

052-12R-1116
Install a Conduit System
Status: Approved

Security Classification: U - Unclassified

Distribution Restriction: Approved for public release; distribution is unlimited.

Destruction Notice: None

Foreign Disclosure: FD1 - This training product has been reviewed by the training developers in coordination with the Ft. Leonard Wood, MO foreign disclosure officer. This training product can be used to instruct international military students from all approved countries without restrictions.

Conditions: You are in a secure environment, at a prepared site, given a mission to install a conduit system, plans and specifications, Personal Protection Equipment (PPE), electricians tool kit, materials take off list, required materials, special equipment, current doctrine and NEC. This task should not be trained in MOPP 4.

Standards: Install a conduit system without error, using the Go / No-Go criteria, IAW with the construction plans and specifications, current doctrine and NEC, without injury to Personnel, damage to equipment or the environment.

Special Conditions: None

Safety Risk: Low

MOPP 4: Never

Task Statements

Cue: Soldier has been given a mission to install a conduit system.

DANGER

None

WARNING

None

CAUTION

None

Remarks: None

Notes: Power distribution beyond the breaker panel may include one or more of the following types of conduit.

1. Electrical Metallic Tubing (EMT)
2. Electrical Nonmetallic Tubing (ENT)
3. Flexible Metal Conduit (FMC)

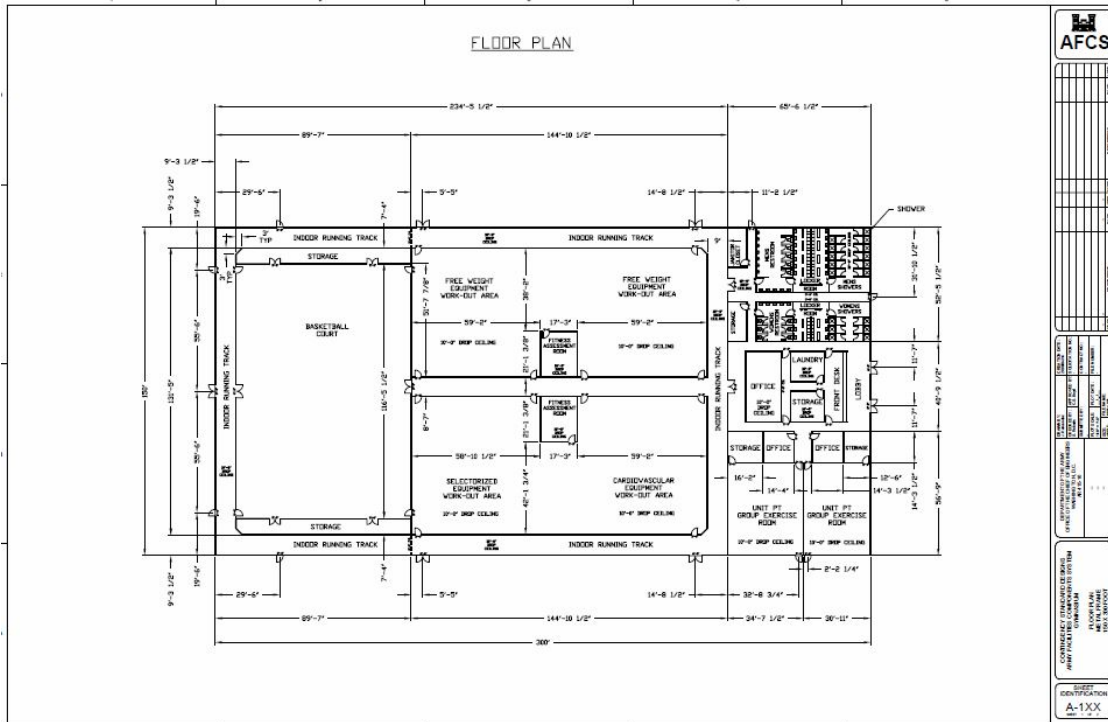
For the purpose of this task, the procedure to install each type are described in steps 3, 4, and 5. Evaluate Soldiers based on the type(s) of conduit the plans and specifications require.

