Chapter 5

FASTENERS AND FASTENING METHODS

Engineering Practices

ENPRA101A

Topic 5-1

FASTENERS AND FASTENING METHODS

INTRODUCTION

- It is a designers responsibility that the design of a plant or building is safe. This includes making sure that all equipment and services are securely fixed.
- This topic outlines available fasteners and methods for fixing equipment to:
  - Timber
  - Masonry (Brickwork, concrete, stone)
  - Hollow walls
  - Steel,
  - Aluminium
  - Sheet metal

FIXING TO TIMBER

NAILS

Fig PF-5-1-1(a)
Galvanised Clout

Fig F-5-1-1(b)
Bullet Head (jolt head)
and Flat Head Nails

FIXING TO TIMBER

NAILS (Cont'd)

Uses:

- **Clouts** – Typically used to fix conduit saddles or accessory brackets to timber structure prior to lining being installed.
- **Nails** - In electrical installations nails have limited application due to the permanent nature of the method.

Tools:

- Hammer, or
- pneumatic nail gun, or
- explosive charge nail gun

FIXING TO TIMBER

NAILS (Cont'd)

Sizes:

- Shank diameters: 1.00mm to 9.00mm
- Lengths: 12mm to 250mm

Preparation:

- None

Method:

1. Nail is hammered through fixture into base material

FIXING TO TIMBER

WOOD SCREWS

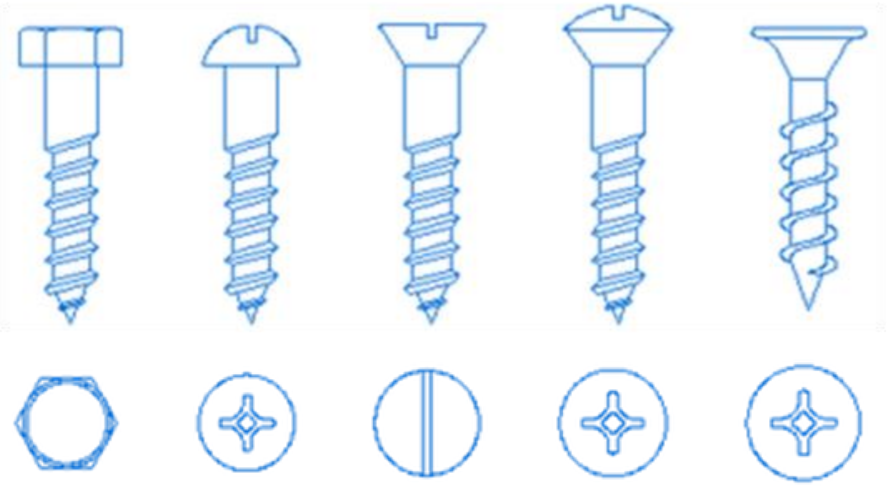


Fig F-5-1-2
Typical screw
head types

FIXING TO TIMBER

WOOD SCREWS (Cont'd)

Uses:

- Used anywhere where fixing to timber. clad timber is required. They are easily removed and refitted using the same location

Tools:

- Manual Screwdriver with correct driving head for screw, or
- Power screwdriver with correct driving head for screw

FIXING TO TIMBER

WOOD SCREWS (Cont'd)

Sizes:

- Shank diameters: 2.84mm (4 gauge) to 9.45mm (24 gauge)
- Lengths: 6mm to 150mm

Preparation:

- Pilot hole needs to be drilled into base material and a shank clearance hole needs to be available in fixture

Method:

1. Screw is rotated into pilot hole using manual or power screwdriver

FIXING TO CONCRETE

CAST-IN-PLACE SYSTEMS

- Fixing anchor is positioned before the concrete is poured.

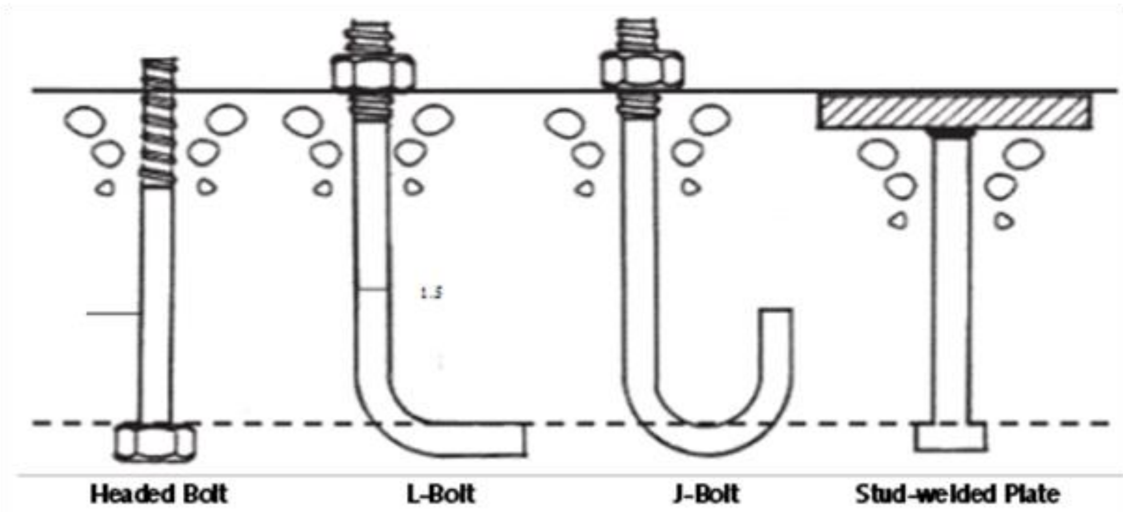


Fig PF-5-1-3
Typical Cast-In-Place concrete anchors

FIXING TO CONCRETE

CONCRETE NAILS

Description:

- Case hardened steel that has a spiral built into the shaft.

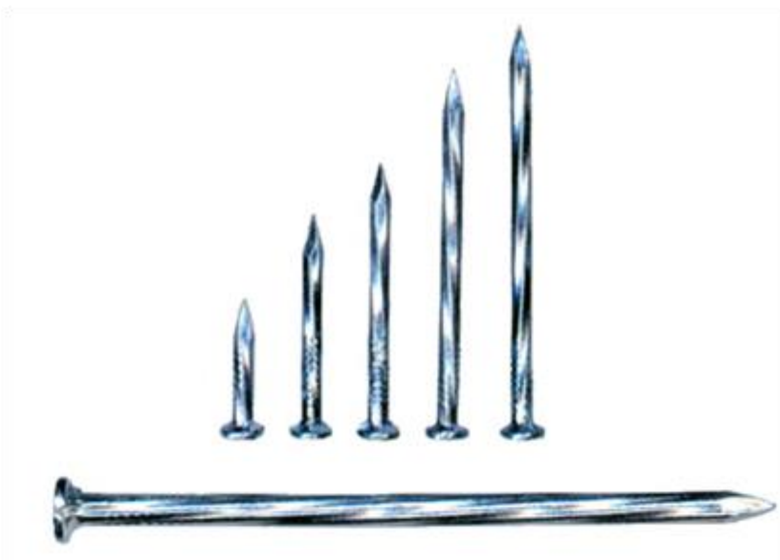


Fig PF-5-1-4
Concrete Nails

FIXING TO CONCRETE

CONCRETE NAILS (Cont'd)

Uses:

- The nails can be driven through timber plate directly into concrete.

