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Low Voltage Design: Maximum Demand

18 October 2023 | Technical Topic Webinar

Ms. Alex Gregory,

EIT Lecturer and AECOM Principal Engineer

Engineering Institute of Technology.

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Introduction - Presenter

Ms. Alex Gregory

EIT Lecturer and AECOM Principal Engineer

- Chartered Professional Engineer (CPEng) with Engineers Australia
- Registered Professional Engineer (RPEQ) in QLD
- National Engineering Register (NER)

Agenda

1	What is maximum demand (MD)
2	MD for AS/NZS 3000
3	How to calculate MD • Existing Building Vs New Building • Various Methods – VA Rate, AS/NZS3000, Other services
4	Diversity
5	Lessons learnt

What is Maximum Demand

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- Maximum demand is the maximum current (Amps) which can be drawn by an electrical installation.

  Maximum Demand $\neq$ Consumption

- The maximum demand is the sum of all ‘downstream’ equipment

- The electrical installation is *sized* for the expected maximum demand including:

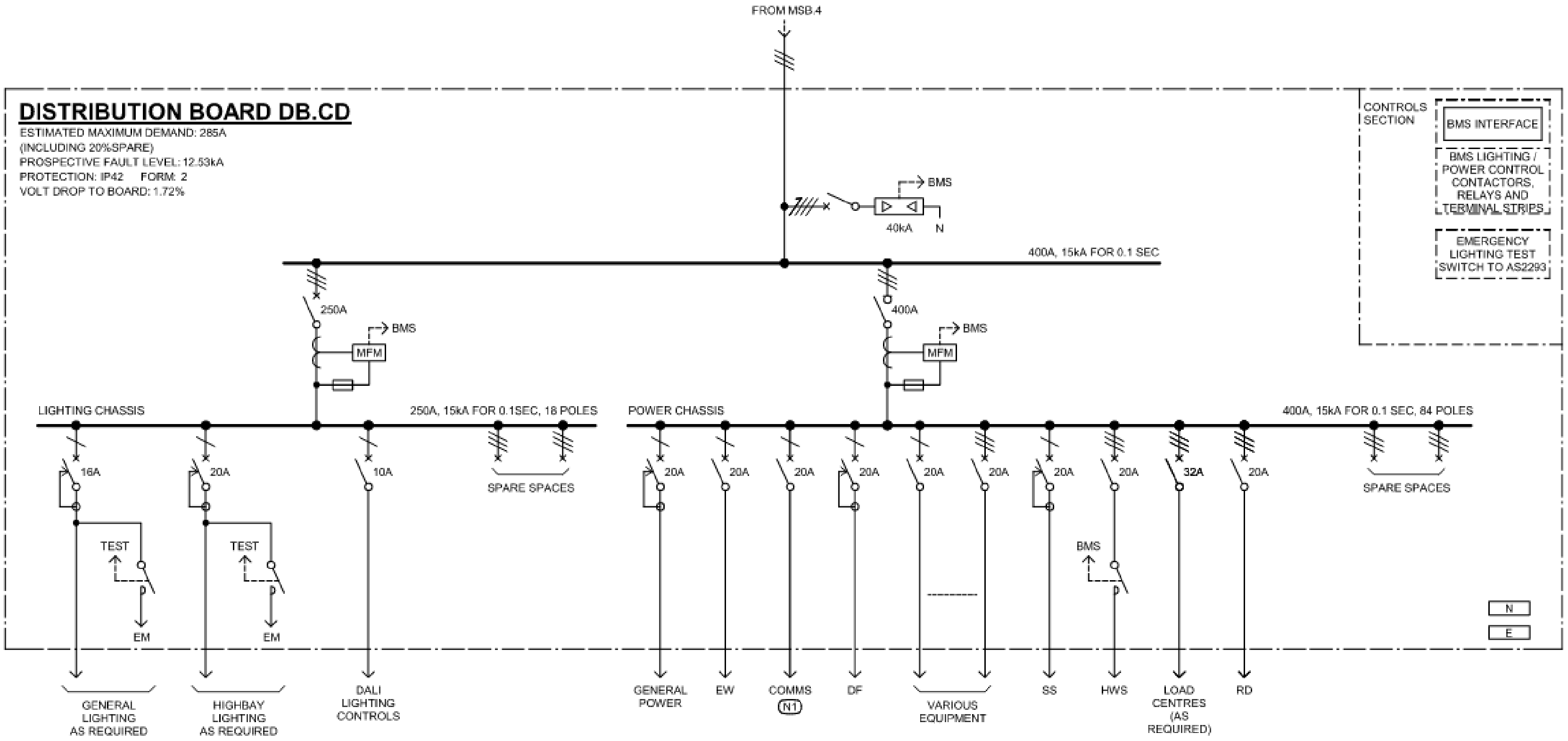
Transformers	Main Switchboard	Distribution Boards	Protective Devices	Cables

