The minimum height to which the overhead service conductors are to be connected are 3. 7 metres above the finished grade level, or for a greater height it is necessary to maintain it at a minimum height of 6. 1 metres for clearance of the Commission’s over head service line over roads.

Every industrial installation shall be adequately controlled by a manually operable, physically and electrically separated fused main switch or circuit breaker. This disconnecting means shall be readily accessible to authorized or qualified personnel, properly identified and preferably located near to the service conductors as possible.

Conductors and Cables

Service Entrance Conductors are the portion of the installation between the point of entrance and the consumers’ main disconnecting device. This generally means it is the customer cable to which T & TEC connects to give supply from the service line. The service line is connected to the Distribution main.

T&TEC service connects only to a single consumer’s entrance cable at the point of supply to a building. The overhead line service conductors must be connected at a minimum height of 3. 7 meters above finished grade level. For height that is greater it is necessary maintain a minimum height of 6. 1 meters for clearance of the service line over roads. The entrance cables to the point of supply shall be in either rigid metallic conduit treated against corrosion or other approved non-corrosive enclosures or shall be concentric

or tamper-proof cable form the consumer’s terminals to the metering equipment and should preferably continue to the consumer’s main switch. If conduit is used, only standard conduit elbows and fittings to facilitate pulling of the cables should be allowed. An approve weather head is required at the consumer’s terminals at the point of supply and a minimum of 0. 5 meters of cable must be left for connection to the Commission’s overhead service line. Attachment to the commission’s conductors shall be made a point no less than 0. 3 meters form the weather head. The consumer must also provide and install terminating lugs for connecting to cables with conductor sizes larger than 95mm2. For underground entrance cables, it is preferred that for 115/230V and 230/400V installations, the Consumer’s terminals at the point of supply be located at a pole furnished and maintained by the consumer.

Size of Conductors Conduits And Cables

The size of an entrance cable for a building with two or more metered installations supplied at 115/230 or 230/400 volts shall not be less than 16 sq. mm. This cable size is for copper conductors with rubber, polythene or P. V. C. insulation. Other approved cables can be used with equivalent current carrying capacities.

The size of every conductor shall be such that its current rating, is necessary, of rating factors appropriate to the type of cables and the conditions of installation, is not less than the maximum sustained current which will normally flow through it. Also the size of the conductor shall be that the voltage drop from the consumer’s terminals to any point in the installation does not exceed 2. 5% of the declared nominal voltage when the

conductors are carrying the maximum current under their normal conditions of service.

Single core cables armoured with steel wire shall not be used for carrying alternating current

MINIMUM INSTALLATION BENDING RADIUS

During installation, PVC armored cables should not be bent to a smaller radius than six times the overall diameter for cables having circular conductors and eight times for other armored cables. Every cable termination shall be accessible for inspection and shall be mechanically and electrically sound. The insulation tape or braid shall be removed no further than is necessary.

PROTECTION OF CABLES

Conductors of cables shall be insulated with the correct class of insulation in accordance with the appropriate standard to withstand a voltage not less than the highest sustained voltage to which they are likely to be subjected. Any insulation damaged by soldering otherwise shall be cut away and replaced by suitable insulation at least as thick effective as the original installation. Termination of cables should not be in locations where flammable and/or explosive dust, liquid, vapor or gas is likely to be present. Otherwise the termination shall be enclosed in a flameproof fitting. For paper or varnished-cambric-insulated, metal-sheathed cable, a wiped metal sleeve or joint box, filled with insulating compound shall be provided.

Laying of cables underground

Cables underground must be 18″ deep buried in red sand (sand bed) surrounded by concrete slabs then covered with red danger tape over the slabs. If the cable is passing under a roadway, the cable must be a concrete duct and must be inspected before being buried.

Positioning of transformer and switchgear

All service equipment which include transformers, panels, switch gear etc, must have a working space of 3 feet around them, they must be positioned where they are easily accessible to the authority, in an upfront foremost position away from pedestrian travel, if it is pedestrian travel place billards around them to prevent people from crashing into them.

Metering

Metering can be accomplished through socket type metering or three phase metering, the later being more expensive.

