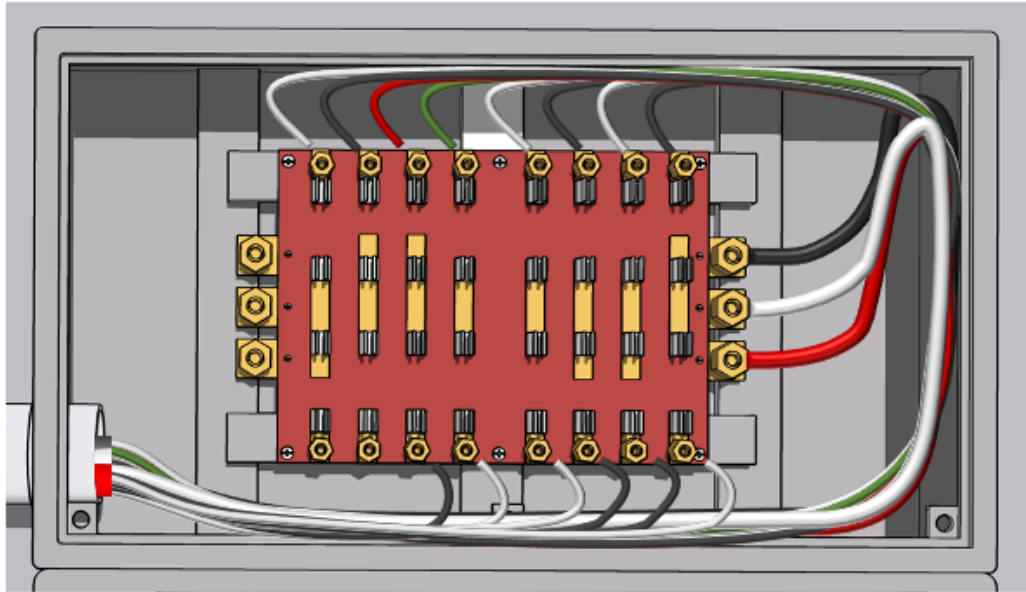





Conductor Treeing and Hook-Up Skills



Title slide



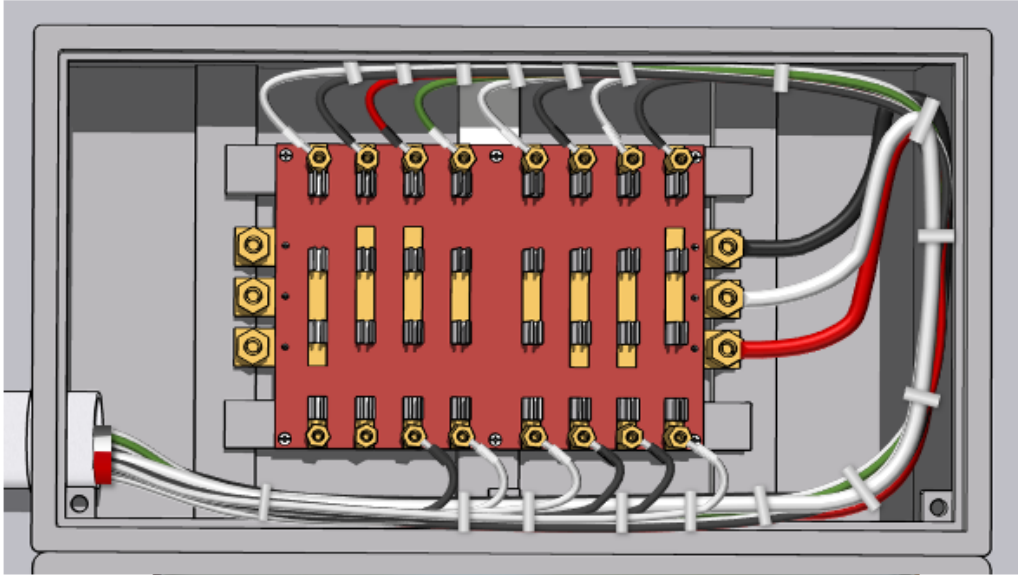
Training Objectives

- **In this lesson, you will learn**
 - How to properly connect conductors and the risks of incorrect installation
 - How to identify the proper phasing of electrical power
 - The importance of properly tagging conductors, and especially the importance of temporary tags during installation

In this lesson, you will learn how to properly connect conductors, including how to identify the electrical cable phasing. We will also discuss the damage that may be caused by incorrect connections and the importance of tagging cables, especially during installation.

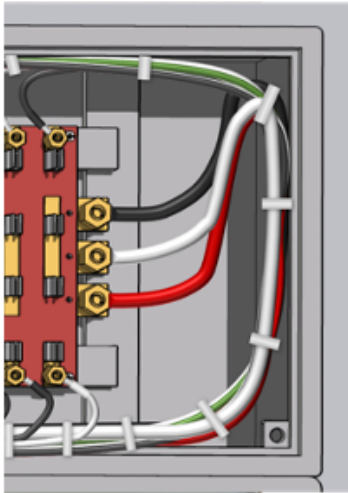
Basic Conductor Treeing

Conductors in a Distribution Box should be bundled together within the enclosure as shown in this picture



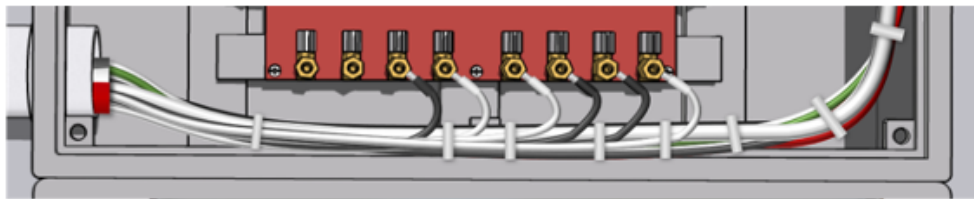
Conductors in a Distribution Box should be bundled together to present a neat, organized appearance. This makes it easier and safer to work in the distribution box if future changes are required. Using tie wraps at regular intervals also helps prevent chafing of the cables.

