TEC INTERNATIONAL

MICC GROUP

MICC Wiring System 1083C

2 Hour Fire Rated UL/ULC Certified Cable Installation Manual

This manual covers termination and installation recommendations for the MICC Wiring Cable (System 1083C) for the North American market.

It is assumed that

- the application, selected cable, and installation has been properly reviewed
- the cable selection has been carried out and sized properly to code
- the installation has been properly designed and will be carried out by competent trained electricians according to applicable national and local codes.

Since this manual is only a guide and all situations cannot be covered, please call TEC/MICC for special installations if there are any questions. We encourage Engineering and Electrical Contractors to contact TEC/MICC for any advice if in doubt.

Product Guarantee

Please refer to TEC/MICC for full details of our terms and conditions which reference our warranties.

MICC cables are designed to protect for the lifetime of the installation, given that the design and installation have been carried out by competent and qualified professionals.

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Introduction

MICC - the Ultimate in Fire Survival

Fire, fire casualties, and fire losses have significantly increased over the last thirty years, insured losses continue to grow and this doesn't take into account the trauma experienced by the survivors.

The designer, installer, and the manufacturer must take responsibility to ensure products fully meet the requirements of fire standards, the NEC (or CEC), and/or local regulations.

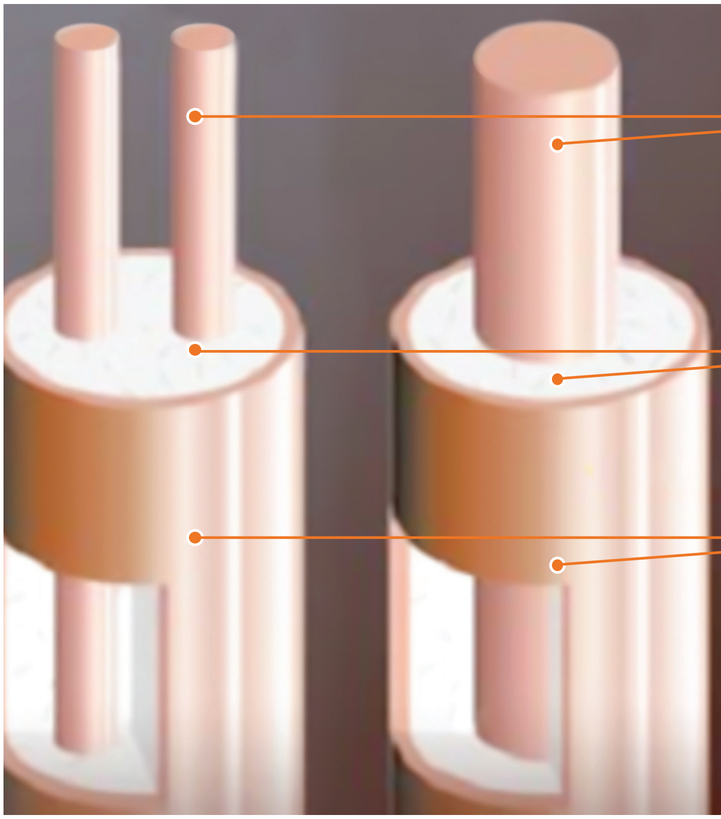
The MICC Mineral Insulated Wiring System provides the user with the highest available essential circuit protection. Mineral insulated wiring cables are known and proven in the fire wiring industry since 1936.

TEC and the MICC Group design, manufacture, and market cables for projects around the world and service a range of products in the nuclear, oil, petrochemical, and construction industries.

Cable Construction

The most important property of mineral insulated cable is its exceptional resistance to fire. This feature and the cable's unique construction places MICC brand cable in a class of its own. When combined with the characteristics, described in the following pages, the versatility of the MICC brand wiring system is unmatched.

With a basic inorganic construction of a copper sheath and copper conductors, together with a mineral insulant, the cable provides a unique combination of dependability, versatility, and performance. This construction, with melting points of 1083°C for copper and 2800°C for the insulant, provides the unsurpassed fire survival properties which enable the cable to continue to carry current at temperatures over 1000°C.



MI Wring Cable

Copper Conductors

- Copper and nickel clad copper
- Melting point 1083 °C

Magnesium Oxide (MgO) Insulation

- High temperature ceramic - 2800 °C

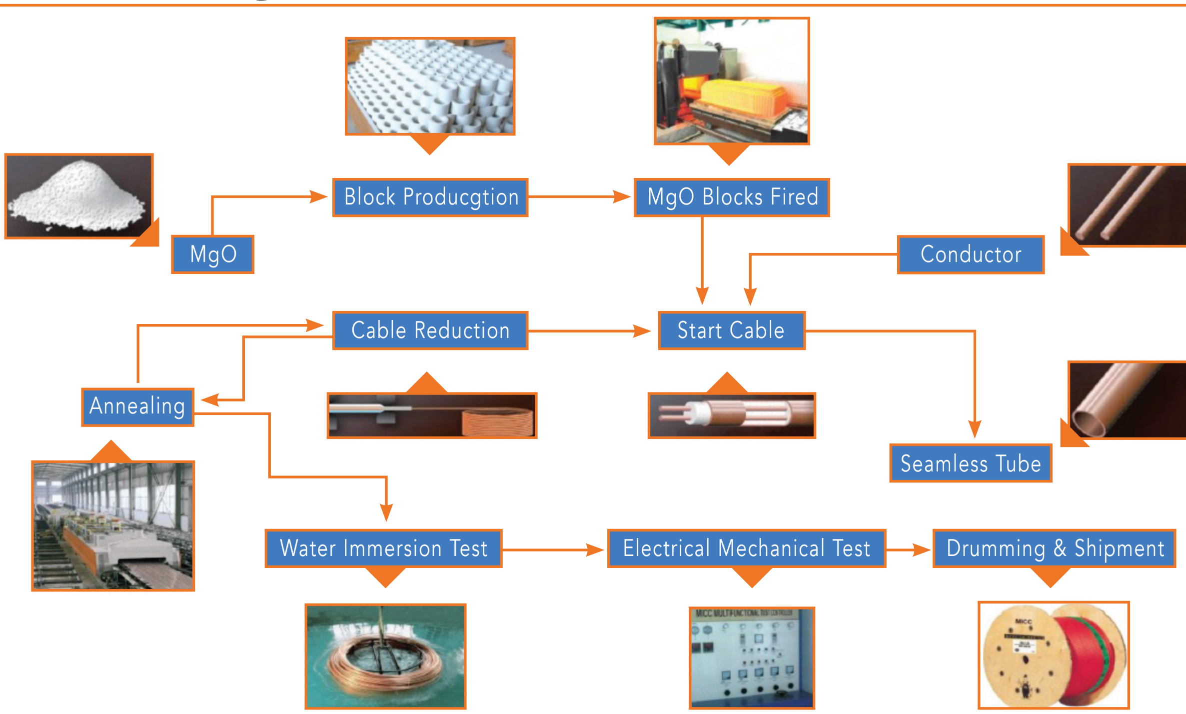
Copper Sheath

- Copper

The qualities and characteristics have not changed.

The unique benefits and unbeatable performance have not changed.

Manufacturing Process



For more details refer to our website www.tecwiring.com and www.micccorp.com

MICC wiring cables are used in a multitude of applications and environments. A truly range-taking product unsurpassed by any other product and requires no conduit or concrete protection to enhance its use.

Real fire circuit integrity performance by furnace testing (Furnace testing 2 hours or more 1,010°C (1850 F) + hose stream)
Zero toxic emissions (not: just low halogen & high CO)
Zero flame propagation (not: limited flame propagation for external fire only)
Zero smoke (not: just ‘claimed’ low smoke)
Zero heat of combustion (not: high fuel element & high heat of combustion, & high oxygen consumption & high CO emissions)
Zero environmental impact in installation, service life & disposal (100% recyclable)
Zero impact from rodents, termites, and insects (not: just no damage under the outer steel armor)
High Short Circuit Ratings (high safety - no self-ignition)
High Overload resistance (high safety - no self-ignition)
Characteristic Impedance (no significant change during fire or hose stream)
Mechanical integrity across normal and abnormal operating temperature range (Cable does not soften at operating or overload temperatures)
Non-aging (no reduction in elongation at break to 50% absolute in 2.3 years at rated temp.)
Small Size (diameter) (less installation space needed)
Fewer attachments required (longer attachment distances due to less sag)
Waterproof (Solid copper outer jacket)
Radiation proof (use permitted in reactor chamber of Nuclear Power Station)
Bio/Chemical Hazard safe (fully sealed cable at each end and through full length)
Crush resistant (not just unidirectional cut resistant)
No OHS issues (Occupational Health & Safety for installation and handling)
Proven fire protection performance (in service over 80 years)

The standard range of the cable provides the ideal solution for almost all electrical circuits.
One voltage grade is available – 600 volts with conductors from 10AWG to 500MCM giving current ratings up to 700 amps.

MICC offers a full range of complementary termination and installation accessories plus tools that provide for a complete wiring system.

Reliability

Specifying the right cable for a particular application is the first step. The key to reliability is in the manufacturing process.

The cable must be free from material and manufacturing defects that will be revealed in service. TEC/MICC constantly monitors all manufacturing processes and operates the most stringent Quality Assurance procedures to give you that kind of reliability. It is a factor that provides vital significance where cables are to be installed in locations where future access will be difficult.

At the same time, we recognize that modern commercial and industrial activities create even greater demands on performance and reliability. Consequently, our manufacturing techniques are under continuous review to ensure that control and monitoring of materials and processes stay industry-leading, fully integrated, and precisely documented.

Product Availability and Service

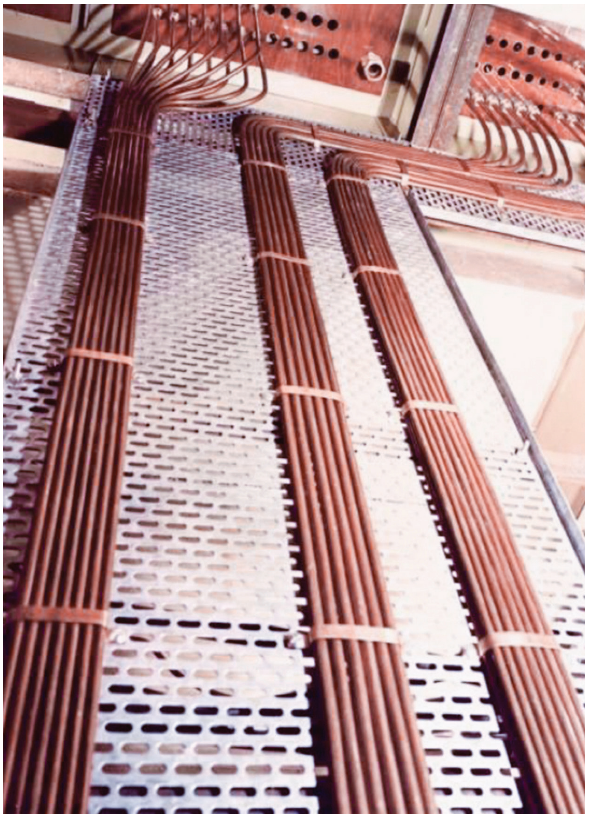
TEC/MICC has chosen a select number of MI cable installation expert distributors and installers of MI in North America. These dedicated experts are geographically situated to offer a national distribution network to meet your requirements and provide a local service.

Quality products must be matched by quality service for the continually expanding and demanding MICC Cables market. These conditions can best be met by local distribution experts and the manufacturer working in unison. The local expert is your first point of contact, they are familiar with the product and can readily provide the answers to any of the normal questions.

Our experienced technical staff and local experts exist to serve you in overcoming any application problem. Skilled design resources and project management capability enable us to become integrally involved with any inquiries and ensure you get the right cable for the job - a cable that will continuously carry the required current at the specified voltage in demanding and difficult conditions.

While installation is routine, there may be times when you are faced with an unusual problem. This is when the technical group from TEC/MICC can be called upon. Our engineers and local experts are always ready to help and a telephone call will often resolve the question. If necessary, they will visit your premises or site to demonstrate the installation and terminating techniques for MICC Cable. If needed, a more in-depth local training program can be provided.

Service in the widest possible sense is of tremendous value, we aim to provide, prompt and courteous service always. Your local TEC/MICC expert can offer sales support, a comprehensive supply and distribution service. Alternatively, you can contact MICC Technical Support Service where an engineer will be pleased to answer your call.



NEC Fire Rated Applications:

The NEC recognizes critical electrical circuits that, in the event of a fire, must continue to perform their intended functions. NEC Article 695 and Article 700 address "Fire Pump" and "Emergency System" applications respectively.

Both require a minimum of a 2-hour fire-resistance rating which can be achieved through various methods.
This requirement applies to the following:

- Fire Pump Feeders
- Emergency Generator Feeders
- Emergency Exhaust Fans
- Emergency Lighting
- Exit Signs
- Firemen's Elevators

North American Standards and Approvals

For the North American Market (Canada and the USA) MICC complies with the following standards and carries the following approvals:

UL/cUL (where applicable) standards

UL504
CSA C22.2 NO. 124

UL2196

UL486A & B
CSA C22.2 NO. 65-18

UL514b
CSA C22.2 NO. 18.3-12

UL File references

R40151
E514781
E515216

International Standards and Approvals

MICC MI Wiring Cables are manufactured, tested and LPCB approved to BS EN 60702-1.

