IPC
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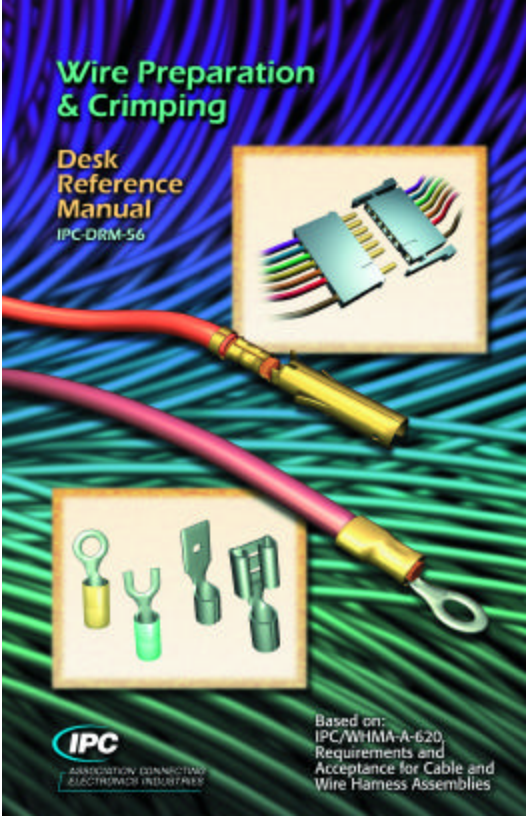
ISBN 1-580984-77-0

IPC-DRM-56
1st printing 7.02



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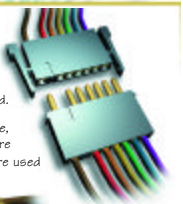
Note:
Only the subjects listed here are detailed in this manual. All other subjects or images used are previews of what will be in the next revision of DRM-56.

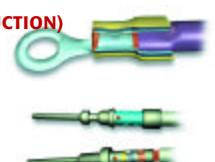
Introduction

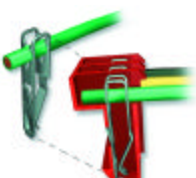
This manual illustrates and translates portions of the IPC/WHMA-A-620 criteria into common terms for new operators who may be unfamiliar with the technical terms used in that standard.



The differences between target, acceptable, process indicator and defect conditions are illustrated and everyday common words are used in the descriptions.

Those who desire a more technically exact format should use IPC/WHMA-A-620, Requirements and Acceptance for Cable and Wire Harness Assemblies.





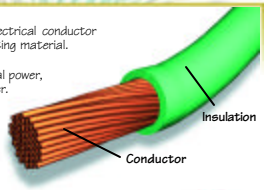
Based on: IPC/WHMA-A-620,
Requirements and Acceptance for Cable and Wire Harness Assemblies

Wires

Wires typically consist of an electrical conductor such as copper, and an insulating material.

The conductor carries electrical power, like a garden hose carries water.

Insulation usually covers the conductor to protect it from touching, or shorting, against components or other wires.



Conductors are either stranded or solid , and are usually copper or plated copper. Most of the wire used in wire harness assembly is stranded.

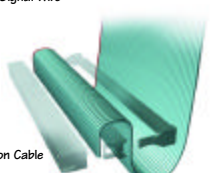
Wire insulation may be made from various materials including Teflon® or PVC – and may be different colors for identification purposes.

There are two different functions performed by wires.

Power wires carry power supply voltage. They distribute operating power within an electronic device.

Signal wires are generally smaller than power wires. They carry the lower voltage signals that control the functional operation of an electronic device, or provide data input and output.

Ribbon cable is an example of a number of small signal wires bonded into a flat cable

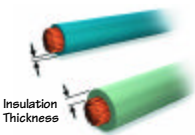


Wire Gauge

The size of the wire is important to the efficient flow of electricity. The more electrical current the wire must carry, the larger the wire needs to be.

Wire size is specified by AWG, or American Wire Gauge. AWG is a reverse numbering system where the larger numbers refer to the smaller wires. In other words, number 18 AWG wire is smaller than a 14 AWG wire. 0000 gauge is very large wire.

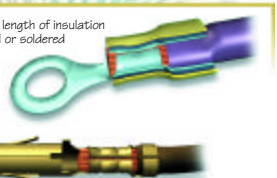
It's important to realize that the wire stranding and insulation type or thickness can vary within a particular wire size. This can be due to voltage, temperature and/or environmental requirements.