Performance Steps

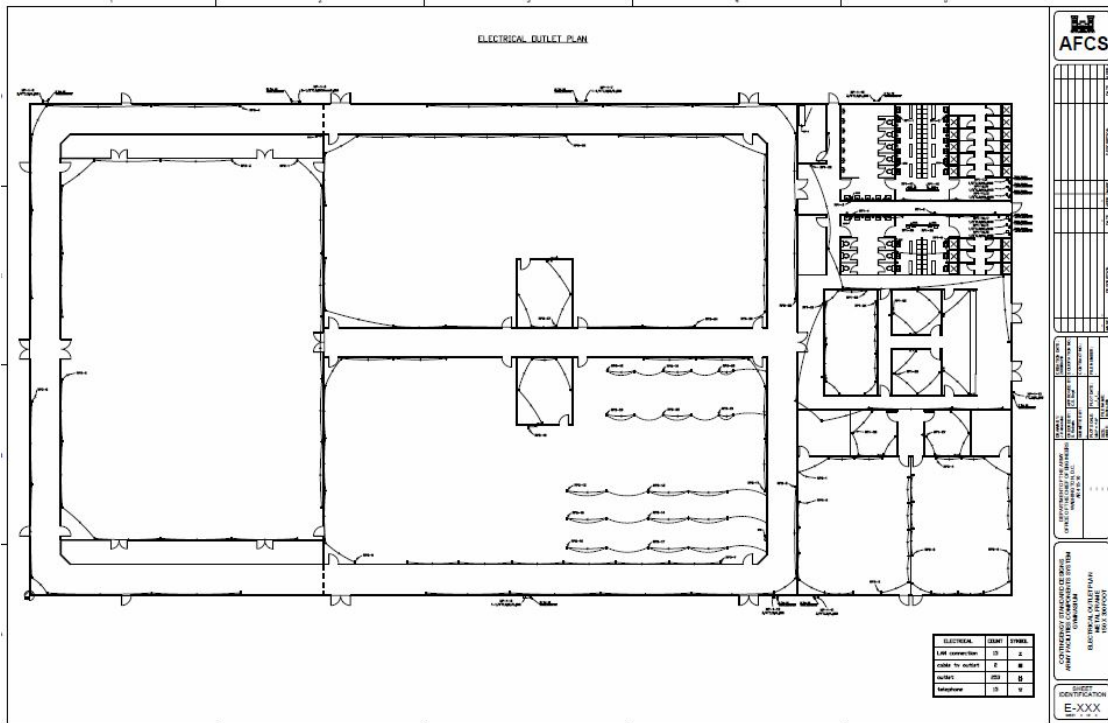
WARNING

When cutting conduit/tubing keep your non-cutting hand approximately 6" away from the cutting device/tool. Failure to do so can result in personal injury.

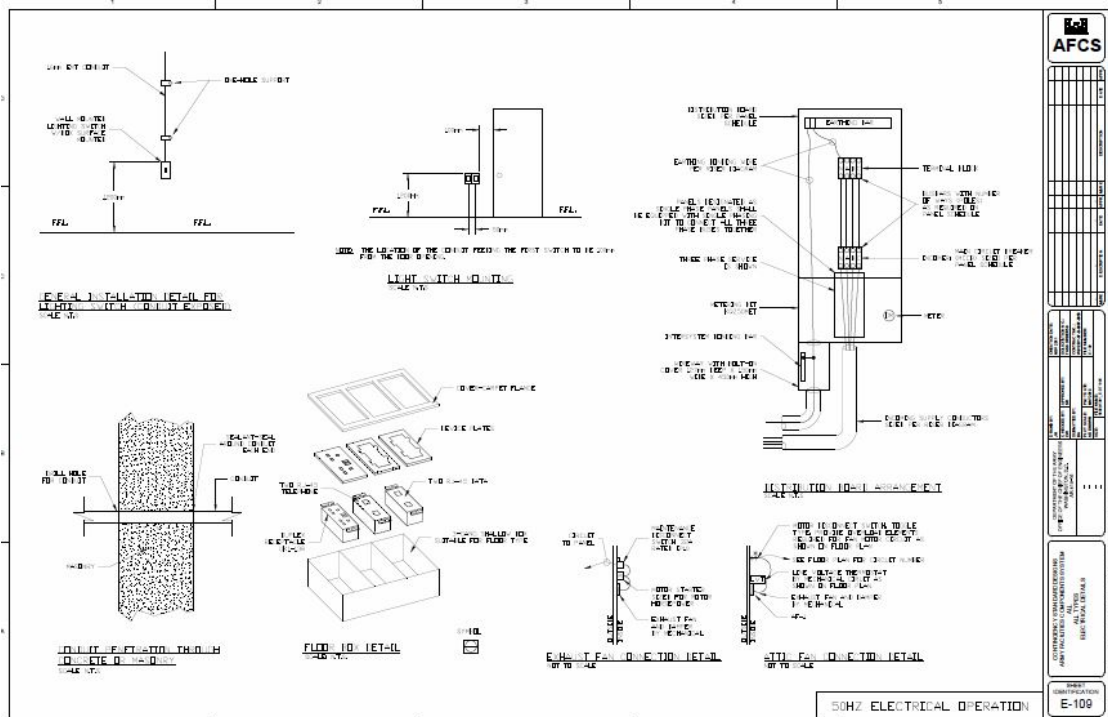
1. Review construction plans and specifications.



