

SECTION 54 WIRING AND ACCESSORIES

1 GENERAL

1.1 CROSS REFERENCES

General

Conform to the *General requirements* worksection.

Related worksections

Conform to associated worksections as follows:

- *Electrical general requirements, Cable support and duct systems.*

1.2 STANDARDS

General

General: To AS/NZS 3000 and the recommendations of SAA HB301.

Fire and mechanical performance classification: To AS/NZS 3013.

Selection of cables: To AS/NZS 3008.1.1.

Distribution cables: To AS/NZS 4961.

Testing

To AS/NZS 3017.

1.3 INTERPRETATIONS

Definitions

Extra-low voltage: Not exceeding 50 V a.c. or 120 V ripple-free d.c.

Low-voltage: Exceeding extra-low voltage, but not exceeding 1000 V a.c. or 1500 V d.c.

High voltage: Exceeding low-voltage.

Abbreviation

MIMS: Mineral-insulated metal-sheathed.

1.4 POWER SYSTEM REQUIREMENTS

Design

Power cables and conductors for which the contractor has design and selection responsibility:

- All general control, signalling, load-shedding & switching cabling etc that is not indicated in the contract drawings.
- All earthing cables. To be sized to meet all requirements of AS/NZS 3000.

2 QUALITY

2.1 PRE-COMPLETION TESTS

Site tests

Visually inspect the installation before testing. Record on a checklist. Test and verify the installation to AS/NZS 3000 Section 6, using the methods outlined in AS/NZS 3017. Record the results of all tests.

MIMS cable systems: Test the insulation resistance

- at the time of termination; and
- 24 hours later.

2.2 SUBMISSIONS**Cable routes**

If not shown on the drawings in detail, submit details of the following:

- Sub-main cable tray routes and signs.
- Switchboard cupboard layouts including risers.

Shop drawings

Provide shop drawings for the following:

- Cable routes.
- Cable tray and trunking routes.
- Underground conduits and pits.
- Invert levels for underground conduits.
- Depth of burial for cables and conduits.

These shop drawings are to be provided in paper and electronic format (on CD) in the building maintenance manual.

Technical data

Provide technical submissions with at least the following information:

- Design basis and performance parameters.
- Layout of cable supports and enclosures on the current architectural background coordinated with the structure and other services.
- Pit locations with construction grid references.
- Invert level or depth of burial for underground enclosures.
- Samples.
- Accurate records of installed underground enclosure systems.

Power cable ratings calculations

General: If cable sizes are not given, submit calculations of current ratings and voltage drop.

Standard: To AS/NZS 3008.1.1.

Shop drawings

Submit shop drawings of column mounting bases.

3 MATERIALS

3.1 WIRING SYSTEMS**General**

Selection: Provide wiring systems appropriate to the installation conditions and the function of the load.

Earthing systems

Provide an earthing system complying with AS/NZS 3000 Part 5.

Communications applications: Provide earthing systems for communications applications complying with AS/ACIF S009.

Electrodes

Determine electrode resistivity in accordance with ESAA EG 1.

Earth and bonding clamps

Provide proprietary earthing and bonding clamps.

Standard: To AS 1882.

Selection

Provide the following systems:

- Cast concrete slabs: Cable in heavy duty UPVC conduit.
- Accessible spaces: Thermoplastic insulated and sheathed cables.
- Concealed spaces: Thermoplastic insulated and sheathed cable in heavy duty conduit.
- Plant rooms: Thermoplastic insulated and sheathed cable in heavy duty conduit or installed on cable tray.
- Plastered or rendered surfaces: Thermoplastic insulated and sheathed cable in heavy duty conduit.
- Stud walls without bulk insulation: Thermoplastic insulated and sheathed cables.
- Stud walls with bulk insulation: Thermoplastic insulated and sheathed cables in UPVC conduit.

3.2 INSTALLATION

Standard

Fire or mechanical damage: Classifications to AS/NZS 3013.