Tools:

- Hammer

Sizes:

- Generally available in diameters ranging from 1.8mm to 5mm with lengths 20mm to 125mm

FIXING TO CONCRETE

CONCRETE NAILS (Cont'd)

Preparation:

- None

Method:

1. The nail is driven through timber plate into concrete using a hammer.

FIXING TO CONCRETE

CONCRETE SCREWS

Description:

- Case hardened steel with alternating high and low threads. Anchor is removable, and is set in place by rotation forming threads in the masonry.

Fig PF-5-1-5
Concrete Screw

FIXING TO CONCRETE

CONCRETE SCREWS (Cont'd)

Uses:

- Used for medium duty applications in either temporary or permanent anchoring into substrates such as concrete, brick, hollow brick or block. It is useful for close-to-edge or close-to-anchor fixing as it does not expand and burst the surrounding substrate.

Tools:

- Power drill with masonry bit
- Screwdriver with correct tip or spanner if screw has hex head

FIXING TO CONCRETE

CONCRETE SCREWS (Cont'd)

Sizes:

- Available in sizes ranging from 5mm to 16mm and with various head types including hex head

Preparation:

- Correct size pilot hole must be drilled into base material

Method:

1. Pilot hole is drilled deeper than required to contain accumulated dust
2. Screw is driven in using manual or power screwdriver

FIXING TO CONCRETE

NYLON ANCHORS:

Description:

- Nail expanding anchor for solid masonry and hollow wall constructions. Anchor can be removed if required. It is hammered in but has screwdriver slot to initiate removal when required. It is fitted through fixture

Fig PF-5-1-6
Nylon Anchor

FIXING TO CONCRETE

NYLON ANCHORS (Cont'd)

Uses:

- Used for Light duty applications.

Tools:

- Power drill with masonry bit
- Hammer
- Screwdriver (for removal)

Sizes:

- The nylon anchor is available in 4.5 and 6mm diameters

FIXING TO CONCRETE

NYLON ANCHORS (Cont'd)

Preparation:

- Same size hole as anchor is drilled into base material
- Fixture must have matching hole

Method:

1. Anchor is inserted through the hole in the fixture and into the hole in the base material
2. The expander pin is then driven into the nylon shank using a hammer.

FIXING TO CONCRETE

PLASTIC WALL PLUGS :

Description:

- Extruded plastic plugs inserted into a specific diameter hole in masonry. Fluted on the outside to prevent rotation. Fluted interior hole that accepts a wood screw.

Fig PF-5-1-7
Plastic Wall Plugs

FIXING TO CONCRETE

PLASTIC WALL PLUGS (Cont'd)

Uses:

- Used for Light duty applications.

Tools:

- Power drill with masonry bit
- Hammer (for tapping plug into hole)
- Screwdriver

Sizes:

- Available for screw gauge ranges: 4.5-6, 8-9, 10-12, 14-16

FIXING TO CONCRETE

PLASTIC WALL PLUGS (Cont'd)

Preparation:

- Slightly smaller diameter hole than plug diameter is drilled into base material
- Fixture must have matching hole

Method:

1. Plug is tapped into hole
2. Correct size wood screw is driven through the fixture into the plug.

FIXING TO CONCRETE

SLEEVE ANCHORS:

Description:

- Centre core bolt, with expansion cone on the end, surrounded by full length sleeve. Tightening the head pulls the centre bolt up into the sleeve and the cone expands and provides grip along the full length.

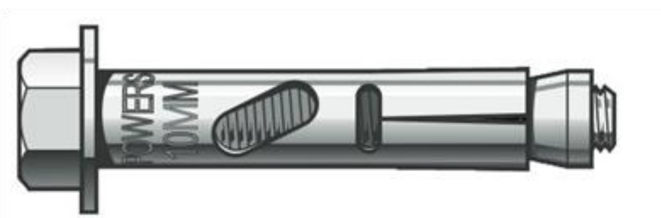


Fig PF-5-1-8
Sleeve Anchor

FIXING TO CONCRETE

SLEEVE ANCHORS (Cont'd)

Uses:

- Used particularly in weaker materials such as brick and sandstone (that would shatter with other bolts). Has the advantage of being fitted through fixture.

Tools:

- Power drill with masonry bit
- Spanner

Sizes:

- Available with nut head or with a bolt head, M6 to M20

FIXING TO CONCRETE

SLEEVE ANCHORS (Cont'd)

Preparation:

- Same size hole as anchor is drilled into base material
- Fixture must have matching hole

Method:

1. Anchor is inserted through the hole in the fixture and into the hole in the base material
2. Bolt/Nut is rotated to expand the sleeve and wedge the anchor within the hole

FIXING TO CONCRETE

DROP-IN ANCHORS :

Description:

- Installed in a predrilled hole by use of a setting tool that drives a plug into the expansion portion of the anchor. The lower section of the anchor is expanded into the concrete, which experiences local crushing.

Fig PF-5-1-9
Drop-in Anchor

FIXING TO CONCRETE

DROP-IN ANCHORS (Cont'd)

Uses:

- Used particularly where only a shallow hole is able to be drilled.

Tools:

- Power drill with masonry bit
- Special setting tool
- Spanner or Screwdriver depending on screw or bolt selected

FIXING TO CONCRETE

DROP-IN ANCHORS (Cont'd)

Sizes:

- M6 to M20

Preparation:

- Same size hole as anchor is drilled into base material
- Fixture must have matching hole

FIXING TO CONCRETE

DROP-IN ANCHORS (Cont'd)

Method:

1. Anchor is inserted into the hole in the base material
2. Using the proper sized setting tool the expander plug is driven towards the bottom of the anchor until shoulder of setting tool makes contact with the top of the anchor
3. Standard machine screw or bolt is used to secure fixture

FIXING TO CONCRETE

CONCRETE WEDGE ANCHORS :

Description:

- A heavy duty, torque controlled expansion anchor, for permanent anchoring into concrete. Used for heavy duty applications and has the advantage of being fitted through fixture.

Fig PF-5-1-10
Concrete Wedge Anchors

FIXING TO CONCRETE

CONCRETE WEDGE ANCHORS : (Cont’d)

Uses:

- Structural Anchorage, Seismic Attachments, Retrofit Projects, Machinery Anchorage and Lighting Standards..

Tools:

- Power drill with masonry bit
- Spanner

Sizes:

- M6 to M20

FIXING TO CONCRETE

CONCRETE WEDGE ANCHORS : (Cont'd)

Preparation:

- Same size hole as anchor is drilled into base material
- Fixture must have matching hole

Method:

1. Anchor is inserted through the fixture into the hole in the base material
2. Using spanner the nut/bolt is tightened wedging the anchor

FIXING TO CONCRETE

CHEMICAL ANCHORS :

Description:

- Steel studs, bolts and anchorages are bonded into a substrate, usually masonry and concrete, using a resin based adhesive system.
  In most cases the resulting bond is stronger than the base material itself and does not impart load stress to the base material as with expansion type anchors

FIXING TO CONCRETE

CHEMICAL ANCHORS : (Cont'd)

Description:

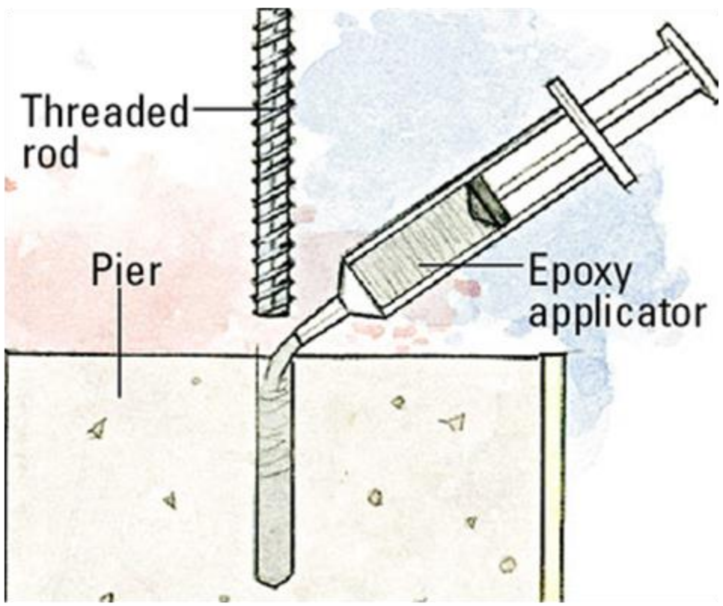


Fig PF-5-1-11
Chemical Anchor

FIXING TO CONCRETE

CHEMICAL ANCHORS : (Cont'd)

Uses:

- Used for close to edge fixing, in areas of high vibration.
- Can be used in damp areas and outdoors with suitable studs
- Used where high shear strength is required

Tools and Expendables:

- Power drill with masonry bit
- Epoxy chemical anchor kit
- Threaded stud or required anchor

FIXING TO CONCRETE

CHEMICAL ANCHORS : (Cont’d)

Preparation:

- Slightly larger diameter hole than anchor is drilled into base material
- Hole must be clean and roughened

Method:

1. Epoxy is injected into hole with applicator
2. Anchor is inserted into hole with rotating motion and allowed to set

FIXING TO CONCRETE

POWDER-ACTUATED FASTENERS :

Description:

- A **powder-actuated tool** is a nail gun used in construction and manufacturing to join materials to hard substrates such as steel and concrete - known as "direct fastening“.
- Relies on a controlled explosion created by small chemical propellant charge, similar to the process that discharges a firearm.

FIXING TO CONCRETE

POWDER-ACTUATED FASTENERS : (Cont'd)

Description: (Cont'd)

Fig PF-5-1-12
Powder Actuated Tool;
Fasteners, and Power Cartridges

FIXING TO CONCRETE

POWDER-ACTUATED FASTENERS : (Cont’d)

Uses:

- Used for very fast installation of fixings to concrete and steel, e.g. long runs of cable trays.

Tools and Expendables:

- Powder Actuated Tool;
- Correct fasteners for the base material
- Correct cartridges (appropriate power)for the base material

FIXING TO CONCRETE

POWDER-ACTUATED FASTENERS : (Cont'd)

Sizes:

- Cartridges are colour coded to indicate power
- Drive pins are available for concrete or steel in various sizes

Preparation:

- No preparation of base material required

FIXING TO CONCRETE

POWDER-ACTUATED FASTENERS : (Cont'd)

Method:

- The tool is loaded with correct cartridge and fastener.
- The tool is then compressed against the work surface and the trigger is actuated driving the fastener through the material being fastened into the substrate.

FIXING TO HOLLOW WALLS

HOLLOW WALL ANCHORS:

Description:

- Metal, pre-assembled fasteners for use in cavity walls.
- Has anti rotation barbs which press into the base material.
- Has collapsing legs with an integral - screw is able to be removed without loosing the anchor inside the cavity

Fig PF-5-1-13
Hollow Wall Anchor

FIXING TO HOLLOW WALLS

HOLLOW WALL ANCHORS: (Cont'd)

Uses:

- Suitable for light weight fixing to thin board or plasterboard.

Tools:

- Power drill
- Screwdriver

Sizes:

- M4 to M6 for wall thickness 0 to 38 mm

FIXING TO HOLLOW WALLS

HOLLOW WALL ANCHORS: (Cont'd)

Preparation:

- correct size hole is drilled into base material
- Fixture must have screw clearance hole

Method:

1. Anchor is inserted into the hole in the base material
2. Screw is turned with screwdriver to expand the anchor
3. Screw is removed and placed through the hole in the fixture and into the hollow wall anchor and re tightened

FIXING TO HOLLOW WALLS

SELF DRILLING PLASTERBOARD ANCHOR :

Description:

- self-drilling plasterboard anchor
- Does not need pre-drilling
- Available in zinc die cast and non-conductive nylon.

Fig PF-5-1-14 Self Drilling Plasterboard Anchor

FIXING TO HOLLOW WALLS

SELF DRILLING PLASTERBOARD ANCHOR : (Cont'd)

Uses:

- Suitable for light weight fixing to thin board or plasterboard.

Tools:

- Screwdriver

Sizes:

- Only the one size is available - suitable for 6-8 gauge screws

FIXING TO HOLLOW WALLS

SELF DRILLING PLASTERBOARD ANCHOR: (Cont'd)

Preparation:

- No drilling of base material required
- Fixture must have screw clearance hole

Method:

1. Anchor is placed on the end of a Phillips head screw driver
2. Self-drilling point of anchor is placed against the base material and driven in until head is flush
3. Fixture is positioned and suitable screw driven through fixture into anchor

FIXING TO HOLLOW WALLS

SPRING TOGGLE ANCHOR:

Description:

- The spring toggle is a two-part assembly consisting of a machine screw and a spring wing toggle.

Fig F-5-1-15
Spring Toggle Anchor

FIXING TO HOLLOW WALLS

SPRING TOGGLE ANCHOR: (Cont'd)

Uses:

- Suitable for light weight fixing to thin board or plasterboard.
- Cannot be re-used as spring toggle drops into cavity when screw removed

Tools:

- Screwdriver
- Power drill

FIXING TO HOLLOW WALLS

SPRING TOGGLE ANCHOR: (Cont'd)

Sizes:

- Sizes available are for 3, 4, and 5mm metal thread screws up to 100mm long

Preparation:

- Relatively large hole must be drilled through the base material large enough for the folded toggle to fit in
- Fixture must have screw clearance hole

FIXING TO HOLLOW WALLS

SPRING TOGGLE ANCHOR: (Cont'd)

Method:

1. Screw is inserted through the fixture and then threaded into toggle anchor
2. Toggle is folded completely and inserted into the hole until the wings pop open
3. Screw is then tightened

FIXING TO HOLLOW WALLS

GRAVITY TOGGLE ANCHOR :

Description:

- Very similar to spring toggle above except it uses an off-centre pivoting toggle that flips over once its passed through the wallboard. Also requires a large hole.

Fig F-5-1-16
Gravity Toggle Anchor

FIXING TO STRUCTURAL STEEL

- The methods available of fixing to structural steel or indeed any steel that is not seen as “sheet steel” are as follows:
  - Nut and bolt (where the steel shape and its fitment to the structure allows)
  - Tapped (threaded hole) for metal thread bolt
  - Self drilling and self tapping screws
  - Powder actuated tool (same as for concrete)
  - Welding
  - Clips

FIXING TO STRUCTURAL STEEL

- The use of steel is becoming more commonplace and is now used even in residential buildings
- Some of the more common shapes of structural steel are shown in **Fig PF-5-1-17**