Current

Type

0 – 200

Single phase

> 200

Three phase wiring

200-500

Current transformer metering

> 500

High voltage metering

Generally, a single meter is used to measures all electrical energy supplied at that single location. It records the number of units (kilowatt hours) of electricity you have used and is quite easy to read, and consumption records are simple to keep. The Trinidad and Tobago Electricity Commission uses the recorded electricity usage to accurately calculate the consumer electrical bill. The three types of meter normally use are the digital, the Dial and the AMI meters. The service entrance cable is connected to the meter. If a splitter box is to be used first splitter box then the meter . If no splitter box is used, then connect only to the meter. Splitter arrangements can also be used to split the load.

In metering there are a few regulations that must be followed in connection, positioning and reading. They are as followed:

For an indoor-type meter, the consumer shall provide a meter-board for mounting the meter. This board shall be of an approved size, and shall be made from 19mm hard-wood stock, free from knots set plumb, and level and securely fastened for substantial supports

In order to make meters more accessible, the tops of the meters should not be greater than 1. 8m or less than 1. 5m above floor or finished grade level. A clear space of at least 0. 9m in front of all meters must be available at all times.

Meters should not be located over doorways, along stairways or directly under water pipes or drain pipes. They should also be mounted free from shock, vibrations and mechanical injury.

Meter sockets should be installed on an outer wall of the building. In a building elevated more than 2. 4m above ground, the meter should be located on one of the supporting columns of the building.

Meters for a multi-level building shall be grouped in one location on either the basement or ground floor in an accessible location. Where there are greater than 6-metered installations, groups of at least 6 meters can be installed on the basement, ground floor, or an accessible upper floor.

Outdoor socket-type meters shall be installed for single phase 115/230V installations up to a maximum of 200A; meter sockets of the ring less type can be used, but must be provided with an approved means for sealing the cover.

Outdoor socket-type meters shall be installed for three-phase 115/230V and 230/400V. Installations with loads up to 200A per phase. Whole current or self-contained socket-type meters shall meter such installations

For 201-500A loads per phase, current transformers shall be used. The commission shall install a current transformer cabinet, meter-board and meter cabinet where necessary. The meter cabinet shall have a minimum depth of 25. 4cm. Between the current transformer cabinet and the meter board, a 20mm conduit containing three (3) 1. 5mm2 red, white and blue, and four (4) 2. 5mm2 red, white, blue and black 600V insulated conductors

must be provided by the consumer. The conductors should be a maximum 15m in length. Lengths of at least 0. 9m must be provided outside the two ends of the conduit to permit the external connections to the meter and current transformer.

Three-phase, 115/230V and 230/400V installations requiring loads in excess of 500A per phase shall be supplied and metered at high voltage. The metering unit shall be installed on a Distribution Pole or in the consumer's transformer substation subject to the conditions of the supply.

Fig. 4 Typical Installation Single Metered Low Voltage Supply

Figure : Single meter high voltage supply

CIRCUIT BREAKERS

A circuit breaker is a device for closing and interrupting a circuit between separable contacts under both normal and abnormal conditions, with selection based on the type of application being either alternating current (ac) or direct current (dc). The established voltage rating of a circuit breaker is based on its clearance or space, between electrical circuits and between electrical components and the ground. Circuit breaker voltage ratings indicate the maximum electrical system voltage on which they can be applied. Circuit breakers voltage must be equal to or greater than voltage of the electrical system on which they are used.

Circuit breakers have two types of current ratings; continuous current rating and fault current-interrupting capacity.

Low voltage (less than 1000 VAC) types are common in domestic, commercial and industrial application, include:

MCB (Miniature Circuit Breaker)-rated current not more than 100 A. Trip characteristics normally not adjustable. Thermal or thermal-magnetic operation. Breakers illustrated above are in this category.

MCCB (Molded Case Circuit Breaker)-rated current up to 1000 A. Thermal or thermal-magnetic operation. Trip current may be adjustable in larger ratings.

Low voltage power circuit breakers can be mounted in multi-tiers in LV switchboards or switchgear cabinets.

Positioning of circuit breaker

A circuit breaker in a wet location or outside a building must be enclosed in a weatherproof enclosure. This enclosure must be so equipped as to prevent moisture and water from entering and accumulating within the cabinet.