The LPCB/BRE (www.redbooklive.com) certification refers to the following standards:

BS EN 60702-1:2002 -Mineral Insulated cable and their terminations with a rated voltage not exceeding 750V

BS6387:1994-Performance requirements for cables required to maintain circuit integrity under fire conditions.

BS 5839-1: 2002+A2:2008 -Fire detection and alarm systems for buildings.
Code of practice for system design, installation, commissioning, and maintenance.

MICC terminations for metric size cables are tested per BS EN 60702-2

Other MI Cable Standards and Codes

BS 8434 – Methods of test for assessment of the fire integrity of electric cables

BS 6387 – 1994 Performance requirements for cables required to maintain circuit integrity under fire conditions.

IEC 60331 – Test for electric Cables under fire conditions. Circuit integrity.

BS EN 5588 – Fire Precautions in the design, construction, and use of buildings.

BS 5839 – Fire detection and alarm systems in Buildings.

BS EN 5266 – Emergency Lighting. Code of practice for the emergency lighting of premises.

BS 7671: 2015 – Requirements for Electrical Installations. IEE Wiring Regulations.

BS 60079 – Code of Practice for the selection, installation, and maintenance of electrical apparatus for use in P otentially Explosive Atmospheres.

London Underground – Fire Survival Cable (MICC) EME-SP-14-028-A1

Markings – TEC's MICC branded UL Certified cable marked as follows

TEC/MICC MI 600V (UL) 2196/(ULC) S139 FHIT/7: 1083C FRR 2H 600V [ELECTRICAL LISTINGS] [PN] [DATE]

Additional Applicable Codes and Standards

These instructions found in this manual form a part of the manufacturer's instructions. In addition, installation or application of parts of the following applicable Code(s) and Standard(s) may be required:

(i) CSA-C22.1, Canadian Electrical Code, Part 1, Safety Standard for
Electrical Installations;
(ii) CAN/ULC-S524, Installation of Fire Alarm Systems;
(iii) ANSI/NFPA 70, National Electrical Code;
(iv) ANSI/NFPA 72, National Fire Alarm and Signaling Code;
(v) ANSI/NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems;
(vi) ANSI/NFPA 502, Standard for Road Tunnels, Bridges, and Other Limited Access Highways;
(vii) Any applicable local standards and/or Codes.

Handling and Storage

On receipt and before being held in storage we require the cable references are confirmed and insulation resistance (IR) is measured using a 500 volts insulation tester connected across the conductor(s) and the metallic sheath and conductor to conductor. Test results should not be less than 100 MΩ. However, site conditions may reduce this and a value of 20 MΩ is acceptable even in dry conditions. Wet conditions may reduce this even further but, in any case, a value of <5 MΩ should be considered evidence of a problem to be investigated.

Like all electrical products, TEC/MICC must be managed and stored appropriately. Cables shall be stored to protect them against physical damage and the environment. Protection from construction equipment, falling objects, chemical spills, and other hazards shall be considered in selecting storage areas and environments. Fencing or other barriers shall be used to protect cables and reels against damage by vehicles or other equipment moving about in the storage area.

Cable Reels

Reels shall be stored upright on their flanges, not stacked. Handling shall be in a manner that prevents deterioration of and physical damage to the reel and the cable. Reels of cables must not be dropped from any height. Cable reels should be handled utilizing equipment designed for that purpose. Always load and store reels up right on their flanges and block securely.
Reels can be hoisted with a properly secured shaft extending through both flanges.
Cradle both reel flanges between forklift forks.
Lower reels CAREFULLY from a truck using a hydraulic gate, hoist, or forklift.

Upended heavy reels will often be damaged. Do not lift by a single reel flange as cable or reel may be damaged. Never allow forklift forks to touch the cable surface or reel wrap. Never drop reels. Lifting or handling of cable reels should be done in such a manner that the lifting/handling device does not make direct contact with the cable or its protective covering. Care shall also be taken so that the flange of one reel does not impact cable on another reel. If any of these cases occur, the cable shall be examined for damage.

The following methods are recommended for the lifting of cable:

- A crane or boom-type equipment may be used by inserting a suitable shaft, which is properly secured, through the reel arbor hole and lifting with slings. A spreader or other device should be used to minimize sling pressure against the reel flange.
- Forklift type equipment may be used to move smaller, narrower reels. Forklift forks should be placed so that lift pressure is on the reel flanges, not on the cable, and must reach across the reel so the lift is against both reel flanges.
- Reels may be moved short distances by rolling. Reels should be rolled in the direction that the cable is wound. This will tend to tighten the cable windings, not loosen them. Surfaces over which the reels are to be rolled should be firm, level, and clear of debris including protruding stones, stumps, and other material that may damage the cable if the reel straddles them. Make sure there are no objects in the way that could damage the cable surface by preventing the reel flanges from bearing the total weight.

Cable Reels (cont)

If a cable is transferred to another reel, the drum diameter of the reel shall be equal to, or greater than the original reel drum diameter. Reel flanges should be in good condition to prevent damage to the cable. The reel should be capable of accommodating the cable length with at least 1 1/2 inches of clearance below the top of the flange. The reel shall have an adequate weight capacity. Care shall be taken to assure that cable limits for bending radius are not violated and the cable is not twisted during reeling or installation. Appropriate precautions for reeling and unreeling should be followed. Identification and/or marking information shall be transferred to the new reel using a permanent marking method.

Cables shall be handled carefully during unreeling to prevent damage due to kinking or bending to radii smaller than allowable limits. During handling, cables shall not be laid on rough ground, run over, dragged over sharp objects, or other such treatment that could cause damage.

To prevent cables from settling into soft ground and prevent reels from rotting, storage should be on a firm surface, paved if possible, or on planking in an area with good drainage. For these reasons, storage of cable should, preferably, be indoors.

The cables should be stored vertically, and payoffs/swifts/jack stands should be employed to ease cutting and installation.

Although copper has immense resistance to many corrosive agents, heavy concentrations of acids or alkalis may harm the cable.

Please consult MICC for guidance if needed.

Storage

Cables are protected from the direct effects of weather with wrapping or lagging when shipped. When received, the protective covering or wrap on the cable should be inspected for evidence of shipment damage. Whenever possible, the factory-applied protective cover should be left in place until removal is necessary. The additional cover material should be used to protect against the effects of the environment in which the cable is stored, such as outdoors or in excessively dirty, dusty areas. The cover should be resistant to the environment and should be chosen to shield cables from the deleterious effects of the sun. If possible, ventilation should be provided to dissipate any heat buildup. Both ends of the cable on a reel should be securely fastened to the reel flange and sealed to prevent the entrance of moisture. When shipped, the exposed ends of MICC cables are protected by shrinkable, molded end caps. These caps are weatherproof and should adequately seal the cable against moisture and other contaminants during shipment and storage. Whenever end seals are damaged, missing, or removed look for moisture in the cable. If moisture is found, use suitable measures to dry the cable core and rectify any harmful effects of the moisture, such as corrosion, before installation. If storage is outdoors or in an environment where considerable dirt and moisture are present, protection of the exposed cable ends with shrinkable, molded end caps or other suitable means is recommended.

Packaging and Handling

In certain circumstances, the packaging of cables, e.g. large heavy drums, or sharp edges of metal components of cables could constitute a safety hazard and individuals should therefore take due care for their safety when handling these items.

Disposal of Scrap Cable

When disposing of scrap cable, follow all environmental regulations.

General

When MI cable is stripped and terminated, cut edges can cause abrasions to the skin and loose powder may irritate if it enters the eyes. For these reasons gloves and safety glasses are recommended when handling.

Following local and national regulations, TEC/MICC has produced a series of material safety data sheets, which are available upon request:

Data-sheets are available on the following:

MgO, Magnesium Oxide - mineral insulant.
PVC conductor insulating sleeving, Ref. RZP & RZE.
Grey plastic sealing compound, Ref. TRMX.

Pre-Installation

Survey and carry out any necessary risk assessments using available risk checking tools/checklists. Ensure the installation will be carried out in a planned and safe way. (found on page 34)

Length

Check that the length of the cable specified on the label agrees with the length specified on the schedule or site drawings.

Electrical Test

MICC cables are supplied with temporarily sealed ends but before installation and moving to the installation location, the insulated cable should be tested following established procedures. We recommend insulation resistance (IR) is measured using a 500 volts insulation tester connected across the conductor(s) and the metallic sheath and conductor to the conductor. It should not be less than 100 MΩ. However, site conditions may reduce this and a value of 20 MΩ is considered to be acceptable even in dry conditions. Wet conditions may reduce this even further but in any case, a value of <5 MΩ should be considered evidence of a problem to be investigated.

All measurement and test equipment should be calibrated.

Precautions

All appropriate precautions should be taken when installing cables, including following OSHA and other applicable regulations. Improper installation procedures can significantly damage or impair the operation or performance of electrical cables. While different cable constructions may have varying degrees of resistance to physical damage, no technology will guarantee a damage-proof cable. Therefore, in addition to observing standard safety practices, the following safety precautions should be observed:

- Ensure that the cable reel is properly secured before cable installation.
- Pulling devices and the pull rope should be used within their rating to prevent breaking of the rope or devices under tension.
- Appropriate measures should be taken to protect personnel should breakage of the pull rope occur.
- Personnel should not stand in line with a pull rope that is under tension.
- Pull ropes should be stored clean, dry, out of direct sunlight, and away from extreme heat.
- Some synthetic rope, particularly polypropylene, polyethylene, and aramid (which are not properly treated) may be weakened by prolonged exposure to ultraviolet (UV) rays. Pull ropes should be checked before each pull for signs of aging or wear, including frayed strands and broken yarns. A heavily used rope will often become compacted or hard indicating reduced strength. If there are any concerns regarding the condition of the rope, it should not be used. No type of visual inspection can accurately and precisely determine residual strength.
- Most commercial cable lubricants are water-based. Any cable lubricant spilled on the floor should be cleaned up or covered immediately.
- Appropriate precautions should be taken when working around energized cables and equipment.

This section provides practical guidance on accessories used in terminating and installing MICC MI Cables, using tools found in the average electrician's kit as well as the range of specialized tools designed for speed and efficiency.

MICC cable termination kits are provided by TEC/MICC to compliment the cable range Certified by UL.

A complete termination consists of two basic units. They are the seal and the gland. The seal separates and insulates the conductors from each other, and the sheath also seals the cable insulation. The gland secures the cable into the apparatus, provides mechanical protection for the seal, and provides earth continuity when required.

The brass pot seal is screwed onto the end of the cable and filled with TEC/MICC manufactured sealing putty before a disc and sleeving completes the end seal termination

If a brass compression gland is employed this must be slid on the cable before the pot seal is fitted

See the MICC table below for termination versus cable type.

MICC Cable			MICC Seal Kit				Kit Contents			
							Assembled Gland	Brass Seal Pot	Cap with Insulating Sleeving	TRMX Putty
MICC PN	OD (Nom. inch)	Cond. OD (Min. inch)	Qty	Cable Config	Kit PN	Gland Thread Size (NPSM)	Qty	Qty	Qty	Qty
Single Conductor										
CC1H10W	0.277	0.094	1	1C 10	MI01010-050	1/2"	2	2	2	1
CC1H4W	0.402	0.189	1	1C 4	MI01004-050	1/2"	2	2	2	1
CC1H3W	0.449	0.221	1	1C 3	MI01003-075	3/4"	2	2	2	2
CC1H2W	0.449	0.248	1	1C 2	MI01002-075	3/4"	2	2	2	2
CC1H1W	0.496	0.278	1	1C 1	MI01001-075	3/4"	2	2	2	2
CC1H1/0W	0.512	0.313	1	1C 1/0	MI011X0-075	3/4"	2	2	2	2
CC1H2/0W	0.580	0.351	1	1C 2/0	MI012X0-075	3/4"	2	2	2	2
CC1H3/0W	0.621	0.402	1	1C 3/0	MI013X0-075	3/4"	2	2	2	2
CC1H4/0W	0.684	0.443	1	1C 4/0	MI014X0-100	1"	2	2	2	2
CC1H250W	0.746	0.480	1	1C 250	MI01250-125	1-1/4"	2	2	2	3
CC1H350W	0.834	0.569	1	1C 350	MI01350-125	1-1/4"	2	2	2	3
CC1H500W	1.000	0.679	1	1C 500	MI01500-125	1-1/4"	2	2	2	3
Two Conductors										
CC2H10W	0.449	0.094	1	2C 10	MI02010-075	3/4"	2	2	2	2
CC2H4W	0.684	0.189	1	2C 4	MI02004-100	1"	2	2	2	2
CC2H3W	0.768	0.221	1	2C 3	MI02003-125	1-1/4"	2	2	2	3
CC2H2W	0.865	0.248	1	2C 2	MI02002-125	1-1/4"	2	2	2	3
CC2H1W	0.975	0.278	1	2C 1	MI02001-125	1-1/4"	2	2	2	3
Three Conductors										
CC3H10W	0.480	0.094	1	3C 10	MI03010-075	3/4"	2	2	2	2
CC3H4W	0.746	0.189	1	3C 4	MI03004-125	1-1/4"	2	2	2	3
CC3H3W	0.834	0.221	1	3C 3	MI03003-125	1-1/4"	2	2	2	3
Four Conductors										
CC4H10W	0.590	0.094	1	4C 10	MI04010-075	3/4"	2	2	2	2
Seven Conductors										
CC7H10W	0.621	0.094	1	7C 10	MI07010-100	1"	2	2	2	2

Terminating Accessories, Tools, & Installation Aids

MICC Ringer

When using side cutters or a stripping rod to strip the cable sheath, the ringing tool is used to score a light groove around the cable sheath to neatly finish the stripping action.
To order use Ref. ZR.