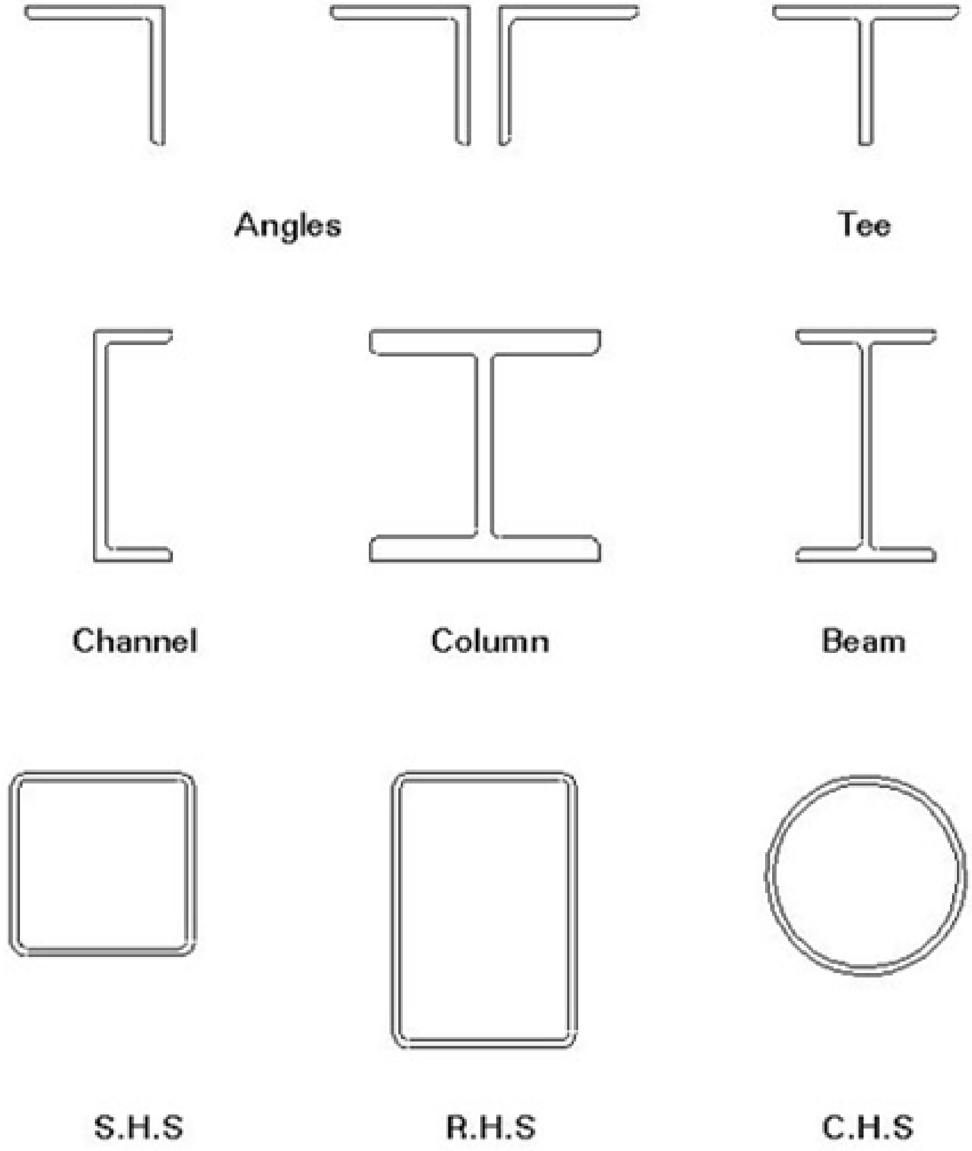


Fig PF-5-1-17
Common Standard
Steel Sections

BOLT AND NUT METHOD

- A **nut** is a type of fastener with a threaded hole used opposite a mating bolt to fasten parts together.
- In applications where vibration or rotation may work a nut loose, various locking mechanisms may be employed eg:
  - Adhesives
  - safety pins or lockwire,
  - nylon inserts, or
  - slightly oval-shaped threads.

BOLT AND NUT METHOD

- Common bolt sizes range from M6 to M24 (ie M6 is shank diameter 6mm)
- Available in various materials, eg stainless steel, mild steel, galvanised steel etc.
- Nuts are graded with strength ratings compatible with their respective bolts.
- Sizes smaller than M6 are more often referred to as machine screws or metal thread screws rather than bolts (See **Fig PF-5-1-18(a)** and **(b)**).

FIXING TO STRUCTURAL STEEL

BOLT AND NUT METHOD

Fig F-5-1-18(a)
Assorted Hex Head Machine Thread Nuts and Bolts

Fig F-5-1-18(b)
Assorted Bolts Nuts and Washers

BOLT AND NUT METHOD

Threaded Hole and Bolt

- Where the back of the steel is not accessible for placing a nut onto a bolt then if there is sufficient thickness of steel, a hole can be drilled and threaded (tapped) to suit a machine bolt.
- The bolt is then inserted through a clearance hole in the fixture with perhaps a washer and a spring washer and tightened.

SELF TAPPING AND SELF DRILLING SCREWS

- **Metal self drilling screws** (see **Fig F-5-1-19(a)**) have a hardened drill point that will drill and thread in structural and mild steel.
- Fine threads (less than 1.5mm pitch) are used with thicker steel, over 2.4mm thick.
- Coarse threads are normally used for steel of lesser thicknesses, 1.0-2.4mm thick.
- The screws are generally driven by a power device and the operation can be extremely efficient where large numbers are involved.

FIXING TO STRUCTURAL STEEL

SELF TAPPING AND SELF DRILLING SCREWS

SELF TAPPING AND SELF DRILLING SCREWS

- A **self-tapping screw** (see **Fig PF-5-1-19(a)**) (sheet metal screw, wood screw, lag bolt) cuts its own thread (like a tap), but there must already be a pre-drilled hole.

Fig F-5-1-19(a)
Self Tapping Screw

SELF TAPPING AND SELF DRILLING SCREWS

- **A self-drilling screw** (see **Fig F-5-1-19(b)**) has a hardened drill point that will drill and thread in structural steel and mild steel up to 6mm thick.

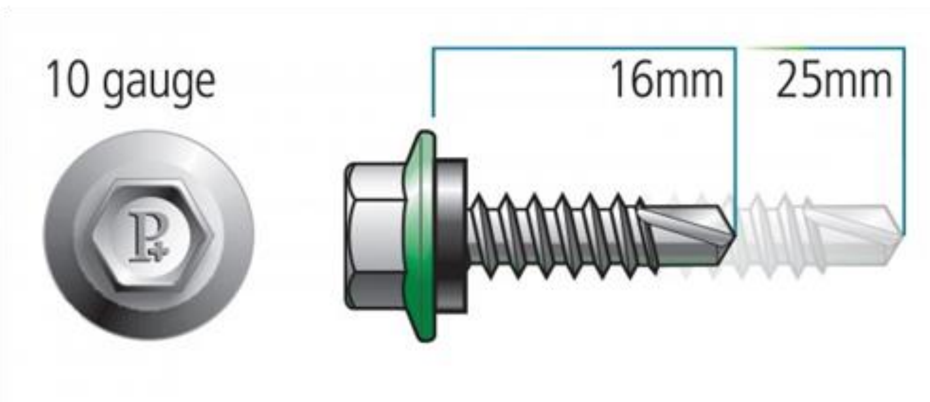


Fig F-5-1-19(a)
Self Drilling Screw

FIXING TO STRUCTURAL STEEL

WELDING

- Fusion welds are defined as joints between two or more components of similar material, formed by fusion (melting) of the parent material.
- The main type of welding used for in-situ fixing of brackets and the like to structural members is electric-arc welding.
- Figure **Fig F-5-1-20** illustrates the most common types of weld in engineering practice and interpretation of some of the welding symbols commonly used.