Circuit breakers must be mounted so that there is at least 6. 35mmm of airspace between the enclosure and the wall or the supporting surface, with exceptions being metallic cabinets and cut-out boxes which may be installed without the airspace on a concrete, masonry, tile or similar surface.

All circuit breakers should be installed at least 2m above the floor or working platform.

Fuse

A fuse is placed in an electrical current circuit so that when current flow exceeds the rating of the fuse it “ blows” or “ blows out.” The elements in

the fuse melt, opening the circuit and preventing other components of the circuit from being damaged by the over current. The size of the metal fuse element determines the rating. Once a fuse “ blows” it must be replaced by a new one.

Standards for the Use of Circuit Breakers and Fuses

The minimum sizes of main switches or circuit breakers permitted on consumer’s installation are as follows:

Characteristic of supply

Minimum Current rating

115 volts, 2 wire, 1phase

30 amperes

115/230 volts, 3 wire, 1 phase

60 amperes

115/230 volts, 4 wire, 3 phase

60 amperes

115/400 volts, 4 wire, 3 phase

60 amperes

Table : circuit breaker sizes

The consumer shall furnish and install a high voltage circuit breaker at the primary disconnecting means for an installation with a maximum demand in excess of 800 KVA.

In a building with more than one separately metered Consumer’s Installation a metal splitter box with a suitably sized Circuit Breaker for each Installation shall be installed between the Consumer’s Entrance Cable and the meter sockets by the Consumer/s or Landlord. Provision shall be mode on the splitter box for the Commission to apply its seals or locks. Each Circuit Breaker In the splitter box shall be suitably identified with the Consumer’s Installation connected to it.

Where there are seven or more separately metered Consumers Installations in a building, a main disconnecting means or Circuit Breaker shall be installed between the Consumers’ Entrance Cables and the group of Circuit Breakers In the splitter box by the Consumers or Landlord. Provision shall be made for the sealing or locking of this switch or breaker by the Commission.

Consumer shall furnish and install a high voltage Circuit Breaker as the primary disconnecting means for an Installation with a maximum demand in excess of 800 KVA. The Consumer should conform with the Commission’s Specification with respect to the rating and rupturing capacity of the Circuit Breaker. The limits of the Consumer’s protection setting shall be stipulated by the Commission to ensure discrimination with the protection of the Commission’s system.

It is recommended that the Consumer maintain an adequate supply of spare parts for the normal maintenance of his circuit breaker and ancillary apparatus.

The selection of the type of circuit breaker most suitable for protection of a DC installation depends mainly on the following criteria:

The current, which determines the rating of the equipment;

The rated voltage, which determines the number of poles in series necessary for breaking;

The maximum short-circuit current at the point of installation, which determines the breaking capacity;

The type of network.

It is recommended that the consumer maintain an adequate supply of spare parts for the normal maintenance of his circuit breaker and ancillary apparatus

BRANCH CIRCUITRY

A branch circuit is defined as that part of an electric circuit extending beyond the last circuit breaker or fuse. The branch circuits start at the breaker box and extend to the electrical devices connected to the service. Branch circuits are the last part of the circuit supplying electrical devices. These circuits are classified in two different ways, according to the type of loads they serve or according to their current-carrying capacity.

Motors

The table below show the supplies required for motors with different power rating.

Motor power rating /watts

Supply

750 and below

115/230, single phase

Between 750 and 5. 6K

230, single or 3 phase

5. 6K and over

230/400, 3 phase

For single-phase motors rated between 3. 75 Kilowatts and 5. 6 Kilowatts it should be arranged for no load starting. Motors of over 5. 6 kilowatts must be arranged for reduced voltage starting. The commission will be prepared to consider direct online starting of motors of these sizes where the supply to the consumer’s installation is at high voltage. Any apparatus having power rating larger than 2. 5 KVA can be supplied at either 115/230, single phase. Apparatus greater than 2. 5KVA up to and including 15 KVA in size can be supplied at 230 volts, single phase. Any rating larger than 15 KVA in size can only be supplied from a three-phase supply. Single-phase appliances and motors supplied from a 3 or 4 wire installations shall be so connected that

the operating current unbalanced would be a minimum. Three phase motors should be protected against single phasing conditions. When the rotor of the motor is locked, the motor requires the highest current. Direct online starters can be used also, if current goes and comes.