MICC Stripper (Small)

Suitable for cables below 0.354" (9mm) diameter.
To order use Ref. ZSUS.
To order Spare Blades use Ref. ZSUSB

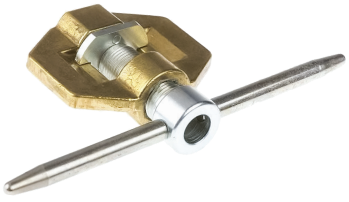
MICC Stripper (Large)

Suitable for cables above 0.354" (9mm) diameter.
To order use Ref. ZSU.
To order Spare Blades use Ref. ZSUB

The tools carried in the average electrician's kit are usually adequate to carry out effective terminations on MI cables except for crimping the pot closure. However, for efficiency and convenience, we offer the following range of purpose-designed tools.

MICC Potter

This tool ensures quick and accurate screwing on of the brass pot and is used in conjunction with the appropriate RGM cable gland. Four sizes are available to cover
the range of seals.
To order use ZPM + size of the seal.



MICC Crimp

The MICC Crimp is a robust long-life tool that applies a three-point crimping action
to the brass pot seal, securely locking the cap into position. It is available for ½" and ¾" seal sizes.
To order use Ref. ZDC + size of the seal.

MICC Straightener

Designed to assist in the preliminary dressing of cables before supporting. The small tool is suitable for cables up to approximately ½" mm diameter. (For larger cables, the initial dressing can be carried out with the aid of MICC Benders)
To order use Ref. ZBS3 or ZBS5.

MICC Bending Levers

MICC Cable can normally be bent by hand, but to assist in the symmetry of multiple bends on large installations or where the heaviest cables are involved, bending levers can save time.
Two sizes are available.
For cable diameters between 0.629" (16mm) and 1" (25.4mm) order Ref. ZBLB.
For cable diameters between 0.394" (10mm) and 0.629" (16mm) order Ref. ZBLA.

Notes: 'Pigtails' can be left at the end of the cable to allow for the final installation of junction boxes and safe removal if necessary.

Copper is a soft metal but can be dressed into position using a hammer with a block of wood to protect the cable.

Various clips and saddles are available.

MICC Standard Terminations and Supporting

Brass Pot Seal Comprising:
Threaded Brass Pot, Sealing Compound, Pot Closure, Insulating Sleeve.

Brass Compression Gland Comprising:
Back nut, Compression Ring, Gland Body.

Self-threading brass screw on seals that comply with applicable requirements is available for all cable sizes and are stamped with the cable size.

Seal Dimensions

150°C Medium Temperature Seal

This seal is recommended for operation in the temperature range of 105°C to 150°C. It can also be used for short-duration higher temperature applications. The seal assembly kit comprises the brass pot, cap, conductor sleeving, and sealing compound.
To order use Ref. RPCD + cable size.

There is also an earth tail version in which the brass pot is provided with an integral150mm long protective conductor tail.
To order use Ref. RPCN + cable size.

The TRMX Compound is not shown.

105°C Brass Seal

Recommended for all normal wiring applications requiring continuous operation in the temperature range minus 80°C to plus 105°C.

The seal assembly kit comprises the brass pot, cap, conductor sleeving, and the RMX sealing compound.
All brass seal packs contain sufficient black conductor sleeving to insulate 6" (150mm) conductor tails.
To order use Ref. RPS + cable size.

Where longer conductor tails are required additional sleeving is available as follows.
To insulate longer conductor tails use PVC extension sleeving
Ref. RZP + conductor size.

Tag Earth Tail Washers

Tags are 150mm lengths of green/yellow 1.5mm2 or 2.5mm2 earth wire fitted at one end with a 20mm tag washer.
When used in conjunction with a brass gland they will provide primary or supplementary earth continuity in plastic or metal enclosures respectively.

They are also suitable for use with brass glands and plain brass seals as an alternative to the use of earth tail seals.
To order Tags use Ref. RLT + conductor size + 20.

Brass Locknuts and Zinc Plated Lock Washers

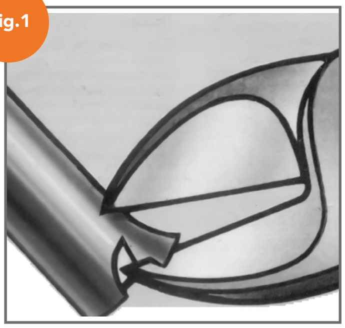
These are available for securing externally threaded glands into plain hole entries to ensure mechanical tightness and earth continuity.
To order Lock Nuts use Ref RLM + size.

Terminating MI cable (see illustrated procedure below)

General procedures for terminating are provided below. Be advised that MICC cannot be responsible for the effectiveness of termination.

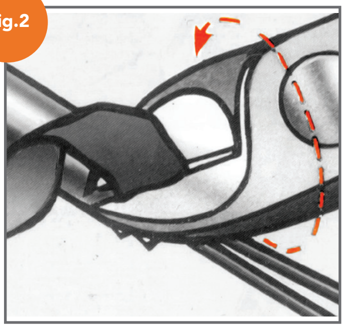
The environment should be clean and dry. Tools should be in good working order and used for the purpose that they are designed. Terminating materials must be of MICC type and be compatible with the cable.

Fig.1



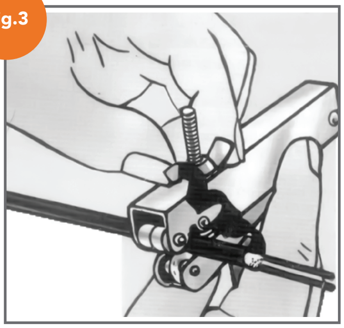
This method uses a tool normally carried in any electrician's kit. Grip the edge of the sheath between the jaws and twist the wrist clockwise, then take a new grip and rotate through a small angle (Fig. 1).

Fig.2



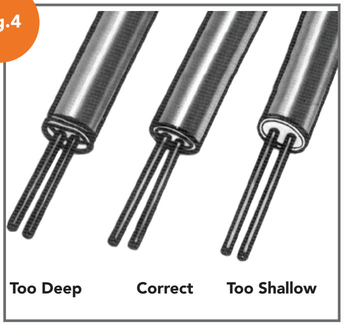
Continue this motion in a series of short 'rips', keeping the side-cutters at about 45° to the line of the cable, removing sheath spirally (Fig 2).

Fig.3



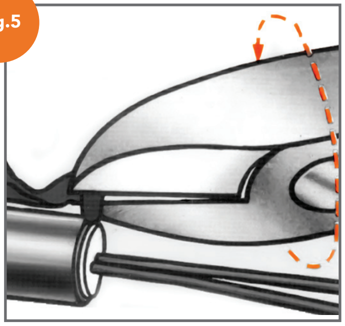
When approaching the terminating position, the cable sheath should be ringed with a ringing tool. This tool, shown in use here (Fig. 3), is used to cut a groove around the sheath so that it will break away cleanly and at exactly the right place. Tighten the wing nut until the wheels have enough grip to allow the tool to support its weight in a horizontal position, then an additional quarter to half a turn according to the size of the cable.

Fig.4



Rotate the cutter around the cable for one complete turn, or more if the first cut appears shallow. The correct depth for the groove is half the thickness of the sheath and reference to (Fig.4), will show the results of over or undercutting.

Fig.5



When the rip is about to break into the ring, bring side-cutters to right angles with the cable. Finish off with the side-cutters held parallel to the cable (Fig.5). Wipe the conductors to remove any insulant. The cable is now ready for sealing.

Fitting the Pot

Two methods are available for fitting the pot.

(i) Using pliers or pipe grips.

(ii) Using the pot wrench tool (only when terminating with a gland).

Glands and if required gland shrouds should be slid onto the cable sheath before screwing on the pot unless using the pot wrench method when the gland is fitted at the same time as the pot.

Method One - Using Pliers or Pipe Grips

Grip the knurled base of the pot with the pliers (Fig. 6a) and screw the pot onto the sheath until the sheath is level with or protruding slightly from the shoulder inside the pot (Fig. 6b).

With small diameter cables, it is advisable to grip the cable sheath with pliers just behind the pot, to prevent twisting of the cable. Do not reverse the screwing motion while fitting the pot as this can cause slackness of the pot, which can affect sealing performance or earth continuity. If fitting an earth tail pot, the pot should be turned until the earth tail is midway between the adjacent conductor(s) to ensure alignment with the disc (Fig. 6b). The fitting operation may be assisted by applying a slight amount of oil to the sheath, ensuring no oil contaminates the powder insulant.

Fig.6a

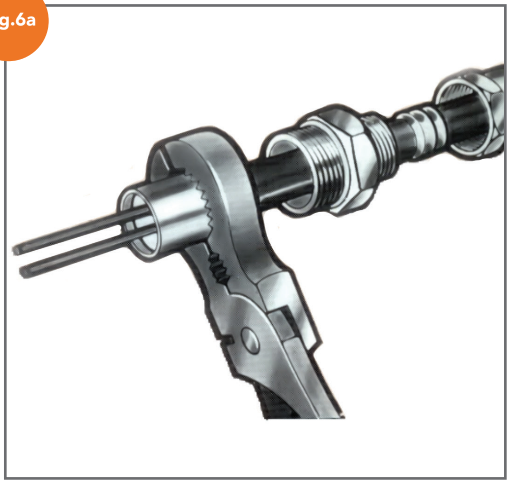


Fig.6b

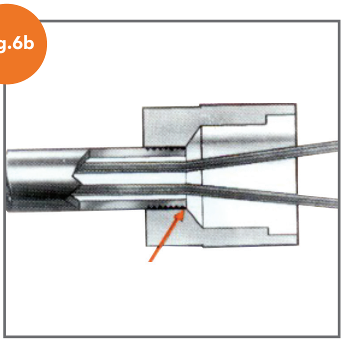
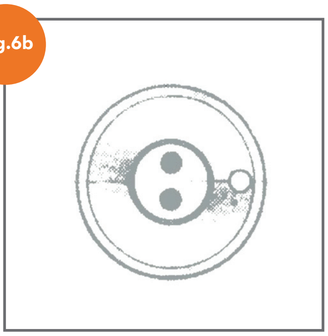


Fig.6b



Method Two - Using the Pot wrench

The pot can usually be applied more quickly using the pot wrench and the straightness of the pot is ensured. Pot wrench tools Ref. ZPM + size is available for all sizes of the pot.

Place gland nut and a compression ring on the stripped end of the cable and position the pot into gland body and screw into the tool (Fig 7). Finger tightness is not sufficient. The assembly must be lightly tightened up using pliers or an adjustable wrench.

The sheath should be approximately level with or slightly protruding from the shoulder. End view of correctly fitted earth tail pot.

Fitting the Pot

Slide gland body, pot, and tool assembly onto the cable and turn pot wrench in a clockwise direction while applying sufficient forward pressure to engage the internal screw thread (Fig. 8).

Continue rotating the tool until the sheath is level with or protruding slightly from the shoulder inside the pot.

With small diameter cables, it is advised to grip the cable sheath with pliers just behind the pot to prevent the twisting of the cable. Do not reverse the screwing motion while fitting the pot, as this can cause slackness of the pot which can affect sealing performance or earth continuity. When fitting, remove the pot wrench from the gland body (Fig. 9). When unscrewing the pot wrench grip the gland body with pliers or a spanner to prevent the pot from unscrewing from the sheath.

Fig.7

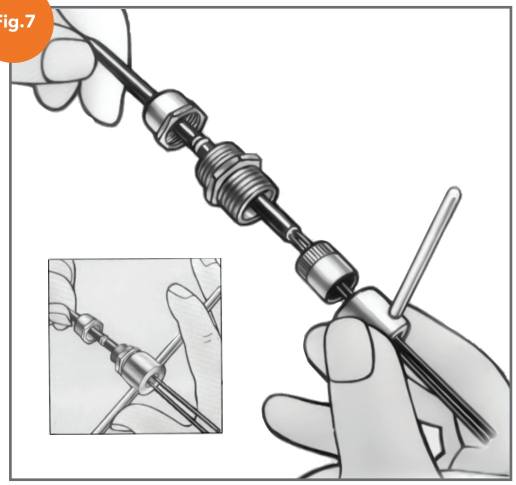


Fig.8

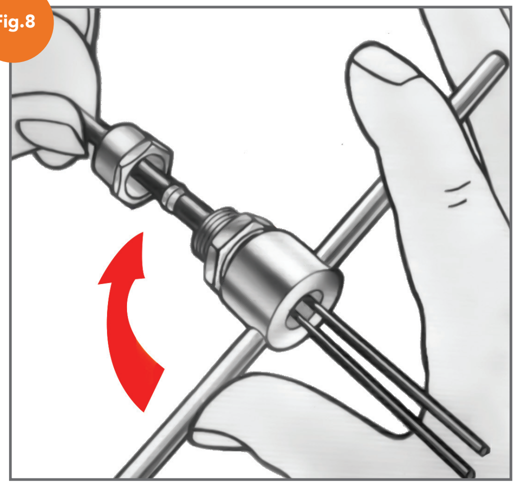
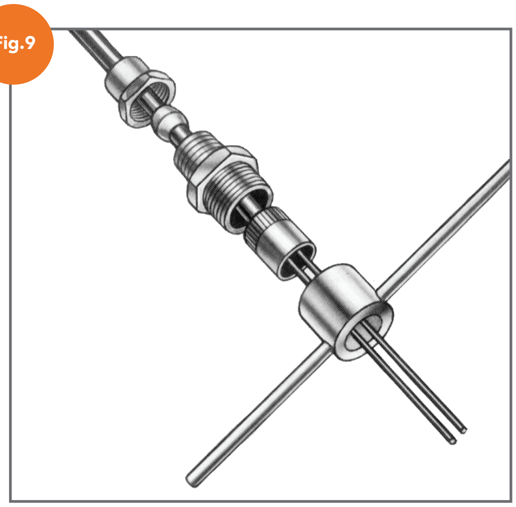


Fig.9



Fitting the Pot (cont)

After fitting the brass pot examine the interior carefully and remove any debris that may have resulted from the screwing action. If appropriate, check for the squareness of the pot by sliding the gland over the pot.