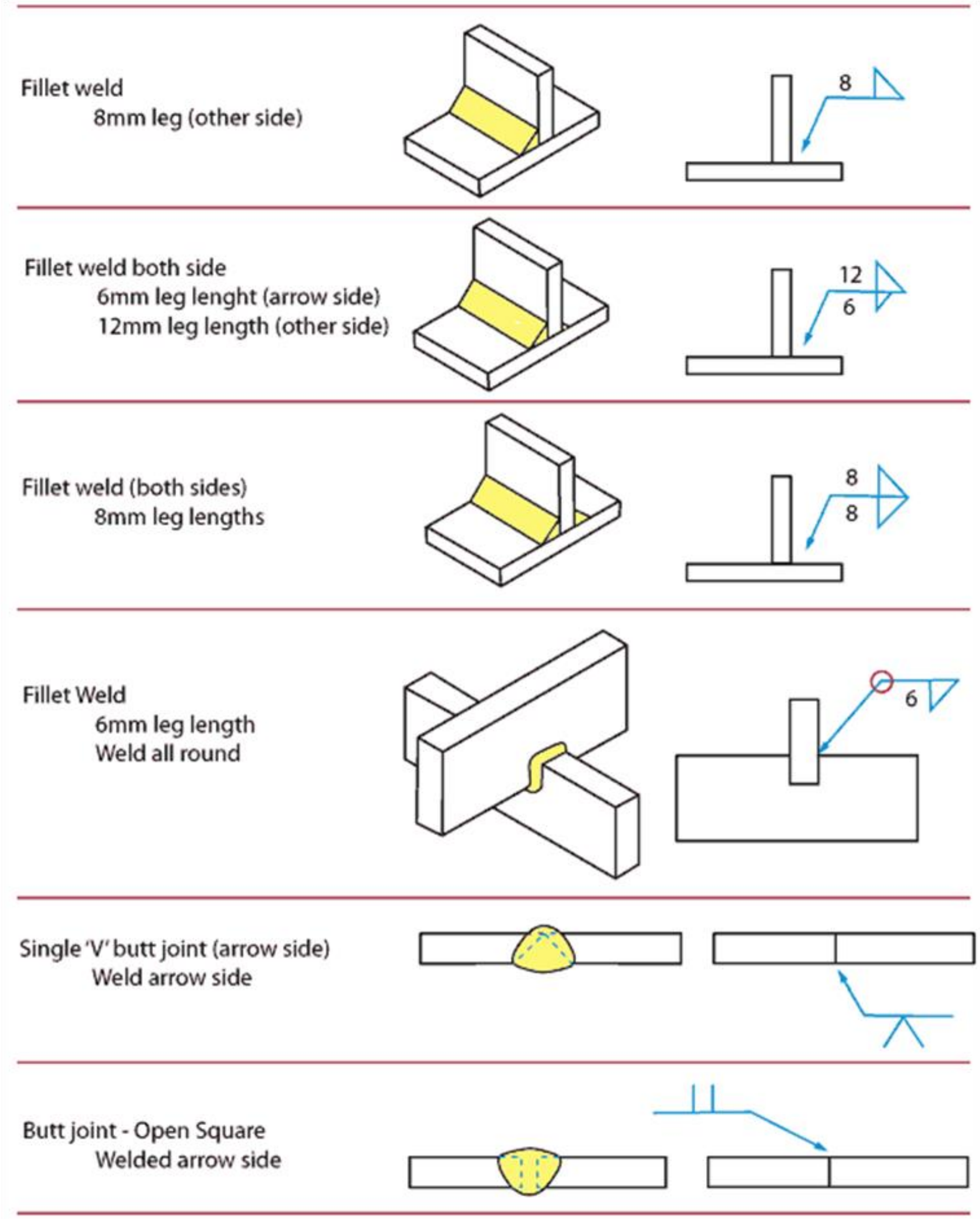


Fig F-5-1-20
Basic Welds and their Symbols

FIXING TO STRUCTURAL STEEL

CLIPS

- Where drilling, cutting or welding is not possible 'clip-on' type fixings are available albeit for smaller conduits and piping (See **Fig PF-5-1-21**)

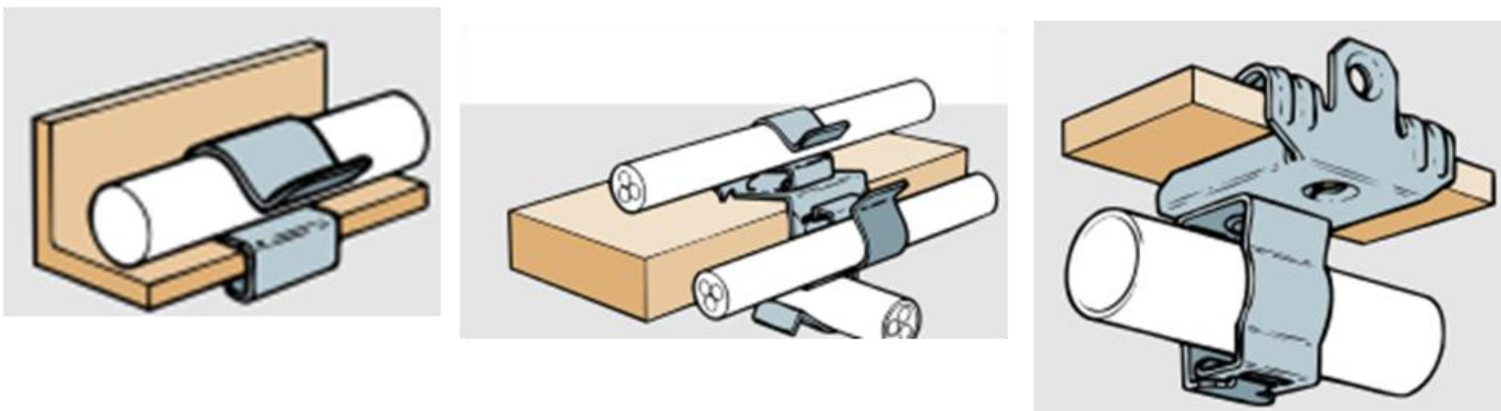


Fig PF-5-1-21 Conduit Clips

FIXING TO ALUMINIUM and SHEET METAL

Aluminium

- Because of its soft nature some of the methods used for attaching to steel cannot be used on aluminium.
- As with steel, the strongest fixing is the nut and bolt.
- Aluminium can be drilled/tapped for screws and bolts but there is significantly less tensile and shear strength than for equivalent steel fixings. The same goes for self drilling and self tapping screws.
- Aluminium cannot be easily welded in-situ and it is too soft for powder actuated tool fixing.

FIXING TO ALUMINIUM and SHEET METAL

Sheet Metal

- In nearly all cases fixing to sheet metal is using self tapping screws or blind rivets ('pop' rivets).
- Pop rivets, are tubular and are supplied with a mandrel through the centre (See **Fig PF-5-1-22**).
- The rivet assembly is inserted into a hole drilled through the parts to be joined and a special tool is used to draw the mandrel into the rivet.
- This expands the blind end of the rivet and then the mandrel snaps off.

FIXING TO ALUMINIUM and SHEET METAL

- Blind rivets are prone to failure from corrosion and vibration.
- Unlike solid rivets, blind rivets can be inserted and fully installed in a joint from only one side of a part or structure, "blind" to the opposite side.
- Available in flat head, countersunk head, and modified flush head with standard diameters of 3, 4 and 5 mm.
- Blind rivets are made from soft aluminium alloy, steel (including stainless steel), copper, and Monel

FIXING TO STRUCTURAL STEEL

FIXING TO ALUMINIUM and SHEET METAL

Fig F-5-1-22
Blind (Pop) rivets

Chapter 6

WIRING SYSTEMS

Engineering Practices

ENPRA101A

Topic 6-1

FACTORS AFFECTING THE SUITABILITY OF WIRING SYSTEMS

INTRODUCTION

In selecting a wiring system consideration must be given to:-

- the degree of support required and available for the cabling and cabling enclosures;
- fire protective measures – i.e. some circuits such as lifts or fire fighting equipment require special arrangements;
- reliability of connections, or ease of changing connections or position of equipment;
- mutual detrimental influences, ie the effect of one cable on another cable;
- the protection required against external influences,

INTRODUCTION

wiring system considerations (Cont'd):-

- the actual cable sizes which must suit:
  - current requirements of the circuit,
  - voltage drop considerations,
  - and fault loop impedance;
- the cost of the system not only in material terms but installation time.

