

# NP001.9

## Electricity Supply to Large Customers

Other documents in this series include:

- NP001.1 Design and Construction of Network Assets – General Requirements
- NP001.2 General Specification for Underground Electrical Reticulation
- NP001.3 General Specification for Overhead Electrical Reticulation
- NP001.4 General Specification for Overhead Rural Residential Subdivisions
- NP001.5 General Specification for Overhead Commercial and Industrial Subdivisions
- NP001.6 General Specification for URD Subdivisions
- NP001.7 Reliability Criteria for Distribution Networks
- NP001.8 Handover Documentation
- NP001.10 Documentation Requirements

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Authorised by	Prepared by:	Issue Date: 14 Feb 2008	Status: Approved
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## 1 General Information

### 1.1 Introduction

This publication is designed to assist developers and customers in early planning stages should the supply requirements necessitate the establishment of a substation on a property as required by Power and Water's Service and Installation Rule 2.7.

### 1.2 Definitions

**Act** is the *Electricity Reform Act 2000*, and includes Regulations made under the Act.

**Capacity** means the rated demand applicable to a particular lot of land or customer, and refers to an average demand over a 15 minute period. Note that it does not refer to the calculated maximum demand under the *Wiring Rules*, which is generally higher than the average demand.

**Capacity Charge** is a non-refundable capital contribution towards the present or future cost of upgrading the distribution network (see Network Policy NP 004).

**Capital Contribution** is a non-refundable payment towards the cost of constructing a network asset owned by Power and Water (see Network Policy NP 004).

**Certificate of Compliance** is a certificate issued by an Electrical Contractor certifying that work on an electrical installation has been carried out in accordance with AS/NZ 3000 (the *Wiring Rules*) and the *Service and Installation Rules*.

**Customer/Developer** will usually be the same person. Generally the customer will be the person that owns the premises and will consume electricity. The developer is the

person responsible for negotiating conditions of supply.

**Electrical Safety Regulator** is the person so appointed under the Act.

**Load Limiting Circuit Breaker** is a circuit breaker, complying with the *Wiring Rules* and Clause 5.56 of the *Installation Rules*, that is used to limit the load of an installation to an agreed capacity in accordance with this Policy.

**Low Voltage (LV)** refers to supply at a nominal voltage of 230/400 volts. The nominal voltage range at the Point of Supply is 230/400 +10% -6% in accordance with AS/NZ 60038; however, Power and Water currently maintains a voltage range of 230/400 +10% -2%.

**Notice of Intention** is the "Notice of Intention to Carry Out Electrical Installation Work" as defined in the *Service and Installation Rules*.

**Point of Supply** is the point where Power and Water makes supply available. For low voltage supply, this is one of the following:

- (a) A nominated point on a distribution substation located on the customer's property.
- (b) A (usually fused) point on a Power and Water pillar located on the customer's property

For high voltage supply, the point of supply will be as agreed between the customer and Power and Water, and will generally be at the terminals of a high voltage metering unit located on the customer's property.

**Project Officer** is a person appointed or contracted by Power and Water to design extensions and augmentations to the network.

**Retailer** is the organisation contracted to supply electricity to the customer. In most cases this is the Retail Division of Power and Water, but may not be so in the case of contestable customers.

**Service Rules, Installation Rules, and Metering Manual** should be read in conjunction with this Policy. They set out many of the conditions applicable to services and metering.

**Wiring Rules** is the Australian Standard AS/NZ 3000.

### **1.3 Deciding Whether a Customer Substation is Required**

Calculation of the maximum demand of a new development is critical to a satisfactory outcome. At the design stage the two options are calculation in accordance with the SAA Wiring Rules, or by assessment.

When deciding the size of a substation, Power and Water will look at the Wiring Rules calculation, but will also assess the building size and type. As a general guide, the following figures are useful:

Office space – 70 VA/m<sup>2</sup>

Supermarkets – 70-100 VA/m<sup>2</sup>

Shops, restaurants – 60 VA/m<sup>2</sup>

Units – 4.5 to 7.5 kVA/unit depending on size and quality

The necessity of a substation will vary with circumstances. In most locations, an installation with a potential maximum demand of less than 100kVA should not need a

separate substation; the exception is rural and remote areas. However, even in developed areas, it is possible that there is no local low voltage reticulation available.

Where the potential maximum demand is greater than 200kVA, a customer substation will normally be required.

Between 100 and 200kVA, a decision on whether a customer substation is required will depend on a number of factors, such as the number and size of substations in the area, distance between them, and the capacity of the low voltage network.

Where the potential maximum demand of an installation exceeds 100kVA, the customer should not make commitments in relation to the development until the method of supply is resolved.

Power and Water may have to carry out extensions to the distribution system in order to supply large customers. There may also be significant requirements to install a customer chamber, earthing, provision for cable routes into and out of the substation, access issues, and so forth.

Adequate lines of communication between the customer and Power and Water are essential to ensure that the project flows smoothly.

#### **1.4 Contact Details and Project Liaison**

The customer's first point of contact at each of Power and Water's Regional offices should be:

Darwin/ Katherine	Manager Distribution Development	89245729
Alice Springs / Tennant Creek	Services Development Officer	89517312

For the Darwin/Katherine area, the Manager Distribution Development will appoint a Project Officer to supervise the project. The Project Officer will be Power and Water's representative on site. No commitments should be made by the customer unless first approved by the Project Officer.

From time to time the Manager Distribution Development may appoint other persons to carry out particular functions, such as quality auditing or testing. Refer to NP 020 "Guidelines for Developers of Electrical Infrastructure" for further details.

#### **1.5 Notice of Intention**

A "Notice of Intention" form must be lodged with Power and Water as soon as a decision to proceed is made. The Notice must include details of the electrical loads to be connected, as well as drawings of the proposed connection arrangement.

Where additional equipment is intended to be connected, a Notice of Intention must be submitted where required by the Service and Installation Rules. In some cases, the installation of additional equipment may trigger the need for a customer substation; it is therefore essential that this be determined before any commitments are made.

#### **1.6 Tariff**

Generally, large customers will be contestable in accordance with the *Electricity*

*Networks (Third Party Access) Act and Code.* Consequently, the customer should contact their proposed Retailer to determine tariffs and related issues.

### **1.7 Method of Supply**

Generally, only one substation is installed to supply a property. Power and Water will install sufficient transformer capacity to meet the assessed demand of the premises and in the event of failure of plant or periodic maintenance, customers will be required to restrict their electricity usage to the capacity of the supply which can be provided in the circumstances.