Installation methods table

Wall construction	Installation and concealed cabling facilities
Rendered masonry partition	Flush wall box - conduit chased into wall
Double sided face brick partition	Vertically mounted flush wall box with conduit concealed in cut bricks
Face brick external cavity wall	Flush wall box with thermoplastic insulated cables in conduit run in cavity and tied against inner brick surface, or thermoplastic sheathed cables run in cavity
Stud partition	Rewirable

Handling cables

Report damage to cable insulation, serving or sheathing.

Stress

Ensure that installation methods do not exceed the cable's pulling tension. Use cable rollers for cable installed on tray/ladders or in underground enclosures.

Straight-through joints

Unless unavoidable due to length or difficult installation conditions, run cables without intermediate straight-through joints.

Cable joints

Locate in accessible positions in junction boxes.

Extra-low voltage circuits

Individual wiring of extra-low voltage circuits: Tie together at regular intervals.

Conductor colours

General: For fixed wiring, provide coloured conductor insulation. If this is not practicable, slide at least 150 mm of close fitting coloured sleeving on to each conductor at the termination points.

Active conductors in single phase circuits: Red.

Active conductors in polyphase circuits:

- A phase: Red.
- B phase: White.

- C phase: Blue.

Tagging

Identify multicore cables and trefoil groups at each end with stamped non-ferrous tags clipped around each cable or trefoil group.

Marking

Identify the origin of all wiring by means of legible indelible marking. Refer to electrical drawings.

Cable systems

Provide the following systems:

- Cast concrete slabs: TPS cable in heavy duty UPVC conduit.
- Accessible spaces: TPS cable.
- Concealed spaces: TPS cable in UPVC conduit.
- Plant rooms: TPS cable in heavy duty UPVC conduit.
- Plastered or rendered surfaces: TPS cable in UPVC conduit.
- Stud walls without bulk insulation: TPS cables.
- Stud walls with bulk insulation: TPS cable in UPVC conduit.

Where TPS denotes Thermoplastic Insulated and Sheathed.

Thermal insulation: In walls filled with thermal insulation, install TPS cables in PVC conduit.

3.3 POWER CABLES**Cable**

Use multi-stranded copper cable generally, except for mineral insulated metal sheathed (MIMS).

Minimum size:

- Lighting sub-circuits: 1.5 mm².
- Power sub-circuits: 2.5 mm².
- Sub-mains: 6 mm².
- Refer to electrical drawings.

Voltage drop: Install final subcircuit cables within the voltage drop parameters dictated by the route length and load.

Fault loop impedance: Provide final subcircuit cables selected to satisfy the requirements for automatic disconnection under short circuit and earth fault/touch voltage conditions.

Underground residential distribution systems: Select cables according to AS/NZS 4026.

Distribution cables: To AS/NZS 4961.

3.4 MIMS - INSTALLATION**General**

Maintain manufacturer's seals until joint or termination is made. Remove moisture by heating cable ends.

Seals

Temporary seals: Fit temporary seals to the open ends of cables cut and not immediately used.

Terminations: Fit termination seals at ends of cable runs as soon as the cable has been cut to length, stripped back, and the moisture driven out.

Through joints: Same fire-rating as the cable.

Sheath earthing

If MIMS cables enter metal enclosures, earth sheaths to non-ferrous plates secured to the enclosures. Where sheaths terminate at plates, fully insulate, colour code, and fix the conductors to the enclosures.

Bonding

Bond metal sheaths of single core cables in multi-phase circuits with proprietary earth bonding clips or clamps.

Separation

Separate MIMS cables from tough plastic sheathed (TPS) cables and UPVC conduits by at least 25 mm.

Eddy currents

Arrange single core cable entries into non-ferrous metal gland plates to minimise eddy currents.

Vibration

Connections with vibrating equipment: Loop cables in a complete circle next to the point of connection.

3.5 FIRE-RATED (OTHER THAN MIMS) - INSTALLATION**General**

If exposed to mechanical damage, provide protection to AS/NZS 3013.