CONSTRUCTION METHODS

- The wiring system chosen is dependent on the type of building (construction methods and materials) and its function (factory, office block, flats etc).
- Construction methods can be multi-level, single level, underground.
- Materials may be timber, steel, aluminium, concrete, brick, or mixtures of all of these.

CONSTRUCTION METHODS

Typical construction methods are:

- **Domestic**
  - timber / steel frame
    - brick veneer
    - PVC or aluminium clad
  - cavity or double brick
  - Steel re-enforced concrete slab.

The cavity between frame and cladding or brickwork offers a suitable a medium for cables such as T.P.S. (Thermoplastic Sheathed) and orange circular.

CONSTRUCTION METHODS

- **Industrial and Commercial (non-domestic)**
  - **Precast concrete**. Produced by casting concrete in a reusable mould which is then cured in a controlled environment, and transported to the construction site.
  - Post-cast or Post tensioned concrete. Steel re-enforcing is tensioned after pouring concrete into removable formwork.
  - **Prefabricated building.** Type of building that consists of several factory-built components or units that are assembled on-site to complete the unit.

CONSTRUCTION METHODS

- **Industrial and Commercial** (Cont'd)
  - **Standard In-situ cast concrete**. Formwork must be constructed and concrete is transported to the building site. Any services required such as electrical require careful planning with conduits and pipes installed into the formwork prior to concrete pour. Close liaising is required with structural engineers to ensure that conduits, pipes, etc do not affect the structural integrity of the poured slab.
-

INSTALLATION CONDITIONS

- Any wiring system selected must be suitable for the environment it is to be installed into.
- Depending on AS/NZS 3000 requirements cables can be installed either enclosed or unenclosed.
- Unenclosed cables require sheathing.
- Examples of unenclosed cables are:
  - ➢ Insulated and sheathed cables on a cable ladder or tray
  - ➢ MIMS cable fixed directly to a concrete wall
  - ➢ Insulated and sheathed armoured cable buried direct in ground

INSTALLATION CONDITIONS

- Examples of enclosed cables are:
  - Insulated unsheathed cables in steel conduit fixed to brick wall
  - Insulated and sheathed cables in cable trunking fixed to a wall
  - MIMS cable in trunking fixed to a wall
- See table 3.1 of AS/NZS 3000:2007 for more examples.
-

EXTERNAL INFLUENCES

- AS/NZS 3000:2007 requires that wiring systems be able to operate safely and function properly in the conditions to which they are likely to be exposed
- The conditions as per AS/NZS 3000:2007 are:
  - **Ambient temperature**. Wiring systems must be suitable for the highest and lowest local ambient temperatures.
  - **External heat sources**. Wiring systems must be protected against the effects of heat from external sources.
  - **Presence of water or high humidity**. Wiring systems must be selected and installed so that high humidity or the entry of water does not cause damage.

EXTERNAL INFLUENCES

- **Presence of solid foreign bodies**. Wiring systems must be selected and installed so as to minimize the entry of solid foreign bodies during installation, use and maintenance.
- **Presence of corrosive or polluting substances**. Parts of the wiring system likely to be affected must be suitably protected.
- **Impact.** Wiring systems must be selected and installed so as to minimise the risk of mechanical damage
- **Vibration.** Wiring systems subject to vibration that is likely to cause damage e suitable for the conditions.

EXTERNAL INFLUENCES

- **Other mechanical stresses**. Wiring systems must be selected and installed so as to minimise damage during installation, operation and maintenance.
- **Presence of flora and/or fauna**. Where this is expected to be a hazard, either the wiring system must be selected accordingly, or special protective measures adopted.
- **Solar radiation (direct sunlight)**. Where a wiring system may be exposed to direct sunlight, it should be designed for the conditions or adequate shielding must be provided.
- **Hazardous areas**. Wiring systems in explosive gas and dust atmospheres must be in accordance with relevant regulations

SELECTING WIRING SYSTEMS

- Wiring systems are a combination of the cable type, supports and where required the enclosure that protects the cable.

COMMONLY USED CABLE TYPES

Common types of cable are shown following. Note that this is only a small selection and cables come in an almost infinite array of configurations in which the following properties can be varied:

- conductor material – copper or aluminium
- number of conductor strands (determines flexibility of cable)
- Conductor size (determines current carrying capacity)
- Insulation material and thickness (determines voltage rating, operating temperature and current carrying capacity)
- Number of cores (for multicore cables)

SELECTING WIRING SYSTEMS

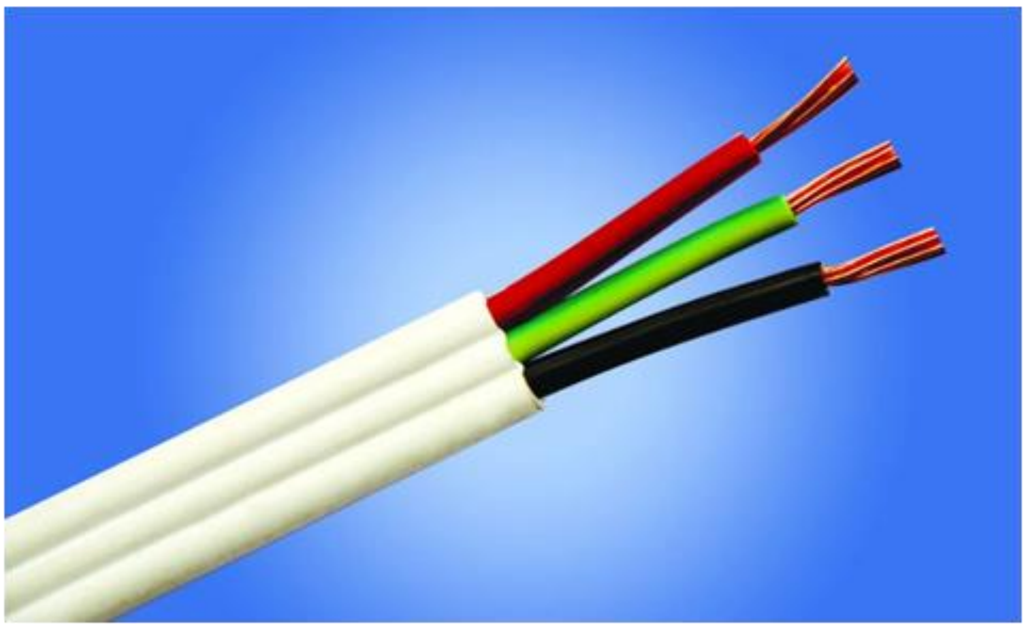
COMMONLY USED CABLE TYPES

Fig PF-6-1-1(a) - Unsheathed building wire, or TPI cable (Thermo-Plastic Insulated)

SELECTING WIRING SYSTEMS

COMMONLY USED CABLE TYPES

Fig PF-6-1-1(b) – Flat Insulated and sheathed cable



SELECTING WIRING SYSTEMS

COMMONLY USED CABLE TYPES

Fig PF-6-1-1(c) – Mineral insulated metal sheathed cable (MIMS)

COMMONLY USED CABLE TYPES

Fig PF-6-1-1(d) – Armoured Cable

Fig PF-6-1-1(e) – Circular Insulated and sheathed cable

COMMONLY USED CABLE TYPES

Fig PF-6-1-1(f) – XLPE(Cross Linked Polyethylene) High Voltage Cable

COMMONLY USED CABLE SYSTEMS

Enclosed Cables

- Clause 3.10.1 of AS/NZS 3000:2007 states, "*Insulated, unsheathed cables shall be enclosed in a wiring enclosure throughout their entire length.*"
- TPI cables must be enclosed in conduit or similar enclosure, to provide double insulation, mechanical protection, and cable support.