The demand is assessed from the list of items of equipment to be connected, provided by the customer, taking into account the rating and function of each item. Information on floor areas, lighting intensities and space-heating and cooling arrangements is also sought and taken into account. Where additional load is proposed for an existing installation, any loads to be disconnected should also be listed. It is essential that details of the proposed connected load be provided at an early stage of negotiations to enable the determination of the supply arrangement and avoid unnecessary delays.

Power and Water generally provides a low voltage supply to customers. However, under certain circumstances, i.e., size of load, access availability etc, Power and Water may decide that the customer can be best supplied at high voltage. See Clause 2.1.5 and 3.2 for details of supply at high voltage.

The need to settle the method of supply at an early stage in the design of the project is stressed. If the full details required in the application for supply are not available at this early stage, a letter should be sent giving sufficient information to enable preliminary consideration to be given to the means of supply.

### **1.8 Provisions for a Substation**

Having decided that supply can best be given by establishment of a substation, a condition of supply is that, in accordance with Power and Water's Service and Installation Rule 2.7.1, the customer provides, free of cost, a suitable space on the premises for Power and Water's use to accommodate transformers, switch gear and other equipment. The space shall be enclosed in an approved manner, and the customer shall provide satisfactory arrangements for access and tenure.

Any new customer substation shall be designed in accordance with one of the standard designs set out in Standards Manual Volume 1 or 2 (as applicable).

All arrangements for the establishment of the substation will be conducted through a *Project Officer* whose name, telephone number and location will be advised.

The customer must provide suitable accommodation for Power and Water's extension of mains within the premises and ensuring that vegetation within the customer's premises does not come within Power and Water's easements, as specified in Clause 1.12. Failure of the customer to comply will lead to disconnection of supply in accordance with Power and Water's Service and Installation Rule 1.5.

### **1.9 Sequence of Events**

- (1) Power and Water receives a letter requesting supply and providing details of

the development and load.

- (2) If it is believed that the new customer will be contestable, Power and Water will advise the procedures to be followed. These are set out in Network Policy NP015 Applications for Supply by Contestable Customers.
- (3) Power and Water assesses the load and determines the size and the type of substation required and advises the developer of its requirements.
- (4) The substation location is discussed and a suitable location is agreed upon.
- (5) The developer prepares and submits drawings showing substation details for Power and Water and the building certifier's approval prior to construction.
- (6) Power and Water sends the customer/developer an offer, detailing the terms and conditions under which the substation will be established, including any capital contribution required, and the agreed *capacity*.
- (7) Details of the customers' mains and main switchboard details are submitted by the developer for approval.
- (8) The developer advises Power and Water when substation construction commences so that earthing may be installed and inspections carried out at various stages during construction.
- (9) The developer accepts Power and Water's offer and any associated condition.
- (10) Any contribution required is to be paid prior to Power and Water commencing work. For larger amounts, part payment may be acceptable (see the *Distribution System Extension Policy*).
- (11) The developer arranges for the substation chamber to be approved by a building certifier, prior to hand-over to Power and Water. A copy of Certificate of Occupancy shall be provided to the Project Officer.
- (12) "As constructed" drawings, and proof of easement creation shall be provided to the Project Officer.
- (13) Power and Water installs all necessary equipment to provide supply to the customer.
- (14) Certificate of Compliance received by Power and Water.
- (15) Supply available.

Normally supply is made available within 3 months of hand-over of the substation building/fence/foundation or payment of any contribution whichever is the later. Some developments may require special material purchases to be made. Additional time is required in these cases.

## **1.10 Responsibilities and Costs**

### **(a) Customer Responsibilities and Costs**

The customer is responsible for:

- Supply and installation of any conduits, duct ways, cable trays and the like on the customer's property to Power and Water's requirements.
- Supply and installation of any cable turning pit on the customer's property.
- Substation civil works - civil works shall include any levelling or

clearing of the site, erection of any building or enclosure and any foundations required to meet Power and Water's requirements.

- Supply and installation of consumer mains from the point of supply.
- Registration of easements and right-of-ways.
- Payment of any capital contribution required under the Capital Contribution Policy or DSEP.
- Maintenance of the building and other civil infrastructure (e.g., conduits, cable trays) for the life of the substation.

### **(b) Additional Costs**

Apart from costs that the customer normally incurs, special charges may arise where:

- The mains and or substation installation is considered to be temporary, or special or additional to that necessary to meet the demand of the premises.
- The load has unusual characteristics, which makes it uneconomic for Power and Water to supply it without imposing a charge as provided for in Clause 2.7.2 of the Service and Installation Rules, or in the *Distribution System Extension Policy*.
- The segregation of supply facilities is considered necessary to avoid interference with the supply of other customers.
- Supply has been made available (in accordance with the arrangements made), but is not used within a period of six (6) months.
- The location of the substation is such that it is necessary for Power and Water to install special transformers or to have special supply arrangements.
- The point of supply is in a position other than the preferred location nominated by Power and Water.

### **(c) Power and Water's Responsibilities**

Power and Water will:

- Supply and install substation equipment including transformer, high voltage switchgear, low voltage switchgear and substation earthing.
- Supply and installation of high voltage reticulation to the substation.

### **1.11 Building Costs**

The developer is required to provide and install, at no cost to Power and Water, any cable pit or duct line necessary on the premises.

In general if a package/kiosk substation can meet the anticipated electrical demand, a developer may select this design (however, this option is not available in the Darwin CBD). The developer must provide a suitable excavatable site, and the concrete plinth required, as detailed in Power and Water's Underground Manual Volume 2.

Package/kiosk substations are generally limited in size to 1000kVA. Package/kiosk substations are only used singly. Consequently, a package substation is not suitable where the prospective load of the development is likely to exceed 1000kVA.

If the substation is not of the package type, the developer is required to provide the necessary building works in accordance with Power and Water's requirements. It is necessary for the developer to engage the services of a qualified architect/consulting engineer. Power and Water's Project Officer will advise the developer's representative which standard designs are suitable for meeting the assessed demand of the premises.

It is sometimes necessary to extend or alter a substation enclosure in order to meet a customer's need for increased supply. In such cases the extension or alteration shall be carried out at no cost to Power and Water.