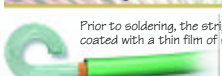
Wire Stripping

Wires need to have a specific length of insulation removed before being crimped or soldered to a terminal or contact.

Strip length is determined by the type of terminal or contact being used.



Wire Tinning *(Only for Soldering)*



Prior to soldering, the stripped wire needs to be tinned, or coated with a thin film of solder. Tinning is done so that the wire won't be damaged when it is bent. Tinning also improves solderability.

Wires that have been tinned cannot be used in crimp terminals.

Crimped Contacts & Terminals

Introduction

Both crimped contacts and terminals come in a variety of shapes and sizes, and in two types of barrels – **open and closed.** Open and closed barrels are defined on page 13.

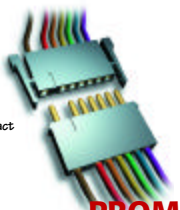
Contacts

Contacts are usually small and are designed to fit into a connector insert, or housing.

Contacts can be either stamped and formed or machined.

Stamped & Formed Contact

Machined Contact



Terminals

Terminals are designed to connect a wire to a screw or mating termination. The most common types include ring, fork and spade.

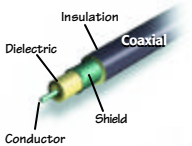
Terminals may or may not have an insulation crimp, or an outer insulation sleeve.

Coaxial, Triaxial & Twinaxial Cables

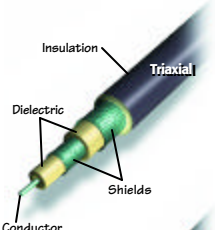
Introduction

These types of electronic cables transmit radio frequencies for broadcast and other types of data transmissions that require stable, high frequency signals. (covered in next version of this DRM)

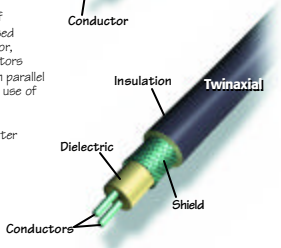
Coaxial cable consists of four basic parts: a center conductor that carries the electronic signal; an outer conductor that shields the center conductor from electronic noise; a dielectric made from foam insulation that separates the center and outer conductor; and an outer jacket that protects the parts inside. The size and type of material of the dielectric determines the electrical characteristics of the cable.



Triaxial cable has two outer conductors or shields separated by a second dielectric layer. One shield serves as a signal ground, while the other serves as an earth ground, providing better noise immunity and shielding.



Twinaxial cable has a pair of insulated conductors encased in a common outer conductor, or shield. The center conductors may either be twisted or run parallel to one another. A common use of twinax cable is high-speed balanced-mode multiplexed transmission in large computer systems. Balanced mode means that the signal is carried on both conductors, which provides greater noise immunity.



For information on Cable Requirements and Acceptance Criteria, refer to: IPC/WHMA-A620 – Requirements and Acceptance for Cable and Wire Harnesses.

Classification

Assembly requirements are divided into three classes depending on the ultimate use, life expectancy and operating environment of the electronic assembly. Those classes are as follows:

Class 1 General Electronic Products

Includes products suitable for applications where the major requirement is the function of the completed assembly.

Class 2 Dedicated Service Electronic Products

Includes products where continued performance and extended life is required and for which uninterrupted service is desired but not critical. Typically, the end use environment would not cause failures.

Class 3 High Performance Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment **must** function when required.

Notes: Product examples of class types are given for rough estimate only. The environment that a product operates in remains the critical factor in determining classification. For instance, a radio that must function on the surface of Mars will not be in the same class as your typical car radio. The inspector shall not select the class for the part under inspection. The user and manufacturer need to agree on the class to which any product belongs. This should be stated in the procurement documentation package.

Accept and/or reject decisions must be based on applicable documentation such as contract, drawings, specifications such as IPC/WHMA-A-620 and IPC/EIA J-STD-001 and other referenced documents.

Acceptance Criteria

Criteria are given for each class in one or more of the following levels of condition:

- **Target**
- **Acceptable**
- **Process Indicator**
- **Defect**

The examples below show the definitions of each acceptance criterion.

Class 1, 2, 3 Target Condition

A condition that is close to perfect; however, it is a desirable condition and not always achievable and may not be necessary to ensure reliability of the assembly in its service environment.

