VOLTAGE DROP - GUIDELINES

The introduction of AS/NZS 3000:2000 (Wiring Rules) has modified the requirements for voltage drop consideration in domestic installations. This has been based on ensuring that the electrical installation is designed and adequate wiring is installed to ensure a safe installation.

Instances have occurred under short circuit conditions, where the protective device has not operated because of excessive voltage drop caused by the impedance of long circuits. Increasing adoption of overseas wiring Standards has enhanced the safety requirements of electrical wiring and equipment installed within electrical installations.

Other changes have resulted in savings for the majority of electrical consumers, for example; no requirement for minimum size of consumer's mains, no limit on the number of main switches, no limit on the number of lighting points per final sub-circuit, no limit on the number of socket outlet points per final sub-circuit, etc.).

However, in some cases the changes may result in the need to install larger consumer's mains than would have been required under the previous version of the above Standard, for example, high rise building and extended runs of underground or overhead conductors.

The size of any consumer's mains should be determined following a review of the design of the overall installation. This review should consider all options, viz:

(a) Seasonal and daily variations of electrical demand by the consumer.

(b) Determining the maximum demand– electrical loading of the installation.

(c) Limitation of Maximum Demand.

(d) Type of the Electrical Load – Hot Water Service, Stove, Air-conditioner etc.

(e) Type of Electricity Supply - number of phases.

(f) Method of installation of Wiring Systems.

(g) Cable sizing of various circuitry - consumers mains, sub-mains and final sub-circuits.

(h) Conductor parameters – Milli-Volt per Amp-metre.

(i) Point of supply location – Transformer on-site.

(j) Provision for future additional Electrical Loading.

A proper assessment of all the above factors should result in an optimum economic design for the consumer's installation.

Seasonal and Daily Variations of Electrical Demand by the Consumer

Many domestic installations contain loads, which are subject to control by the Electricity Supplier. These loads include storage hot water systems and storage heating systems. In the past supply to these loads were only made available at periods other than peak demand periods. Changes to electricity pricing arrangements have resulted in these controlled loads being available at different times during the day. This resulted in an amendment being made to the previous version of AS 3000:1991 (Amdt No.6 January 1997) which deleted the dispensation for controlled loads. This may impact on some existing electrical installations where the consumers mains were sized to accommodate the previous diversified controlled loads. However, a minimum size current carrying capacity of consumers mains and sub-mains was still required by those Wiring Rules.

Determining the Maximum Demand – Electrical Loading of the Installation

The maximum demand of consumers mains and submains of an electrical installation shall be determined by one of four methods as per Clause 1.8.3 of AS/NZS 3000:2000 i.e. by Calculation, Assessment, Measurement or Limitation. The most common method appears to be by calculation. **However, for existing installations it may be prudent to use a determination method other than the calculated or assessed method**. This may allow for a reduction in conductor sizing and a reduction of costs for the consumer.

Limitation of Maximum Demand

A fixed setting or an adjustable circuit-breaker may be used to limit the maximum demand of consumers mains and submains, or the maximum demand may be determined by the sum of the current settings of the circuit-breakers protecting the associated final subcircuits.

Type of Electrical Loading – Hot Water Service, Stove, Air-conditioner, etc

Where a separate final sub-circuit supplies electrical equipment the conductors must have the ability to carry the electrical demand of that equipment. Consideration for voltage drop, method of cable installation and the short circuit temperature performance of the cable must also be considered.

Type of Electrical Supply - Number of Phases/Wire

Different configuration of wiring systems may result in economic savings to the customer. Where practicable, an existing single-phase 2-wire installation re-configured for either 3-wire single-phase or two-phase - in general, halves the conductor size. A calculation would need to be performed to determine the exact minimum size that will satisfy the requirement of AS/NZS 3000:2000.

Method of installation of Wiring Systems

Three main factors influence the selection of a particular cable to satisfy the circuit requirements:

- Current Carrying Capacity – dependent upon the method of installation and the presence of external influences, such as thermal insulation, which restrict the operating temperature of the cable.
- Voltage Drop - dependent upon the impedance of the cable, the magnitude of the load current and the load power factor.
- Short-circuit Temperature Limit - dependent upon energy produced during the short-circuit condition.