Typical Floor Plan
052-12R-1116-1



Typical Outlet Plan
052-12R-1116-2



Typical Electrical Schedule
052-12R-1116-3

- a. Determine the type of conduit from the plans and specifications.
- b. Determine measurements and location for placement.
- c. Confirm details for fastening the specific equipment.

2. Verify the materials takeoff list.

- a. Confirm the types and quantities of conduit/tubing needed to install the system is available.

Note: EMT Definition:

*An unthreaded thin-wall raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings.

*EMT is generally made of steel (ferrous) with protective coatings or aluminum (nonferrous).

Uses and advantages:

*Electrical metallic tubing (EMT), commonly called thin-wall conduit, is metallic tubing that can be used for exposed or concealed electrical installations.

*Its use should be confined to dry interior locations because it has very thin plating that does not protect it from rusting when exposed to the elements or humid conditions.

*It is less expensive than rigid conduit and much easier to install. *The process of bending requires less effort, and the ends do not have to be threaded.

*In comparison to the other wiring systems, it ranks behind rigid conduit but ahead of the other types of wiring when considering the quality and durability of the installation.

Size:

*Minimum, EMT smaller than trade size 1/2 inch shall not be used. *Maximum, The maximum size of EMT shall be trade size 4-inch.

FMC:

Materials:

*Flexible metal conduit resembles armored cable in appearance but is more adaptable than cable because various sizes and numbers of wires can be pulled into it after it is installed.

Size:

Minimum:

* Flexible metal conduit less than trade size 1/2 inch shall not be used unless permitted by code to use trade size 3/8 inch.

* 3/8 inch flexible metal conduit is permitted to be used as the manufactured or field installed metal raceway (1 1/2 feet to 6 feet in length) to enclose tap conductors between the outlet box and the terminal housing of recessed luminaires.

* Flexible metal conduit is also permitted to be used as a 6 feet luminaire whip from an outlet box to a luminaire.

Maximum:

*Flexible metal conduit larger than trade size 4-inch shall not be used.

ENT:

Definition:

* A nonmetallic pliable corrugated raceway of circular cross section with integral or associated couplings, connectors, and fittings for the installation of electrical conductors.

* ENT is composed of a material that is resistant to moisture and chemical atmospheres and is flame retardant.

* A pliable raceway is a raceway that can be bent by hand with reasonable force, but without other assistance.

* ENT is not intended for use where flexibility is necessary, as at motor terminations to prevent transmission of noise and vibration, or for connection of adjustable luminaires or moving parts.

* It is available in 10' sections or in 200' coils.

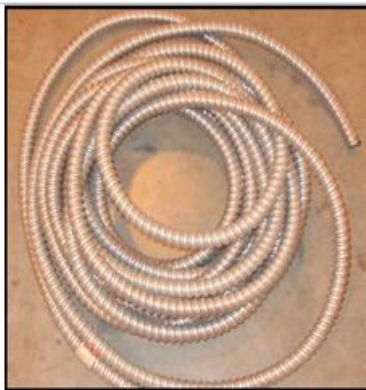
Size:

* Minimum, ENT smaller than trade size 1/2 inch shall not be used.

* Maximum ENT larger than trade size 2 inch shall not be used.



Typical EMT



Flexible Metal Conduit



Typical ENT

Typical conduits

- b. Confirm connection components needed to install the conduit/tubing system is available.