3.6 BUSDUCTS**Systems**

Type: Proprietary type-tested systems made up of integral lengths and fittings containing solid busbar conductors and housings, assembled in sections to form complete fully enclosed and insulated low impedance power distribution systems.

Standard: To AS 3439.2.

Selection

Ratings: Provide busduct selected to meet nominated current ratings and, if used as consumer's mains, to match the statutory authority's substation equipment.

Degree of protection: For complete assembly, at least the following:

- Indoor use: IP40.
- Weatherproof (partial exposure): IP54.
- Outdoor use: IP55.

Indoor system accessories

For current ratings ≤ 400 A: Provide fuse, fuse switch or circuit breaker type plug-in connection boxes. Provide interlocks to enable plug-in boxes to be safely installed or removed on an energised system. Provide plug-in boxes whereby earthing to the busduct housing is achieved before connection of active conductors.

For current ratings > 400 A: Provide bolt on T-off boxes.

Expansion joints: Provide expansion joints in vertical runs, to allow for expansion and contraction of the busduct system.

End caps: Provide end caps or covers to fully enclose ends of busducts not connected to equipment.

4 TERMINATIONS

4.1 COPPER CONDUCTORS**General**

Other than for small accessory and luminaire terminals, terminate copper conductors to equipment, with compression-type lugs of the correct size for the conductor. Compress using the correct tool or solder.

Within assemblies and equipment

General: Loom and tie together conductors from within the same cable or conduit from the terminal block to the point of cable sheath or conduit termination. Neatly bend each conductor to enter directly into the terminal tunnel or terminal stud section, allowing sufficient slack for easy disconnection and reconnection.

Alternative: Run cables in UPVC cable duct with fitted cover.

Identification: Provide durable numbered ferrules or other approved labels fitted to each core, and permanently marked with numbers, letters or both to suit the connection diagrams.

Spare cores: Identify spare cores and terminate into spare terminals, if available. Otherwise, neatly insulate and neatly bind the spare cores to the terminated cores.

4.2 BUSDUCT INSTALLATION**General**

Horizontal runs: Support busducts at maximum intervals of 2 m, with adjustable hangers and steel angle supports. Provide runs that are straight and level. Install hangers at least 300 mm from joint centres. Secure busducts to angle supports with proprietary clamps.

Vertical runs: Support with a combination of fixed and spring type hangers to allow for expansion and contraction of the busduct system.

Fittings: Provide elbows, offsets and junctions for changes in direction. If necessary, provide weatherproof covers and gaskets.

5 WIRING ENCLOSURES AND CABLE SUPPORTS

5.1 STANDARDS**General**

Cable trunking systems to AS/NZS 4296

Conduits and fittings for electrical installations: AS/NZS 2053 Parts 1, 2, 3, 4, 5, 6, 7 and 8.

5.2 DESIGN**General**

Cable support and duct systems for which the contractor has design and selection responsibility:

- Conduits, cable tray, catenary system, etc not shown on electrical contract drawings.

5.3 CONDUITS**Minimum sizes**

Metallic and non-metallic conduits: 20 mm.

Rigid conduits

Provide straight long runs, smooth and free from rags, burrs and sharp edges. Set conduits to minimise the number of fittings.

Set out

If exposed to view, install conduits in parallel runs with right angle changes of direction.

Inspection fittings

Locate in accessible positions.

Draw cords

General: Provide draw cords in conduits not in use. Leave 1 m of cord coiled at each end of the run.

Material: Polypropylene cord 5 mm² minimum size.

Draw-in boxes

General: Provide draw-in boxes at intervals not exceeding 30 m in straight runs, and at changes of level or direction.

Underground draw-in boxes: Provide gasketed covers and seal against moisture.

5.4 CONCEALED CONDUITS

Routes

Run conduits concealed in wall chases, embedded in floor slabs or installed in inaccessible locations directly between points of termination, minimising the number of sets. Do not provide inspection fittings.

Conduits in concrete slabs

Route: Do not run in concrete toppings. Do not run within pre-tensioning cable zones; cross pre-tensioning cable zones at right angles. Route to avoid crossovers and minimise the number of conduits in any location. Space parallel conduits at least 50 mm apart.