The minimum cable size will be the smallest cable that satisfies the above requirements. With experience it will become apparent that the different nature of installations will determine which of the requirements predominate. In general, the current carrying capacity requirements will be the most demanding in relatively shorter route lengths of domestic premises and the like where factors such as electrical protection, cable grouping, and thermal insulation occur. **The voltage drop limitation is usually the deciding factor for longer route lengths.**

Cable Sizing of Various Circuitry - Consumers Mains, Sub-mains and Final sub-circuits

The cross-sectional area of every current-carrying conductor shall be such that the voltage drop between the point of supply and any point in the electrical installation does not exceed 5% of the nominal supply voltage.

AS/NZS 3000:2000 allows a voltage drop dispensation for final subcircuits, with distributed load (such as socket-outlets or lighting), where half the current rating of the protective device may be used in the voltage drop determination. **This dispensation is no longer restricted to domestic installations.**

For final sub-circuits other than distributed load such as, hot water service, stove, air-conditioner etc., no such dispensation is provided. It is important to note that instances have occurred under short circuit conditions, where the protective device has not operated because of excessive voltage drop caused by the impedance of long circuits.

Consider the following examples where different combinations of conductor sizes may have a considerable cost impact if not designed in the most economic manner.

For a single-phase two wire Electrical Installation where the;

- calculated maximum demand is 63 Amps.
- route length is 120 metres (between the point of supply and the main switchboard).
- route length of a 4.8kW electric hot water service final sub-circuit is 30 metres.

(A) ---63 amps-- (B) -----20 amps---- (C)

(A) = Point of Supply (B) = Main Switchboard (C) = Hot Water Service

Example	Consumers Mains	*Volt Drop*	Final Sub-circuit	*Volt Drop*	*Total Volt Drop*
1	**240mm^2**	*0.78%*	**2.5mm^2**	*4.22*	*5%*
2	**70mm^2**	*2.43%*	**4.0mm^2**	*2.57%*	*5%*
3	**50mm^2**	*3.30%*	**6.0mm^2**	*1.70%*	*5%*
4	**35mm^2**	*4.00%*	**10.0mm^2**	*1.00%*	*5%*

Voltage Drop (Total) = (Volt Drop Consumers Mains [A-B] + Voltage Drop Final Sub-circuit [B-C])

Conductor parameters

Conductor parameters, which affect the determination of voltage drop, include conductor resistance, impedance, size of conductor, conductor material, installation methods, conductor arrangement, conductor configuration, nominal voltage, power factor, conductor temperature and current carrying capacity. Some of these factors become more relevant as the size of the conductor increases.

Specific Information can be sourced from AS/NZS 3008.1.1 or cable manufacturers. Please note that the various voltage drop tables in the Standard are relevant to three-phase voltage drop and conversion to single-phase may be necessary, viz: to convert three-phase voltage drop (mV/A.m) values to single-phase values, multiply to three-phase values by 1.155.

Point of Supply – Location

Where an alteration of an electrical installation requires a change of method of conductor installation, for example, undergrounding an overhead electric line, consideration should be given to the relocation of the existing point of supply. On a rural property it may be more economical for the electricity supplier's assets (sub-station) to possibly be relocated closer to the installation.

Provision for future additional Electrical Loading

In general, good design of an electrical installation should ensure that adequate spare capacity is allowed for future additional electrical load. The question arises as to what is adequate spare capacity – your electrical experience in this regard is invaluable. Consultation with the owner/occupier to address their future loading needs is essential. In a competitive business environment this issue could be seen as a value adding exercise to your clients needs.

Commercially available computer programs may be used to assist in the determination of maximum demand, voltage drop and other electrical design information.

Further advice or information can be obtained from your Licenced Electrical Inspector or from the Office of the Chief Electrical Inspector by telephone 9203 9700 or by e-mail (info@ocei.vic.gov.au).