Note: Tubing and fittings:

This tubing, as its name implies, has a thinner wall than rigid conduit but has the same interior diameter and cross sectional area. All couplings and connections to boxes are threadless and are of clamp or compression type. Some fittings are similar to sleeves and are secured to the tubing by an impinge/hydraulic crimping tool, which pinches a circular indentation in the fittings to hold them firmly against the tubing. Others have threaded bushings that are tightened to force the tapered sleeve firmly against the tubing.

Install electrical metallic tubing box connectors after mounting boxes in their location. Compression type box connector has four components:

Internal locknut: Used to secure the box connector to the metallic box.

Box connector body: Used to connect the EMT and the box together.

Compression ring: The compression ring assists in locking the EMT into the connector.

External locknut: The external locknut locks the conduit in its proper location.



Typical Pipe Fitting Hydraulic Crimping Tool
052-12R-1116-5



Typical Couplings and Connectors
052-12R-1116-6

3. Install EMT as required and IAW the plans and specification.

a. Measure against the framing/actual site where the EMT will be installed, to determine the required length.

Note: Fittings, boxes and connectors are part of the length. The total length measurement must include the distance (engagement) the EMT goes into a fitting, box or connectors.

b. Secure the EMT in the pipe vise.

c. Transfer required measurements to the EMT using a suitable device such as a marker or grease pencil.

d. Cut the required lengths of EMT using a pipe cutter or hacksaw.

Note: You can use a hacksaw or a standard pipe cutter to cut EMT. When using a hand hacksaw, hold the conduit in a vise and keep the cut at right angles to the length of the pipe.

e. Ream the EMT with a hand reamer.

Note: Regardless of the cutting method used, a sharp edge always remains inside the EMT after cutting. Before installing remove this edge with a pipe reamer or a file to avoid conductor damage. This process is called reaming.

f. Measure and mark the EMT for bending.

g. Bend the EMT with the bender.

Note: Use extreme care when bending electrical metallic tubing to avoid kinking the pipe or reducing its inside area. Bends shall be made so that the tubing is not damaged and the internal diameter of the tubing is not effectively reduced.

There are three types of bends: Offset - Used to avoid contacting a part of the structure or to bring the EMT out from the structure to match a knockout in a box or panel. An offset bend is two equal bends in opposite directions. 90 degree - Used to go over or around an obstacle. Back-to-Back - Used at two inside corners that are close together in the structure.

Most benders have engineered features that lead to perfectly predictable and repeatable bends. The engineer features include:

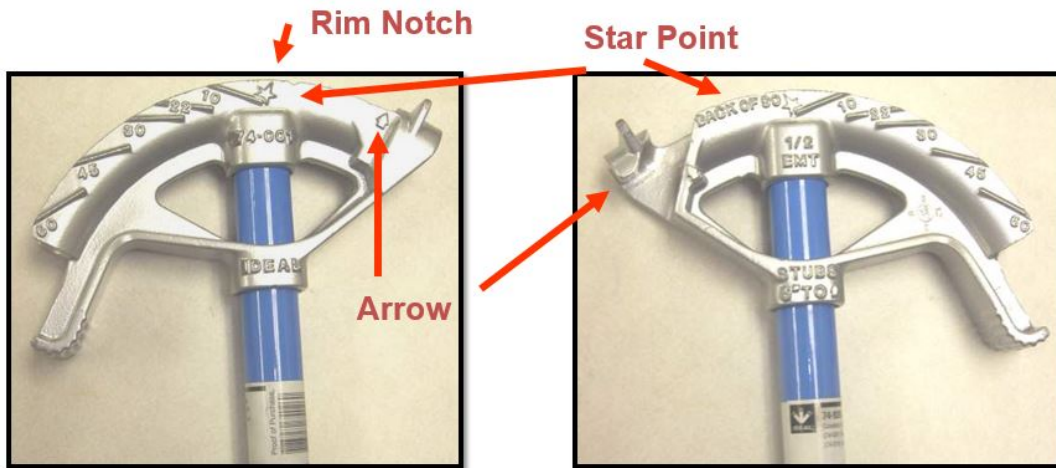
Arrow: To be used with stub, offset and outer marks of saddle bends.

Rim notch: Locates the center of a saddle bend.