During the equipping of a substation chamber / enclosure, the developer may be required to provide, at no cost to Power and Water, a temporary single-phase 20A supply to the substation to enable power tools and equipment etc. to be used.

In addition the customer is required to:

- Pay any rates and taxes applicable in respect of the substation premises.
- Maintain in a satisfactory condition all access and drainage provisions.
- Maintain in a satisfactory condition the building structure, including any external doors, gates, ventilation equipment etc. and external finishes.
- Take all necessary action to ensure dry wall and floor conditions.

## **1.12 Electricity Easements and Right-Of-Ways**

Easements are required over the substation and any mains within the premises for the installation and maintenance of Power and Water's overhead lines and/or underground cables. Additionally, a right-of-way is required between the substation premises and the property boundary, as detailed in Clause 2.5. Easements and right-of-ways are to be registered under the Land Title Act, the Law of Property Act and the Planning Act, as appropriate, at no cost to Power and Water.

### **(a) Overhead Lines**

Where an overhead line is erected, an easement width of 10 metres is required. Larger trees are permitted outside the easement providing they do not present a hazard to the line. Network Policy *NP021 Easement Guidelines* sets out the conditions associated with an overhead line electricity easement on private property.

The *Electricity Reform (Safety and Technical) Regulations* also impose legal restrictions on buildings, approach distances of plant, etc.

### **(b) Underground Cables**

Where an underground cable is installed, an easement width of 3 metres is required. The easement is to be kept clear of encroachments or other services unless otherwise agreed to.

The *Electricity Reform (Safety and Technical) Regulations* also impose legal restrictions on excavation in the vicinity of underground cables.

### **(c) Crown Land**

Where a government body requires a substation and/or overhead lines or underground cables on Crown Land, suitable arrangements shall be made by

the developer to ensure that Power and Water' assets are protected to a similar extent as in the case of easements.

## **2. Construction Requirements**

### **2.1 Substation Type**

The five (5) types of substations which may be installed on a customer's premises are:

1. Pole type
2. Package/kiosk type
3. Ground type
4. Indoor - surface chamber, basement chamber or upper level
5. High voltage intake station

A description of each type and their application is given below:

#### **2.1.1 Pole Type Substation**

This type of substation is only used on customer's premises in rural or industrial areas, or for installations of a temporary nature.

The high voltage line from the street boundary to the substation, and all substation equipment, is mounted on poles. The maximum transformer capacity is 500kVA. Multiple pole substations at the same site are not permitted.

The customer's point of supply is the transformer low voltage fuses on the pole. The easement requirements are as detailed in Section 1.12.

#### **2.1.2 Package Type Substations**

This type of substation is generally used in residential and small commercial and industrial areas.

All equipment is mounted within an enclosure supplied or approved by Power and Water, and mounted on the ground on a concrete plinth installed by the developer to Power and Water's requirements.

The maximum transformer capacity is 1000kVA for pad (square) substations, and 500kVA for 900 x 3000 or 1000kVA for 1300 x 4000 kiosk substations. Note that the latter substation can incorporate a 4-way RM6 or similar RMU.

The customer's point of supply is from the low voltage compartment within the package substation. Power and Water will install a low voltage circuit breaker or Stripe fuse as required.

#### **2.1.3 Ground Type Substations**

This type of substation is generally used in industrial areas or in a rural area where the load exceeds the capacity of a pole type substation.

All equipment is mounted on the ground within a fenced enclosure. The fencing generally consists of 50 rnm type 'A' 3 mm galvanised chain wire, 2.4m high, with 3 strands of barbed wire on top. Alternative forms of fencing

include concrete blocks and zincalume or colourbond fencing panels. Provided these panels present no toe-holds which would facilitate climbing, and they are taken to a height of 2.4m or more above surrounding levels, the barbed wire necessary with mesh construction is not required. All building work must be approved by a building certifier.

Access to one gate position is necessary for vehicles and only one step up to the substation floor level is permissible at this gate. This should be taken into account in determining the substation floor level. Steps with a landing of minimum dimension 1000mm square and a handrail are required outside the other entrance gate if the floor level is more than 525mm above finished ground level. In general, the substation floor level should not be higher than 600 mm above the area outside the substation where a crane or forklift would carry a transformer.

It is necessary to ensure that the effectiveness of the substation fence or wall in preventing unauthorised access is not reduced by the proximity of raised areas near the substation. In some cases, raising the height of the substation fences or walls or using several strands of barbed wire on galvanised supports fixed to the substation wall may be required. Full details of any such proposal should be included in the lock-in drawing. Note the requirements of the *Electricity Reform (Safety and Technical) Regulations* in relation to storage of materials adjacent to a substation.

The maximum single transformer capacity is currently 1000 kVA and the customer's point of supply is the low voltage compartment within the substation enclosure. For customers with a need for larger transformer sizes, Power and Water may negotiate special arrangements in relation to spares. This may involve a capital contribution from the developer.

#### **2.1.4 Indoor Type Substations**

This type of substation is used in commercial areas and where the rating of a package substation is likely to be exceeded.

The indoor substation contains all equipment within the building. The substation chamber can be free standing or form an integral part of the premises, and should be within 20 m of the property boundary. Where the substation is more than 20 m from the property boundary, the customer will be charged for the cost of additional high voltage cable.

Three types of indoor substations are used:

- a) surface chamber – located at ground level
- b) basement chamber – located below ground
- c) upper level chamber – located above ground level

The maximum single transformer capacity is 1500kVA. Standard designs are available for one, two and three transformer substations. The customer's point of supply is from the low voltage terminals of a circuit breaker or breakers within the substation, or at wall bushings mounted in the substation wall.

### **2.1.5 High Voltage Intake Substation**

Detailed conditions covering customers supplied at high voltage will be negotiated individually.

The customer provides all transformers, high voltage and low voltage equipment and is responsible for its maintenance.

The customer's high voltage installation commences at the load terminals of the metering equipment, or other nominated point, such as an outgoing circuit breaker. The customer will terminate the consumer's mains at this point. However, Power and Water may be prepared to carry out the termination of such cables provided the customer bears the full cost.

The size of cable to be installed by the customer should be selected in consultation with the Project Officer and should take into account the possibility of future load growth and the necessity for the cable to be adequate for the prospective fault level.

The protection settings of Power and Water's equipment must be coordinated with the customer's. The customer's consultant must liaise with Power and Water's Manager to ensure that suitable protection settings are established.

