Section I - Introduction
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Preface

This *Distribution Substation Manual* contains the approved standard arrangements for the design, construction and installation of distribution substations, connection of customers to these substations and interconnection of the substations to the surrounding HV and LV networks.

It supersedes the *Distribution Substation Standards Manual*. All drawings within this *Distribution Substation Manual* begin with the prefix DSM. This has been done to avoid any confusion with drawings contained in the superseded *Distribution Substation Standards Manual*, which began with the prefix DSS.

Although the design principles and arrangements contained in this Manual are intended to be generally applicable to all installations, there are two areas within the distribution network which require special consideration. These are:

11kV Perth CBD - Specific design principles apply in this areas. The HV Network Arrangements and Substation Arrangements contained in this Manual should be used in conjunction with the principles outlined in *Report No ESD 78/92 - CBD Distribution Load Transfer Project, Project Planning Report* (October 1992)

33kV Rural - Due to the extremely low usage, new substation equipment has not been developed for 33kV at present. The Substation Arrangements contained in this Manual are therefore not directly applicable to 33kV. However, the Network Engineering Branch is available to consult on specific 33kV designs as required.

This Manual does not contain any equipment fabrication drawings. These are now contained in a separate manual.

This Manual is to be used in conjunction with the following documentation :

- *Distribution Design Manuals* - Volumes 1 to 5
- *Distribution Construction Manual*
- *WA Electrical Requirements*
- *Underground Distribution Schemes Manual*
- *General Conditions for Individual Customers* - DSB 95/5
- *Substation Installation Requirements* - DSB 95/6

Report No ESD 78/92 - CBD Distribution Load Transfer Project, Project Planning Report (October 1992)
Introduction

The information contained in this Introduction is intended to provide guidelines on the format, contents and use of the Distribution Substation Manual.

Format and Content of the Manual

The drawings contained within this Manual are divided into nine Sections as listed below. Each Section contains its own drawing index, with revisions listed in Section D – Drawing Revision List. In addition, some Sections contain additional design notes at the beginning of the Section.

Section D - Drawing Revision List

The drawing revision list contains the list of the latest updates that have been made on all the drawings in the manual.

Section 1: Customer Supply Arrangements

(DSM-1 Drawings)

This Section contains drawings showing the standard arrangements for the connection of LV or HV customers to new or existing distribution substations. These drawings are intended to enable the designer to select the correct method for connection of a customer.

Section 2: HV Network Arrangements

(DSM - 2 Drawings)

This Section contains drawings showing the standard arrangements for the interconnection of a new distribution substation into the existing HV network. These drawings are intended to enable the designer to select the required substation arrangement and also the correct method of interconnecting the substation with the HV network.

Where arrangements other than those shown in this Manual are proposed, approval shall first be obtained from the Network Engineering Branch.
Section 3: Substation Arrangements

(DSM - 3 Drawings)

This Section contains drawings showing the standard arrangements for distribution substations. Each substation arrangement drawing has either three sheets (for fire rated installations) or four sheets (for non fire rated installations). These sheets are described below. The first three sheets are common to all substation arrangements. The last sheet (Permissible Screening Arrangements) is only applicable for substations which are not required to be fire rated.

- **Sheet 1 - Civil and Land Requirements** - showing the land area required for the substation and any civil construction requirements (but no civil design details). For substations which are required to be fire rated, this sheet will also show the requirements for the fire rated enclosure.

  This sheet is intended for issue to the customer. In conjunction with the *Substation Installation Requirements DSB 95/6*, it describes the customer’s responsibilities in relation to the design and installation of the substation.

- **Sheet 2 - Equipment and Installation Details** - showing what equipment is required within the substation and its physical arrangement on the site. All equipment shown is based on assemblies contained in the *Distribution Construction Manual*. This sheet serves two purposes:
  
i. Firstly it enables the designer to build up an assembly list in DQM for the substation (for cost estimating purposes). A copy of this sheet can be retained on the design file for future reference.

  ii. Secondly it assists in defining construction information to other groups - for example, a marked up copy can be issued to Power Services Branch (PSB) Electrical Workshop for the construction of equipment such as an LV kiosk and another copy can be issued to PSB Construction Services Section for site installation requirements.

- **Sheet 3 - Operational Clearances** - showing the operational clearances required around items of equipment within the substation. These drawings are intended to provide the designer with the basis of the substation site area requirements to allow flexibility if alternative site areas/shapes are required in specific cases to satisfy a customer’s need.
• **Sheet 4 - Permissible Screening Arrangements** (only provided for substations which are not required to be fire rated) - showing what screening requirements are permissible around substations. This sheet is intended for issue to the customer. In conjunction with the *Substation Installation Requirements DSB 95/6*, it details the customer’s options and responsibilities in relation to the erection of screening around the substation site.