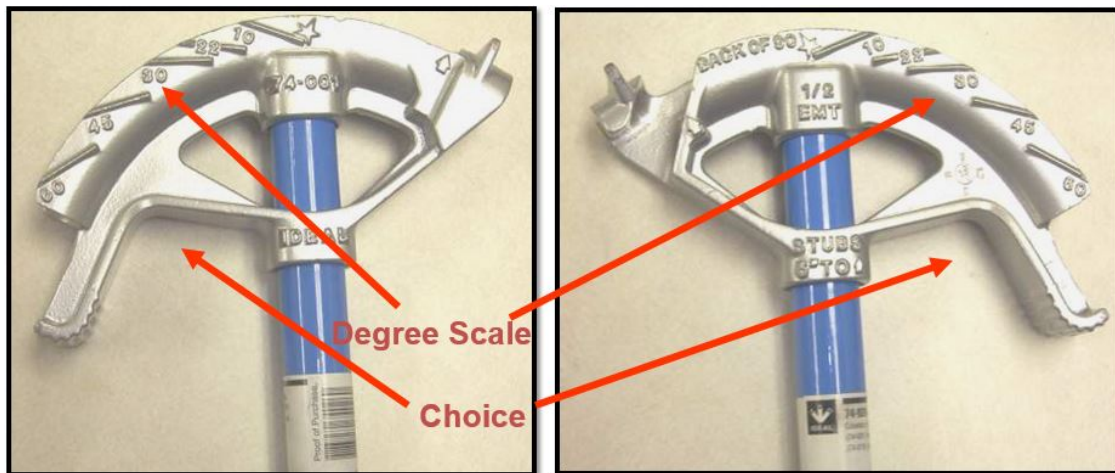
Star point: Indicates the back of a 90-degree bend.

Degree scale: For offsets, saddles and those special situations.

A choice: High strength ductile iron or lightweight aluminum. This is where you can step on the bender to assist in making the bends made on the floor.



Typical Pipe Bender (1)
052-12R-1116-7



Typical Pipe Bender (2)
052-12R-1116-8




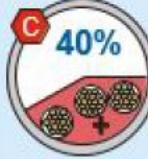
- h. Connect the EMT to the electrical boxes with the connectors or the fittings.
- i. Ensure that all connections are mechanically secure.
- j. Install the EMT mounting straps IAW the plans, specifications and NEC.
- k. Install the conductors in the EMT system.

Note: The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9 of the NEC. Table 1 of the NEC specifies the maximum fill percentage of a conduit or tubing.

Table 4 of the NEC provides the usable area within the selected conduit or tubing. Table C.1 in the NEC gives the maximum number of conductors in electrical metallic tubing.

Conductor Fill - Percent of Raceway Area Permitted

Chapter 9, Table 1

 <p>A 53% Cable is treated as 1 conductor and can take up to 53% of the cross-sectional area of a raceway.</p>	 <p>B 31% Two conductors can take up to 31% of the cross-sectional area of a raceway.</p>
 <p>A 53% One conductor can take up to 53% of the cross-sectional area of a raceway.</p>	 <p>C 40% Three or more conductors can take up to 40% of the cross-sectional area of a raceway.</p>

Example: NEC Table 1. Percent of Cross Section of Conduit and Tubing for Conductors	
Number of Conductors	All Conductor Types
1	53
2	31
Over 2	40

052-12R-1116-9
Conductor Fill - Percent Of Raceway Permitted

Article 358 — Electrical Metallic Tubing (EMT)													
Metric Designator	Trade Size	Nominal Internal Diameter		Total Area 100%		60%		1 Wire 53%		2 Wires 31%		Over 2 Wires 40%	
		mm	in.	mm ²	in. ²	mm ²	in. ²	mm ²	in. ²	mm ²	in. ²	mm ²	in. ²
16	½	15.8	0.622	196	0.304	118	0.182	104	0.161	61	0.094	78	0.122
21	¾	20.9	0.824	343	0.533	206	0.320	182	0.283	106	0.165	137	0.213
27	1	26.6	1.049	556	0.864	333	0.519	295	0.458	172	0.268	222	0.346
35	1¼	35.1	1.380	968	1.496	581	0.897	513	0.793	300	0.464	387	0.598
41	1½	40.9	1.610	1314	2.036	788	1.221	696	1.079	407	0.631	526	0.814
53	2	52.5	2.067	2165	3.356	1299	2.013	1147	1.778	671	1.040	866	1.342
63	2½	69.4	2.731	3783	5.858	2270	3.515	2005	3.105	1173	1.816	1513	2.343
78	3	85.2	3.356	5701	8.846	3421	5.307	3022	4.688	1767	2.742	2280	3.538
91	3½	97.4	3.834	7451	11.545	4471	6.927	3949	6.119	2310	3.579	2980	4.618
103	4	110.1	4.334	9521	14.753	5712	8.852	5046	7.819	2951	4.573	3808	5.901

052-12R-1116-10
Usable Area Within The Selected EMT

4. Install ENT as required and IAW the plans and specification.

a. Measure against the framing/actual site were the ENT will be installed, to determine the required length.