Class 1, 2, 3 Acceptable

This characteristic indicates a condition that, while not necessarily perfect, will maintain the integrity and reliability of the assembly in its service environment. Acceptable can be better than the minimum end product requirements to allow for shifts in the process.

Class 1, 2, 3 Process Indicator

A process indicator is a condition that does not affect the form, fit, function or reliability of a product. Process indicators should be used to improve the manufacturing process.

Class 1, 2, 3 Defect

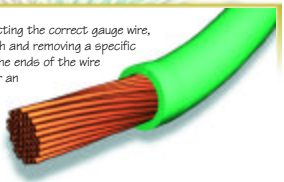
A defect is a condition that is insufficient to ensure the form, fit or function of the assembly in its end use environment. The manufacturer shall rework, repair, scrap, or "use as is" based on design, service and customer requirements.

Note: Many of the illustrations shown as process indicators or defects are exaggerated in order to show the reasons for this classification.

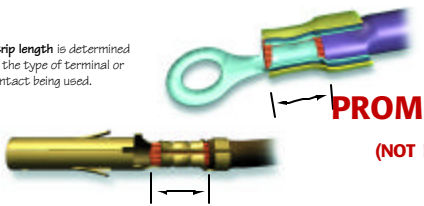
Wire Preparation

Wire preparation involves selecting the correct gauge wire, cutting it to the proper length and removing a specific length of insulation so that the ends of the wire can be crimped or soldered for an electrical connection.

This section provides the criteria for stripping wires.



Strip length is determined by the type of terminal or contact being used.



Wire Stripping Criteria

Class 1, 2, 3 Target Condition

Strands are not scraped, nicked, severed or otherwise damaged.

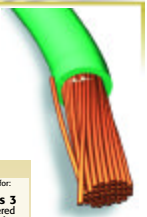
Strands are not flattened, untwisted, buckled, kinked or otherwise deformed.

Insulation has been trimmed neatly with no signs of pinching, pulling, fraying, discoloration, charring or burning.

Strand Damage

Class 1 Acceptable
Class 2, 3 Process Indicator
(see table below) Defect

Strands that are **scraped, nicked, or severed** become a defect when they exceed the limits specified in the Table below.



Defective Strand Damage

Total number of Strands in the wire	Maximum number scraped, nicked or severed for: Class 1, 2 Crimped or Soldered	Class 3 Crimped Terminations	Class 3 Soldered Terminations
Less than 7	0	0	0
7-15	1	0	1
16-25	3	0	2
26-40	4	3	3
41-60	5	4	4
61-120	6	5	5
121 or more	6%	5%	5%

Note: No damaged strands for wires used at a potential of 6kV or greater.
Reference: IPC/WHMA-A-620 Table 3-1.

Conductor Deformation -Loss of Spiral

Class 1 Acceptable
Class 2, 3 Defect

The general **spiral lay** of the strands has not been maintained.

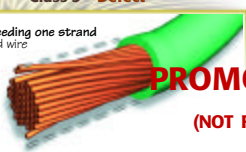
Conductor Deformation

Class 1, 2, 3 Acceptable

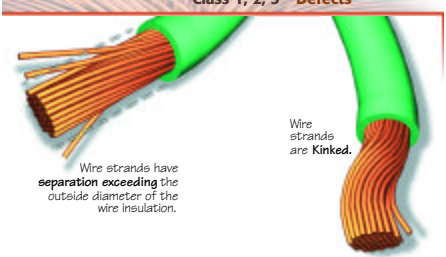
Wire strands can have some **separation (birdcaging)** but do not exceed one strand diameter or extend beyond the wire insulation outside diameter.

Class 1 Acceptable
Class 2 Process Indicator
Class 3 Defect

Wire strands have **separation exceeding one strand** diameter but do not extend beyond wire insulation outside diameter.



Class 1, 2, 3 Defects



Insulation Damage

Class 1, 2, 3 Acceptable
Class 2 Process Indicator

Slight uniform **impression in the insulation** from the gripping of mechanical strippers. Insulation thickness is not reduced by more than 20%.

Uneven or ragged pieces of insulation are less than half of the insulation outside diameter or 1 mm, whichever is less.