Slide the disc (Fig. 10) over the conductors and into the pot recess to check for fit, and then partially withdraw. First, fit the headed sleeves into the disc as shown (Fig. 10a). Pull the head hard against the face of the disc.

Press TRMX compound into the pot from one side only, to avoid cavities, with thumb preferably behind the paper to ensure cleanliness (Fig. 11). Fill the pot, overfilling slightly. Care should be taken to avoid contamination of the sealing compound.

Slide the disc up to the pot and press it into the pot recess with the aid of a pair of pliers, applying pressure only to the face of the cap (Fig. 12).
The seal is now ready for crimping

Fig.10 Fig.10a

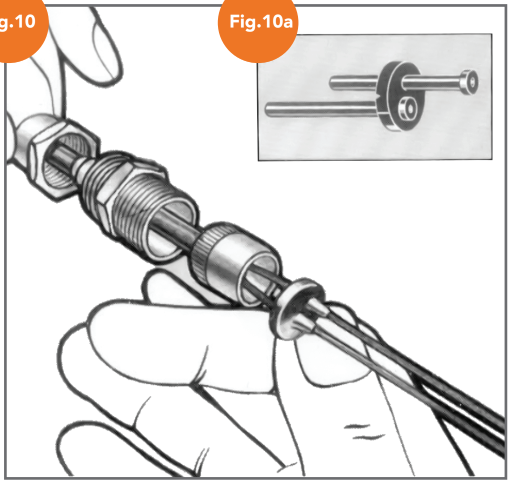


Fig.11

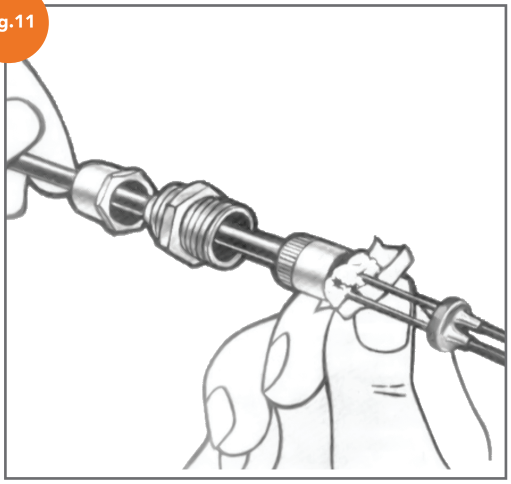
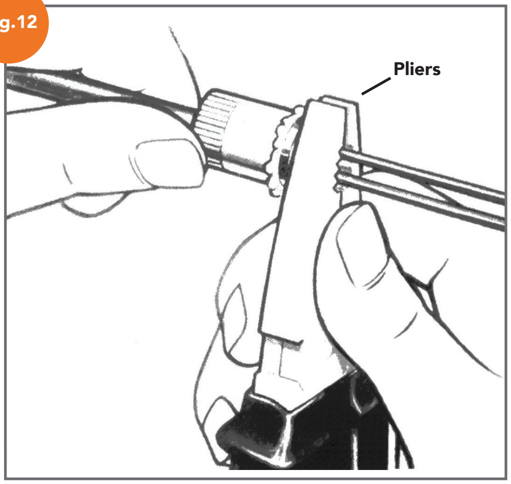


Fig.12

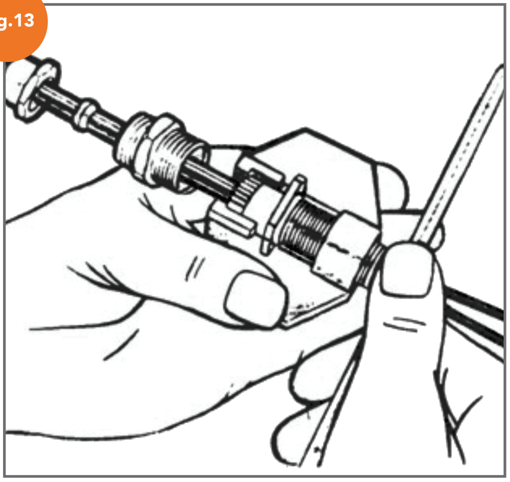


Crimping the Pot

Crimp Tool Ref. ZDC, 3-point crimps for Screw on Seals.

Fully slacken the drive screw using the handle. Slide the conductors through the hole in the crimping plate and the center of the hollow drive screw. Place the pot into the seating in the brass body and tighten the screw until it is fully hand tight, (Fig. 13) which will drive the disc fully into the pot recess and secure it in position using the three indent crimps. Then slacken and remove the tool. Cut the conductor insulating sleeving to the required length and slide it over the conductors. The seal is now complete.

Fig.13



Testing

The seal should be visually inspected for obvious defects. If there is a minor fault e.g., incomplete crimping, it may be required to repeat the operation. However, it may be necessary to remove the seal and re-terminate, the instructions for which are given later.

After both ends of a cable have been terminated with permanent seals, the cable should be subjected to an insulation test at a D.C. voltage appropriate for the intended operating voltage i.e. 500 V D.C. for 250 Volt or 500 Volt operation (Fig. 14).

Never test a cable that has unsealed ends because this will result in false readings. The purpose of this initial test is to check for major faults, e.g., short circuits within the pot, in which case the fault should be located and rectified. The IR should be noted and compared with the value measured at least twenty-four hours later. This second reading should be at least 100MΩ and have risen from the initial value. Initial low readings may result from cable sealed in high humidity conditions, in which case a higher second reading will indicate effective sealing.

Fig.14

Installation

Cables should be selected per the requirements of the latest edition of the NEC (NFPA70) or CEC in consideration of local regulations

Installation Design Data

Note:

1. Ensure the correct drawings or schedules are available to determine where the cables are to be installed.
2. Compare cable tag information with information in 1) and confirm length and type – check this label carefully!
3. Inspect the cable and accessories for damage
4. Check the IR of each cable using a 500V IR tester (Megger). The minimum acceptable IR shall be 100 MΩ
5. WARNING – cables failing MUST not be installed and either returned to MICC for repair or repaired locally – please contact MICC. for advice
6. Ensure that all metal joining processes on the installation have been completed.
7. Check before installation that actual install lengths and available lengths are comparable
8. Ensure that the installation surface is free from burrs, nicks, and sharp edges. These could cause damage to cables during installation and are also a hazard to the installers
9. Check that any surface treatments (paint, coatings, etc) have been completed.
10. The radii of any curves should be left as large as possible to allow for any subsequent adjustments.
11. After the cable has been installed it may be necessary to adjust for excess or shortage of cable length by redistribution on the installed surface. Severe mismatch should have been checked before installation but, if necessary, the project engineer responsible should be informed so an appropriate decision can be taken.

In all cases, reference must be made to NEC (NFPA70) or CEC (specifically refer to Article 332 of the NEC code NFPA 70 for regulations on installation) then local regulations for the state (or province) must be considered for:

- Cable ampacity
- Volt drop calculations.
- Installation methods being considered.
- Derating of ampacity
- Earthing/grounding – the size of the protective conductor
- Any other correction factors for the installation

For particular applications please refer to NFPA70 for guidance searching ‘Type MI’, ‘mineral-insulated, or ‘mineral’.

Surface Preparation

It is good practice to ensure that the surface is clean and free from rough areas, sharp edges, or burrs that could cause damage to the cables during installations.

All welding or mechanical engineering site work should be completed before cable installation begins.

Good practice – test the Insulation Resistance again (IR)

Before starting the installation the cable to be installed should be checked for IR using a 500 volts IR tester (Megger) connected across the conductor(s) and the metallic sheath and conductor to the conductor. It should not be less than 100 MΩ. However, site conditions may reduce this and a value of 20 MΩ is considered to be acceptable even in dry conditions. Wet conditions may reduce this even further but in any case, a value of <5 MΩ should be considered evidence of a problem to be investigated.

Mounting Materials & Substrate

MICC cable should be installed and supported on suitable materials - seek guidance from MICC if necessary. Installation should be made on the substrate which is designed to withstand the effects of fire – typical substrates are concrete or reinforced concrete used for the construction of high occupancy buildings or those buildings which need to provide a fire withstand capability such as gas filling stations.

Cable Supports

When installing any life-critical circuit, it is essential that the cable supports will be able to support the cable before, during, and after a fire and will not contribute to the ignition or spread of the fire. If the supports are inadequate, the cable can sag or come away from the wall or tray.

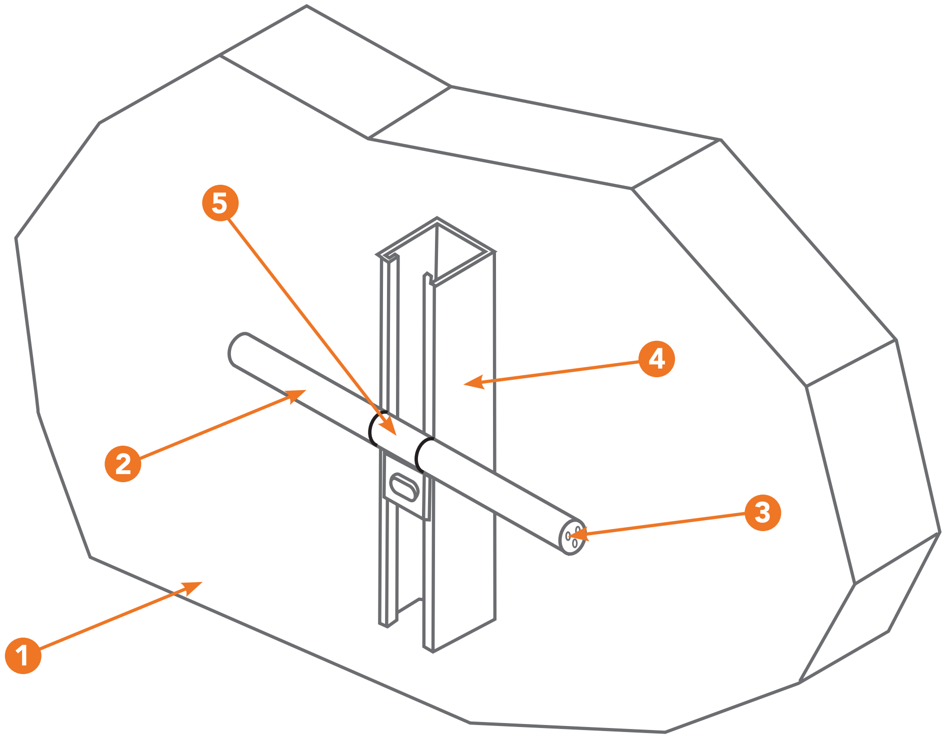
Only use support materials that complement the benefits of MICC cables.
Cable supports must have 2-hour fire-rated capability – only the recommended support components will offer the 2-hour fire-rated approval.

The cable should be installed per NEC article 300 (specifically 300.4) and Article 392 (see article 332 on applicable sections).

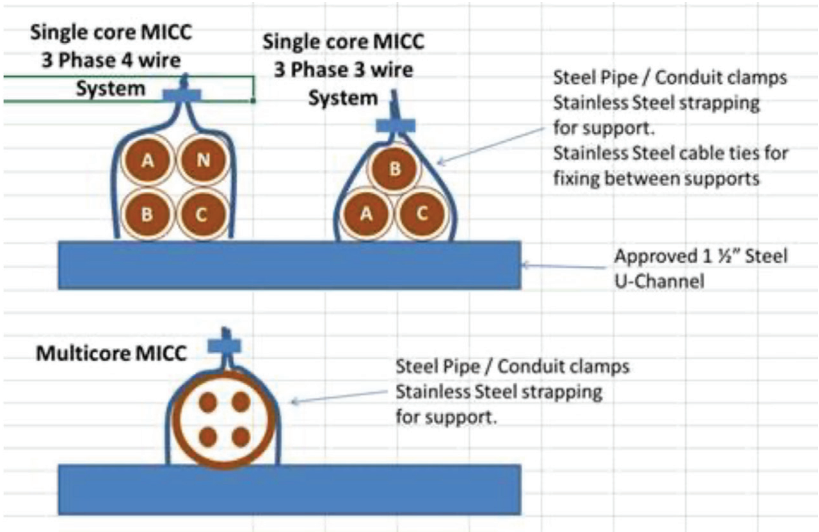
Cable Supports (cont)

Specifically, the system shall be constructed of the following components:

Reference to below drawing	Part Description
4	Slotted Strut Channel
5	Channel nuts
5	Stainless Steel Channel fittings (Range: 2AWG to 500Ccmil)
5	Copper Cable loops (Range: 14AWG to 3/0)
5	Stainless Steel Bolts
5	Stainless Steel Nuts
5	Stainless Steel Washers
2 (multi-cable)	Stainless Steel worm gear or similar stainless steel clamps



1. Wall/substrate
2. Cable
3. Cable
4. Strut Channel
5. Cable support (Cu or SS only)



Temperature

Bare sheathed cables can be installed at temperatures down to -30 deg F (-35 °C C).
When preparing the cable for installation and in coil format, carefully unroll the coil. DO NOT pull out into a spiral. Avoid twists or kinks. Wherever possible avoid installing the cable over rough surfaces and take precautions over sharp edges to prevent damage to the cable.