Note that where a customer requires a non-standard substation arrangement (for example where an odd shape site exists), the above drawings can be made available to the customer. It is then the customer’s responsibility, in conjunction with his architect, to prepare an alternative arrangement design. This design must meet all of WPC’s operational requirements and any relevant Australian Standards requirements shown on the drawings. The design must be submitted to WPC for approval.

**Section 4 : Kiosks - Arrangements and Installation Guide**

*(DSM - 4 Drawings)*

This Section contains drawings showing the standard arrangements and installation requirements for the various items of kiosk enclosed equipment used by WPC. This includes HV ring main switchgear kiosks (RMU’s), modular package substations (MPS’s), and LV switchgear kiosks. Each kiosk arrangement drawing has two sheets as follows:

• **Sheet 1 - General Arrangement** - showing the physical arrangement and dimensions of the kiosk. This sheet is intended mainly for issue to customers to provide them with an idea of the size and appearance of the equipment.

• **Sheet 2 - Installation Guide** - showing the requirements for installation of the equipment, for example, lifting points and installation sequences. This sheet is intended for issue to groups responsible for installation of the equipment on site.
Section 5 : Substation Fire Protection Requirements

(DSM - 5 Drawings)

This Section contains drawings showing the fire protection requirements for distribution substations. These drawings are intended to provide the designer with guidelines on determining the fire risk zones around a substation and what protection measures are necessary in the risk zones. These drawings can also be issued to customers for the same purpose.

Section 6 : Miscellaneous

(DSM - 6 Drawings)

This Section contains drawings relevant to distribution substations, which are of an ancillary nature and which are referenced on one or more of the above drawings. They include:

Substation Ducting Cross Sections - showing the required cross sections of ducts into distribution substations.

Substation Exhaust Fan And Distribution Board Details - showing the details and distribution board for the fan required in a fully enclosed substation with no cross flow ventilation.

Extensible Switchgear Support - showing the details of the support stanchion/beam for extensible type switchgear in a HV switchroom.

Transformer Lifting Details - showing the detail for lifting transformers using lifting eyes or a monorail.
Section 7 : Superseded Equipment - Installation Guide

(DSM - 7 Drawings)

This Section contains drawings showing the installation requirements for superseded equipment, specifically, the old style of transformers installed in non fire rated compounds, IPS transformers and IPS transformers with HV switchgear.

These drawings bring the installation of this superseded equipment in line with the new concepts of transformer installation to avoid the potential for problems when excavation occurs around the transformer during the installation of cables.

Section 8 : Distribution Automation

(DSM - 8 Drawings)

This Section contains drawings relevant to the automation and typical configuration of switchgears as well as the termination and wiring of isolators inside the switchgears. These include:

Common drawings – showing the detail associated with the automation of all type of switchgears.

Manufacturer's specific drawings – showing typical components and arrangement of components inside a switchgear specific to a certain manufacturer.

Section 9 : 33kV Substation Arrangements

(DSM - 9 Drawings)

This Section contains drawings showing the standard arrangements for 33kV district and sole use substations.
Use of the Manual

New distribution substations are required to meet the load requirements of customers. There may be a discrete customer (eg, a single commercial or industrial customer) or a number of new customers (eg a new subdivision). The following steps describe how the Manual is to be used to select the most appropriate substation arrangement, how it is to be interconnected to the HV network and how the customer is to be supplied from the substation.

Step 1
In the case of a new discrete load, determine the customer’s maximum load demand. This is discussed in detail in the Distribution Design Manual Volume 3 - Supply to Large Customer Installations.

Step 2
Determine the type of substation required, ie, District, Sole Use or Customer Owned. This is discussed in detail in the Distribution Design Manual Volume 3 - Supply to Large Customer Installations. It is also discussed briefly in Section I.2.1 of these notes.

Step 3
In the case of a district substation, determine the additional capacity required to feed back into the street.