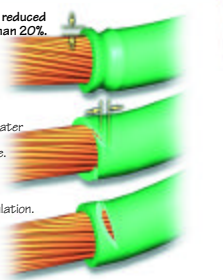
Insulation is **discolored** from thermal stripping operation.

Class 1, 2, 3 Defects

Insulation **thickness is reduced** by **more than 20%.**

Ragged pieces of insulation are greater than 50% of the insulation outside diameter or 1 mm, whichever is more.

Any **cuts or breaks** in insulation.

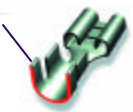


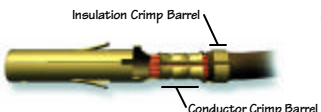
Crimping

Crimping is a common method of terminating wires to contacts and terminals. Crimping occurs inside the barrel. There are two types of barrels – open and closed.

Open Barrel

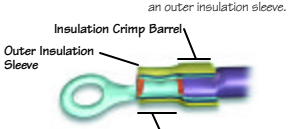
Open barrels have **two "U-shaped"** areas – one to crimp the wire conductor and one to crimp the wire insulation. The purpose of the insulation crimp is to provide strain relief.





Closed Barrel

Closed barrels have an **"O-shaped"** or closed area where the wire is inserted and crimped. This type may also have an insulation crimp and an outer insulation sleeve.



Carrier Cut-off Tabs

Contacts and terminals for crimping often arrive on a reel or spool, bound together by strips of metal at one or both ends of the crimp.

They are removed from this carrier by cutting the connecting tab before or during the crimping process.

Parts of a Open Barrel Crimp

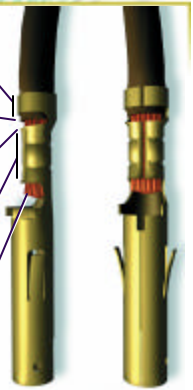
Insulation Support Crimp
The insulation support crimp provides strain relief for the wire. The crimp needs to hold the insulation as firmly as possible without cutting through the conductor strands.

Insulation Inspection Window
The insulation inspection window shows the position of the insulation in relation to the transition area between the insulation support crimp and conductor crimp.

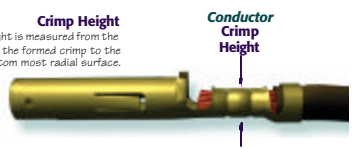
Bellmouth
The bellmouth is the flare that is found on both edges of the conductor crimp, acting as a tunnel for the wire strands. This tunnel reduces the possibility that a sharp edge on the crimp will cut or nick the wire strands.

Conductor Crimp
The conductor crimp describes the mechanical compression of the metal contact around the conductor. This is what creates the continuous conductive electrical path.

Conductor Brush
The conductor brush refers to the wire strands that extend past the conductor crimp on the contact side of the termination.



Crimp Height
Crimp height is measured from the top surface of the formed crimp to the bottom most radial surface.

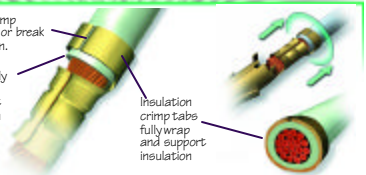


Note: All crimping needs to comply with the manufacturer's published requirements. The two methods of verifying the reliability of a crimp are by measuring the conductor crimp height and by performing a destructive pull test. Pull testing measures the force it takes to pull apart the termination between the contact and the wire.

Insulation Support Crimp

Crimp
Open Barrel

Class 1, 2, 3 Target Condition



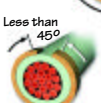
Deformations

Class 2, 3 Acceptable

Minor deformation of the insulation surface as long as the crimp tabs do not cut, break, penetrate or puncture the surface of the wire insulation.

Crimp tabs provide a minimum **side support** of 180° to the wire insulation and both tabs contact the top of the wire insulation.

Crimp tabs do not meet at the top, but encircle the wire leaving **an opening of** 45° or less at the top.



Punctures

Class 1 Acceptable
Class 2 Process Indicator
Class 3 Defect

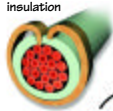
Puncturing of the insulation surface by the insulation crimp tabs, provided that the tabs do not penetrate down to the conductor.

Insulation Support Crimp

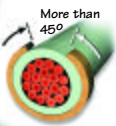
Crimp
Open Barrel

Class 1, 2, 3 Defects

The insulation crimp **tabs pierce the insulation** penetrating down to the conductor.