  - You may size your infrastructure inclusive of future spare capacity / expansion

What is Maximum Demand

Let’s look at an example

- Maximum Demand / Diversified Demand / Sizing of infrastructure



What is Maximum Demand (AS/NZS 3000)

Reference to Maximum Demand un AS/NZS 3000

- Section 1.6.3 – The Principal
- Section 2.2.2 – How to calculate maximum demand
- Appendix C – Details and Examples

1.6.3 Maximum demand

The maximum demand of an electrical installation shall be determined, taking account of the capacity, physical distribution and intended use of electrical equipment in the electrical installation and the manner in which the present requirements might vary.

Consumer mains, submains and other electrical equipment of an electrical installation shall be designed and installed to meet the maximum demand.

What is Maximum Demand (AS/NZS 3000)

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AS/NZS 3000 Section 2.2.2

Most Common method, especially for new projects / construction in early stages.

Used for more specific / bespoke installations

Useful for existing installations / to validate your calculations

Note:
In most cases, circuit breaker settings for downstream boards/equipment will be higher than a calculated max demand

2.2.2 Maximum demand

The maximum demand in consumer mains, submains and final subcircuits, taking account of the physical distribution and intended usage of electrical equipment in the electrical installation and the manner in which the present requirements might vary, shall be determined using one of the methods set out in Items (a) to (d).

If the actual measured maximum demand is found to exceed that obtained by calculation or assessment, the measured value shall be deemed to be the maximum demand.

(a) *Calculation* The maximum demand may be calculated in accordance with the guidance given in this Standard for the appropriate type of electrical installation and electrical equipment supplied.

NOTE: Guidance on the determination of maximum demand is provided for basic electrical installations in Appendix C.

It is recognized that there may be considerable differences in loading from one electrical installation to another. Alternative methods of calculating the maximum demand may be used taking account of all the relevant information available for any particular electrical installation.

(b) *Assessment* The maximum demand may be assessed where—

A1

(i) the electrical equipment operates under conditions of fluctuating or intermittent loading, or a definite duty cycle; or

(ii) the electrical installation is large and complex; or

(iii) special types of occupancy exist.

(c) *Measurement* The maximum demand may be determined by the highest rate of consumption of electricity recorded or sustained over a period of 30 minutes when demand is at its highest by a maximum demand indicator or recorder.

(d) *Limitation* The maximum demand may be determined by the current rating of a fixed setting circuit-breaker, or by the load setting of an adjustable circuit-breaker.

The maximum demand of consumer mains and submains may be determined by the sum of the current settings of the circuit-breakers protecting the associated final subcircuit/s and any further submain/s.

What is Maximum Demand (AS/NZS 3000)

- Appendix C: Maximum Demand

- General Principal:
- Load current for each type of equipment is contributed to achieve a maximum demand current
- Different method for ‘Domestic Installation’ than for ‘Commercial Installation’

- (More on this in later slides)

Existing Building Maximum Demand Calculation Methods

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- Metering Information / Billing information
- The longer metering is on the system, the more accurate the results will be
- Think about what is ‘typical’ for that installation and what is happening within the facility during the metering – if you see a very low number in one the recordings, see what the cause is
- <u>Key Information to take away from the data:</u>
- Peak / maximum drawn (at any one time): Your infrastructure needs to be sized to handle this load
  - Ensure it is not an anomaly
  - Use the data to graph a load profile (daily / weekly / seasonally) as much as you can
  - Discuss / understand what is contributing to this large load (is it repetitive)?
- The average load: This is your ‘diversified load’ and assists in understanding the average running load of the installation

Existing Building Maximum Demand Calculation Methods

- Metering Information / Billing information
- Not all metering info is useful!