Note the requirements of the *Network Technical Code* in relation high voltage supply.

## **2.2 Multiple Substation Installation**

Power and Water generally provides supply to one substation location. However, Power and Water may, at its discretion, permit more than one substation to be installed to service a development. This permission will only be given if:

- (a) The low voltage supplies from the various substations are clearly segregated to the Project Officer's satisfaction.
- (b) Supply from one substation is not feasible due to particular load requirements.
- (c) The developer pays a contribution for each additional substation, as detailed in the Distribution System Extension Policy (Network Policy NP004).
- (d) The developer pays the cost of any additional high voltage line.

Refer also to Rule 5.63 of the *Installation Rules*.

## **2.3 Indoor Substation Chambers**

The construction requirements incorporated in the standard drawings for substation chambers are designed to ensure:

- Protection of vulnerable portions of the customer's premises from damage which may occur in the event of failure of oil-filled electrical equipment.
- Protection of substation equipment and mains from fire and deluge originating outside the substation.
- That dry wall and floor conditions are maintained to a high standard.

- Substantial containment within the chamber of the insulating oil of a transformer in the event of tank failure.
- Suitability of the floor to support heavy equipment and of walls to support equipment requiring heavy-duty fixings.
- An adequate degree of strength and fire segregation.

### **2.3.1 Floor**

The chamber designs in Volume 2 of the Standards Manual give construction details for the condition where the substation floor sits on the ground.

Alternatively, suspended slab construction to carry the equipment loadings indicated in the appropriate standard design detail drawing may be used, with the conduits encased in concrete. A chartered structural engineer (CPEng) must carry out the design and one copy of the structural drawing must be submitted.

Where there will be another floor directly below the substation floor, Power and Water will install the earthing electrodes under the lowest floor directly below the substation. The builder must provide secure protection for the earthing connections between the substation chamber and the electrodes. This provision is generally a straight run of two 38mm-nominal-bore-galvanised water pipes, with draw wires, from the earthing-electrode positions to the positions nominated.

These provisions must be shown in detail on the building lock-in drawing. The Project Officer will give further advice regarding such requirements on site (at the builder's request) when construction has reached an appropriate stage.

### **2.3.2 Roofing**

The standard surface and basement substation designs specifically cover the case of a chamber incorporated within a weatherproof portion of a larger building. They can also be used for free-standing substation buildings, provided the ceiling slab is covered with a weatherproof metal roof or a specially approved waterproof membrane. Proposals for use of a membrane will be considered only if guaranteed by a reputable company.

Alternatively, the freestanding substation may be provided with a roof in one of the following forms:

- Steel decking on steel or hardwood timber framework with a one-hour-fire-rated, plasterboard ceiling.
- Tiled roof on steel or hardwood timber framework with a one-hour-fire-rated plasterboard ceiling.

All building work is to be in accordance with the Building Code of Australia and local building requirements.

### **2.3.3 Ventilation**

Due to the need to dissipate heat released by substation equipment under normal operating conditions, it is necessary to provide adequate natural air

circulation between a substation chamber and open air.

Surface-chamber designs require weatherproof metal louvred panels of a specified design in order to achieve adequate ventilation. The area immediately outside the louvres must not be subject to fire risk or frequent pedestrian use.

The basement-chamber designs require an inlet ventilation duct and outlet-ventilation duct, each entering the substation chamber in a specified area and leading to a suitably located opening on the outside of the building.

The required natural ventilation-duct cross-sectional area is specified on the substation layout drawing and assumes a duct length not exceeding 10m and up to three right-angle bends, the cross-section being rectangular with a ratio of dimensions not exceeding 4: 1. If the duct configuration is unfavourable, the cross-sectional area may have to be increased or other action may be required to ensure adequate airflow.

Louvred panels with integral screens, to exclude vermin, birds and weather, are generally necessary at external openings to ventilation ducts.

The bottom edge of any ventilation duct opening is to be at least 3m above the pavement. This measurement can be reduced to 2.2m above the pavement providing that upward deflecting vanes are provided to direct any substation air away from pedestrian traffic.

The substation ventilation ducts must not contain other services, give access to other portions of the building or form part of the ventilation system for the building.

The strength and fire rating of the walls of ventilation ducts must be the same as for those specified for substation walls, and consequently normal air-conditioning-duct construction is not acceptable.

A fire damper is required to be provided and installed in each duct opening in a basement substation to close off air supply in the event of fire.

#### **2.3.4 Basement Chambers**

Basement substations and high voltage switching stations shall be at the first useable level below the ground surface (an adequate clear corridor shall be provided to enable a 5 tonne capacity fork lift to access the substation from outside the building).

The access route for personnel and light equipment must not involve the climbing up or down of more than one storey of steps.

In the case of basement substation ladder-type access chambers, the standard maximum depth from pavement to foot of ladder is 4300mm and any proposal to provide additional ladder length or extra steps will be considered only if practically unavoidable.

Substation walls must not be in contact with damp ground and reliance on the effectiveness of a waterproofing membrane is not acceptable.

Where a retaining wall or rock face adjoins, the substation wall must be separated from it by a cavity. The cavity shall extend below substation-pit floor level and be connected to a gravity-drainage system or an automatically discharged sump.

In situations where the substation pits or conduits are below the level to which the surrounding water table may rise under any conditions, both the wall cavities and the under-floor area of the substation are to be gravity-drained to a suitable discharge point or to a collection well. The latter must be external to the substation and have a reliable automatic discharge pumping system. This should generally incorporate two self-priming pumps, the circuit wiring and protection arrangements for which are independent and the means of control accessible to authorised persons only.

The substation floor and walls must be designed by a qualified and practising structural engineer to be suitable for withstanding the hydrostatic pressure to which they may be subjected in the event of pump failure and must incorporate water-stopping membranes at construction joints. Details of the floor and wall design and drainage system must be included in the lock-in drawing.

In addition to the above requirements, the following may be required if flooding is expected (or is not expected and subsequently occurs). A pump installation shall be installed to Power and Water's specification, which will normally incorporate special provision for pump discharge above flood level and a larger volume collection well. This requirement may be notified by Power and Water either prior to the establishment of the substation or at any time while the substation is in service.

### **2.3.5 Upper-Level Substations**

In the case of large high-rise buildings, where more than one substation is necessary to meet the load, consideration will be given to locating additional substations at upper levels, provided a reasonable case is presented to justify departure from the normal practice of locating substations near the street-access level.