Note: Fittings, boxes and connectors are part of the length. The total length measurement must include the distance (engagement) the EMT goes into a fitting, box or connectors.

- b. Secure the ENT in the pipe vise.
- c. Transfer required measurements to the EMT using a suitable device such as a marker or grease pencil.
- d. Cut the required lengths of ENT using a ENT cutter.



052-12R-1116-11
Typical Nonmetallic Tube Cutter

- e. Connect the ENT to the electrical boxes with the connectors or the fittings.

Note: Use extreme care when bending electrical nonmetallic tubing to avoid kinking the tubing and reducing its inside area. Bends shall be made so that the tubing is not damaged and the internal diameter of the tubing is not effectively reduced.

- f. Install the ENT mounting straps IAW the plans, specifications and NEC.

Note: ENT shall be securely fastened at intervals not exceeding 3 feet. In addition, ENT shall be securely fastened in place within 3 feet of each outlet box, device box, junction box, cabinet, or fitting where it terminates.

Exception 1: Lengths not exceeding a distance of 6 feet from a luminaire (fixture) terminal connection for tap connections to lighting luminaries (fixtures) shall be permitted without being secured.

- g. Install the conductors in the ENT system.

Note: Chapter 9, Table 5 of the NEC provides the required area for each conductor.

If conductors are of the same wire size, instead of doing the calculations, the tables of Annex C, with 12 sets of tables, very accurately indicates the maximum number of conductors permitted in a conduit or tubing.

Table C.2 in the NEC gives the maximum number of conductors in electrical nonmetallic tubing.

In many installations, it is necessary to use more than one wire size in a conduit run. In such cases, the conductors cannot have a combined or cross-sectional area equal to more than the allowable percent of cross sectional area of conduit.

5. Install FMC as required and IAW the plans and specification.

a. Measure against the framing/actual site were the FMC will be installed, to determine the required length.

Note: Fittings, boxes and connectors are part of the length. The total length measurement must include the distance (engagement) the EMT goes into a fitting, box or connectors.

b. Secure the FMC in the pipe vise.

c. Transfer required measurements to the FMC using a suitable device such as a marker or grease pencil.

d. Cut the required lengths of FMC using a special cutter designed for this type of conduit.

e. Connect the FMC to the electrical boxes with the connectors or the fittings.

Note: Use extreme care when bending FMC to avoid kinking the conduit or reducing its inside area. Bends shall be made so that the tubing is not damaged and the internal diameter of the tubing is not effectively reduced.

f. Install the FMC mounting straps IAW the plans, specifications and NEC.

Note: FMC shall be securely fastened in place by an approved means within 12 inches of each box, cabinet, conduit body, or other conduit termination and shall be supported and secured at intervals not to exceed 4 ½ feet.

g. Install the conductors in the FMC system.

Note: The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9 of the NEC.

Table 1 of the NEC specifies the maximum fill percentage of a conduit or tubing.

Chapter 9, Table 5 of the NEC provides the required area for each conductor.

If conductors are of the same wire size, instead of doing the calculations, the tables of Annex C, with 12 sets of tables, very accurately indicates the maximum number of conductors permitted in a conduit or tubing.

Table C.3 in the NEC gives the maximum number of conductors in flexible metallic conduit.

Where flexibility is not required after installation, flexible metal conduit shall be permitted to be used as an equipment grounding conductor when installed in accordance with 250.118(5).

Exception: If used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, an equipment grounding conductor shall be installed.

Exception: Where the length of the total ground-fault return path exceeds 6 feet or the circuit overcurrent protection exceeds 20 amperes, a separate equipment-grounding conductor must be installed with the circuit conductors.

(Asterisks indicates a leader performance step.)