Treeing Appearance



Individual conductors of cables shall be:

- Formed into groups
- Secured in place
 - to present a neat , professional appearance
 - to prevent chafing of insulation due to vibration

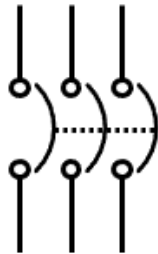


Individual conductors should be formed into groups and connected. This makes it easy to check that the installation matches the plan. Keeping the distribution box neat eases any future work required in the box. Bundling cables with tie wraps helps prevent movement and damage to insulation from chafing.

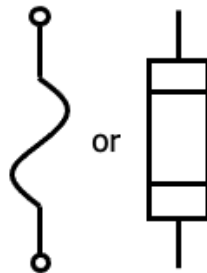
Breakers and Fuses

These are symbols you will see on a schematic that are representative of breakers and fuses.

3-Pole Circuit
Breaker



Fuse



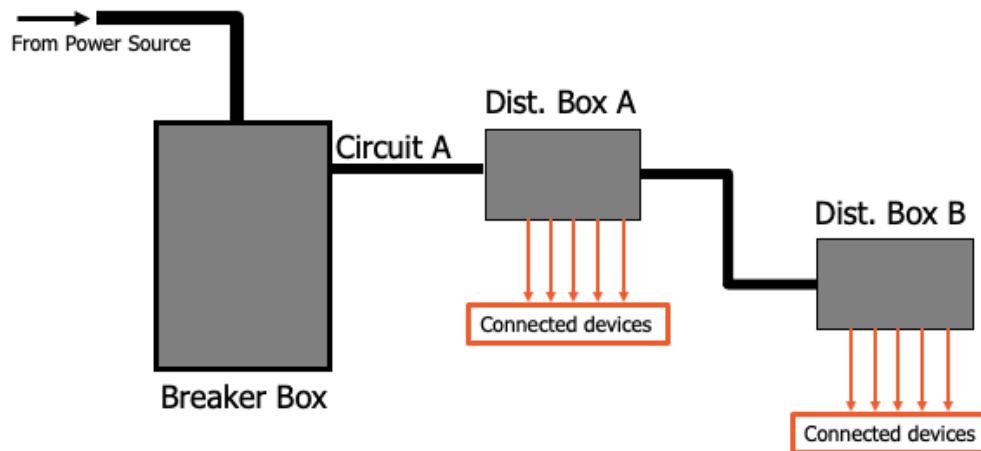
Circuit Breaker



These are the kinds of symbols used to represent fuses and breakers that you will see on a electrical schematic.

Lighting Distribution System

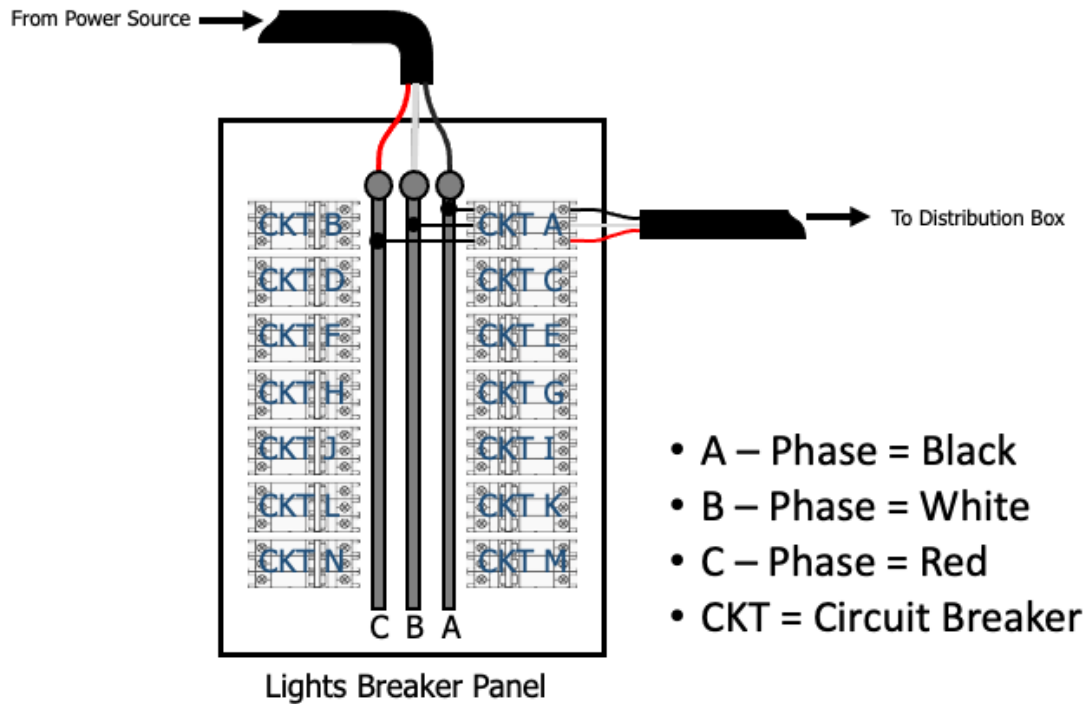
Overall Sample Electrical System Topology



The electrical system distributes power from the main power source to all of the electrical systems on board the ship. This example shows one of those main power sources being directed to a breaker box which then divides the power across multiple circuits connected to distribution boxes with fuses, which power individual components in the areas where they are located. Next, we will look at how each of these components work.