Dry-type transformers (containing no oil or other liquid) are used in all upper-level substations. Where dry-type transformers are used, the developer will bear the additional cost above that for standard oil-filled transformers.

A high-voltage switching station for upper-level substations shall be located in a chamber provided by the customer within one floor of street-access level. The high-voltage rising mains and associated earthing, signalling, protection and control cables between this switching station and the upper-level substation are subject to normal supply negotiations. They shall be contained in an approved separate, locked, fire-isolated riser shaft incorporating fire barriers between floors and with provision for access at each floor for the installation and subsequent maintenance of cables.

Special arrangements for personnel access under normal and emergency conditions and specially designed, permanent lifting facilities are necessary and the developer is responsible for providing and maintaining such facilities and for the whole lifting operation involved in installing or removing heavy equipment.

There are no standard designs for upper level substations and cable risers. The developer's architect designs these in all cases, with guidance from the Project Officer.

## **2.4 Substation Location**

Power and Water prefers substation locations to be on or near the street boundary, and certainly within 20 m. The Project Officer will advise on the preferred point of entry to the premises for the high voltage mains.

Additionally, the substation generally needs to be located next to the main switchboard. Unmetered mains will not normally be permitted above 15 metres. A substation location therefore needs to be worked out that complies with all of the requirements, including vehicle and personnel access, ventilation, future site development, safety and future load requirements.

Note that where the unmetered mains exceeds 15 metres, the mains will have to be increased in size to limit voltage drop to not more than 0.5% at maximum demand.

### **2.4.1 Construction Costs**

Where a choice can be made between differing forms of substation accommodation, relative costs should be carefully considered. For example, a basement chamber is much more expensive than a surface chamber or ground type enclosure.

### **2.4.2 Reticulation Costs**

The charge made for extension of high voltage mains to a substation site away from Power and Water's preferred location should be compared with the saving which may result from reducing the length of consumers' mains and sub-mains provided by the developer within the installation. Consequently, even for a contestable customer, Power and Water may require a capital contribution for any high voltage mains considered to be necessary only to reduce the cost of consumer's mains. In general, where the length of high voltage cable from the property boundary exceeds 20 m, a capital contribution will be required.

### **2.4.3 Access Requirements**

These include access for personnel, vehicles and equipment to both the substation and associated mains in accordance with Clause 2.5.

### **2.4.4 Segregation Requirements**

Substation equipment must be segregated effectively from neighbouring areas and buildings, which are subject to fire risk.

It is also necessary to site the substation in a location where it will not be the

subject of noise complaints from residents in the vicinity. These matters are dealt with generally in Clause 2.9.

#### **2.4.5 Foundation Requirements**

The substation site is required to be stable and clear of any obstruction that could interfere with the installation of the earthing electrodes, which may extend to a depth of 10m or more.

Filling material shall be clean, stable, reasonably fine and shall be compacted.

#### **2.4.6 Encroachments and Other Services**

Services, such as drains, sewers, pipes and wiring, are not permitted to pass through the substation area or the ground below it. In the case of package substations, this area includes a 3.5m x 3.5m easement; for large kiosk substations, the easement is 3.0 x 5.5m. In the case of indoor and basement substations, it includes the access passageways and ventilation ducts.

The substation chamber or enclosure must be free of encroachments into the required floor and pit areas. Columns and walls may however, occupy certain areas provided they do not conflict with consumer's mains conduits and ventilation ducts, or hinder replacement of equipment.

#### **2.4.7 Oil Spill Containment**

Standard pole transformer, package and ground substation designs make no provision for oil containment. It may be necessary to make such provision depending on the site selected in order to comply with:

- the *Wiring Rules*
- AS 1940 -The Storage and Handling of Flammable and Combustible Liquids

For substations outdoors, substations shall not be so located that, in the event of a tank rupture and fire, burning oil will endanger buildings or persons.

#### **2.4.8 Area Drainage**

The substation shall be free of the risk of flooding and storm water damage and any drains provided must be effectively maintained by the customer. Special requirements applying to basement site conditions are set out in Clause 2.3.4.

#### **2.4.9 Hazardous Areas**

The substation equipment and the access route to it must not be within an area that is classified as "Hazardous" in the *Wiring Rules*.

#### **2.4.10 Protection from Vehicles**

Package substations, chain wire enclosures of ground type substations, external walls of indoor substations and personnel hatchways associated with basement substations are required to be protected from damage by vehicles.

The protection may be in the form of an "armco" barrier or other means

approved by Power and Water. Alternatives providing equivalent protection, such as a 230mm kerb, will also be considered. Where the location is such that there is a risk of vehicles backing up to the kerb, no less than 1500mm of clearance is required between the kerb and the portion of the substation requiring protection. All barriers are to be installed at the developer's cost.

#### **2.4.11 Future Site Development**

It is essential that provision be made for future development of the premises. Package and ground type substations are not suitable for building over and substation relocation is costly to the developer.

### **2.5 Access Requirements**

Unless access is direct to the substation from a dedicated public road, the following requirements are to be met by the developer:

#### **2.5.1 Personnel**

A permanent all weather access route at least 1.2m wide is required to the substation entrances for use by personnel at all times of the day and night, with unobstructed access using only Power and Water's standard key. One substation door or hatchway must be accessible for the delivery of tools and minor equipment by means of a hoist mounted on a truck. Access through areas that are dangerous to personnel, due for instance to the employment of a guard dog, is not acceptable. Entry into the substation is not available to the customer except with Power and Water approval.

Power and Water is prepared to supply and fit, at a charge, padlocks to any gates involved in gaining access to the premises. They may be used in conjunction with a locking bar or chain and a padlock supplied by the developer to give access to both parties using different keys. An equivalent system using night-latch locks supplied and installed by the developer can be arranged. Such locks must be capable of fitting with standard Power and Water barrels.

Each standard substation design shows at least two means of exit from the chamber or enclosure. The developer must ensure that each of these doorways or gates gives access to an open area suitable for escape from the substation and the building in an emergency.

Any access passage through a building from a substation chamber to such an area must be of fire rated construction and arranged for Power and Water's exclusive use.

Where a basement substation has two doorways into the chamber, each must be served by a separate access area, leading by hatchway or doorway to an open area suitable for escape.

Personnel hatchway entrances to a basement substation are acceptable only if they are within the customer's premises and are so located that vehicles cannot be driven over them. They shall be provided by the developer. The depth from the pavement to the foot of the ladder in the entrance chamber should not exceed 4.3m.