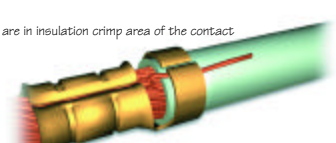
Crimp tabs that encircle the wire but leave an **opening of more than 45°** at the top.



The insulation crimp **tabs do not provide support** at least 180 degrees around the insulation.

Both insulation crimp **tabs are not in contact** with the top of the insulation.

Conductors are in insulation crimp area of the contact

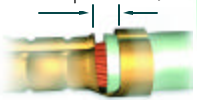


Insulation Inspection Window

Crimp
Open Barrel

Class 1, 2, 3 Target Condition

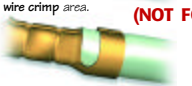
Both insulation and conductor are visible within the **inspection window,** with the transition line centered.



Class 1 Acceptable
Class 2, 3 Process Indicator

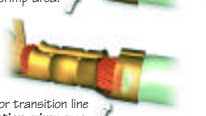
Insulation is flush with the end of the insulation crimp tabs and **does not enter the inspection window** area.

Insulation is flush with, but **does not enter the wire crimp** area.



Class 1, 2, 3 Defects

Insulation **extends into** conductor crimp area.



Insulation and conductor transition line **is within insulation crimp** area.

Bellmouth

Crimp
Open Barrel

Class 1, 2, 3 Target Condition

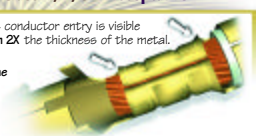
Bellmouth at each end of the conductor crimp area.

Bellmouth height at the conductor entry end is **2X the thickness** of the contact/terminal base metal.

Class 1, 2, 3 Acceptable

Bellmouth at conductor entry is visible but **less than 2X** the thickness of the metal.

Bellmouth **only at the conductor entry** end and not at the conductor brush end of the crimp.



Class 1, 2, 3 Defects

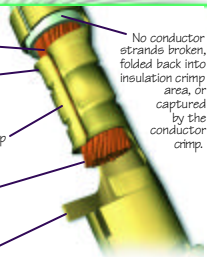
No visible bellmouth at the conductor entry end of the crimp.

Excessive bellmouth indicating over crimping or undersize wire gauge.

Conductor Crimp

Crimp
Open Barrel

Class 1, 2, 3 Target Condition



Strands not twisted, cut or modified to fit into the terminal.

There is no insulation in the conductor crimp area.

Crimp is centered on the conductor crimp area with correct bellmouth.

Conductor extends to the middle of the brush area.

Locking tabs in place with no signs of deformation or damage.

No conductor strands broken, folded back into insulation crimp area, or captured by the conductor crimp.

Class 1, 2 Acceptable
Class 3 Process Indicator

Minor **deforming** of the contact, such as a **banana shape,** that does not alter its form, fit, function or reliability.

Note: A trial mating may be required for final acceptance.

Class 1 Acceptable
Class 2, 3 Process Indicator

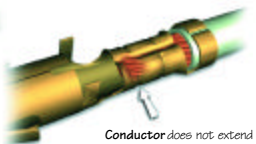
Crimp **indentations not uniform** but do not affect form, fit, function or reliability. Conductor is flush to end of conductor crimp area.

Conductor Crimp

Crimp
Open Barrel

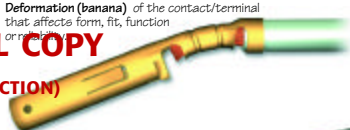
Class 1, 2, 3 Defects

Insulation extends into conductor crimp area.

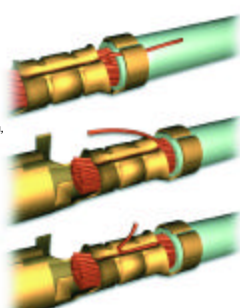


Conductor does not extend out of the crimp area.

Deformation (banana) of the contact/terminal that affects form, fit, function or reliability.



Any **loose conductor strands** that are outside the crimp area, trapped strands, folded back strands.



Conductor Brush

Crimp
Open Barrel

Class 1, 2, 3 Target Condition

The conductor strands protrude slightly past the end of the conductor crimp forming a "conductor brush".

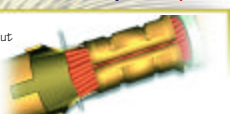
The conductor strands forming the brush are kept together as a group and are not flared out.