COMMONLY USED CABLE SYSTEMS

Enclosed Cables (Cont'd)

- The exception to the above requirement is if unsheathed cables are installed:
  - as aerial conductors
  - in an enclosed wall cavity between an accessory and a wiring enclosure or sheathing terminated within 100 mm of the hole over or within which the accessory is mounted;
  - within switchboards, metering and similar enclosures;
  - as earthing or equipotential bonding conductors
  - as an extra-low voltage circuit

COMMONLY USED CABLE SYSTEMS

Enclosed Cables (Cont'd)

- The types of enclosures permitted for TPI cables are:
  - Steel conduits
  - Flexible metal conduit
  - Rigid and flexible insulating conduit.
  - Corrugated insulating conduit
  - Cable trunking systems
  - Other wiring enclosures providing mechanical protection at least equivalent to those listed above

COMMONLY USED CABLE SYSTEMS

Enclosed Cables (Cont'd)

- TPS cables in most cases do not require enclosure except where they are "likely to be disturbed" in which case mechanical protection is required.
- Cables installed within a ceiling are **not** expected to be subject to mechanical damage and do not require additional mechanical protection (enclosure).

COMMONLY USED CABLE SYSTEMS

Un-enclosed Cables

- Only cables which are double insulated are suitable for un-enclosed installation.
- Clips, cleats, ladders and cable tray are used as support.

COMMONLY USED CABLE SYSTEMS

Underground cables

- Underground cables may be installed either buried direct or in an enclosure.
- Smaller conductors are normally enclosed for mechanical protection.
- Larger cables are direct buried to reduce cost.
- Single insulated or unsheathed cables are not permitted to be installed buried direct.

COMMONLY USED CABLE SYSTEMS

Underground cables (Cont'd)

- Underground wiring systems are classified as one of three types. The type of cable and form of enclosure determine the category assigned to the underground wiring system
  - **Category A**: the wiring system is inherently suitable for installation below ground and no further mechanical protection is required.
  - **Category B**: the wiring system is suitable for installation below ground only with additional mechanical protection provided for the cable or cable enclosure

COMMONLY USED CABLE SYSTEMS

Underground cables (Cont'd)

- ➢ **Category C**: the wiring system is laid within a channel chased in the surface of rock

- Tables 3.5 and 3.6 of AS/NZS 3000:2007 summarise underground wiring system categories.

Aerial cables

- To cover large distances at minimal cost an aerial wiring system is used.
- The types of cable which are suitable as aerials are listed in rule 3.12.1 of AS/NZS 3000:2007.

COMMONLY USED CABLE SYSTEMS

Catenary Wiring Systems

- Catenaries are used to support cables not suitable for aerial wiring (See Fig. 6-1-2).
- For example a circular TPS cable strung between two supports of any distance will not be able to support its own weight.
- The requirements for cables in catenary system are listed in rule 3.13.1 of AS/NZS 3000:2007 .

Fig. PF 6-1-2
Catenary Cable System

COMMONLY USED CABLE SYSTEMS

Safety Service Wiring Systems

- Formally known as emergency systems electrical safety services supply such apparatus as;
  - fire detection
  - warning and extinguishing systems
  - smoke control systems
  - evacuation systems
  - Lifts.

COMMONLY USED CABLE SYSTEMS

Safety Service Wiring Systems (Cont'd)

- Any electrical wiring system that could be described as "emergency equipment" or an "essential service" is required to maintain supply when exposed to fire.
- Cables such as MIMS or 'Radox' are required.
- Section 7.2 of AS/NZS 3000:2007 outlines the requirements for Safety Services installation and Appendix H of AS/NZS 3000:2007 provides guidance on the application of the 'WS' (Wiring System) classification.

COMMONLY USED CABLE SYSTEMS

Safety Service Wiring Systems (Cont'd)

- In accordance with AS/NZS 3013 the 'WS' system classifies wiring systems according to their ability to:
  - maintain circuit integrity under fire conditions for a specified period and;
  - maintain circuit integrity against mechanical damage of specified severity.

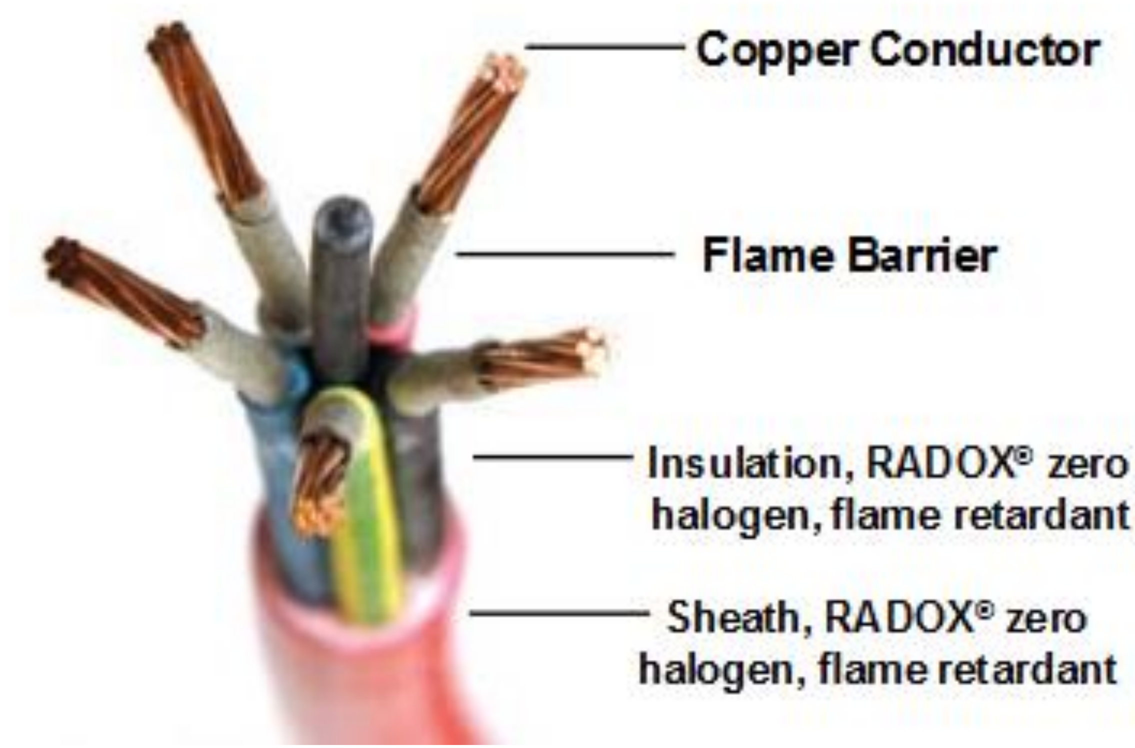


Fig. PF 6-1-3
"Radox" flame retardant cable

COMMONLY USED CABLE SYSTEMS

Busbar Trunking (Busway) Systems

- Distribution busbar distributes power along its length through tap-off points, typically at 0.5 or 1 m centres
- Advantages over conventional wiring systems:
  - On-site installation times are reduced compared to hard-wired systems.
  - It provides increased flexibility in design and versatility with regard to future modifications.
- Tap-off units are plugged in to supply a load; this could be a sub-board or individual machines.