### **2.5.2 Heavy Equipment**

A mobile crane and heavy truck are generally used to move transformers in and out of the substation. Any access route that will be used for this purpose must be suitable for all weather conditions and be constructed to withstand the loads which it is likely to bear. In this regard a typical mobile crane has an unladen rear-axle loading of 15 tonnes; the rear-axle group comprising two axles. Where it is necessary for the crane to transport the transformer along the access route and also in the manoeuvring area adjacent to the substation, the surface of the right of way should be capable of withstanding a rear-axle group and/or outrigger loading of 21 tonnes. The loading on any one pad may be up to 15 tonne with a total load on any two pads of 21 tonnes. This loading must be provided for in the design of any paving or suspended slab within the customer's premises.

The width of the right of way required is 4m for reasonably straight routes with increased width at bends and in the manoeuvring area adjacent to the substation, where lifting operations will be carried out. The surface grade along the right of way should not exceed 1:8 and in the transformer handling area should not exceed 1:20.

For any pavement section other than a straight run, the route shall be designed by a competent person taking into account the manoeuvring envelope of a typical 6 x 4 crane vehicle. This design shall be approved by the Power and Water Project Officer prior to proceeding.

In general, parking a vehicle immediately outside the substation shall not block an driveways or entrances.

The headroom required along the route for the passage of the crane and other vehicles is generally 4m and there should be no obstructions or height restrictions within the manoeuvring area, which would constrain unloading of the transformer.

Any reinstatement that may be necessary, in the event of damage to the paved surface of a right of way, is the responsibility of the owner of the premises.

Basement substations are designed with access for transformers through hatchways in the roof. The developer is required to provide and install the transformer hatch cover as part of the building work. Adequate space must be provided for the temporary storage of the hatch cover in a location on the premises where it will not impede traffic during transformer movements.

In some areas, 5 tonne fork lift trucks are readily available. For substations in such areas, Power and Water may consider designs incorporating provision of access for standard fork lift trucks.

### **2.5.3 Mains**

Where the substation is set back from the property boundary, the conduits from the substation are to be extended to Power and Water's nominated point of entry at the property boundary,

The developer shall reinstate finished surfaces on his premises. As a

precaution against future damage to the cable due to excavation, or floor drilling where cables are installed within a building, the developer shall, where practicable, provide a suitable form of permanent surface marking to warn of the presence of the cables, at 3.0m intervals along the cable run.

#### **2.5.4 Hoardings**

Where hoardings obstruct the installation of mains or heavy plant, the hoardings shall be dismantled or modified to enable Power and Water to carry out its work. To avoid delays in establishing the substation, these requirements should be ascertained as early as practicable.

#### **2.6 Selection of Design**

Once the anticipated maximum demand of the project has been estimated, the Project Officer will advise on which standard designs are suitable from those listed in Table 1 (Appendices Section) for the substation required.

#### **2.7 Lock-In Drawings**

The developer should prepare for the builder's guidance a lock-in building drawing that shows the following:

- The location of the substation in relation to adjoining construction and to the street. If not on the street alignment, this should include the access route, type of road surface, relative levels of the roadway, any overhead obstruction and any steps to be provided at substation doorways.
- Any precautions that should be taken to meet segregation requirements set out in Clause 2.9.
- Drainage arrangements in the vicinity of the substation.
- The conduits for the customer's mains.
- Any extension of conduits for Power and Water's mains external to the substation. (See Clause 2.5.3).
- Any galvanised pipes required in accordance with Clause 2.3.1 for the protection of the substation's earthing conductors.
- A clearly delineated area of the lock-in drawing with the note -

"The builder is required to carry out all work in this area in accordance with Power and Water's drawing No's ... and ... together with this drawing."

**NOTE: *Details contained in the standard design drawings must not be transferred to the lock-in drawing and only specifically agreed variations or alternative forms of construction referred to below should be shown in the delineated area.***

- Any variation from the standard design drawings.
- Any other features, such as ventilation ducts or water-stopping membranes, needed to convey to the builder the detailed information needed, in addition to that shown on the standard drawing, in order to carry out the building work.

Three copies of the lock-in drawings shall be submitted to the Project Officer for inspection.

## **2.8 Special Designs**

Power and Water may permit the establishment of a different type of substation from that determined by Power and Water to be appropriate for the development. Approval will only be given if the substation type requested is suitable for the area and the developer pays all additional costs incurred by Power and Water.

Standard designs should be adhered to wherever practicable. Power and Water may approve the use of a non-standard design in special circumstances, providing Power and Water's requirements are met.

The customer is responsible for all construction and structural drawings of substations to meet Power and Water's and the Building Certifier's requirements. Detailed construction drawings are to be submitted for approval before work commences.

## **2.9 Building Segregation**

### **2.9.1 Fire**

Transformers in substations must be effectively segregated from neighbouring areas and buildings, which are subject to fire risk.

The walls, ceiling and ventilation ducts of substation chambers, where they are the means of separation between the substation and the interior of the building, shall have a fire rating of four hours. In any case, the chamber and its openings must comply with Building Code of Australia (BCA) fire resistant construction requirements and fire segregation requirements.

Any portion of a building, which is not sheltered by a non-ignitable blast-resisting barrier, and is within 3m of the housing of a package substation or 3.5m of a transformer in a ground type (chain wire) substation (measured from the vertical centre-line of the transformer) shall have a two-hour fire rating.

Care must be taken with any ground-level substation to ensure that transformer oil cannot drain to a point close to buildings or other flammable structures. Where the lay of the land would allow burning oil to run within 3.0m of any habitable structure, then bunds or similar suitable means shall be employed to prevent the flow of oil.

Masonry walls and solid gates with a non-ignitable internal face are also required for ground type substation enclosures if the area adjacent to the substation may be used for storage of combustible material.

### **2.9.2 Noise**

Transformers emit a constant low-pitched hum, which may give rise to complaint in some circumstances. Special precautions in siting or construction may be necessary, particularly in the case of package and ground type substations, if there is existing or prospective residential development in the vicinity.

Generally, package substations should not be located closer than 10 metres to

any residence. Larger substations should be enclosed with block walls or similar. Subsequent to the commissioning of a substation, if noise complaints are received, the developer is responsible for mitigating the problem.