Minimum cover: Conduit diameter or 20 mm.

Conduit size: 25 mm maximum diameter.

Fixing: Fix directly to top of the bottom layer of reinforcing where the conduits pass above a single layer of reinforcing.

Prohibited floor slabs

Do not run conduits in the floor slabs of boiler rooms, plant rooms and tank rooms.

Hollow-block floors

Locate conduits in the core-filled sections of precast hollow-block type floors.

Columns

Conduits in columns:

- Maximum 4 per column.
- <25mm diameter.
- Locate conduits centrally in each column.

Bends: Enter columns via bends with minimum radius of 150 mm. Do not use elbows.

Chasing: Do not chase columns.

5.5 METALLIC CONDUITS AND FITTINGS

Standard

Metallic conduits and fittings: AS/NZS 2053.7 or AS/NZS 2053.8.

Type

Screwed steel.

Corrosion protection

For steel conduits, paint ends and joint threads with zinc rich organic primer to APAS-2916.

Expansion joints

General: Provide flexible couplings consisting of flexible conduit and fittings, at

- structural expansion joints; and
- in long straight runs if the ambient temperature varies by more than 40°C.

Movement: Provide conduit support saddles close to flexible couplings to permit free movement for expansion and contraction.

5.6 NON-METALLIC CONDUITS AND FITTINGS

Standards

Non-metallic conduits and fittings: AS/NZS 2053 Parts 2, 3, 4, 5 or 6.

Restriction on Use

Do not install PVC conduit in locations where:

- exposed to direct sunlight;
- subject to mechanical damage or high ambient temperatures.

Conduits in roof spaces

Locate below roof insulation and sarking. In accessible roof spaces, provide mechanical protection for light-duty conduits.

Conduit in slabs

High compression corrugated conduit, restrained at regular intervals to achieve a nominally straight run.

Associated fittings

Type: The same type and material as the conduit.

Wall boxes on UPVC conduits: For special size wall boxes not available in UPVC, provide prefabricated earthed metal boxes.

Inspection fittings

Provide inspection-type fittings only in accessible locations and where exposed to view.

Joints

Type: Cemented or snap on joints.

Expansion couplings: If encased in concrete, do not provide bellows type.

5.7 FLEXIBLE CONDUIT**Application**

The use of flexible corrugated non-metallic conduit is strictly prohibited unless the Superintendents Representative gives specific permission.

Type

Use heavy duty PVC flexible conduit with associated fittings unless otherwise specified.

Colour

Grey.

Use

In addition to its use on expansion joints, fit flexible conduit to equipment and plant subjected to vibration or where necessary for adjustment or ease of maintenance.

Length

The maximum length of a flexible conduit connection shall be sufficient to allow maintenance.

5.8 DUCTED WIRING ENCLOSURES**Ducting**

Provide purpose-made ducts, skirting ducts and floor ducts, incorporating segregation where used for multiple services. Provide rigid supports. Round off sharp edges and provide bushed or proprietary cable entries into metallic ducting.

Accessories

General: Provide purpose-made accessories and covers to match the duct system. Provide screw-fixed covers, or clip-on covers removable only with the use of tools.

Cable support: Except for horizontal runs where the covers are on top, support wiring with retaining clips at intervals of not more than 1000 mm.

5.9 CABLE SUPPORTS

System

Provide a complete cable support system consisting of trays or ladders and including brackets, fixings and accessories.

Manufacture

Provide proprietary trays, ladders, fittings and accessories from a single manufacturer in the same application.

Cable ladders: Run small cables <13mm diameter in cable trays or ducts.

Cable trays

Materials:

- Interior: Zinc-coated steel, or steel with two-pack liquid coating, air-drying enamel or stoving enamel finish.
- Exterior: Hot dip galvanized steel.
- Minimum steel thickness:
- Trays < 150 mm wide: 1 mm.
- Trays > 150 mm, < 300 mm wide: 1.2 mm.
- Trays > 300 mm wide: 1.6 mm.