Step 4
Determine the minimum number and sizes of transformers required to be installed in the substation. In the case of a new discrete load, before this can be determined it may be necessary to discuss the level of security required by the customer (eg, the customer may require 2 x 500kVA transformers rather than 1 x 1000kVA transformer). See Section I.2.2 of these notes for a more detailed discussion on the selection of minimum transformer sizes.
Step 5
Select the most appropriate Customer Supply Arrangement drawing (contained in Section 1 of this Manual) based on the above information. Note that the transformer size in conjunction with the customer’s maximum load demand will determine the size of fuse, link or disconnect required for the customer and also whether or not the customer’s switchboard must be contiguous. See Section I.2.3 of these notes for a more detailed discussion on the requirements for a contiguous switchboard.

Step 6
Determine whether a modular package substation (MPS) arrangement or non MPS arrangement is required. See Section I.2.4 of these notes for a more detailed discussion on the choice between MPS and non MPS arrangements.

Step 7
Select the most appropriate HV Network Arrangement drawing (contained in Section 2 of this Manual) based on the neighbouring HV network to which the substation will be connected. Note that HV transformer fuse sizes are provided in drawing DSM -1-02.

Step 8
Determine the fire protection requirements for the substation based on the proposed location of the substation in relation other land uses in the vicinity (eg other structures or buildings) and the drawings contained in Section 5 of this Manual. See Section I.2.5 of these notes for a more detailed discussion on the fire protection requirements for substations.

Step 9
Select the correct Substation Arrangement drawing (contained in Section 3 of this Manual) from the table on the HV Network Arrangement drawing based on the substation type and fire protection requirements.
Step 10

Based on the Substation Arrangement drawing and other information determined in previous steps (e.g., transformer size, type and size of customer fuse / link / disconnect, and need for a contiguous switchboard), finalise the design and prepare an assembly list for the substation. The optional check boxes on the Substation Arrangement drawing can be used to provide construction information.

In the case of a non fire rated substation, the customer’s requirements for screening of the substation should also be determined at this point. See Section I.2.6 of these notes for a more detailed discussion on substation screening.
Selection of Substation Types

A District substation is defined as one with LV connections to the street mains. In most cases, it is limited to 2 MVA and is available to customer’s who will not cause interference problems to other customer’s connected to the same LV network. The substation should ideally be located within the property on the street boundary, with a maximum setback of 30 metres (to limit LV volt drop on street feeds).

A Sole Use substation is defined as one with no LV connections to the street mains. In most cases, it is limited to 2 MVA but under certain circumstances this can be increased by the use of multiple LV metering. Subject to WPC’s approval, there is no limit on the distance which it may be set back from the boundary. It is available to customer’s who satisfy one or more of the following criteria:

• The customer has a disturbing load.
• The customer has a large site with the load centre located considerably more than 30 metres from the property boundary.
• The location of the site is such that an LV feed to the street will never be required.
• The customer either now or in the future will require all the transformer capacity.

In both District and Sole Use substations, WPC owns, operates and maintains all equipment. The decision to install a District or Sole Use substation always remains with WPC and not the customer. Where HV switchgear is required for a District or Sole Use substation, the setback limits for the switchgear are provided on the appropriate HV Network Arrangement drawing.

A Customer Owned substation is defined as one from which the customer takes supply on a HV tariff. The customer owns and is responsible for all equipment other than WPC’s metering equipment and any HV switches connecting the substation to WPC’s network.

Where a HV metering unit is installed, the output terminals define the point of supply. However, under some circumstances (mainly relating to low HV side load current), a customer owned substation may be provided with low voltage metering even though a HV tariff is applicable. The point of supply for such an arrangement will be determined by WPC and an adjustment for transformer losses will be required.
Sizing of Transformers

Transformers have an overload capability which allows them to operate above their nameplate rating. This overload capability is dependent on the load cycle to which the transformer is subject (e.g., residential or commercial). Transformer overload/cyclic rating capabilities are provided in *Report ES65 Rev A - March 1987*.

The maximum discrete load that can be supplied from a District substation is the nameplate rating of the transformer. The transformer overload/cyclic rating capability is not to be taken into account when selecting the minimum transformer size required. This overload/cyclic rating capability is the minimum that should be left available to feed back into the street (this is reflected in the load ranges shown on the Customer Supply Arrangement drawings in Section 1 of this Manual). Where the street feed requirements exceed the transformer overload/cyclic rating capability plus the difference between the discrete load value and the nameplate rating, a larger transformer should be selected.

The maximum discrete load that can be supplied from a Sole Use substation is nominally the nameplate rating of the transformer. However, in selecting the minimum transformer size, the overload/cyclic rating capability of the transformer can be taken into account based on the specific load profile of the customer.