Lighting Distribution System

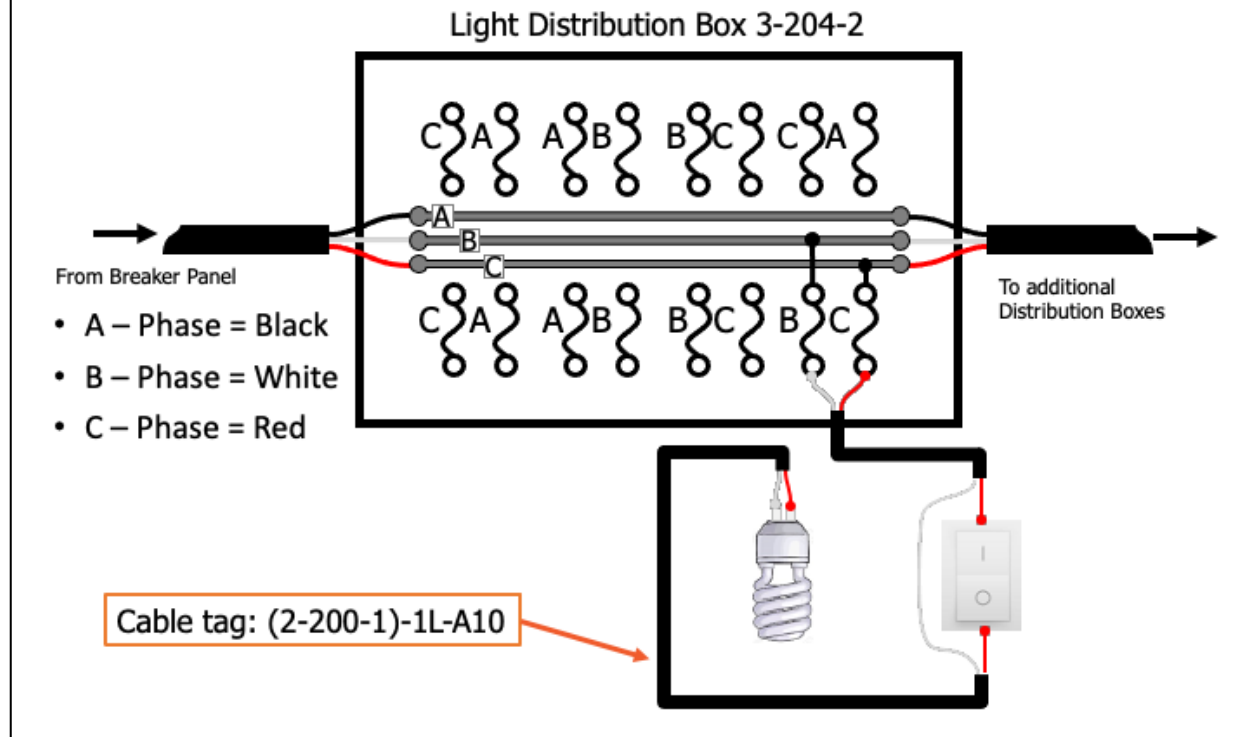
Main Breaker Panel



Here you see a typical Lighting Distribution System with the connection of a cable from the power source to a breaker panel. Each breaker in the circuit panel feeds distribution boxes which in turn provide power to downstream lighting. Breakers protect the circuits they power from over current conditions and provide a way to disconnect the power for maintenance and repair without impacting other circuits.

Lighting Distribution System

Light Distribution Box (typical lighting layout)



Each circuit breaker on electrical distribution panels can be connected to lighting distribution boxes that power systems at specific locations throughout the ship. Distribution boxes often use fuses to improve safety. Connectivity through the fuse is broken if faulty equipment downstream causes an overcurrent condition. This isolates faults from other equipment and reduces the potential for damage.

Although these distribution boxes may receive power from all 3 phases, connection points are labeled to identify which specific phase powers the connection. These are labeled A, B or C. By convention, Phase A uses the BLACK wire, B uses the WHITE wire, and C uses the RED wire..

Which phase provides power is important information and will be specified on the hookup sheet as well as the cable tag information. In some cases, distribution boxes may be wired in series with all power coming from a single circuit on the main panel.

Feeder Connection Information: The "Hook-up Sheet"

- Lists connected branch circuits
- List of materials section identifies specific parts and quantities
- Footer block specifies the Distribution Box model type

FEEDER CONNECTION INFORMATION									
FEEDER CONNECTION		FEEDER CONNECTION						REVISIONS	
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION	DATE
11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11

BRANCH CIRCUIT CONNECTION INFORMATION									
BRANCH CIRCUIT	WIRE TYPE	WIRE SIZE	WIRE COLOR	WIRE LENGTH	WIRE WEIGHT	WIRE VOLTAGE	WIRE CURRENT	WIRE TEMPERATURE	WIRE RESISTANCE
1	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
2	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
3	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
4	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
5	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
6	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
7	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
8	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
9	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
10	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11

LIST OF MATERIALS									
ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL	REMARKS	DATE	BY	REVISION
1	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
2	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
3	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
4	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
5	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
6	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
7	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
8	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
9	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
10	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11

FEEDER CONNECTION INFORMATION									
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION	DATE
11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11

LIST OF MATERIALS					
REV	ITEM	TOT QTY	RESV QTY	SMPN	DESCRIPTION
A	1	12		16504292	Fuse, Style F60,
A	2	2		16504293	Fuse, Style F60,

(73BA)-1L-A4 & A5 COMBINED CABLES F-4

SYM NO	613	PANEL	4517-DB67
REV	B		
SH	75		

Information needed to connect conductors is provided on the Feeder Connection Information page, commonly referred to as the "Hook-Up Sheet." The table portion of a conductor hook-up sheet includes information on the equipment in a particular distribution box. The hook-up sheet Footer identifies the distribution box model type and version.

Hook-up Sheet

(Feeder Connection Information section)

Review List of Materials Section

- Check notes for cable & circuit information
- Install temporary hook-up tags

The diagram illustrates the process of identifying cable requirements from a Hook-up Sheet. It shows a 'Feeder Connection Information' table, a 'List of Materials' table, and a physical '4 conductor cable' with four colored wires (black, white, red, green). An arrow points from a label in the List of Materials to a text box explaining that the label describes wiring for two circuits (73BA-1L-A4 & 73BA-1L-A5) using a single 4-conductor cable.