When the cable runs have been completed ensure that the slackness due to excess length is evenly distributed along the whole length of the cable run.

Insulation Resistance

IR (IR) should be checked before installation. Using a typical 500Vdc Megger follows conventional IR checks between conductors and conductor to sheath - IR readings should be higher than 100MΩ. If the IR is below 20 MΩ the IR can be recovered by warming the cable using a heat source starting 6 inches from the end of the cable, seal, and wait 12 hours to see the IR recover.

Vibration

MICC Cable is sufficiently pliable to carry the supply to motors and other equipment where slight differential vibration may occur. Such vibration can be absorbed by introducing a loop in the cable immediately before it enters the enclosure. In cases of severe differential vibration, the cable should be terminated into a junction box adjacent to the vibrating equipment, and the final connection made via a flexible conduit and/or cable.

Inspection

Please use the checklist below (Commissioning section) as guidance for the inspection procedure. Period of inspection should be tested annually.

This page may be photocopied as necessary to provide an adequate number of checklists. Please use the checklist below (Commissioning section) as guidance for the inspection procedure.

Project		**Area**	
Location/panel		**Contractor**	
Lead installer		**Installer**	
Pre-Installation Ghecks – General			
Metal joining processes complete		Smooth installation surface	
Surface treatment check		Pressure testing completed check	
JBs/ancillaries installed			
Pre-Installation Checks – Cable			
Drawing number/schedule reference			
Tag reference		Cable reference	
Actual lengths checked		Length	Type
Pre-Install IR value		Damage check	Other
Commissioning Checks			
Cable glands fitted to JBs		Earthing check	
Electrical protection check		JBs area classification check	
Electrical connections tight		IR check	
Metal joining processes complete		Smooth installation surface	
Surface treatment check		Pressure testing completed check	
JBs/ancillaries installed			
Pre-Installation Checks – Cable			
Drawing number/schedule reference			
Tag reference		Cable reference	
Actual lengths checked		Length	Type
Pre-Install IR value		Damage check	Other
Commissioning checks			
Cable glands fitted to JBs		Earthing check	
Electrical protection check		JBs area classification check	
Electrical connections tight		IR check	

Pulling In Cables

General

A sufficient length of cable should be removed from the pulling end to ensure that an adequate length of undamaged cable is available for termination.

Cables that are electrically paralleled for the same circuit should be cut as closely as possible to the same length before termination.

The cable(s) should be identified with non-conductive tags on both ends of the installation.

Cable slack should be provided at transition points between non-connecting trays or raceways, and equipment. A sufficient length of cable core should be pulled into equipment, panels, and boxes to permit neat arrangement of conductors and compliance with the following:

- Any minimum required separation distance is maintained.

Conductor Tensile Strength

It is assumed that the method used to attach the cable to the pull rope transfers all forces to the conductor. The tensile strength of the conductor then becomes a limiting factor for the force that can be applied. Copper elongates slightly before breaking, which changes the resistance characteristics. A safety factor is used to prevent this, as well as other items.

Cable Attachment Methods

If a cable is pulled into the tray segment the cable should be attached to a pull rope. If possible both the armor and conductors should be gripped simultaneously. Cables may be gripped with a basket weave device, by gripping the conductors with a pulling eye or similar device, or by a combination of these methods. At the start of each pull, check that there is no movement of the cable core pulling out of the armor. If any movement is noted, it may be necessary to reinforce the grip between the armor and the core. One method that can be used is to drive three or four nails about two inches apart and around the circumference of the cable through the armor and into the conductor through the copper. These nails can be placed through the spaces of the basket grip weave. Be sure to cut off this section a sufficient distance behind the nails before terminating. Short lengths of cable may be laid in place or pulled with a basket grip only, providing the strain does not elongate the armor beyond the conductors. Longer cable lengths should be pulled by the conductor and the armor. This may be done utilizing a pulling eye on the conductors, which is tied to the eye of a basket grip used on the armor and securing the tail end of the grip to the outside of the cable.

For high force pulls, care should be taken not to stretch the insulation, jacket, or armor beyond the end of the conductor nor bend the ladder, trough, or channel out of shape.

Cable grips and pulling eyes should be installed according to the manufacturer's instructions. All cable connections to the pulling device should be formed in a cylindrical configuration and the leading section of the assembly should be smooth and tapered. The following general rules should be observed.

Pulling Eye

Attachment should be to the conductors only and not the outer coverings.

Pulling

Set up to pull as much of the cable as possible, preferably the total length. Position sheaves and pulling ropes, avoiding all obstructions so the cable will move freely during the pulling operation. Attach the pull rope to the cable by suitable means. The armor should be fastened to the pull rope and/or the conductor to prevent relative movement of the conductors and armor. Utilize supplementary pulling lines with wire grips as applicable. The cable should be pulled straight off the reel. Use light back pressure on the cable reel to avoid reverse bending or overrunning as the cable leaves the reel. Back-pressure can be applied by a reel brake or by wedging a two-by-four against the flanges of the reel. Maintain a slow but steady speed of up to 20 to 25 feet per minute, avoiding stops and starts as much as possible. Adjust the pulling speed to eliminate galloping (surging). When pulling around a bend, use as large a radius as possible, if necessary, hand-feed to keep long smooth curves. Sheaves or other guiding devices can be used provided the bends are not too severe.

Cable Reference	Cable Size (Awg/Mcm)	Cable Only Lbs (Kgs)	Cable Reference	Cable Size (Awg/Mcm)	Cable Only Lbs (Kgs)	Cable Reference	Cable Size (Awg/Mcm)	Cable Only Lbs (Kgs)
1 core			2 & 3 core			4 core & 7 core		
CC1H10W	10	250/115	CC2H10W	10	570/260	CC4H10W	10	700/320
CC1H4W	4	600/270	CC2H4W	4	1200/550	CC7H10W	10	1100/500
CC1H3W	3	720/325	CC2H3W	3	1600/730			
CC1H2W	2	800/365	CC2H2W	2	2000/910			
CC1H1W	1	1000/455	CC2H1W	1	2500/1135			
CC1H1/0W	1/0	1200/550	CC3H10W	10	600/270			
CC1H2/0W	2/0	1400/635	CC3H4W	4	1700/775			
CC1H3/0W	3/0	1700/775	CC3H3W	3	2100/955			
CC1H4/0W	4/0	2200/1000						
CC1H250W	250	2500/1135						
CC1H350W	350	3200/1455						
CC1H500W	500	4400/2000						

Cable Data and Full Production Lengths

Approximate longest production lengths are detailed in the cable data tables below.

Number of Conductor(s)	AWG Conductor Size	MICC Cable REF.	Conductor Diameter			Cable OD			COND. Resistance / 1000 FT.	Weight / 1000 FT	Coil Length
			MAX. Inch	NOM. Inch	MIN. Inch	MAX. Inch	NOM. Inch	MIN. Inch	MAX. Ω	NOM. LBS.	NOM. Ft/m
1	10	CC1H10W	0.113	0.102	0.094	0.279	0.277	0.275	1.080	141.4	1969/600
1	4	CC1H4W	0.225	0.204	0.189	0.404	0.402	0.400	0.269	307.3	1345/410
1	3	CC1H3W	0.239	0.229	0.221	0.451	0.449	0.447	0.210	377.8	1066/325
1	2	CC1H2W	0.270	0.258	0.248	0.451	0.449	0.447	0.169	412.5	1066/325
1	1	CC1H1W	0.299	0.289	0.278	0.498	0.496	0.494	0.130	501.4	886/270
1	1/0	CC1H1/0W	0.340	0.325	0.313	0.514	0.512	0.510	0.106	567.4	755/230
1	2/0	CC1H2/0W	0.383	0.365	0.351	0.582	0.580	0.578	0.084	715.1	591/180
1	3/0	CC1H3/0W	0.426	0.410	0.402	0.623	0.621	0.619	0.067	853.2	541/165
1	4/0	CC1H4/0W	0.481	0.460	0.443	0.686	0.684	0.682	0.052	1050.7	427/130
1	250MCM	CC1H250W	0.528	0.500	0.480	0.748	0.746	0.744	0.044	1239.1	348/106
1	350MCM	CC1H350W	0.618	0.590	0.569	0.836	0.834	0.832	0.032	1611.7	315/96
1	500MCM	CC1H500W	0.743	0.707	0.679	1.002	1.000	0.998	0.022	2269.3	220/67
2	10	CC2H10W	0.113	0.102	0.094	0.451	0.449	0.447	1.080	319.9	663/202
2	4	CC2H4W	0.225	0.204	0.189	0.686	0.684	0.682	0.269	795.6	387/118
2	3	CC2H3W	0.239	0.229	0.221	0.770	0.768	0.766	0.210	1001.8	308/94
2	2	CC2H2W	0.270	0.258	0.258	0.867	0.865	0.863	0.169	1265.5	249/76
2	1	CC2H1W	0.299	0.289	0.278	0.977	0.975	0.973	0.130	1591.9	197/60
3	10	CC3H10W	0.113	0.102	0.094	0.482	0.480	0.478	1.080	386.1	581/177
3	4	CC3H4W	0.225	0.204	0.189	0.748	0.746	0.744	0.269	1024.6	338/103
3	3	CC3H3W	0.239	0.229	0.221	0.836	0.834	0.832	0.210	1269.1	269/82
4	10	CC4H10W	0.113	0.102	0.094	0.592	0.590	0.588	1.080	541.0	394/120
7	10	CC7H10W	0.113	0.102	0.094	0.623	0.621	0.619	1.080	688.7	486/148

Cutting to Length

When cutting to length from standard coils, the approximate measurement can be derived by applying the formula 3.14 x mean diameter of coil to give a length per turn and counting the number of turns.

Straightening & Dressing

Immediately before supporting, the cable may be straightened by hand or by utilizing our straightening tool or a bending lever. A final dressing may be carried out using a hammer and a wooden block, rubber mallet, etc. Never use a metal hammer alone as it may result in dents.

Bending

The bending radius should be following the table on bending radius or NEC code – article 332.24.

All normal bending may be carried out without the use of tools however, two sizes of bending levers are available for use with the larger diameter cables or when multiple bends are required. These levers are specially designed to prevent cable damage during bending.

The bending radius should normally be limited to the bending radius stipulated below, which permits further straightening and re-bending if required.

When offsetting the cable to enter an enclosure via a gland, 25-50mm of straight cable should be left between the gland and the final bend, or by incorporating pigtails, to facilitate withdrawal of the gland from the enclosure.

The minimum bending radius is:

Cable O.D.(Outside Diameter)	NEC	CEC
0.75in(19mm) and smaller	5 times cable diameter	6 times cable diameter
Larger than 0.75in(19mm)	10 times cable diameter	12 times cable diameter

Work hardening of the sheath will occur if repeatedly bent and straightened – this should be avoided

TEC Recommended Support Distances

For fire survival circuits it is necessary to use metallic supports, for example, the TEC Clips and Saddles, to ensure cables are maintained in position during a fire.

Actual installation cost is probably the greatest factor involved in putting in a cable system. This is because the labor time is governed by the number of supports required to install the cable. A real cost advantage can be gained, while MCC Cable has a high degree of pliability because of the fully annealed copper, it is also extremely robust, hence it can be installed in substantial lengths with fewer supports than other cable types.

The maximum space between supports are:

Cable diameter	Horizontal/Vertical Supports	Straps/Gear Clamps
Single conductor: 4/0 AWG and larger Multi conductor: 10 AWG 7-cond, 4 AWG & larger	6 ft	3 ft
Single Conductor: 10 AWG, 4 AWG to 3/0 AWG Multi-Conductor: 10 AWG 2-cond, 10 AWG 3-cond & 10 AWG 4-cond	4 ft	N/A

Work hardening of the sheath will occur if repeatedly bent and straightened – this should be avoided

Wiring to Smoke Extraction Equipment

Smoke extraction fans are specifically designed to operate at very high temperatures and TEC cables are therefore the obvious choice as supply cables.

Such equipment is normally high temperature/short term rated, e.g.300°C for half an hour.

Current Rating Ref Method - "Clean" Earthing Systems

Certain installations may require the provision of circuit protective conductors (C.P.C.'s), functional earthing conductors, or screens, which are unique to a particular circuit. This type of wiring may be specified to enable leakage-currents of individual circuits to be separately monitored or to provide a "clean" earth connection for equipment that is likely to malfunction if subjected to invasion by switching transients and other "noise" present in the general earthing system. Examples of equipment likely to be adversely affected are computers, other information technology equipment, and intrinsically safe hazardous area equipment.

This type of CPC and all the equipment connected to it must be insulated from other CPC's and extraneous metalwork along the route of the circuit. When such a system is to be wired with TEC cable it will be necessary to insulate the copper sheath (the CPC) from the general earthing system. When it is also necessary to insulate the cable glands from metallic enclosures, an insulating bush Ref. R.Y.I. can be installed between the gland and the enclosure. In such instances, earth tail seals may be utilized.

Current Rating Ref Method - “Clean” Earthing Systems (cont)

Some environments are extremely corrosive to copper. Contamination can come from fertilizers, animal droppings, pesticides, or other chemicals, seepage water, concrete additives, ammonia, and strong acids.