Plugs

Plugs in most residential and commercial establishments do not exceed 150V between conductors on branch circuits. That is, they are usually rated at 15-20A with exception to a 240V circuits.

Lighting

Lighting circuits usually do not exceed 150 watts to ground. These circuits are usually rated at 15 amperes or less in most homes and commercial establishments due to the fact that at some time during the use of the device the consumer may see the need to replace the fixture.

Qualify personnel only should service the lighting fixtures. When installing for industrial purposes the voltage to the ground on the lighting circuit could be as much as 330V. With these conditions incandescent fixtures must be mounted 8 feet or more above the floor or at the available height. Where conditions do not permit 8 feet, then the fixtures should not be readily accessible (i. e. they should be encased, etc). Such a supply would be provided by a 3-phase, 4-wire 277/480V wire system.

For public and commercials areas the voltage should not exceed 300V to the ground. Trinidad and Tobago wiring code law states that no final circuit should provide more than 15 lighting fixtures.

Type of receptacle	Maximum Number of Outlets	Maximum Branch Rating (Amps)	Maximum Cable Cross-section (mm2)	Remarks
DOMESTIC				
Socket outlet other than kitchen or laundry	6	20	2. 5	15 A Duplex
Kitchen	2	20	2. 5	15 A Duplex
Laundry	1	20		

2. 5

20 A Duplex

Air condition

1

20

2. 5

15 A, 230V Duplex

INDUSTRIAL

Lighting

6 x 115V

8 x 115V

15

20

1. 5

2. 5

200VA per outlet

Receptable outlets

3

4

5

15

20

30

1. 5

2. 5

4. 0

500VA per outlet

GROUNDING

Grounding is one of the most important factors involving electrical wiring, it provides safety to personnel, equipment and safety.

Standards for Grounding

i) All wiring installations shall include a consumers’ earth terminal or the equivalent to which the following shall be connected by an earth-continuity conductor:

All metal work associated with the wiring system including cable sheets, armor, conduits, ducts, and boxes.

Exposed metal of apparatus

Earth terminals of socket-outlets

One point of the secondary winding and of the metal work of any transformer used in the installation, except where the transformer is contained in apparatus

ii) The connection to the earth electrode or any other means of earthing shall be readily accessible and soundly made by use of soldered joints or substantial clamps of non-ferrous material and where connection is made to a metal pipe of external diameter not exceeding 100mm, clamps of an approval type shall be used.

iii) The earthing lead shall be connected to the line side of the consumers' main disconnecting means, to an effective earth electrode buried in the ground, for example a metal water pipe system having metal to metal joints or to a copper strip or rod. Connection to a water pipe shall be made as near as practicable to the point of entry onto the ground. Gas piping or non-metallic water piping shall not be used. Metal frames or portable, stationary and fixed electric appliances operating on circuits above 50 volts to ground shall be earthed in an approved manner. Metal fixtures and lighting equipment installed on outlets wired with grounded multicore cable, with metal raceway, grounded metal-clad cable, non-metallic sheathed cable on circuits operating at more than 50 volts to ground shall be earthed.

iv) Socket-outlets and cord connectors equipped with grounding contacts shall have those contacts effectively earthed. The branch circuits or branch circuit wiring shall include or provide a grounding conductor to which the earthing contacts with the receptacle or cord connector shall be connected.

The armour of the metal-clad cable or a metallic raceway is acceptable as a ground connector. Equipment shall be considered as grounded where mechanically connected in a permanent and effective manner to metal raceway, the armour of the meta-clad cable, the grounding conductor in a non-metallic or to a separate grounding conductor not smaller than 2. 5mm2, provided that the raceway or grounding conductor is itself grounded in an approved manner.

v) The earthing arrangements of the consumer installation shall be such that on the occurrence of a fault of negligible impedance from a phase or non-earthed conductor to adjacent exposed metal, a current corresponding to 3 times the rating of the fuse, or one and a half times the setting of the over-load circuit-breaker can flow, so that the faulty circuit can be made dead. Alternatively and in every instance where this requirement cannot be met, an earth-leakage circuit breaker shall be installed. A voltage-operated earth-leakage circuit breaker shall be connected between the consumer earth terminal and a suitable earth electrode. The connection between the earth terminal operating coil and earth electrode shall be insulated.