## **2.10 Agreements and Approvals**

It is advisable not to proceed with substation construction until a supply offer has been accepted, and a drawing submitted to the Project Officer has been stamped as approved. Any additional requirements for compliance with the BCA and local building requirements, should be ascertained by the developer.

The developer must also obtain the approvals of a building certifier at the earliest practicable date and copies of drawings showing the location of the proposed substation with the approval of the building certifier stamped thereon is requested for noting by the Project Officer.

A buried earthing-electrode system is necessary for the substation. This is installed by Power and Water's staff or contractor in undisturbed or suitably filled ground, free of obstructions, under a floor of the building, preferably directly below the substation. The builder is required to give at least 14 days notice of intention to pour the concrete slab over the electrode area to facilitate installation of the electrodes and cables. The builder is also required, if requested, to assist in lifting drilling plant with the site crane and to make a suitable water supply available.

To ensure co-ordination, the customer shall ensure that the Consultant or Project Manager (as relevant) takes these factors into account in the Project Plan with suitable witness points. In some cases, it may be appropriate for the customer's electrical contractor to install the earthing system.

It should be noted that all joints in earthing systems that are below slabs must be made using brazing or cadweld, and must be inspected by Power and Water's Project Officer before the slab is poured. If this is not practicable, Power and Water may approve inspection and photographic recording of the earthing system by an agreed agent.

The Project Officer will arrange for the installation of the earthing electrodes when requested by the builder and give advice as necessary. Any advice is given on the understanding that Power and Water does not accept responsibility for failure to meet the stated requirements.

The importance of close liaison is stressed, because failure to fully comply with these requirements will result in expense to the developer in rectifying errors and may affect the program for providing supply. In this regard, before the substation enclosure will be accepted for equipping, it must be complete in all respects and suitable access must be available for the delivery of heavy equipment.

## **3 Customer's Electrical Installation**

### **3.1 Supply at 230/400V**

#### **3.1.1 Compliance with Regulations**

The customer's electrical installation must comply with the requirements of the *Wiring Rules*, the *Service and Installation Rules*, and the *Meter Manual*.

Developers and/or their consultants and contractors should make themselves fully aware of these publications.

The electrical contractor must submit a *Notice of Intention* (NIW). Full details of the proposed installation, including consumers' mains, main switchboard and metering arrangements, shall be forwarded with the NIW before the relevant work proceeds.

### **3.1.2 Formation of Supply**

Power and Water will provide a 3 phase 50Hz 230/400V supply within normal commercial limits from its substations. The developer is responsible for the installation of customers' mains up to the point of connection to Power and Water's equipment.

Where a supply is provided to an installation direct from a substation remote from the premises, Power and Water will install mains to a point nominated. The customer's mains are generally installed to this position and connected to the incoming mains in a suitable termination enclosure.

Metal-sheathed cables shall be provided with a PVC or equivalent sheathing in the vicinity of the substation low voltage switchboard and in the associated pit, if there is a possibility of them touching other cables.

In addition, if MIMS {Mineral Insulated Metal Sheath} cable is used, the developer shall install the seals near the bottom of the substation switchboard, insulate the conductors, bond the sheaths and fix the cables in position in a satisfactory manner.

### **3.1.3 Metering**

The installation shall be metered in accordance with Power and Water's *Meter Manual*.

The developer shall submit drawings of proposed metering layouts. Work should not commence until approval has been given.

### **3.1.4 Power Factor**

The installation shall comply with Clause 4.6 of Power and Water's *Service and Installation Rules*.

Consideration should be given in the initial design to the effects of inductive loads on the premises and provision of power factor correction equipment to maintain the required minimum power factor at all proposed metering points.

It should be noted that most larger customers will utilise a kVA demand tariff. This will require power factor correction equipment to minimise cost.

### **3.1.5 Supply Voltage**

The line to neutral voltage at the substation busbars is generally maintained in the range 240V to 253V (RMS), the variation over any particular day generally being considerably less than this range.

Momentary voltage dips and spikes may occur and customers are advised to install stabilisers, surge diverters or filters in supplies to any particularly

voltage sensitive equipment and to ensure, where appropriate, that under-voltage releases and relays are suitably designed to avoid unnecessary operation.

It should be noted that the nominal standard voltage is now 230/400V. The relevant Australian Standard is AS/NZ 60038. This voltage has now also been adopted by the *Wiring Rules*. Power and Water does not intend to change the above voltage range at present, and will advise customers before implementing any change.

### **3.1.6 Equipment Causing Interference with Supply to Other Customers**

Connection of equipment considered capable of causing undue interference to the supply of other customers may be refused. Reference should be made to Rule 4.2 of the *Service Rules*. The Project Officer should be informed of any proposal to connect equipment of the types described in this Rule.

### **3.1.7 Fault Level**

The *Wiring Rules* require that the customer's installation be designed so that it is capable of performing satisfactorily under fault conditions.

The short circuit current which may occur in a customer's installation supplied directly from a substation is relatively high. It is necessary to suitably design switchboards and wiring and carefully select protection and control equipment of adequate fault rating. The prospective short circuit current at the substation low voltage busbars is advised in writing during the course of negotiations.

Should information be required prior to receipt of this letter, it can be obtained from the Project Officer.

As a guide, the maximum prospective fault level for the different types of substation, at the customer's point of supply is:

Pole Type Substation	14,000A
Package Type Substation	14,000A (residential) 25,000A (commercial/industrial)
Ground Type Substation	25,000A
Indoor Type Substation	25,000A (1000kVA maximum) or 39,000A (1500kVA maximum)

These values have been calculated using the maximum single transformer capacity for each different type of substation. These values are to be applied irrespective of the initial transformer capacity.

Prospective fault levels for multiple transformer substations will be provided on request.

### **3.1.8 Selection of Main Protection Devices**

The customer's main circuit breakers or fuses must be so selected and arranged that, in the event of a fault on the portion of the installation they protect, they will interrupt the fault current rapidly enough to ensure that Power and Water's over current protection devices do not operate.

The characteristics and proposed setting of the customer's largest protection device should be submitted (with a suitable allowance for load bias, if applicable) to the Project Officer, who will verify suitability of protection grading with Power and Water's protective device.

### **3.1.9 Earthing**

In accordance with Service and Installation Rule 4.3, earthing of the customer's installation shall comply with the requirements for the multiple earthed neutral (MEN) system of earthing as laid down in the *Wiring Rules*.