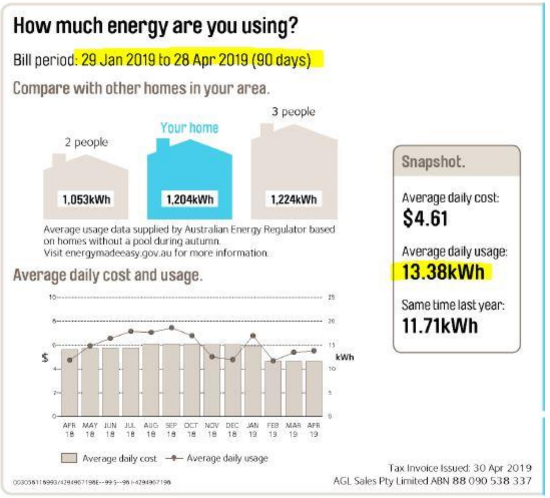
Some meters only record the energy consumption not the kVA, or Amps.

Even if some meters record the amps, the recorded information may be lost.

Ensure metering is done when the building is being used

Most useful: Both average AND peak value in Amps / kVA

Also helps identify existing issues: Power Factor, neutral / earth currents, harmonic issues, large fluctuations in load



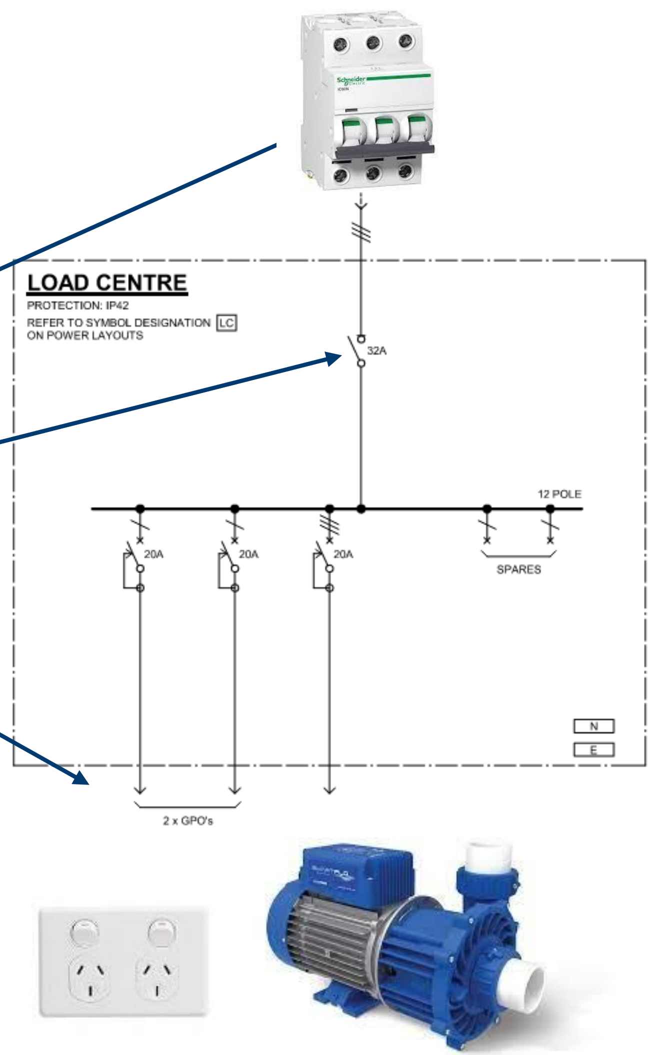
- Q: What about our electricity bill?

Existing Building Maximum Demand Calculation Methods

- 2. Inspect the existing infrastructure
- This method is weaker and can ‘over-size’ your design / installation. E.G lots of DB’s off the shelf are 160 / 250 A as standard.
- Based on assuming ‘worst case’ which is an MD up to the maximum value that switchboard, or supply, can provide.