Feeder Connection Information Table:

FEEDER	FEEDER CABLE	FEEDER CABLE SIZE	FEEDER CABLE TYPE	FEEDER CABLE COLOR	FEEDER CABLE LENGTH	FEEDER CABLE WEIGHT	FEEDER CABLE VOLTAGE	FEEDER CABLE CURRENT	FEEDER CABLE TEMPERATURE	FEEDER CABLE HUMIDITY	FEEDER CABLE LOCATION	FEEDER CABLE NOTES
73BA-1L-A4	73BA-1L-A5	73BA-1L-A6	73BA-1L-A7	73BA-1L-A8	73BA-1L-A9	73BA-1L-A10	73BA-1L-A11	73BA-1L-A12	73BA-1L-A13	73BA-1L-A14	73BA-1L-A15	73BA-1L-A16

List of Materials Table:

REV	ITEM	TOT QTY	RESV QTY	SMPN	DESCRIPTION
A	1	12		16504292	Fuse, Style F60,
A	2	2		16504293	Fuse, Style F60,

(73BA)-1L-A4 & A5 COMBINED CABLES F-4

This label describes wiring of 2 circuits (73BA-1L-A4 & 73BA-1L-A5) by using 1 cable with 4 conductors, each conductor with a different color (black, white, red, green)

4 conductor cable

The list of Material section of a Hook-up sheet also provides information on the the specific connections needed. In this graphic, users see that 2 circuits will be wired using one cable with four different conductors.

Hook-up Sheet

(Branch Circuit Connection Information)



4 conductor Cable

REV	CKT	CKT DESIGNATION	CABLE	PHASE	FUSE SIZE
A	1	(73BA)-1L-A1	D-4	CA	5
A	2	(73BA)-1L-A2	D-4	BC	5
A	3	(73BA)-1L-A3	D-4	BC	5
A	4	(73BA)-1L-A4	F-4	BC	5
A	5	(73BA)-1L-A5	F-4	AB	5
A	6	(73BA)-1L-A6	D-4	AB	5
A	7	(73BA)-1L-A7	D-4	CA	5
A	8	SPARE		CA	

Circuit A4 will use two cables and will connect to phases B and C of the light distribution box

Circuit A5 will use two cables and will connect to phases A and B of the light distribution box

The Branch Circuit Connection Information table on a Hook-Up sheet provides the circuit identification number, the cable used, and the phases connected to power each circuit. Where used, it will also show the ratings of equipment such as fuses.

Hook-up Sheet

(SYM Number)

This information is located at the bottom of the hook-up sheet as illustrated on the image below

RECEIVER CONNECTION INFORMATION									
SYM NUMBER		SYMBOL		SYMBOL		SYMBOL		SYMBOL	
1	2	3	4	5	6	7	8	9	10

BRANCH CIRCUIT CONNECTION INFORMATION									
SYM NUMBER		SYMBOL		SYMBOL		SYMBOL		SYMBOL	
1	2	3	4	5	6	7	8	9	10

LIST OF OPTIONS									
SYM NUMBER		SYMBOL		SYMBOL		SYMBOL		SYMBOL	
1	2	3	4	5	6	7	8	9	10

OPTIONAL EQUIPMENT

SYM NUMBER		SYMBOL		SYMBOL		SYMBOL		SYMBOL	
1	2	3	4	5	6	7	8	9	10

This field shows what "model" of distribution box is used for wiring the circuit. In this case it is an SYM 613, which will indicate which wiring figure to use for this model.

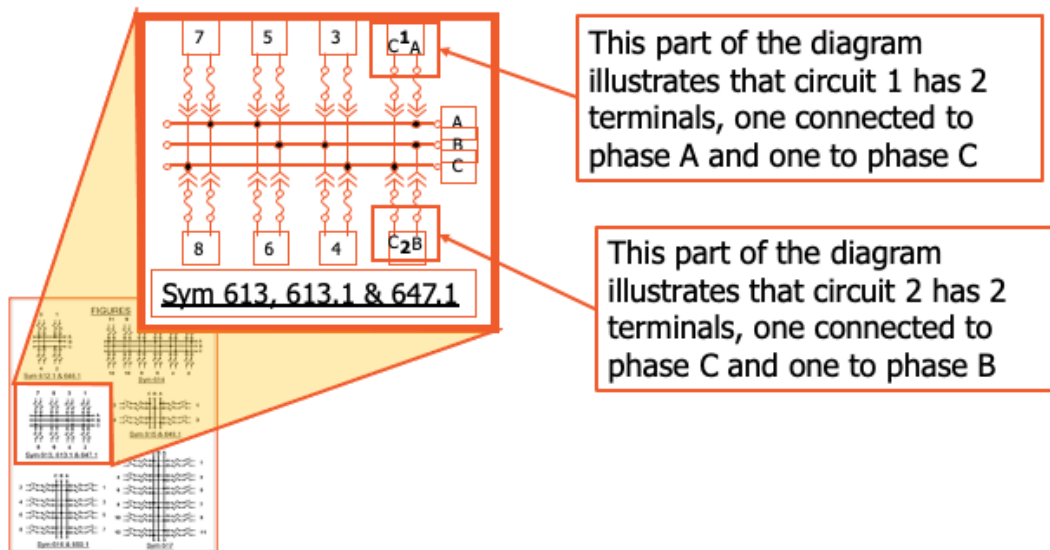
SYM NO	613	PANEL	4517-DB67
REV		8	
SH		75	

SYM stands for symbol. A SYM number represents a particular electrical system device. SYM 613, shown in this graphic, is a particular distribution box. The number is found at the bottom of the information sheet.