Perforations: To Admiralty pattern, reverse stamping.

Fixing to building structure

General: Fix supports to the building structure or fabric by means of direct fixing hangers or brackets suitably rating for the possible load of 200% loaded cable tray.

Spacing: Space supports at maximum interval of 1.5m for cable tray.

Cable fixing

Provide strapping or saddles suitable for fixing cable ties.

Provide steel straps to MIMS cables.

Bend radius

Provide bends with an inside radius ≥ 12 times the outside diameter of the largest diameter cable carried.

Cable protection

Provide rounded support surfaces under cables where they leave trays or ladders.

Access

Provide a minimum of 150 mm free space above and 600 mm free space on at least one side of trays and ladders.

Clearances

From hot water pipes: > 200 mm.

From boilers or furnaces: > 500 mm.

EMI: Locate support systems for electrical power cabling and communication cabling to minimise electromagnetic interference.

Catenary systems

Catenary systems are to be used within ceiling spaces as “branches” off main trunk runs of cable tray and ladder systems.

Wire: Provide stainless steel cable and couplings for catenary systems.

Anchoring: Anchor catenary systems to the structure. Do not fix to any part of a suspended ceiling system.

Design loads: Provide catenary systems designed to support the proposed load of the cables with a spare capacity of 50% loading.

Fixing: Fix cables to the catenary system such that no cable is under stress due to tension or compression. Use proprietary fixings that allow cables to be added or removed without destroying the integrity of the system.

Segregation: Install separate catenary systems for electrical and telecommunications cabling systems. Minimum segregation is required to be maintained from other services as nominated by the regulating standard of the specific service.

6 UNDERGROUND SERVICES

6.1 CABLES IN TRENCHES

Sand bed and surround

Provide clean sharp sand around cables and conduits installed underground.

Sealing ducts and conduits

Seal buried entries to ducts and conduits with waterproof seals. Seal spare ducts and conduits immediately after installation. Seal other ducts and conduits after cable installation.

6.2 UNDERGROUND CABLE ROUTES

Survey

Accurately record the routes of underground cables before backfilling. Include on the record drawings.

Location marking

General: Accurately mark the location of underground cables with route markers consisting of a marker plate set flush in a concrete base.

Location: Place markers at each joint, route junction, change of direction, termination and building entry point and in straight runs at intervals of not more than 100 m.

Concrete bases: 200 mm diameter x 200 mm deep, minimum.

Direction marking: Show the direction of the cable run by means of direction arrows on the marker plate. Indicate distance to the next marker.

Plates: Brass, minimum size 75 x 75 x 1 mm thick.

Plate fixing: Waterproof adhesive and 4 brass or stainless steel countersunk screws.

Marker height: Set the marker plate flush with paved surfaces, and 25 mm above other surfaces.

Marker tape

Where electric bricks or covers are not provided over underground wiring, provide a 150 mm wide yellow or orange marker tape bearing the words "*WARNING - electric cable buried below*", laid in the trench 150 mm below ground level.

6.3 CABLE PITS

General

Draw-in pits: Sizes given are internal dimensions.

Sealing: Reinstated pit wall around duct and conduits to prevent the ingress of water.

Marking: Electrical pit lids are to have the word "ELECTRIC" moulded in them.

Bedding: Bed pits on a minimum of 100 mm concrete extending up walls of pit to form concrete surround.

In-situ construction

For pits $\leq 1200 \times 1200$ mm, provide steel reinforced concrete pits formed in-situ on site.

For pits $> 1200 \times 1200$ m:

- Construct walls and bottoms from rendered brickwork or 75 mm thick reinforced concrete. Incorporate a waterproofing agent in the render or concrete.

Pit covers

General: Provide pit covers to suit expected loads or as outlined by contact drawings or pictorials. Fit flush with the top of the pit.

Standard: To AS 3996.

Weight: < 40 kg for any section of the cover.