  1. Supplying Circuit Breaker Size
  2. Main Switch Size

- 3. High level assessment of connected equipment to validate other methods e.g VA rates
- If there is not a lot of equipment, you can do a rough calculation of the large loads and validate this against a VA rate, or meter data



New Building Maximum Demand Calculation Methods

1. **Volt-Ampere rates:** This is a rate (in VA) applied to a area (m2) based on the type of fitout. Can be applied to a whole building, or
    1. This is a rate applied based on the area of a facility
    2. Useful for high level calculations
    3. Generally covers multiple electrical items e.g Power, Lighting or Power, Lighting and Mechanical
    4. Can be AS/NZS 3000 Rates / Rates from previous projects / Rates provided by specific industries
2. **AS/NZS 3000 Diversified Maximum Demand:** This is detailed 'bottom up' calculation based on all equipment
3. **A combination of above**

It's ok to use a variety of methods to validate your MD, such as:

- Assessment of similar existing building
- Calculated from expected equipment and loads connected

Method: Volt-Ampere Rates

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- VA Rate method:
- Is a pre-defined VA/m2 figure for different types of areas. This figure can be obtained from:
- AS3000 - Table C3
- Technical Guidelines
- Previous Jobs
- AS/NZS 3000 - Table C3
- This table provides MD only for Mechanical and Light and power.
- HOWEVER! kVA for other services would need be added:
  - Hydraulics
  - ICT
  - Fire
  - Lift

TABLE C3

MAXIMUM DEMAND—ENERGY DEMAND METHOD FOR NON-DOMESTIC INSTALLATIONS

Type of occupancy		Energy demand	
		Range, VA/m²	Average, VA/m²
Offices	Light and power	40–60	50
	Airconditioning:		
	— Cooling	30–40	35
	— Reverse cycle	20–30	25
	— Zonal reheat	40–60	50
	— Variable volume	20	20
Carparks	Open air	0–10	5
	EV charging	5–15	10
	Basement	10–20	15
	EV charging	10–30	20
Retail shops	Light and power	40–100	70
	Airconditioning	20–40	30
Warehouses	Light and power	5–15	10
	Ventilation	5	5
	Special equipment	(use load details)	
Light industrial	Light and power	10–20	15
	Ventilation	10–20	15
	Airconditioning	30–50	40
	Special equipment	(use load details)	
Taverns, licensed clubs	Total	60–100	80
Theatres	Total	80–120	100

NOTE: EV charging relates to charging equipment associated with electric vehicles and should be considered in addition to all other energy demands.

Method: Volt-Ampere Rates

- AS/NZS 3000 - Table C3

- Most useful for standard installations (e.g office, residential etc)
- Table C3 provides MD only for Mechanical and Light and power.
- HOWEVER!
- Load for other services would need be added:
  - Hydraulics
  - ICT
  - Fire
  - Lift
  - Specialist equipment

Method: Volt-Ampere Rates

Technical guidelines - based on area classification (known as defined rates)

- Often more accurate than AS/NZS 3000 as they are specifically for the application

Example:

- Queensland Health CIR (Capital Infrastructure Requirements)
- Energex Supply and Planning Manual document

Table 7: Electrical load profile

Department	VA/m2
Catering (commercial kitchen)	200
Day procedures—patient treatment areas	120
Emergency	120
Engineering services (other than on-site catering)	100
Critical care units	120
General inpatient wards	110
Main entrance	80
Mortuary	110
Operating theatre suites	120
Offices	100
Waiting areas, public spaces, corridors	80

TABLE 3.6.1 – Typical ADMD for Various Loads

TYPICAL AFTER DIVERSITY MAXIMUM DEMANDS FOR VARIOUS LOADS	
Individual dwellings	Small 6 – 10 kVA Medium10 – 15 kVA Large15 – 20 kVA
Home units	2 kVA
Caravans	1 kVA
Engineering workshops	25% of connected load, but may be much higher in some industries
Sawmills	100% of connected load unless restricted by the number of operators, the principle being that only one machine can be used by one man at any one time.
Air-conditioning	75% of connected load
City Buildings Fully Air-conditioned	75 – 130 VA/m² (7 – 12 VA/m²)
Welders	See Table 3.6.2

Method: VA Rates

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- We can use values from previous projects OR use the VA rate table in AS3000 or a combination!