Corrosion can also occur cable installed in ducts with high or uncontrolled moisture.

Corrosion of cables can occur when in contact with concrete which has been formulated with additives to improve their qualities, cables buried direct in concrete or run in concrete ducts or on concrete surfaces.

Installations on timbers shall be treated with fireproofing or preserving solutions.

Bare copper sheathed cables installed on ancient stonework inside churches and historic buildings may, in damp situations, become subject to deposits of salts from the stonework.

These deposits are not always harmful but will cause discoloration of the cable, which may be unacceptable.

Copper sheathed mineral insulated cable does not normally require a plastic outer covering, or any other form of additional protection because of the exceptionally high resistance of copper to atmospheric corrosion.

Unlike steel and aluminum, copper does not suffer pitting corrosion.

It is generally accepted that copper is exceptionally durable even when exposed to polluted or marine atmospheres. When first exposed to the atmosphere, copper gradually blackens but after some years acquires a green or blue-green patina which tends to reduce further oxidation.

It, therefore, follows that copper cable sheaths should survive indefinitely in all normal environments, regardless of the presence of moisture or chlorides, with the possible exception, where ammonia or related compounds are present.

In practice, it is therefore important to properly assess the installation environment before utilizing bare copper sheathed cables and we list opposite instances where they should not be used together with the reasons why.

Electrolytic corrosion can result where a copper cable is run in contact with other metals in the presence of an electrolyte but normally this will not affect the copper cable which is almost invariably the more noble metal of the two concerned and thus becomes the cathode. The corrosion will as a rule affect the less noble metal (the anode). Therefore if the other metal is for instance steel, this will corrode and not the cable. The extent of the corrosion is dependent upon the relative areas of the two metals and the amount of moisture present. In the case of TEC Cable on a cable tray, the area of the cable sheath is small compared with the area of the tray, therefore the degree of corrosion of the tray will be low.

In conclusion, therefore, under normal dry conditions, it is acceptable practice to use bare copper TEC Cable on steelwork as this electrolytic action cannot occur without moisture being present.

Fault Finding

NOTE Fault finding should be carried out with the power disconnected from the circuit under investigation.

Low Insulation Resistance (IR)

Low IR (<5 MΩ) is measured using an IR meter placed across conductor and sheath or conductor to conductor, it is caused by either

(i) moisture on the surface of the cable around the seal location

(ii) a faulty seal at the end of the cold lead-in cable

(iii) a faulty joint between the cold lead-in cable and the heating cable or

(iv) a fault in the cable sheath which has allowed moisture to enter the cable

If a cable exhibits a low IR, first remove all moisture from the seal area by drying with cloth or paper towels then retest. If a faulty seal is suspected, the following simple test is very useful. (Note: when attempting to locate faults on circuits involving multiple cable runs, it is preferable to isolate and test individual cable to avoid the errors introduced by parallel connections)

Low IR faults can be identified by appropriate use of heat or freezer spray in the suspect areas to determine the location of the fault. The IR meter should be attached, energized, and observed during these tests – for heat application, the IR will fall and rise as the cable cools – for freezer spray application the IR will rise and fall as the cable warms.

Note that the IR will fall or rise on 'good' cable but it should be seen as a slow fall in IR not associated with moisture ingress.

Equipment that can locate I.R. faults in long lengths of heating cable is:

(i) A Wheatstone bridge set up for high resistance faults – these are commercially available at a reasonable cost and operate by being able to isolate the high resistance fault by accurately using a series of ratios to identify the fault.

(ii) A high power time domain reflectometer – this identifies an I.R. by injecting a large pulse of electromagnetic energy and timing the reflection of the pulse – the I.R. fault will reflect the pulse as it is seen as a termination point – the results are shown visually on an oscilloscope type display The presentation of the reflected wave indicates a break or a low I.R.

Test to Verify Ingress of Moisture

Fig.15

Connect an insulation tester or ohmmeter between one conductor and the copper sheath and obtain a steady reading (a hand-powered insulation tester may not give a steady reading), apply a slight amount of heat to the cable sheath just behind the seal (Fig. 15), a lighted match or cigarette lighter will give sufficient heat. If the seal is faulty and has allowed moisture to enter the cable, the meter reading will fall rapidly as soon as the heat is applied and start to recover when the heat is removed. In situations where it is not practicable to apply heat a freeze spray can be utilized, in which case the opposite effect is observed, i.e. the meter reading will increase as the spray is applied and will fall as the cable returns to its original temperature. This technique is suitable for locating moisture in the cable at positions away from the seals, as can occur with severe sheath damage.

Further advice on all aspects of fault finding may be obtained by contacting TEC.

Removal of a Faulty Seal

Open up the crimps with a pointed tool, e.g. a small screwdriver or side-cutters, to free the disc so that it and the sleeving can be removed from the conductors. Scrape out the compound and unscrew the pot from the cable sheath with a pair of pliers or pipe wrench, gripping the cable behind the pot. Discard the compound and pot. Remove any remaining compound from the conductors and cable end and ensure that no metallic or other foreign bodies remain to contaminate the cable insulant. If possible, remove the threaded length of the cable sheath using one of the sheath stripping methods described previously. At this point, heat can be applied from about 150mm behind the pot to remove any moisture (check with Megger). The replacement seal should then be quickly fitted and tested as described previously.

Improving the Insulation Resistance

As the mineral insulant is capable of absorbing moisture, it is not usually necessary to 'dry cables out' before terminating. When a faulty seal has been removed, all that is necessary is to replace it with an effective seal and the IR will begin to recover. The rate of improvement will depend upon the quantity of moisture that has entered the cable. When the IR is very low or if an immediate improvement is required, it will be necessary to dry out the cable end before terminating. When drying out, first use the technique described previously for locating moisture to ascertain how far the moisture has penetrated along the cable. Then heat the cable to observe significant discoloration at a point approximately 100mm into the cable from the limit of the moisture ingress, slowly move the heated zone towards the end of the cable so that any moisture will be driven out. It may be necessary to repeat this operation if the cable has absorbed a considerable amount of moisture over several years. It is essential that the heating is commenced further along the cable than the moisture has penetrated, otherwise, the moisture may be driven further into the cable. With covered cable, it will be necessary to 'pare' the outer covering back clear of the section to be heated. The covering should then be folded and taped back to prevent damage whilst the cable is hot.

After the cable has cooled the outer covering can be replaced and covered with a helical layer of adhesive insulation tape with a 50% overlap.

Other fault findings

Broken conductors are easy to identify using a multimeter to check the continuity of the conductor from the termination point, If both lead-in cables are physically separate for example in a star termination circuit one of the conductors at one end of the element should be shorted to the sheath to check the continuity using a suitable lead.

Broken conductors can be isolated to a point in the cable using several techniques set out in order of the least technically demanding up to specialist equipment:

(i) a capacitance meter, connected between conductor and sheath, can be used from each end of the cable to measure the capacitance to the break. The ratio of capacitances against the length can be used to locate the fault. For instance, say that we measure 40 uF from one end and 60 uF from the other on a 100 m cable and the cable is 100 uF/100m – this isolates the fault to 40 m in from the 40 uF end. A known length of the same cable should be checked to establish the baseline uF/m – the I.R. should be high on this sample piece.

(ii) Injection of a high power pulsing tone of say 1 kHz and a 'listening' tuned coil with headphones to follow and locate the fault to a point where the tone disappears – this is carried out from both ends. This is usually specialist equipment owned by manufacturers like MICC

(iii) A high power time domain reflectometer – this identifies a break by injecting a large pulse of electromagnetic energy and timing the reflection of the pulse – the break will reflect the pulse as it is seen as a termination point – the results are shown visually on an oscilloscope type display. The presentation of the reflected wave indicates a break or a low I.R.

Conductors touching sheath is usually caused by tight bends being formed in the cable which will force the conductor through the insulating powder until a fault develops. This fault is easy to identify as there will be an extremely low resistance between conductor and sheath. It is also easy to find as the location of the fault in meters will be the ratio of resistances of the conductor measured from conductor to sheath from both ends (as in the capacitance example). Often a touching conductor will result in a broken conductor (due to excessive current if no earth leakage protection is fitted) and then the broken conductor techniques can be used.

Short Circuits and Direct Earth Faults

These may result from misalignment of the conductors within the seal or incorrect and untidy completion of the sheath stripping procedure. They have easily rectified this by re-making the seal.

Removal of a Faulty Seal

See fault finding section page 36.

Improving the IR

It is not usually necessary to dry cables out before terminating.

When a faulty seal has been removed, all that is necessary is to replace it with an effective seal and the IR will begin to recover. The rate of improvement will depend upon the amount of moisture that has entered the cable. Only when the installation resistance is too low to be acceptable in the short term or if an immediate improvement is required, will it be necessary to dry out the cable end before re-terminating?

See fault finding section on recovery of IR

Replacing the Seal

The replacement of the seal should then be fitted and tested as described previously.

Questions and Answers

Can I use bare copper MICC branded cable on a galvanized cable tray?

Electrolytic action may take place when the copper sheath is in contact with the galvanized (zinc) plating of the cable tray. The reason for this is that the electro potential series indicates that zinc is anodic to copper and therefore preferential corrosion of the zinc plating may occur.

The presence of moisture is essential to produce electrolytic action, therefore, in dry conditions, this action will not occur. If moisture is present, then electrolytic action will take place, but the extent of any corrosion is dependent upon the relative areas of the two metals and the conductivity of the electrolyte(moisture in this instance).

In conclusion, electrolytic action will not occur in dry conditions, but damp conditions may result in the tray deteriorating more rapidly than expected. The use of bare copper sheathed MICC Cable on a galvanized tray is therefore not normally a problem.

How do MICC Cables react if they are subjected to radiation?

The cable is manufactured from inorganic materials (copper and magnesium oxide) which make the cable highly resistant to radiation. The seals on the end do have organic compounds but we have successfully tested seals to a radiation dose of 950 megarads without losing their sealing properties. Such a seal consists of a standard seal with the standard PVC sleeving being replaced by silicone elastomer glass braided sleeving.

On some MICC Cables that I have installed, the sheath of the cable seems to run quite warm. At what temperature does MICC normally operate?

The exposed-to-touch current ratings of TEC Cables are based on the sheath temperature of the cable rising by 50°C. The ambient temperature is assumed to be 40°C therefore the sheath can attain 90°C(see section 310.15 tables 310.16, 310.17, and 310.20 of the NEC) when fully loaded. 90°C is hot to the touch but considered normal and acceptable for connected equipment. If required an estimation of the expected sheath temperature at any level of loading can be calculated using the following formula,

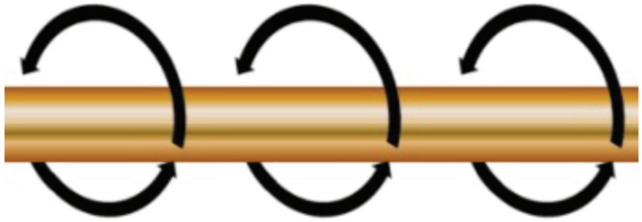
(Ib2/Iz2) x 50°C + ambient temperature (°C)

where
Ib = Load to be carried (amps)
Iz = Effective rating of cable (amps)

What value of IR should I expect on a MICC Cable after installation?

Firstly, the cable should not be tested until permanent seals have been fitted to both ends of the cable. An insulation test carried out 24 hours after the cable has been terminated, should achieve a value above 100 MΩ @500VDC.

What considerations do I need to make for single-core cables carrying large currents (>200A)?



When a ferromagnetic material such as a termination plate in a steel or stainless enclosure is subject to an alternating magnetic field from the current in the cable terminating into the enclosure there are two potential sources of loss

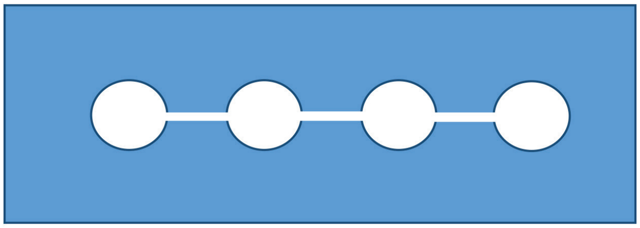
i) hysteresis requires energy to overcome magnetic pole rotation and this ultimately appears as heat and

ii) eddy current losses where the rotating magnetic flux causes induced eddy currents which cause energy loss and also appear as heat.

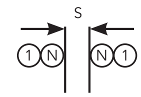
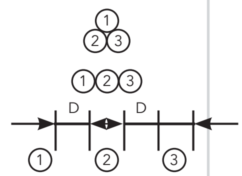
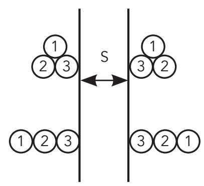
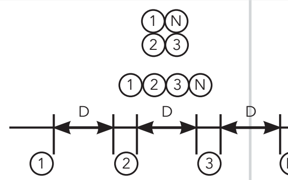
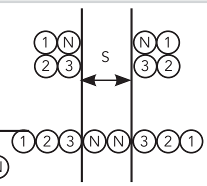
These heating losses are only significant in cables carrying over 200A so these considerations typically apply to single-core cables of size 1AWG and above.

When cables are required to pass through termination plates in enclosures or mounting plates for locating, for example, cable glands, several techniques can be used to minimize these losses.