Grounding of buildings and equipment

It is standard for all wiring installations to have an earth terminal or grounding electrode.

The earth terminal must be connected in the appropriate manner to the circuitry of the installation by means of the earth continuity conductor or the grounding electrode conductor.

Where there is a transformer outside of the building there must also be an additional ground connection from the grounded service conductor to a grounding electrode, either at the transformer or elsewhere outside the building. A grounding connection must not be made however, at the load side of the service disconnecting means.

Where an installation consists of multiple buildings, a grounding conductor must be made at each building.

All the socket outlets and cord connectors in an installation equipped with grounding contacts must have them effectively earthed.

The branch circuits or branch wiring must include a grounding conductor to which the earthing contacts shall be connected.

As a standard all metal fixtures and lighting equipment installed on outlets wired with grounded multi-core cable, metal raceway, grounded multi-clad cable and non-metallic sheathed cable on circuits operating at more than 50 volts to ground must be earthed.

In turn equipment are considered grounded if they are mechanically connected in a permanent and effective manner to a metal raceway (the armour of a metal-clad cable), the grounding conductor in a non-metallic sheath or to a separate grounding conductor not smaller than 2. 5mm2, provided that the raceway is itself earthed in an appropriate manner.

Switch plates, wiring boxes, conduit, cabinets, and lights

Types of equipment that should be grounded

All metal work associated with the wiring system including cable sheets, armour, conduit, ducts and boxes

Exposed metal apparatus

Earth terminals of socket-outlets

One point of the secondary winding and of the metal work of any transformer used in the installation with the exception of transformers contained in apparatus.

Electric motor frames

Equipment needs to be grounded under any of these circumstances:

The equipment is within 8 feet vertically and 5 feet horizontally of the floor or walking surface.

The equipment is within 8 feet vertically and 5 feet horizontally of grounded metal objects you could touch.

The equipment is located in a wet or damp area and is not isolated.

The equipment is connected to a power supply by cord and plug and is not double-insulated.

Types of earth electrodes

Earth mats

Earth mats typically resemble a wire mesh. They are used where there are high voltages, and several cables carrying those high voltages (such as in industrial areas). Each of the multiple cables is grounded to the earth mat rather than connecting all these cables to one grounding electrode. They are used mainly in substations and can be placed above or below ground. Earth plates are used to attain an effective earth in shallow soils with underlying rocks or in locations with large amounts of buried services. They can also provide protection at potentially dangerous places e. g. HV switching positions.

Copper Earth Rods

Copper rods of 20mm or 25mm diameter are used where there are high-resistance earth conditions. It is possible to obtain copper rods with end-on connections where a length may be driven in, the removable hard-steel tip unscrewed, and a further length of rod screwed on. Earth rods take advantage of lower resistivity soils at greater depths than normal excavation will allow. Quality earth rods are commonly made from either solid copper, stainless steel or copper bonded steel.

http://tbn1. google. com/images? q= tbn: lODNxco1mtW8xM: http://www. rcoombs. co. uk/earthstake. jpg[1]

LIGHTING

Main types of lighting fixtures used in workshops

Tubular Fluorescent Lamps:

The high efficiency and relative luminous intensity of such types of lamps results in their extensive use in many workshops. However, fluorescent lamps are highly unsuitable for the lighting of areas containing moving or rotating machinery. The lamps can cause a strobe effect that makes it difficult to observe the movement of the machine and, in some cases, the machine may appear to be stationary.

Color Corrected Mercury Lamps:

These lamps, when used in conjunction with external reflectors are extensively used in industrial lighting, both inside the building and outside.

Incandescent Filament Lamps:

The small filament size allows close optical control for directional and local lighting.

Glare Reduction-

Glare occurs when a light source is seen directly, or by reflection, and is too bright when compared with the general brightness of the rest of the interior. The color of light used in a building should be chosen so as to prevent excessive glare. There are two types of glare, viz. disability glare (which impairs vision) and discomfort glare (which causes visual discomfort). Lamps of intermediate or warm colors should be used for general lighting in order to prevent or minimize glare.

Reducing the luminance of the source causing the glare or changing the relative positions of the observer and the source can also reduce glare.

Lamps should be shielded from direct sight by louvers or reflectors. Also, diffusing ceilings may be used in order to spread the light over a wider are