Evaluation Guidance: Score the Soldier GO if all performance measures are passed (P). Score the Soldier NO GO if any performance measure is failed (F). If the Soldier scores NO GO, show the Soldier what was done wrong and how to do it correctly.

Evaluation Preparation: Provide all the items listed in the conditions section. Brief Soldier: Tell the Soldier to complete the performance measures according to the standards set forth in the task.

PERFORMANCE MEASURES	GO	NO-GO	N/A
1. Reviewed construction plans and specifications.			
2. Verified the materials takeoff list.			
3. Installed EMT as required and IAW the plans and specification.			
4. Installed ENT as required and IAW the plans and specification.			
5. Installed FMC as required and IAW the plans and specification.			

Supporting Reference(s):

Step Number	Reference ID	Reference Name	Required	Primary	Source Information
	NFPA 70	National Electrical Code 2017 Edition	Yes	No	
	TM 3-34.46	Theater of Operations Electrical Systems	Yes	Yes	
	TM 5-704	Construction Print Reading in the Field. AFM 85-27.	Yes	No	

TADSS : None

Equipment Items (LIN):

LIN	Name
LB410A	Bender, Rigid Conduit
MC8002	Tool Kits (Carpentry/Hand Tools)
MC8093	Tool Kit, Electricians JTK -17

Material Items (NSN) :

Step ID	NSN	LIN	Title	Qty
	5120-00-287-4678		Tape, Fish, Flat, 1/4 Inch Wide	1
	5975-00-152-1143		BOX CONNECTOR,ELECTRICAL	1
	5975-00-152-1072		BOX CONNECTOR,ELECTRICAL	1
	5975-00-153-6395		JUNCTION BOX	1
	5975-00-168-2793		JUNCTION BOX	1

Environment: Environmental protection is not just the law but the right thing to do. It is a continual process and starts with deliberate planning. Always be alert to ways to protect our environment during training and missions. In doing so, you will contribute to the sustainment of our training resources while protecting people and the environment from harmful effects. Refer to the current Environmental Considerations manual and the current GTA Environmental-related Risk Assessment card. Caution Statement: Comply with unit Standing Operating Procedures (SOP), Operation Orders (OPORD), local regulations, and/or host nation laws for disposal of solid waste (i.e. scrap wood, excess concrete, nails, etc) generated by construction tasks.

Safety: In a training environment, leaders must perform a risk assessment in accordance with current Risk Management Doctrine. Leaders will complete the current Deliberate Risk Assessment Worksheet in accordance with the TRADOC Safety Officer during the planning and completion of each task and sub-task by assessing mission, enemy, terrain and weather, troops and support available-time available and civil considerations, (METT-TC). Note: During MOPP training, leaders must ensure personnel are monitored for potential heat injury. Local policies and procedures must be followed during times of increased heat category in order to avoid heat related injury. Consider the MOPP work/rest cycles and water replacement guidelines IAW current CBRN doctrine. Soldier needs to wear all safety items and be safe when using tools while performing this task. All tools will be placed back into their boxes when task is complete.

Prerequisite Individual Tasks : None

Supporting Individual Tasks :

Task Number	Title	Proponent	Status
052-12W-1183	Prepare a Materials Take-Off List	052 - Engineer (Individual)	Approved

Supported Individual Tasks : None

Supported Collective Tasks : None

Knowledges :

Knowledge ID	Knowledge Name
052-K-00375	Know Electrical Theory
052-K-00300	Know Electrical Metallic Tubing (EMT)
081-TI-CMN-0034	Know how to remove an electrical burn casualty from the source using nonconductive materials.
052-K-00814	Know Safe Working Procedures for Electrical Circuits and Panels
052-K-01042	Know Basic Electrical Schematics
052-K-01045	Know How to Use a Multi-meter for Electrical Testing

052-K-00797	Know How to Test for Electrical Energy Before Beginning Work on an Electrical Circuit
052-K-01065	Know Basic Content of National Fire Protection Associate NFPA 70E Electrical Safety in the Workplace

Skills :

Skill ID	Skill Name
052-S-00469	Interpret Construction Project Plans and Procedures
301-S-315	Identify the components of electrical power installations.
91L-S-035	Inspect Electrical wiring for proper connection
052-S-00286	Ability to Make Measurements
052-S-00240	Determine Tools Required for Project
052-S-00190	Use of Hand Tools
052-S-00111	Interpret Construction/Design Drawings

ICTL Data : None