ELF VA/m2 rates	Amps	VA	m2	VA/m2	
JLC Clothing Store	331	229383	2028	113.108	
Q store 89RAR (TOTAL)	298	206514	2052	100.6404	NOTE ALL OF THESE INCLUDE THE 25% SPARE CAPACITY
Q store 89RAR (Q store only)	164	113652	1440	78.925	
Q Store 7CSSB	390	270270	2246.4	120.3125	
Workshop 89RAR	706	489258	2437.5	200.7212	
Workshop CSB EIR	720	498960	1482.15	336.6461	
Typical Vehicle Shelter MRE	34	23562	1296	18.18056	
Typical Vehicle Shelter 7CSSB	23	15939	960	16.60313	
Haz Store RAR	7	4851	107.8	45	
89RAR - HQ Office (Level1)	191.2	132501.6	1300	101.9243	
Office Mechanical - NORFORCE				100	NOTE THIS IS BASED ON 200W/m2 of Mech Load at 0.4 coversion plus spare

Reef Project	Area	Reference Project/Room	Light/Power	Total MD	MD (Amps)
				0	
Retail / Café seating	150	AS/NZS 3000 Retail	30	4500	6.5
Office	415	AS/NZS 3000 Office	50	20750	29.9
Foyer / Entry / Open Public Areas	1930	CIR (minus A/C) for waiting areas, public areas	20	38600	55.7
Amenities	243	Air7000 (excl. Hydraulic)	15	3645	5.3
BOH	795	Office (50), Light industrial (15)	25	19875	28.7
Exhibits	1453	ILHS Shelter minus ventilation	25	36325	52.4
Theatre	280	Indigi (56), BBRCCS (200)	100	28000	40.4
Laboratory / Workshop	160	Average of Lab (100, logan), Workshop (250, Defence)	50	8000	11.5
Exhibit Plant Space	576	Office (50), Light industrial (15)	15	8640	12.5
Store	177	Light Industrial - Light and Power	15	2655	3.8
Kitchen	129	Logan / CIR (Same, without mech)	220	28380	41.0
Total	**6308**			**199.37**	**287.7**
				38	

How to Calculate MD – Other Services

- MSB Level or DB Level
  - Mechanical Services/ Hydraulic Services
    - Really understand what the mechanical team have allowed for – talk to them, don't assume
    - Speak to them about their in-built diversity into the loads
    - Do due diligence to check the calculations (Specifically kW vs Amps)
    - Check if they have added their own 'spare' / 'buffer' / 'fat' to ensure we aren't doubling up
    - Check the total of equipment across all three phases / balanced load
    - Check 'running load' against 'rated load' often there is a large difference
    - Discuss Diversity

MSSB-0830-1

Equipment	Description	No. Units	Load per Unit kW	Absorbed Load kW	Phases	Starter	Switch	Indi-cation	Comment
DX-0830-1.XX (Type B)	DX Split	3	1.055	3.17	1	DOL	A/O	R	
FCU-0830-G.XX (Type C)	Ducted DX Precon	1	4.4	4.40	1	DOL	A/O/M	R/F	
FCU-0830-1.XX (Type C)	Ducted DX Precon	1	4.4	4.40	1	DOL	A/O/M	R/F	
EAF-0830-G.XX	Ground Amenities	12	0.02	0.24	1	EC	A/O/M	R/F	
EAF-0830-1.01	Level 1 Amenities and Laundry	1	0.19	0.19	1	EC	A/O/M	R/F	
EAF-0830-1.02	Level 1 Amenities	1	0.16	0.16	1	EC	A/O/M	R/F	
EAF-0830-1.03	Level 1 Kitchen	1	0.01	0.01	1	EC	A/O/M	R/F	
	Controls			1.00	1	-			-
	Absorbed Load			12.62					
	Connected Load			13.57					
	Spare Capacity			3.39					

Location	Building 830 West Plantroom
Classification	Non Essential
Criticality	Non Essential
Fire Mode Operation	Shutdown on fire alarm
Form of Segregation	Form 2b
Degree of Protection	IP54
Fault Withstand	
Colour	X15 Orange to AS 2700
Sub Main By	Electrical Contractor
Sub Main From	Main Switch Board
Mounting & Approximate Size	2100 x 900 x 300
Comments	

Methods – AS/NZS 3000 Diversified Load

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- AS/NZS3000 Appendix C
- Section C2.3 - Domestic Installation
- Section C2.4 - Non-Domestic Installation (this lecture)

- STEP 1
- Using table C2, the MD is calculated by adding the load current for each equipment load group in the installation.
  - Group a – Lighting
  - Group b – Socket Outlets
  - Group c – Cooking appliances
- Noting that this method will determine the total Amps on each phase of the system. The heaviest phase will determine the MD.