Note that for both district and sole use substations it may be possible to install a smaller transformer initially and then upgrade the transformer in the future as load growth dictates (see Section I.2.4).
Size of Customer Fuse/Link/Disconnect and Requirement for a Contiguous Switchboard

Where a customer is fed from a fused LV supply out of a WPC district substation, the magnitude of the load is limited such that the customer’s main switch will grade with WPC’s LV fuse. The maximum size WPC LV fuse which can be used is in turn dependent on the transformer rating/voltage (and in some cases whether the transformer is protected by HV dropout fuses or a RMU fuse switch). In such cases, since the cable to the customer’s point of supply is protected by a fuse, the switchboard can be remote from the substation.

Where a customer is fed from a district substation and the magnitude of the load is such that the customer’s main switch cannot grade with the maximum size LV fuse which can be used with the transformer, the customer must be supplied either from links or a disconnect (depending on the magnitude of the load).

Note that drawing DSM-1-02 provides the maximum size LV fuses that can be used with each transformer or transformer combination (piggybacked).

Where a customer is fed from a sole use substation, the customer is connected directly to the LV bushings of the transformer.

In the latter two cases, since the cable to the customer’s point of supply is not protected, the switchboard must be contiguous with the substation, thus limiting the amount of unprotected cable which is exposed to damage. To be considered contiguous, in the case where the substation is screened, the switchboard must be against the exterior of the screening. In the case where a substation enclosure is constructed, the switchboard must be against the exterior wall of the enclosure. Where there is no screening or enclosure, the switchboard must be immediately adjacent to the edge of the substation site boundary.
Choice of MPS or Non MPS Arrangement

Both the MPS and non MPS arrangements are designed to allow rapid replacement / upgrade of the transformer with no impact on other substation components such as HV or LV switchgear and interconnecting cabling. This means that a smaller transformer can be installed initially and then replaced with a larger transformer in the future as required by load growth.

The MPS arrangement can be used for district substations with a single transformer sized in the range 160kVA to 630kVA (630kVA being the largest transformer that can be used in the MPS). The MPS arrangement is not to be used for sole use substations. Since in sole use situations an LV frame is not required, the non MPS arrangement will serve the same function at a considerably lower cost.

The MPS arrangement is the preferred arrangement where:

- A district substation with a single transformer is required and
- The substation does not need to be fire rated and
- The maximum transformer size (now or in the future) will not exceed 630kVA.

The non MPS arrangement can be used for district and sole use substations with single or multiple transformers sized in the range 160kVA to 1000kVA.

The non MPS arrangement must be used where:

- The substation is to be sole use or
- Multiple transformers are required or
- The substation needs to be fire rated or
- There is a possibility that future upgrade of the transformer to 1000kVA will be necessary.
Substation Fire Protection Requirements

The drawings contained in Section 5 of this Manual provide guidelines on the fire protection requirements necessary for distribution substations. The drawings show the fire risk zones around a substation. No essential public access/exit/escape shall pass through the fire risk zone. In addition, generally, no other structure or building is permitted within the substation fire risk zone unless it has a two hour fire rating (although as noted below, depending on the nature and use of the structure / building, fire protection may not be necessary). In all cases where another structure/building conflicts with the fire risk zone around a substation, the choice exists as to whether to construct a fire rated enclosure around the substation or to fire rate the other structure / building within the fire risk zone.

Note that depending on the nature and use of the structure / building, fire protection may not be necessary. For example, a shed constructed of non combustible materials being used to store non combustible material could be located within a substation fire risk zone without the need for fire rating. However, if the shed also regularly housed people engaged in some form of continuous activity, then either the building or substation shall be fire rated.
Substation Enclosures And Screening Requirements

Where a substation is required to be fire rated, the customer is responsible for the construction of a substation enclosure in accordance with the requirements shown on the Civil and Land Requirements sheet of the Substation Arrangement drawing and also in accordance with the Substation Installation Requirements - DSB 95/6.

However, all the equipment used in WPC’s substation is considered safe from an explosion and contact perspective. Hence, where it is not necessary for a substation to be fire rated, WPC does not require the construction of any enclosure around it. All equipment can be “clustered” on the site in accordance with the Equipment and Installation Details sheet of the Substation Arrangement drawing. The choice to erect some form of screening around such a “cluster” substation is entirely up to the customer (eg, the customer may require it for aesthetic purposes).

In such cases, the customer may erect screening of his choice around the substation (ranging from vegetation to a full enclosure). However, any screening must be installed in accordance with the requirements shown on the Permissible Screening Arrangements sheet of the Substation Arrangement drawing and also in accordance with the Substation Installation Requirements - DSB 95/6.