COMMONLY USED CABLE SYSTEMS

Busbar Trunking (Busway) Systems (Cont'd)

- Tap-offs can normally be added or removed with busbar live, eliminating production down time.
- Installed vertically the same systems can be used for rising-mains applications,
- Protection devices are located along the busbar run, reducing the need for large distribution boards and the large quantities of distribution cables.

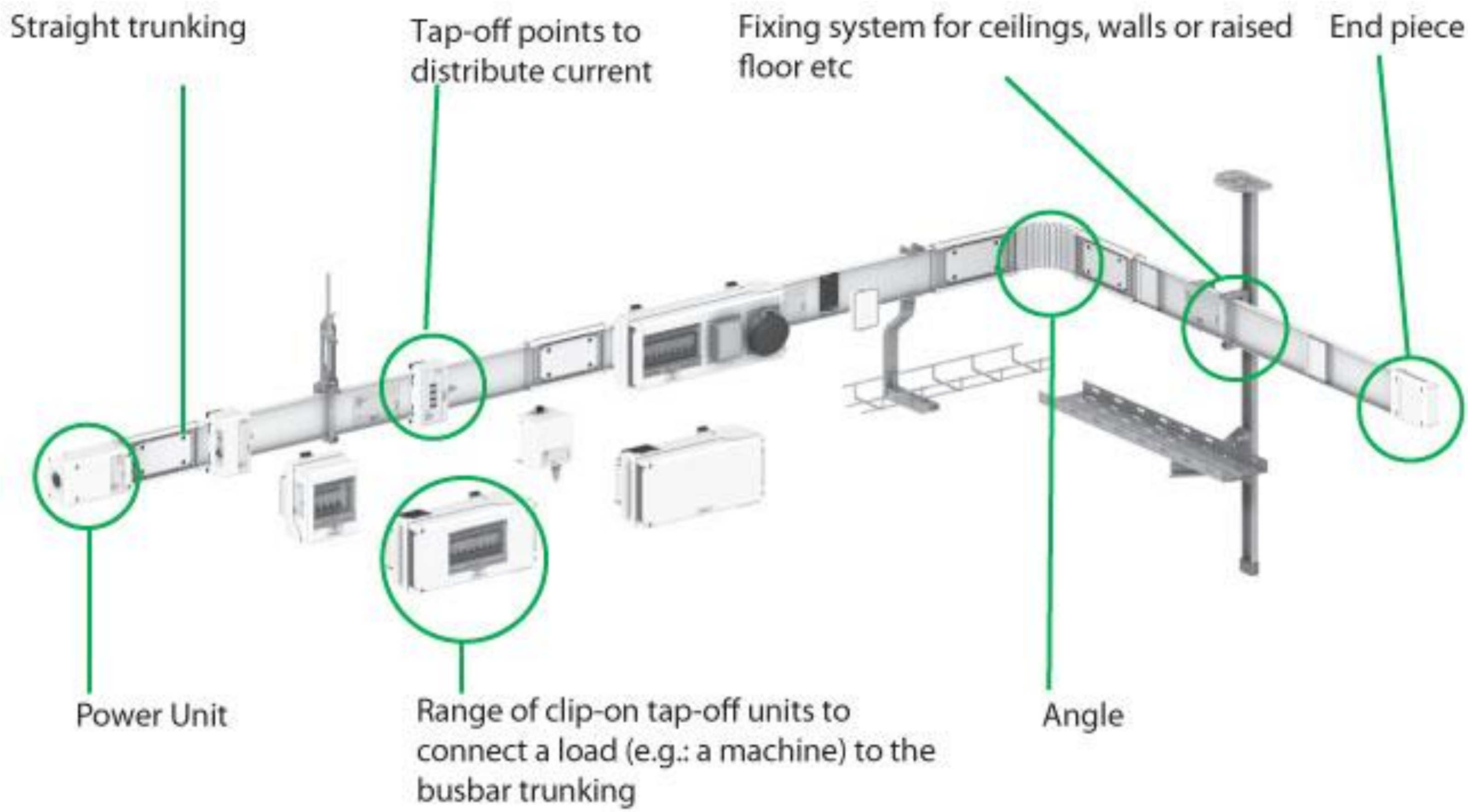


Fig. PF 6-1-4
Busbar Trunking (Busway) Systems

COMMONLY USED CABLE SYSTEMS

Earth Sheath Return (ESR) Systems

- Used with MIMS cable, a substantial installation cost saving is made by combining the protective earthing (PE) conductor and the neutral (N) conductor into a single protective earth neutral (PEN) conductor.

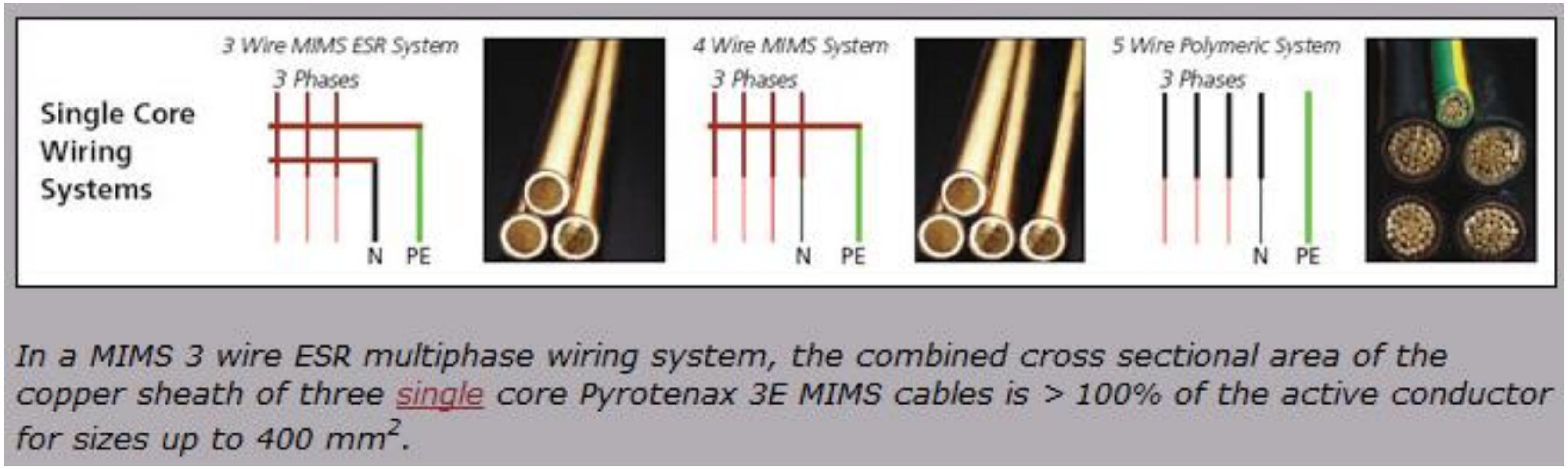


Fig. PF 6-1-5
Earth Sheath Return (ESR) Systems

SUMMARY OF CABLE SYSTEMS

- **Aerial conductors**
- **Catenary systems**.
- **Cable trays' and ladders**.
- **Cable ducts**.
- **Troughing**.
- **Busbar trunking systems or Busways**
- **Track systems**
- **Under carpet wiring systems**.
- **Modular wiring systems**
- **Thermo plastic sheathed' (TPS)**.
- **Conduit systems**
- **Mineral Insulated Metal Sheathed (MIMS) Cable**.


END