SYM model wiring diagram

Review your SYM model wiring diagram diagram

- Locate which phase (A,B or C) each connector is wired to
- Install temporary hook-up tags



Distribution boxes have specific symbol, or SYM, numbers. The wiring diagram for a box can be found using the SYM number. This example provides connection information for SYM 613, 613.1, and 647.1 boxes.

In the expanded graphic section, at the top right you can see that circuit 1 has two terminals which are connected to phase A and phase C. Directly below this, circuit 2 is shown as having two terminals, one connected to phase C and the second to phase B.

Wiring Diagram SYM 613 Box

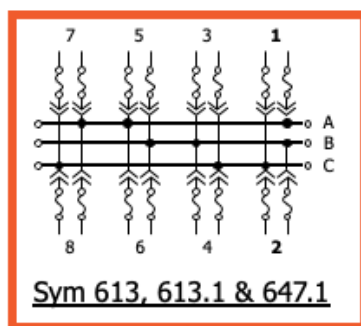
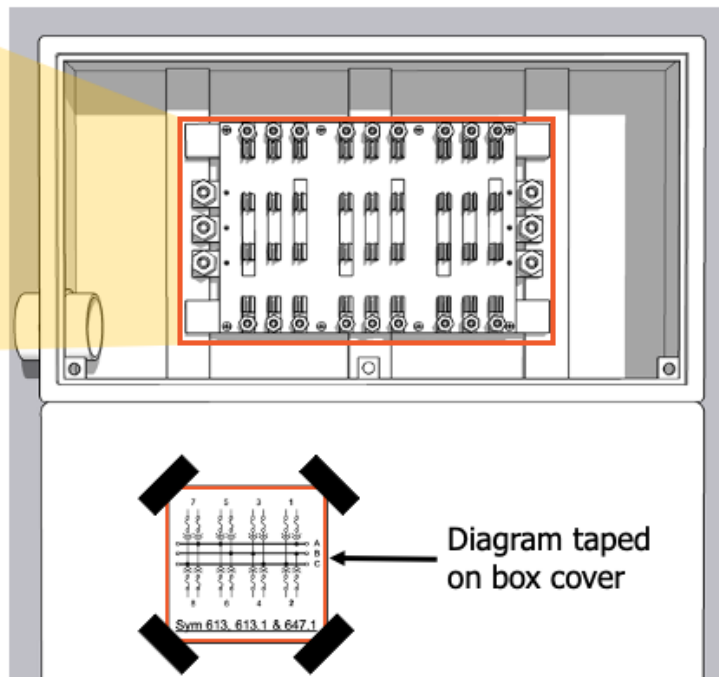
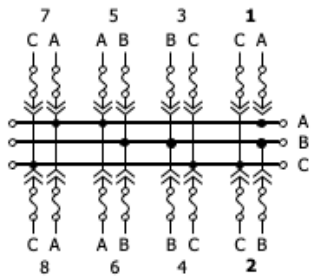


Diagram matches
physical layout of
the connections
in the fuse box



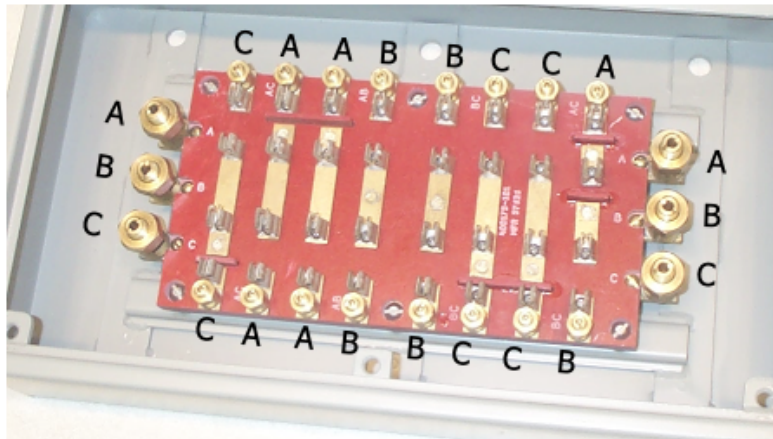
The wiring diagram for a distribution box will match the way the box is actually configured making it easy to see how the cables are connected. It is a good, professional practice to tape the wiring diagram to the box cover.

Mapping Diagram to Box



Sym 613, 613.1 & 647.1

To map wiring diagram to box, align the diagram 3 phases (A,B and C), to match the box 3 phases.

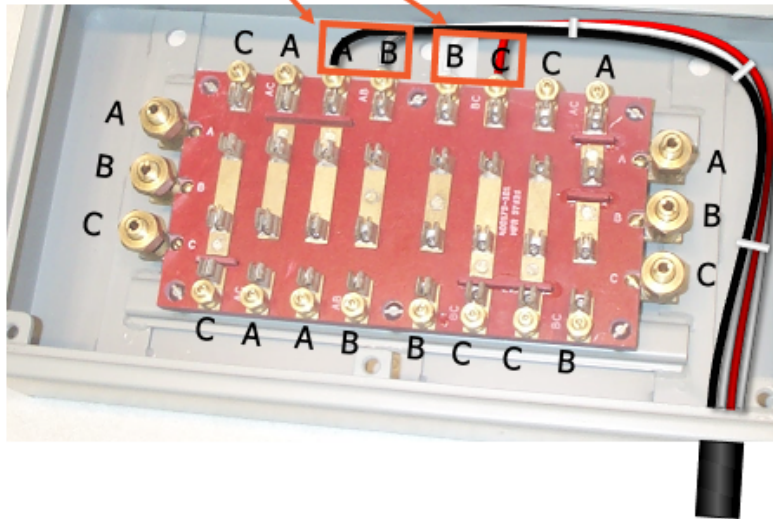


When connecting a distribution box, orient the wiring diagram to match the distribution box. This makes it easier to see what phases are connected to each circuit connection.