Drainage

General: Provide functional drainage from the bottom of each cable pit to the site stormwater drainage system. An absorption or rubble pit may only be used in extreme circumstances and only where specifically approved by the Superintendents Representative.

Stormwater Drainage: Drain all pits with a 50 mm PVC pipe in one corner with the floor of the pit having a fall towards this pipe. Connect drain pipe to a stormwater drainage pipe at a lower level than the bottom of the pit to be drained

Absorption trenches: Minimum size $300 \times 300 \times 2000$ mm.

Conduits: Lay all conduits with a drainage fall of at least 1:100 to drain the pit system to the lowest pit or pits.

Main Switchboard pit: Drainage is to be in the form of a specific drainage conduit which is to be the lowest outgoing conduit from the pit under the MSB.

Alternatively, if a stormwater pipe is not available, provide a sump and drain to it as directed by the Superintendent's Representative.

Sump: Make each sump at least $2000 \times 2000 \times 1000$ mm deep and 1000 mm deeper than the bottom of the pit to be drained. Fill the sump with gravel of not less than 50 mm size to the level of the bottom of the pit being drained and cover with reinforced concrete slabs not less than 50 mm thick. Backfill to the original ground level. Increase depth of sump as necessary to ensure at least 500 mm cover.

6.4 COLUMNS**Definition**

Fabricated columns more than 2400mm high, designed to support accessories outdoors.

Design

General: Provide columns designed, manufactured and tested by a specialist manufacturer.

Dimensions: to AS 1798.

Construction

General: Galvanize columns and fittings after fabrication.

Bases: Provide columns with mounting bases for fixing to reinforced concrete footings.

Accessory mountings: Provide adjustable mountings, to suit accessories, and with provision for rigidly clamping each item in position, once adjusted correctly.

Maintenance access: Provide pole stirrups secured to either side of the column for access to accessories. Locate the first stirrup at least 3m above ground level.

Electrical connections: Provide a recess at the base of the column for access to cables connections and equipment, fitted with a flush mounted cover. For connections higher than 3m provide a catenary wire cable support system.

7 ACCESSORIES

7.1 LIGHTING AND SOCKET OUTLET SWITCHES**Minimum rating**

15 A, 240 V a.c.

Mechanism

General: Construct the face plate and mechanism so that the mechanism cannot be displaced during normal operation, by means of retaining screws.

7.2 GENERAL PURPOSE OUTLETS**Pin arrangement**

Mount outlets with the earth pins at the 6 o'clock position.

7.3 3 PHASE OUTLETS**Minimum rating**

20 A, 500 V a.c.

Pin arrangement

Five round pins mounted with earth pins at the 6 o'clock position, neutral pins in the centre, and the red, white and blue phases in a clockwise sequence when viewed from the front of the outlet.

Plug

Provide a matching plug top for each outlet.

Construction

Surface mounted type of high-impact resistant plastic, with flap lid on the outlet.

7.4 LIGHTING OUTLETS**Pin arrangement**

Standard: 3 flat pin with looping terminal.

Emergency lighting: 4 flat pin if self-contained emergency lighting is to be connected.

7.5 INSTALLATION**General**

Provide flush mounted accessories except in plant rooms.

Surface mounting

Type: Proprietary mounting blocks.

Restricted location

Do not install wall boxes across junctions of wall finishes.

Marking

Label isolating switches and outlets to identify circuit origin.

Installation of ceiling mounted appliances

Connections: Provide flush mounted 3 pin socket outlets on the ceiling next to support brackets.

Fixing: Provide support brackets fixed through ceiling to the building structure. Brace appliances that have unacceptable bending moments, are heavy or vibrate, to prevent horizontal movement.

Lighting outlets

Pin arrangement:

- Emergency lighting: 4 flat pin for self-contained emergency lighting.

- Standard: 3 flat pin with looping terminal.

Lighting switches rating

Minimum: 15 A, 230 V a.c.

Plugs – 230/400 volt

Provide plugs with integral pins of the insulated type to AS/NZS 3112 for all equipment supplied and installed after 3 April 2005.