With ferromagnetic termination plates, one way to significantly reduce these losses is to cut slots between adjacent holes in this manner:



Another way is to avoid the use of ferromagnetic material as the termination plate and in this case, we would recommend brass or aluminum provided it can adequately support the weight and forces involved in terminating the cables into such a plate. In damp or saline conditions care should be taken to avoid any galvanic action between such plates and the steel enclosure. This can be achieved with some corrosion protection coatings – pay attention to the continuance of the earthing of the plate to the enclosure. Plastic (HDPE or ABS) enclosures may be used but again must be mechanically robust enough to support such large cables.

	Single Circuit	More than one circuit or more than one cable per phase in parallel
Current Rating Ref Method	All Appropriate	All Appropriate
Single Phase		
Three Phase 3 Wire		
Three Phase 4 Wire		

D = Cable Diameter

S = Clearance between groups of cables and should be equal to at least 2D to avoid derating. In balanced 3-phase, 4 wire systems employing more than one circuit or more than one cable per phase, the neutrals may be located as shown, or alternatively outside the cable groups.

How long will MICC Cable last in service?

MI cables are made from inorganic materials and therefore do not deteriorate with age. There are many installations throughout the world that are over50 years old and the cable is in perfect condition. In some cases, on very old installations the original neoprene conductor insulating sleeves may have deteriorated but it is a comparatively simple matter to renew these with the present-day standard sleeving.

Are MICC Cables fireproof?

MICC Cables will continue to operate in a fire at temperatures approaching the melting point of copper(1083°C). While certain organic insulated cables claim to be 'fire-resistant or 'high temperature', MICC Cable is truly a fire survival cable.

Can MICC Cable be buried directly in the ground?

MICC Cables are suitable for burying in the ground and are subject to the same procedures as other cables r egarding the depth of the trench, mechanical protection, and identification of routes.

What is the minimum bending radius for TEC Cables?

The usual minimum bending radius specified is typically equal to six times the diameter of the cable sheath. This will allow the cable to be re-bent if necessary.

What are the effects of transient overvoltage surges on MI cables, typically found in generation and control?

Inductive circuits produce transient voltages when the current flowing in them is suddenly interrupted and that under adverse conditions these voltage surges can cause a breakdown in various circuit components. This phenomenon is recognized in the various regulations, and it is the designer's/installers responsibility to ensure compatibility between circuit components. When such circuits are wired, the cable has normally sufficient reserve of voltage withstand to ensure that damage falls elsewhere in the system. Thus, unexplained breakdowns in such components as electric motors, chokes, resistors, transformers, switches, and contactors can occur, although it is common to attribute them vaguely to overloading or to accept them without explanation.

The factors influencing the generation of surges are many and complex; the point in the current cycle at which switching occurs, the exact moment of separation of the contact points, and the presence of stray damping and other losses in the circuit are but a few of the contributory factors. Thus, many pieces of equipment that are theoretically capable of producing troublesome surges, only occasionally do so in practice. Many pieces of equipment that are capable of causing trouble will run for many years, without encountering the conditions which could cause failure.

The installations most likely to cause issues are those which are most frequently switched. Examples are air conditioning installations, refrigeration systems, and others where equipment is cycled every few minutes.

Experience has shown that trouble arises primarily from certain types of equipment.

Experience has shown that trouble arises primarily from these types of equipment:

Fractional Horse Power Star Connected Three Phase Motors

Experience indicates that star-connected motors above 3hp rating, all delta connected and single-phase motors do not need suppression. However, star-connected motors of smaller sizes (particularly in the fractional horsepower range) may easily give rise to switching surges of dangerous magnitude.
Surge suppressors are a reliable way of overcoming the problem.

Contactors

Contactor coils are a likely source of voltage surges.

Lighting

The strike can produce high voltage surges. In many fittings, these are absorbed by the parallel-connected power factor correction capacitor and no surge suppressors are required. However, certain types do not incorporate a power factor correction capacitor and the voltage surges generated within the striking circuits are not necessarily confined to the fittings. On the type of installation in which the control gear is situated remote from the associated discharge lamp, it is not possible to give protection to the connecting cable. It is therefore essential that a suitable High Voltage cable is used.

Dual Speed Fan Motors

Experience shows that dual-speed fan motors may produce significant transients. It is recommended that surge suppressors are fitted to both sets of windings.

Initial Installation

There is a misconception regarding surge suppression that it is an expensive additional operation. But, a small outlay in time and material is sufficient to give an essential safety factor to the electrical installation. Suppressors are recommended for small three-phase star-connected motors and contactor coils.

Existing Installation

MI Cable has the unique ability to recover from a flash-over. Some rare cases have occurred when numerous surge strikes on the same cable have reduced the insulation's withstand against over voltage, and resulted in fuse failure. Under normal operating conditions the cable continues to work satisfactorily, but it may be desirable to fit one of the above suppressors to protect the cable against further surge voltages. Before fitting the suppressor, the condition of the cable should be ascertained by testing the IRat 500 volts and 1000 volts and comparing the two readings. A lower reading at 1000 volts will indicate that the voltage withstands of the cable have been permanently reduced and that it cannot be protected from further voltage surges by one of the above suppressors.

Features

- 2-Hour Fire Rating per UL 2196/ULC S139 with hose stream, Horizontal & Vertical applications
- Simple termination, standard tools available brass connectors
- Available in long lengths
- Welded copper sheath suitable for equipment grounding
- Welded copper sheath forms an impervious armor
- Suitable for wet locations

Performance

- UL Listed type MI per NEC Article 332
- 2 Hour Fire Rating per UL 2196
- Electrical Circuit Integrity System 1083C
- Ampacity when installed per NEC article 330 "Ampacity"

Contractor Installation Notes:

- Install per the NEC or CEC as applicable. Article 330 covers the standard use of Metal Clad Cable and refers to ampacities for multiconductor and single conductor use in free air.
- Follow the Manufacturer's Instructions to assure a valid fire rating. These special installation procedures are necessary to qualify for UL 2196 /ULC S139.
- Cable Supports: All supports must be secured to an equally fire-rated structure with clamps(fasteners) that are steel or have been fire test qualified. This excludes aluminum, die-cast (zinc), plastics, etc.
- Cable support spacing: The above supports must be located at a maximum distance in both the horizontal and vertical orientations.

Cable diameter	Horizontal/Vertical Supports	Straps/Gear Clamps
Single conductor: 4/0 AWG and larger Multi conductor: 10 AWG 7-Cond, 4 AWG & larger	6 ft	3 ft
Single Conductor: 10 AWG, 4 AWG to 3/0 AWG Multi-Conductor: 10 AWG 2-cond, 10 AWG 3-cond & 10 AWG 4-cond	4 ft	N/A

- Termination: Use a UL/ULC listed brass MC connector suitable for a corrugated copper sheath
- Splices: At this time, splices have not been submitted for approval.

When cables are pulled into raceways or trays, they are likely to be subjected to physical stresses that they will never again be required to endure. The prime cause of pulling forces is the friction of the cable against the supporting and contact surfaces. If the supporting surface is straight and horizontal, this friction is caused by the weight of the cable in contact with this surface. If the surface is not horizontal, the weight of the cable also affects the pulling load but is dependent upon the angle of inclination. This angle may add to or lessen the total pulling force, depending upon whether the pull is up or down. When a cable is pulled around a bend, it is in contact with the inner arc of curvature of the bend. If any substantial amount of pulling force has been developed in the cable, the friction load due to the pressure at this point will greatly surpass that due solely to the weight of the cable. Thus, bends in the run increase the pulling load significantly.

Cable Attachment Limit

The maximum allowable tension is also limited by the ability of the device used to connect the cable to the pull rope to withstand the forces applied. When pulling by gripping the conductors with a pulling eye or bolt, the maximum tension is usually limited to 10,000 pounds. This is dependent upon the pulling eye or bolt used and the method of application. The manufacturer's recommendations should be followed. When the insulated conductors are gripped with a properly sized and applied basket weave grip, the limit is 200 pounds per grip. This is based upon the hoop stress applied with a basket grip and the cable construction. Since the attachment by a grip is limited by the slip of the insulation, the insulation may be removed, and friction tape applied over the conductor to increase the pull by grip limit. For this configuration, with a properly sized and applied grip, the limit is 2000 pounds.

When pulling multiple cables together, additional forces may be encountered based on cable geometry. For these cases contact MICC for additional information.

Note that an increase in maximum allowable pulling tension can be obtained by simply increasing the radius of the bend.

Back Tension

The force required to pull a cable off the reel is generally referred to as back tension. This is normally taken to be zero since the cable is fed off the reel. This value may be negative, and light braking may be applied to control the flow of cable to avoid feeding at too great a rate. For downward pulls, considerable braking may be required.

5. Pre-Installation

We recommend the use of the usual sheave and roller techniques to present the cable to the circuit layout.

Cables should not be pulled around corners that have sharp edges such as corners in cable trays, or other obstructions. Cables may be hand-fed around such corners or the use of cable sheaves of the proper radius or other suitable devices may be employed, provided the minimum allowable cable pulling radius and cable sidewall pressure are not violated.

The mechanical stresses placed upon a cable during installation should not be such that the cable is excessively twisted, stretched, or flexed.

During the time that the cables are exposed and during cable pulling activities, they should be protected from nearby or overhead work to prevent damage to the cable jacket/insulation (e.g., do not step on or roll equipment over cables, etc.). Take care to ensure that cables are not left exposed in high traffic areas where the potential for inadvertent damage is significant.

5. Pre-Installation (cont)

Care should also be taken to protect existing cables, splices, and/or terminations from damage when installing new cables through enclosures.

When cable pulling is completed or when the cable is partially pulled, the portion of cable not yet routed to its final destination should be coiled and supported to keep the cable off the floor and prevent damage. The coil should be tied to at least two separate locations or a saddle or similar support should be used so that the cable does not support the coil. Train the cable with as large a radius as practical and not less than the minimum allowable. The cable should be protected so the ties do not damage the cable jacket. If coil location requires additional protective measures, a protective cover should be provided.

Special care should be exercised during welding, soldering, and splicing operations to prevent damage to cables. Appropriate precautions should be taken in the handling, storage, and disposal of materials.

Installation Equipment

Where mechanical assistance is required, pulling equipment of adequate capacity such as a winch that provides a steady continuous pull on the cable should be used. The pulling equipment should be size based on the maximum allowable tension plus a safety margin. The unit should also be capable of developing the maximum speed required with an adequate margin. Pull rope diameter and length will depend on the pull to be made and construction equipment available. If a pull rope is used it should be sized to have a breaking strength not less than the maximum allowable tension times a safety factor. This is a safety precaution to help ensure that the pull rope does not break during the installation. Pull ropes should be chosen with a minimum stretch to reduce the possibility of galloping. All cable monitoring equipment should be calibrated before use.

A swivel should be used between the cable pulling device and the pull rope on all mechanically assisted pulls. On more difficult hand pulls, a swivel may also be advantageous. The primary purpose of the swivel is to prevent damage to the cable from possible twisting forces imparted when pulling the cable. Swivels should be selected that will swivel under anticipated load conditions. Swivels that do not swivel under high load conditions should never be used. Cable rollers and sheaves used for cable pulling should have a smooth surface, use cupped rollers of adequate size, be in good working order, be properly lubricated, and free spinning. The radius of rollers, pulleys, and shelves should be considered when calculating estimated sidewall pressure. When using properly designed segmented sheaves (a fixed combination assembly of rollers), the cable conforms to the radius of the overall assembly with no appreciable increase in pressure from the individual rollers. So, the overall radius of the assembly, rather than the radius of the individual rollers, may be used. Typically, if these devices were used, they should be used on the feeding end where the tension is near zero so that sidewall pressure will be very low. If not properly utilized, these devices may cause damage. Therefore, segmented sheaves should be exposed to allow for inspection. Take care to avoid exceeding the cable pulling radius with pulling equipment (especially at sheaves and rollers).

Setup

Before installation, the installer should determine that the cable(s) can be installed according to the designed routing and minimum bending radius requirements. Precautions should be taken when routing close to hot pipes or other heat sources because of ampacity considerations. The total degrees of bend between pull points should be minimized and be per the NEC or CEC where applicable.

Raceways and cable trays should be examined for acceptability before pulling activities. Permanent supports should be properly installed to ensure the rigidity of the raceway and cable tray so neither the raceway nor the cable will be subjected to damage during the pulling process. Cables should not be installed in trays that are utilized to carry or support equipment, piping, instrument tubing, or other facilities.

The cable should only be pulled into clean raceways or cable trays. Before installing the cable, all debris should be removed. Any abrasions or sharp edges that might damage the cable should be removed. Bushings and dropouts should be installed as required.

Before final termination, the ends of cables located outdoors, in other wet locations, or where contamination is possible, should be capped to prevent the entrance of water or other contaminants. After installation and before final termination, the capped cable ends should be inspected.

Cable reels should be supported so that the cable may be unreeled and fed into the raceway with light braking, so as not to subject the cable to a reverse bend or overruns as it is pulled from the reel. The amount of tension necessary to pull the cable should be minimized. The required pulling tension may be reduced by:

- Proper setup of the cable reel assembly (see figure 7). The setup should ensure that the cable is not kinked or bent beyond the minimum pulling radius or subject to excessive twisting force.
- Pulling in the proper direction. Where practical, a cable pull should begin nearest the end having the greater degrees of bends and exit the end having the least degrees of bends. Also, where vertical sections are encountered, a downward pull is preferred.
- The number and degrees of bends the cable is pulled around under tension should be minimized. This may be accomplished in tray installations by setting up at a bend and pulling the cable straight past any bends at the far end of the installation and feeding additional cable off the reel at the bend. The cable may then be hand-fed around the bend(s) at either end.
- Cable pull tension should be minimized by turning the reel and feeding the cable into the raceway or tray. An experienced cable pulling observer should be stationed at the pulling end and be in contact (visually, by radio, or by phone) with the other members of the crew. A suitable guide device should be used to protect and guide the cable from the cable reel into the raceway or tray. The radius of the feeder device should not be less than the minimum bending radius of the cable. Cables exiting the raceway or tray should be protected by similar means.