10A	12A	10A	
Phase A Total Amps	Phase B Total Amps	Phase C Total Amps	MD = 12A

→ Undi\[…\] same \[…\] at the

- STEP 2:
- Apply Diversity Factor:
- Undiversified Load (From Table C2) X Diversity Factor = Diversified Load

TABLE C2

MAXIMUM DEMAND—NON-DOMESTIC ELECTRICAL INSTALLATIONS

1	2	3
Load group	Residential institutions, hotels, boarding houses, hospitals, accommodation houses, motels[1]	Factories, shops, stores, offices, business premises, schools and churches[1]
(a) Lighting other than in load group (f)[2]	75% connected load	Full connected load
(b) (i) Socket-outlets not exceeding 10 A other than those in (b)(ii)[3, 5]	1000 W for first outlet plus 400 W for each additional outlet	1000 W for first outlet plus 750 W for each additional outlet
(ii) Socket-outlets not exceeding 10 A in buildings or portions of buildings provided with permanently installed heating or cooling equipment or both[3, 4, 5]	1000 W for first socket-outlet, plus 100 W for each additional outlet	
(iii) Socket-outlets exceeding 10 A[3, 5]	Full current rating of highest rated socket-outlet, plus 50% of full current rating of remainder	Full current rating of highest rated socket-outlet plus 75% of full current rating of remainder
(c) (i) Appliances for cooking, heating and cooling, including instantaneous water heaters, but not appliances included in load groups (d) and (j) below	Full connected load of highest rated appliance, plus 50% of full load of remainder	Full connected load of highest rated appliance, plus 75% of full load of remainder
(ii) Charging equipment associated with electric vehicles	Full connected load of highest rated appliance, plus 75% of full load of remainder	Full connected load of highest rated appliance, plus 75% of full load of remainder
(d) Motors other than in (e) and (f) below	Full load of highest rated motor, plus 50% of full load of remainder	Full load of highest rated motor, plus 75% of full load of second highest rated motor, plus 50% of full load of remainder
(e) Lifts	(i) Largest lift motor—125% full load (ii) Next largest lift motor—75% full load (iii) Remaining lift motors—50% full load For the purpose of this load group, the full-load current of a lift motor means the current taken from the supply when lifting maximum rated load at maximum rated speed	
(f) Fuel dispensing units	(i) Motors: First motor—full load Second motor—50% full load Additional motors—25% full load (ii) Lighting—full connected load	
(g) Heating elements associated with thermal storage heaters, including water heaters, space heaters and similar arrangements, such as swimming pools, spas, saunas	Full-load current	
(h) Welding machines	In accordance with Paragraph C2.5.2, taking into account power factor correction	
(i) X-ray equipment	50% of the full load of the largest X-ray unit, additional units being ignored	
(j) Other equipment not covered by load groups above	By assessment	

Methods – AS/NZS 3000 Diversified Load

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AS/NZS3000 Appendix C

- There are good examples in AS/NZS 3000 on how to use the tables
- Make sure you read the NOES associated with the table

TABLE C2

MAXIMUM DEMAND—NON-DOMESTIC ELECTRICAL INSTALLATIONS

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How to Calculate MD – Diversity

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- **What is Diversity:**
- Diversity is an expression of how different loads operate together. In other words, what portion of the total load will the switchboard see at any point in time.