Mapping Diagram to Box

IBA)-1L-A4	F-4	BC	5
IBA)-1L-A5	F-4	AB	5

Putting it all together
this is how you
would connect the
wires to the box



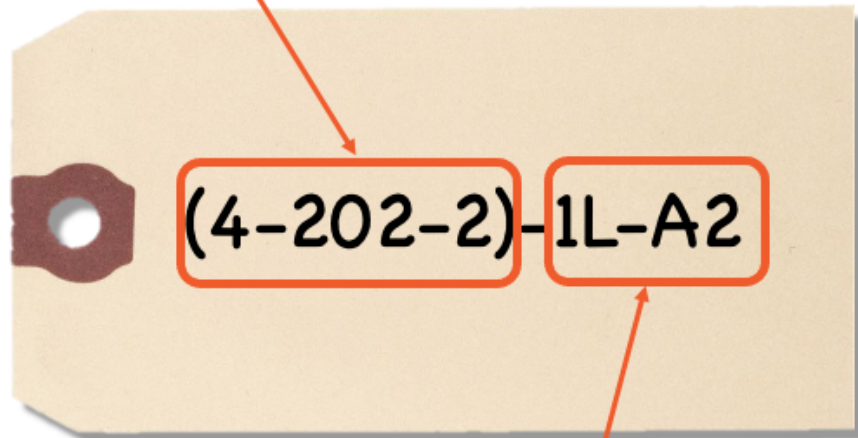
The top graphic is from the hook-up sheet shown previously. It shows the connection of phases inside the distribution box.



Permanent cable tags may be made of metal or plastic. Whatever tag material is used, non-metal materials such as plastic tie wraps secure the tag to the cable.

Temporary Tags - Distribution Box

Main Circuit providing power



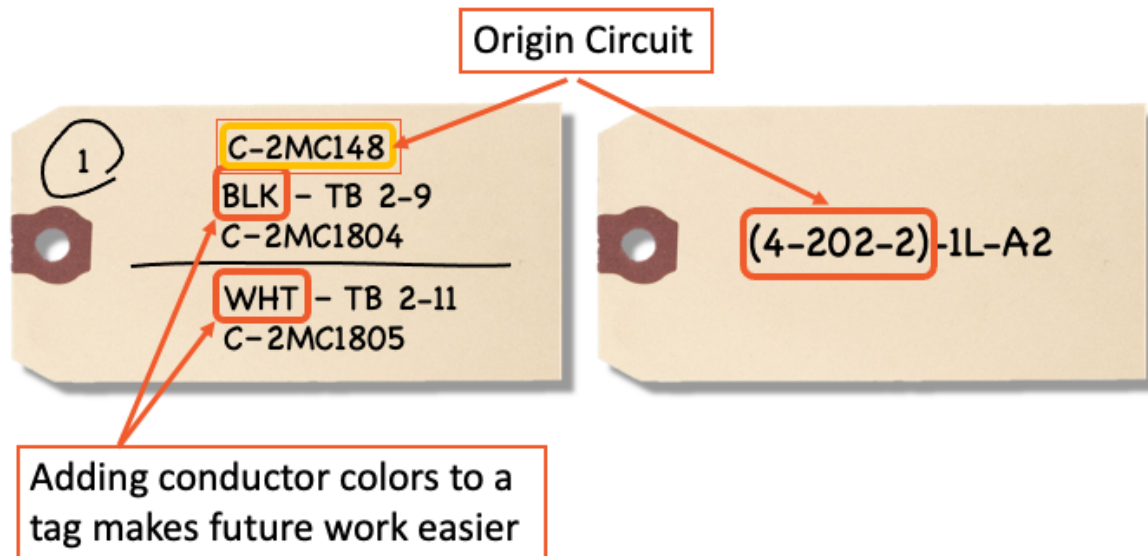
Sub-Circuit Designation

Temporary cable tags are attached during installation until the electrician is ready to install permanent tags.

Temporary tags help electricians keep track of multiple conductors by identifying the power source and destination.

Temporary Tags - Comparison

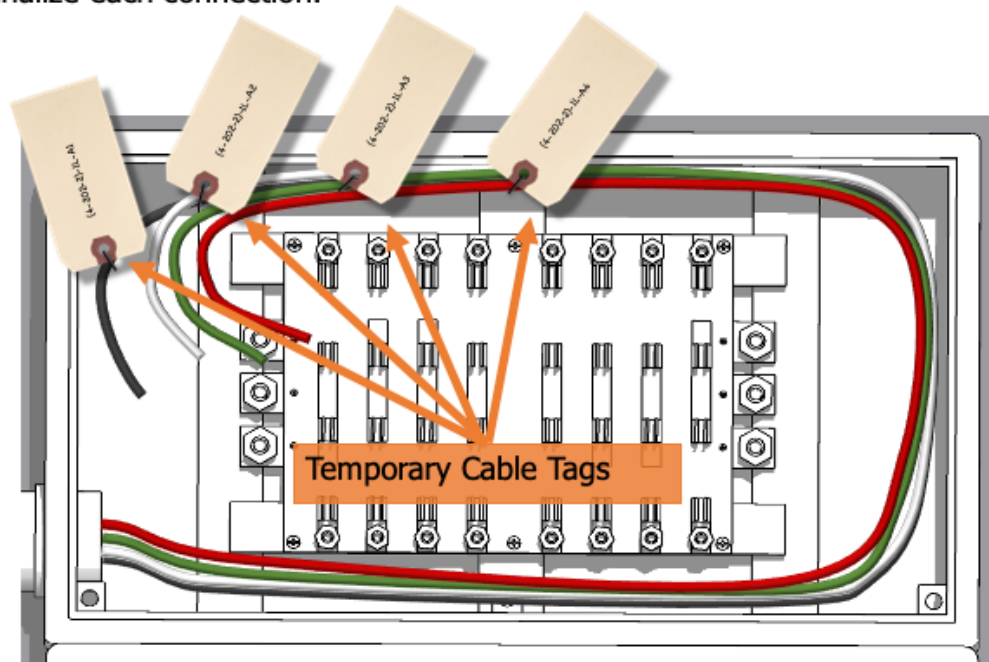
- Cables may have several conductors
- Use cable tags to identify each conductor