### **3.1.10 Stand-by Generation**

Should an alternative source of electrical supply such as a stand-by generator be installed, facilities for connection of the electrical installation normally supplied from Power and Water's system, shall not be installed unless the proposed arrangements have been approved by Power and Water's Customer Connection Officer.

Such facilities shall be arranged through suitable interlocking procedures so that Power and Water's system and service equipment cannot be energised by such alternate source. Typical arrangements are shown in the *Service and Installation Rules*.

A notice shall be fixed on the main switchboard to show that such facilities exist, their point of control, and the conditions under which they may be operated.

## **3.2 Supply at High Voltage**

### **3.2.1 Compliance with Regulations**

The general requirements for customers' high-voltage installations are set out in the *Wiring Rules* and Service Rule 4.7.

The developer shall engage an accredited high voltage testing authority to test the installation. Reports of the results of tests carried out on high-voltage equipment to ensure suitability for service must be forwarded to the Project Officer; a summary should also be included in the *Certificate of Compliance*.

### **3.2.2 Supply Voltage**

The normal range of supply voltage is indicated in each case during the negotiations. Power and Water reserves the right to change the supply voltage and, to facilitate this, new transformers shall incorporate tapplings to cover the range, referred to the primary voltage, from +5% to -5% on a no-load ratio of 11000V or 22000V to 433 V. Other high-voltage equipment should be capable of being operated at the highest voltage level indicated by the above tapping range.

Momentary voltage dips and spikes may occur and customers are advised to install stabilisers, surge diverters or filters in supplies to particularly voltage-sensitive equipment and to ensure, where appropriate, that under-voltage releases and relays are suitably designed to avoid unnecessary operation.

### **3.2.3 Metering Arrangements**

The metering equipment shall preferably be located in an intake station at an agreed, accessible position close to the front property boundary. The meters shall be mounted on a wall in the switching station.

A suitable clear space is required adjacent to the meters for testing and maintenance. Provision is necessary for access to the meters by personnel. Locks shall be fitted with a standard Power and Water barrel.

Where it is not practicable or economic to install an intake station, Power and Water may consider other arrangements. These may include pole-mounted metering equipment in overhead areas, or a combined metering/main switchboard for smaller installations. These should be discussed at an early stage to determine requirements.

### **3.2.4 Intake Station Lighting and Power**

As the intake station does not include a distribution transformer when supply is taken at high voltage, the customer is to provide adequate lighting and a general-purpose power supply in the intake station chamber.

### **3.2.5 Power Factor**

The position is the same as indicated in Clause 3.1.4.

### **3.2.6 Submission of Proposal**

Where it is proposed to supply a new installation at high voltage or where it is intended to alter or add to an existing high-voltage installation, it is necessary for the customer to submit a detailed proposal and await written approval before ordering equipment.

If the customer purchases and installs any high-voltage equipment before the design, construction and method of installation has been approved, Power and Water may refuse to connect any equipment which, in Power and Water's opinion, is not satisfactory.

### **3.2.7 Equipment causing Interference with the Supply to Other Customers**

The position is the same as indicated in Clause 3.1.6.

### **3.2.8 Fault Level**

The *Wiring Rules* require a customer's installation to be designed so that it is capable of performing satisfactorily under fault conditions.

The short-circuit current which may occur in a customer's installation is dependent upon the fault level at the point of supply, any contribution which may be made by large rotating electrical plant connected within the installation, and impedances within the installation. The prospective fault levels on Power and Water's system at the point of supply under normal operating conditions are advised during the negotiation phase. To provide for system development the value given is generally higher than what will exist initially.

### **3.2.9 Selection of Main Protection Devices**

The customer's main circuit-breakers or fuses must be so selected and arranged that, as far as practicable, in the event of a fault occurring on the portion of the installation they protect, they will interrupt the fault current rapidly enough to ensure that Power and Water's over-current protection devices do not operate. Relevant details of the customer's proposed main protection devices should therefore be included in the proposal.

### **3.2.10 Maintenance and Safe Working**

Customers are required to have trained staff or contractors approved by the Electricity Safety Regulator, who can safely operate the installation's high-voltage switchgear.

Every high voltage installation must be regularly maintained in good order so that it will perform the functions for which it is designed. All work on high voltage installations must comply with the relevant statutory regulations, standards and industry guides including but not limited to the following:

- AS/NZS 3000  
SAA Wiring Rules
- AS 62271 series  
High Voltage Switchgear and Controlgear
- AS 1883-1992  
Guide to Maintenance and Supervision of Insulating Oils in Service
- AS 1767-1999  
Insulating Oil for Transformers and Switchgear.
- Electricity Reform (Safety and Technical) Regulations.

## Appendix

### Range of Standard Substation Designs

<b>Substation Type</b>	<b>Approx Rating In Amperes/Phase</b>
Pole Transformer 500kVA	700A
Package 1000kVA	1400A
Kiosk 1000kVA	1400
<b>Ground Type</b>	
One 1000Kva Transformer	1400A
Two 1000kVA Transformer	2800A
<b>Indoor – Surface Level</b>	
One 1000kVA Transformer	1400A
Two 1000kVA Transformer	2800A
Three 1000kVA Transformer	4200A
One 1500kVA Transformer	2100
Two 1500kVA Transformer	4200
Three 1500kVA Transformer	6300
<b>Indoor – Basement and Upper Level</b>	
One 1000kVA Transformer	1300A
Two 1000kVA Transformer	2600A
Three 1000kVA Transformer	3900A
One 1500kVA Transformer	2000
Two 1500kVA Transformer	4000
Three 1500kVA Transformer	6000

#### Notices to Table

- 1 The ratings are based on a commercial load cycle and the transformers operating at their normal full loading rating. They are to be taken as a guide only to the ratings that are generally obtainable. Actual ratings will depend on the particular substation equipment installed and other factors including customer's load cycle and equipment operating characteristics.
- 2 Transformers in multiple transformer substations are not usually connected in parallel. Accordingly, a separate supply will be given from each transformer. The load of the premises should be equally divided between each supply, or as nominated by Power and Water.
- 3 Transformers may be permitted to operate in parallel provided that the switchboard fault rating is sufficient, and provided automatic facilities are incorporated to shed sufficient load to prevent both transformers tripping simultaneously.
- 4 In the event of failure of plant or periodic maintenance, load taken by the premises supplied from a substation will be restricted to that which can be met by the supply capacity which can be provided at the time.