Pull Tension Monitoring

Cable tension should be limited to less than the maximum allowable pulling tension, to help ensure that the installation process does not damage the cable. This may be accomplished by one of the following two methods:

1. Limiting the amount of tension available by the use of a properly sized breakaway link.
   - Breakaway links should be sized to be less than the maximum allowable pulling tension.
   - If the maximum allowable tension is excessive, then a breakaway link should not be used unless estimated tension calculations are performed which indicates the tension to be well within allowable limits.
2. Monitoring the actual tension applied using a tension measuring device.
   - The pull force should be monitored for all high tension pulls (such as mechanical pulls, tuggers, etc.).
   - It is highly recommended that estimated tension calculations be performed for all high tension pulls. If possible, a direct reading tension measuring device should be used.

General

MICC cable is installed and supported in much the same manner as other armored cables whether surface mounted, suspended, in a cable tray, or direct buried. The requirements of UL/ULC should be followed where applicable. Where independent circuits are required or desired, proper separation and segregation should be maintained from other electrical circuits. All conductors of the same circuit and, where used, the grounded conductor and all equipment grounding conductors shall be contained within the same raceway, or cable tray, unless otherwise permitted by the NEC or CEC as applicable. These requirements shall apply separately to parallel circuits.

Where subject to physical damage, conductors shall be adequately protected.
Metal components and cable armor shall be of materials suitable for the environment in which they are to be installed. Metal raceways, cable armor, and, other metal enclosures for conductors shall be metallic-ally joined together into a continuous electric conductor and shall be connected to all boxes, fittings, and cabinets to provide effective electrical continuity. Equipment grounding conductors smaller than 6 AWG shall be protected from physical damage by a raceway or cable armor except when run in hollow spaces of walls or partitions, when not subject to physical damage, or where protected from physical damage.

Cable Support

Install supporting hardware at intervals not exceeding 6 feet for non-fire-rated areas. For fire-rated areas, see limits for UL/ULC (see page 34). When transitioning from a straight run of MI cable to a bend, use additional supports at the start of the bend and the end of the bend as shown.

For 10 AWG conductor size, cable shall be secured within 12 inches of boxes, cabinets, fittings, or other cable terminations. It is recommended that support systems be completed as soon as possible after the cable is installed. Fasten the cable at the far end of the end often installation and work back toward the reel, straightening as you go. Straighten by hand if possible, do not use tools such as a hammer or screwdriver, since this may deform the armor. Although not required, forms made from preformed PVC conduit bends cut in half may be used as a guide when forming bends. Make sure the minimum bend radius is observed. Bend in small increments, do not try to make the entire bend in one operation, shape into the final position gradually. When bending multiple cables at the same place, shape the inner cable and form the other cables to this one. This will provide uniform curves. Do not leave long lengths of cable in a manner that will subject cable to point stresses. If a long length of cable is left hanging coming off a ladder tray, the cable may be damaged by the rung before the connection is completed. Cables should not be held under tension after installation and some slack is desirable in the region of the terminations. In open installations, the cable must be adequately supported to prevent undue strain on the cable and the termination.

Cable Spacing

When multiple multi-conductor cables are used in the same installation, they should be appropriately spaced for ampacity considerations (generally one cable diameter apart minimum) or appropriately derated for ampacity. When multiple single conductor cables are used, they may be laid flat, side by side as close together as possible for all cables in the same circuit. When properly designed, single-conductor cables may be spaced to increase ampacity. Note, the voltage drop should also be evaluated. Multiple circuits should be appropriately spaced for ampacity considerations, or appropriately derated for ampacity. Consult MICC for additional design information. For vertical support in a raceway, call MICC for recommendations.

Electrical Circuit Integrity System

Electrical Circuit Integrity Systems consist of components and materials that are intended for installation as protection for specific electrical wiring systems, concerning the disruption of electrical circuit integrity upon exterior fire exposure.

The specifications for the protective system and its assembly are important details in the development of the ratings. These protective systems are evaluated by the fire exposure and water hose stream test as described in UL 2196 / ULC S139. Ratings apply only to the entire protective system assembly. Individual components and materials are designated for use in a specific system(s)for which corresponding ratings have been developed and are not intended to be interchanged between systems. Ratings are not assigned to individual system components or materials.

Authorities having jurisdiction should be consulted in all cases as to the specific requirements covering the installation and use of these classified systems.

The following instructions are for the MICC Wiring System, a 2-hour fire-rated cable system. This cable is only rated at600 volts (conductor to conductor) when used for 2-hour fire resistive cables.

Open Runs/Installation of Cable in Free Air

Supports and hardware shall be per MICC UL approval requirements and as described herein. Exception, in non-fire rated areas, support spacing may be per the NEC/CEC. Per the NEC/CEC, a minimum of 1/4 inch clearance should be provided at the points of support between the back of the cable and the wall of supporting surface for metal-clad cables used in wet areas. The use of strut fulfills this requirement. A single bolt type pipe clamp can become loose in a fire, and if on a wall, the pipe clamps can become loose and cables may slip off the support.

Installation in Raceways

Installations in raceways need special considerations, so please consult MICC

Cable Trays

Cable trays shall have suitable strength and rigidity to provide adequate support for all contained wiring. A steel tray is required. Each run of the cable tray shall be completed before the installation of cables.

Supports shall be provided to prevent stress on cables where they enter raceways or other enclosures from cable tray systems. Tray supports should be 48 inches on center maximum. Tray supports and trays should be suitable for possible fire conditions.

In other than horizontal runs, the cables shall be fastened securely to transverse members of the cable trays. Additionally, when required to maintain an orderly and neat arrangement of cables or to maintain spacing between power cables, cable ties should be used. Cable ties should be installed at intervals, not exceeding6 feet spacing. Cable ties should be installed snugly, but not to a point to cause damage to the cable. The ties should be compatible with the cable and tray, and suitable for the environment(i.e., do not use plastic tie wraps in a fire-rated area.)

Multi-conductor cables are allowed to be installed in a random configuration. For ampacity considerations, it is suggested that where practical, cables are installed in a single layer and spaced a minimum of one cable diameter apart.

Cable Trays shall be exposed and accessible as permitted by the NEC/CEC. Sufficient space shall be provided and maintained about cable trays to permit adequate access for installing and maintaining the cables. Cable trays should be suitably grounded.

Installation in Cable Trays

When hand feeding (laying) cable in trays and trenches having open tops or removable covers, it is recommended that:

- Personnel be positioned at corners and periodically along the route to "hand feed" the cable into the cable tray, **or**
- Personnel be positioned to "hand feed" the cable along the side of the cable tray and then lay it into the tray.

If the cable is installed by sliding it into the tray (for short distances only), a flame retardant plastic cloth should be used to provide protection.

Lubrication may be necessary. The plastic cloth should be removed after cable pulling is complete.

Sheaves and rollers should be used when installing cables in trays by methods other than hand feeding. In straight runs, a sufficient number of rollers should be used to preclude the cable from dragging on the tray. Sharp bends should be avoided by using a sufficient number of sheave assemblies such that the effective cable bend radius conforms to the contour of the tray bend, to ensure the cable bending radius is adequate.

Cable tray manufacturers may recommend the number, type, and location of the sheaves and rollers as well as for instructions for their application. When this information is not available, the following general guidelines may be used.

The most economical spacing of rollers depends on the weight of the cable to be pulled. In general, the spacing of rollers should range between ten feet for cable weighing over eight pounds per foot and sixteen feet for cable weighing not more than two pounds per foot. When the different size and weight cables are installed on the same cable tray, spacing should be determined for the heaviest cable used.

Installation in Cable Trays (cont)

Rollers for straight sections should be used near each tray support assembly. Such a roller arrangement should suffice for any weight cable to be pulled in that tray.

Cables should be placed neatly, and orderly across the full width of the tray to maintain a uniform level. The cable should be properly spaced for ampacity concerns. Cables should be segregated by voltage level (such as medium voltage and low voltage cables) and separated by function (i.e., power and instrument cables should be installed in separate trays). During installation, where a cable rests on a tray side rail, such as at cable exit points, temporary tray edging should be used to protect the cable. If, after the cable is installed, the cable rests on the side rail then permanent tray edging should be provided. The material used for tray edging should be fire retardant, have a large surface area, be compatible with the installation, and have a suitable temperature rating.

Cables installed in trays having an expansion gap or fitting (to accommodate differential movement)should be placed in the tray in such a manner that a slack section of cable is present.

The expansion gap allows for free movement of the trays without damage to the cable. The cables should not be tied down within five feet of each side of the gap.

Other Installations

Contact Authority Having Justitiction (AHJ) or TEC/MICC for recommendations.

Glossary

Ampacity – The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

ANSI – American National Standards Institute.

ASTM – American Society for Testing and materials.

AWG – American Wire Gage.

Bonding (Bonded) – The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Breakaway Link – A device that is connected in series with the pull rope that is designed to break at a specified tension.

Cable – A cable is either an insulated conductor(one conductor cable) or a combination of conductors insulated from one another (multiple conductor cable).

CEC – Canadian Electrical Code

Circular Mil (Cmil) – The area of a circle one-thousandth of an inch (or one mil) in diameter.

Compatible – A material suitable for use with adjoining materials at the normal operating and emergency environments (i.e., proper size; similar materials, such that no adverse reaction occurs; able to withstand the temperature range, radiation, and other harmful parameters for the area; as recommended for use by the respective manufacturer).

Component – A segment of the cable, particularly pairs, triads, etc.

Conductor – A wire or combination of wires not insulated from one another, suitable for carrying an electrical current.

Estimated Pulling Tension – The calculated pulling tension is based on conduit configuration and cable construction.

Fitting – An accessory such as a locknut, bushing, or another part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

Ground Wire – The conductor leading from a current consuming device to a ground connection.

ICEA – Insulated Cable Engineers Association(Formerly IPCEA).

IEEE – Institute of Electrical and Electronics Engineers (Formerly two separate organizations: AIEE and IRE).

Insulation – As applied to electrical wire and cable, insulation is the covering applied to conductors to isolate and confine the electrical currents which they carry. Insulation materials are of many types, i.e., ceramic, plastic, rubber, etc., and are characterized by high volume resistivity.

Jacket – An extruded plastic or elastomeric material covering applied over insulation or an assembly of components to provide protection acts as a barrier.

Kcmil – A unit of conductor area in thousands of circular mils (formerly MCM).

kV (Kilovolt) – One thousand volts.

LSZH – Low smoke zero halogen material used as an optional jacket on MICC cable.

Maximum Allowable Pulling Tension – The maximum tension that may be applied to a cable or group of cables to prevent damage due to type of grip, conductor elongation, and sidewall pressure.

Maximum Conductor Pulling Tension – The maximum tension that may be applied to a cable or group of cables to prevent damage due to the type of grip and conductor elongation.

MI – UL type designation for metal-clad cables.
These cable designs contain solid copper outer jackets, typically MgO ceramic metal oxide insulation, and solid copper conductors as per NEC Article 332 & UL Standard No. 504.

Multiconductor – More than one insulated conductor within a single cable.

NEC – National Electrical Code.

NFPA – National Fire Protection Association.

Pull Rope – A high-strength line that is attached to the cable to allow it to be pulled.

Reverse Bends – Bends opposite to the direction the cable has been wound on the cable reel.

Sheave – A wheel-shaped device used in cable pulling.

Shield – Any barrier to the passage of interference causing electrostatic or electromagnetic fields, formed by a conductive layer surrounding the cable core. It is usually fabricated from metallic tape, braid, foil, or wire serve.

UL – UL, LLC.
Volt – The practical unit of electromotive force. One volt is required to send one ampere of current through a circuit whose resistance is one ohm.

Voltage Rating – The maximum voltage at which a given cable or insulated conductor is designed to operate during continuous use in a normal manner.

Useful References

AEIC G5, "Underground Extruded Power Cable Pulling Guide".
ANSI/NFPA 70, "National Electrical Code".
ANSI N45.2.2, "Packaging, Shipping, Receiving, Storage, and Handling of Items for Nuclear Power Plants".
ICEA P-46-426/IEEE S-135, "Power Cable Ampacities".
ICEA P-54-440/NEMA WC 51, "Ampacities of Cables in Open-Top Cable Trays".
IEEE 100, "Dictionary of Electrical and Electronics Terms".
IEEE 400, "IEEE Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field".
IEEE 422, "Guide for the Design and installation of Cable Systems in Power Generating Stations".
IEEE 518, "Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources".
IEEE 525, "IEEE Guide for the Design and installation of Cable Systems in Substations".
IEEE 576, "IEEE Recommended Practices for Installation, Termination, and Testing of Insulated Power Cables as Used in the Petroleum and Chemical Industry".
IEEE 690, "Standard for the Design and installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations".
IEEE 1185, "Guide for Installation Methods for generating Station Cables".
NEMA WC 26, "Wire and Cable Packaging".
UL 504 – "Outline of Investigation for Mineral-Insulated, Metal-Sheathed Cable"
UL Subject 1724, "Fire Tests for Electrical Circuit Protective Systems".
UL 2196 – "Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables"
ULC S139 – "Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables"
UL Fire Resistive Directory, Volume 2.

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