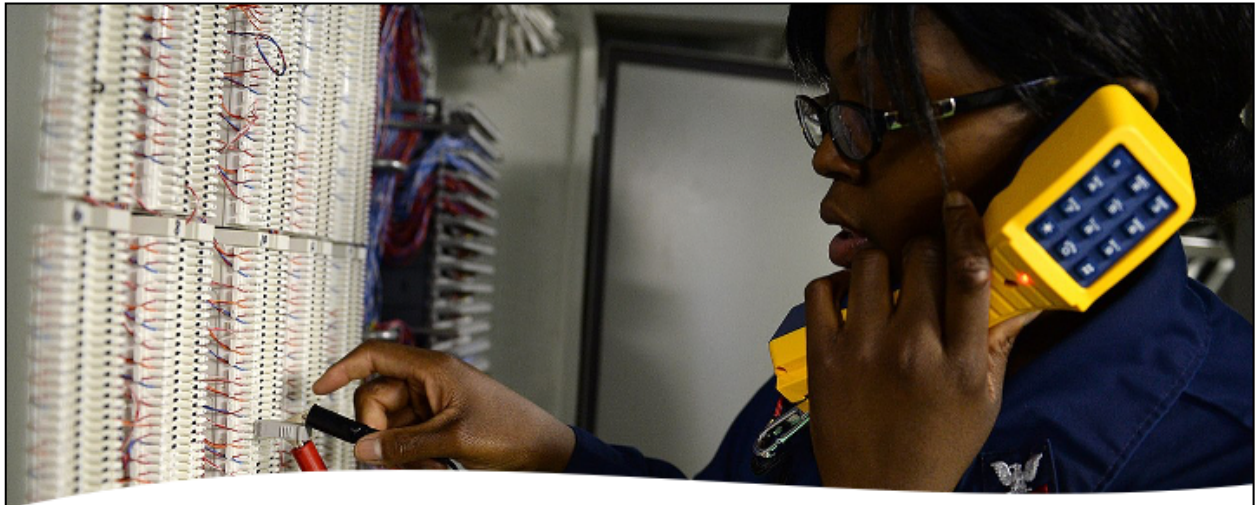
- Temporary tags are an important aid to keeping electrical systems organized and safe. In addition to identifying the circuit involved, you can add as much information as needed. For example, the tag on the left adds the color of each wire to make future work easier.

Conductor Routing

Use temporary cable tags as you work installing wire so that it is easier to identify where to connect the wires as well as what permanent label to add to the wire as you finalize each connection.



Temporary tags make it easier to keep track of all the connections made when wiring a distribution box. Add as much information to these tags as needed.



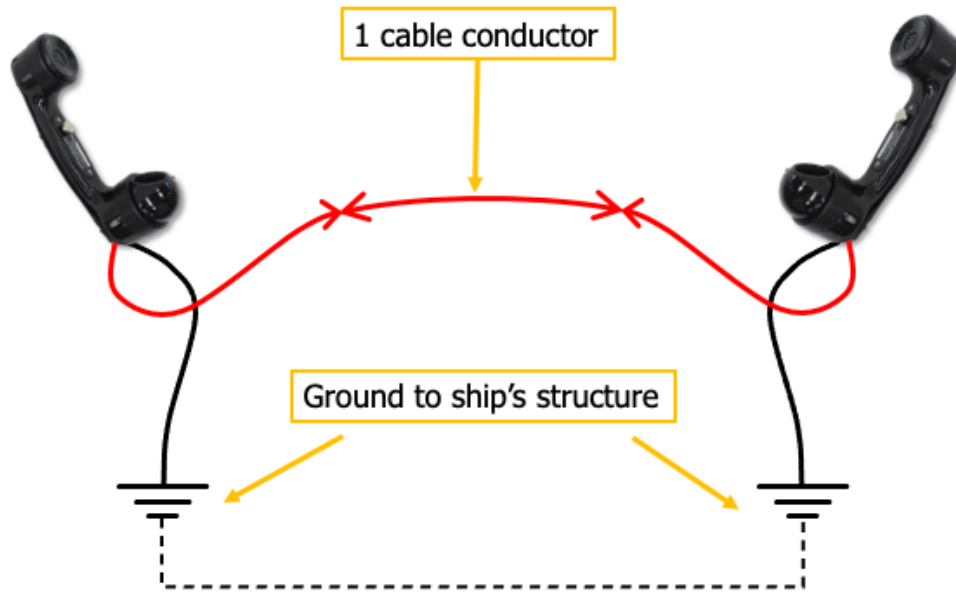
Talk Out The Cable

- Battery operated telephones
 - Requires 2 people
 - Connect 1 lead of each phone to ground on the ship's structure
 - Connect the other phone lead to the conductor
 - Establish communication through a minimum of 1 conductor to verify the cable
 - Talk to each other to verify the cable

Talking out a cable refers to using special battery powered phones to ensure a cable's continuity.

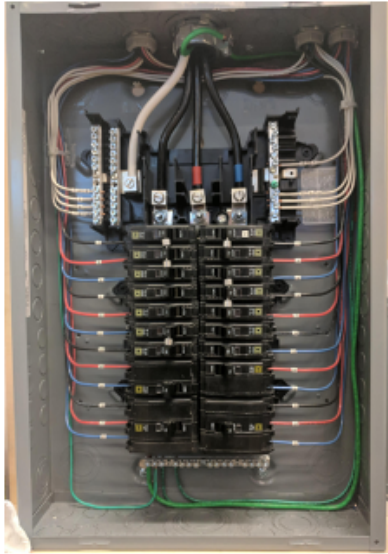
With one person on each end of the cable being tested, the ground lead of the phone is connected to the ship's structure or other suitable ground and the second lead is connected to one of the cable conductors. Of course, you have to be sure the two individuals connect to the same conductor! If the cable continuity is good, the testers will be able to speak to each other using the phones. Talk out the cable on at least one conductor from the cable to verify continuity.