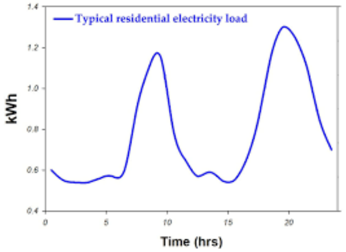
The diversity factors applicable to any given circuit in an installation will depend on a number of features of the installation including—

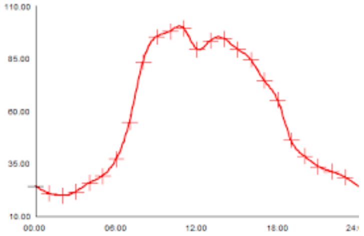
(a) conditions under which the installation is expected to be used, e.g. residential compared with commercial;

(b) operating characteristics of the connected load, e.g. airconditioning load in tropical locations compared with heating loads in cold-climate regions;

(c) number and physical distribution of points provided on the circuit, e.g. socket-outlets provided for convenient connection of portable equipment compared to dedicated or fixed equipment loads; and

(d) size and type of significant loads, e.g. large motors or industrial plant.





Think of it as 'equipment' diversity, and 'process' diversity – Ask yourself:

- How likely is it that *all* equipment of the same type operates concurrently? E.g GPO's
- How likely is it that categories of equipment operate as the same time as others? E.g

Examples of Diversity:

How to Calculate MD – Diversity

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- Example
- If there are 2 x 50kW electrical pumps supplied from a board, we need to understand how the loads will operate together. If one of the pumps is duty stand by, it means it will only operate if the other one doesn't. Therefore, at any point in time, the switchboard will only see 50% of the total load associated with the pumps (50kW). In this case, the diversity factor = 50%.
- What Diversity Factors Should we use
- DB Level – AS3000 method has some diversity built in, therefore **generally** for sizing DB Circuit Breaker and cables, run with the AS3000 diversity (again, think about actual usage within the building)

Duty / Standby equipment

Hot Water Units

Emergency use equipment (fire pump)

Car wash: was and dry?

- MSB Level – think about what the likelihood of all electrical equipment running at maximum demand at the same time is? It's not practical to use summation of AS3000 MD's as your MSB Distribution Boards.

475 AS/NZS 3000:2018

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TABLE C4

UPSTREAM CIRCUIT LOADING AFTER DIVERSITY

Number of circuit-protection devices downstream	Diversity factor
2 and 3	0.9
4 and 5	0.8
6 to 9	0.7
10 or more	0.6

- Substation Level – similarly, if assessing at substation level, it's not likely that every MSB off the substation is running at maximum demand at the same time.

How to Calculate MD – Diversity

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- Substation Level (inter-building diversity)
  - What other loads are on the substation
  - What is the inter-building diversity – notionally 0.8 is acceptable
  - In example below the kVA for each building has been diversified at building MSB level, but then a Substation level diversity must also be applied

Load for Substaion										
	kvA									
TA1	481.7268									
TA2	481.7268									
BED	57			BBRCCS	353.493					
	1020.256				**353.493**		Undiversified at Sub Level			
0..8 Div	816.2045				282.7944		Total Sub TA (div)		1098.999	

Other examples:

Lessons Learnt / Things to be mindful of

- If using AS/NZS 3000 Tables, allocate equipment to the right category
- Don’t just rely on VA rates, validate the MD as the project progresses. Selections are made, most accurate is the full ‘bottom up’ calculation
- A stronger MD cross checks VA rates against similar installations
- Key Equipment Catches:
  - Hot Water Units: Remember storage requires 100% of the load to be factored in!
  - What for electric hot water heaters and their diversity!
  - Duty / Standby means you only need to account for 1! E.g compressors, pumps etc
- Ensure you size everything with spare capacity if you need to!

Lessons Learnt / Things to be mindful of

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- Major issue in Maximum Demand for the rooms/offices
  - AS/NZS 3000 is very conservative with regards to MDs on GPOs
  - Instead, used typical connected loads for the rooms and extrapolated that to each DB
- Be mindful of the affect's of an increase in maximum demand… flow on impact includes:

Affected sizing of cables → trip units of circuit breakers → conduit utilisation → Impact to pit sizing → Cable tray sizing → Switchboard sizing → checking if upstream MSB had enough capacity → Increase in heat rise

Thank you!

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We have a range of courses in Electrical Engineering.

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Professional Certificate of Competency in Hydrogen Energy – Production, Delivery, Storage, and Use	23 January 2024
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Website
www.eit.edu.au

Head Office
1031 Wellington Street West Perth
Perth, WA 6005

Phone
Inside Australia: 1300 138 522
Outside Australia: +61 8 9321 1702

Email
webinars@eit.edu.au

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