Talk Out The Cable Diagram

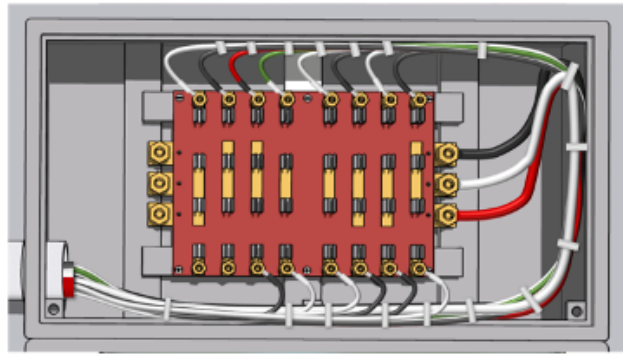


This simple diagram shows the connections made to talk out a cable. The ground lead from each battery powered phone is connected to the ship's structure or other ground. The second lead for each phone is connected to the same conductor. If continuity is intact, the individuals doing the test will be able to speak to each other using the phones.

Treeing Examples



Breaker Panel Box



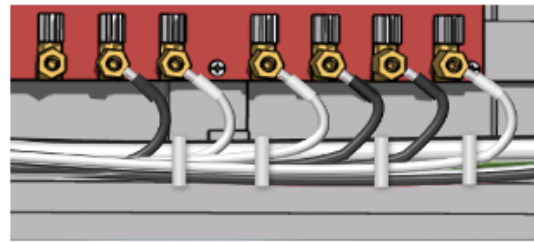
Distribution Box

Always arrange cables neatly and label them to make maintenance and/or repair more manageable

These graphics show two properly connected distribution boxes. Note how the conductors are routed around the outside edge of the box, how tie wraps keep cable bundles intact, and how the direct path between the cable bundle and the connection points keeps the box neat and safe.

Two Conductor Cable

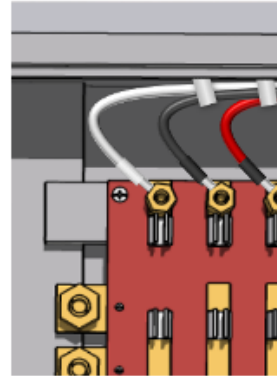
- Some cables include two conductors connecting 2 electrical phases
- The graphic shows connections made with three 2-conductor cables



This graphic shows six connections made using three cables, each with two conductors.

Three Conductor Cables

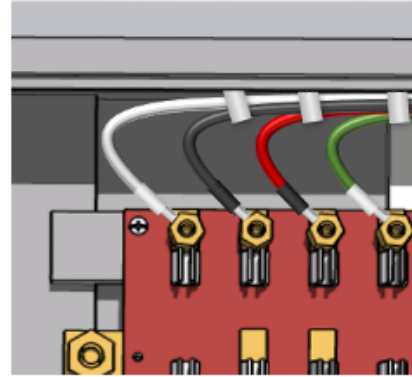
Some cables are a three-conductor cable and can be used to connect to 3 electrical phases each



Connections for a cable with three conductors are shown in this graphic. By convention, Black wires are usually connected to phase A, White wires to phase B, and Red wires to phase C. The bare wire is the ground wire.

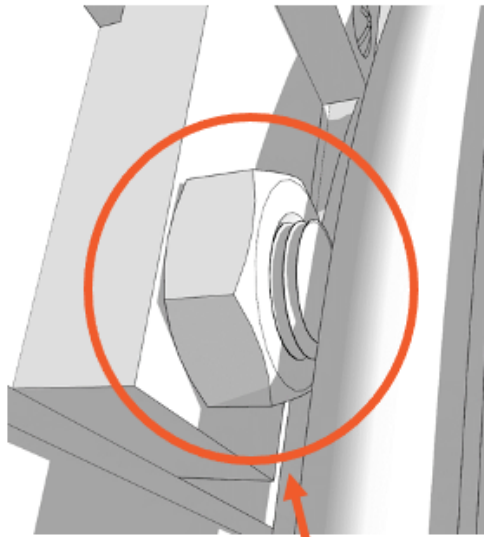
Four Conductor Cable

- Some cables are a four-conductor cable and can be used to connect to 4 electrical phases or 2 separate 2 electrical phases

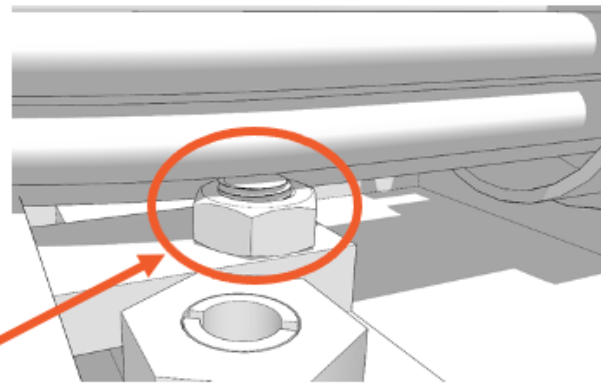


Some cables may have four conductors. When connecting these cables it is especially important to ensure that connections are made exactly as required before energizing the cable! Note the short black sleeve over the red cable and the white sleeve over the green cable. These are used with the wiring diagram to identify connections.

Cable Damage Caused by Poor Routing



Conductors can be damaged due to different factors. These images illustrate cables touching fastener protrusions that with time will damage the wire as it rubs against the sharp edges of the fasteners.



Conductor in contact with stud

Care must be taken when connecting and routing cables. These graphics show a cable routed in a way that allows direct contact with a stud. Though this cable would pass continuity tests, repeated vibrations during ship operations could eventually wear through the cable's insulation, causing a short and potential injury to personnel or damage to equipment. Always check a cable's routing wherever visible.