Class 1 Acceptable
Class 2, 3 Process Indicator

Conductor strands do not protrude past, but **are flush with** the end of the conductor crimp area of the contact.

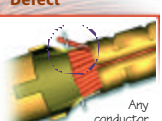
Class 1, 2, 3 Acceptable

Conductor strands are flared out but **do not extend** outside of the contact.



Class 1 Acceptable
Class 2, 3 Defect

The conductor **strands extend into** the mating area of the contact.



Any conductor strands **extending outside of the contact.**

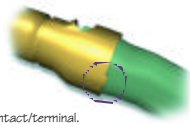
Carrier Cut-off Tab

Crimp
Open Barrel

Class 1, 2, 3 Acceptable

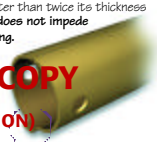
No damage to contact or terminal.

Cutoff does not prevent complete mating of the contact/terminal.



Class 2, 3 Process Indicator

Cutoff tab length at mating end is greater than twice its thickness but **does not impede mating.**



Cutoff tab length at wire entry end is greater than twice its thickness but **does not protrude** when inserted into connector body.

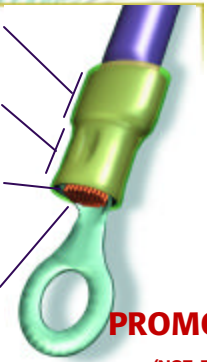
Class 1, 2, 3 Defects

Mating end cutoff tab **prevents complete mating.**

Cutoff tab **protrudes** from connector body when contact has been inserted.

No carrier cutoff tab visible and contact/terminal is **damaged**

Parts of a **Closed Barrel** Crimp

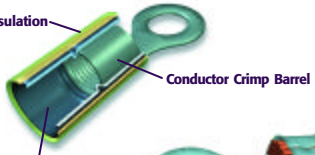


Insulation Support Crimp
provides strain relief for the wire. The crimp needs to hold the insulation as firmly as possible without cutting through the conductor strands.

Conductor Crimp
refers to the mechanical compression of the metal contact around the conductor. This is what creates the continuous conductive electrical path.

Bellmouth
is the flare that is found on both edges of the conductor crimp, acting as a tunnel for the wire strands. This tunnel reduces the possibility that a sharp edge on the crimp will cut or nick the wire strands.

Conductor Brush
The conductor brush refers to the wire strands that extend past the conductor crimp on the contact side of the termination. By seeing the conductor brush, you verify that compression occurs over the full length of the conductor crimp



Note: All crimping needs to comply with the manufacturer's published requirements. The two methods of verifying the reliability of a crimp are by measuring the conductor crimp height and by performing a destructive pull test. Pull testing measures the force it takes to pull apart the termination between the contact and the wire.

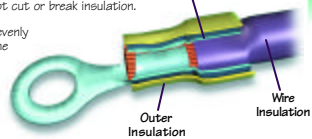
Insulation Support Crimp

Class 1, 2, 3 Target Condition

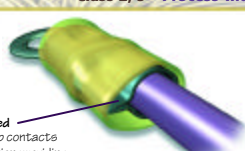
Insulation fully enters and extends inside the **Insulation Support Crimp.**

Insulation crimp does not cut or break insulation.

The insulation crimp is evenly formed and contacts the wire insulation providing support without damaging the insulation.



Class 1 Acceptable
Class 2, 3 Process Indicator

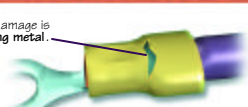


Irregular shaped insulation crimp contacts the wire insulation providing support without damaging the insulation.

Outer Insulation Damage

Class 1, 2, 3 Defect

Outer insulation damage is **exposing metal**.



Conductor Crimp

Crimp
Closed Barrel

Class 1, 2, 3 Acceptable

No insulation in the conductor crimp area.

No conductor strands broken or folded back into crimp area.

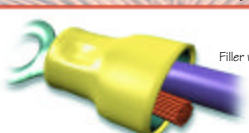
Crimp indentations uniform and meet contact/tooling manufacturer's requirements.

Filler wire or foldback, if specified, is within the crimp and is visible at the entry bellmouth, but does not extend beyond the edge of the terminal insulation.

Class 1, 2 Acceptable
Class 3 Process Indicator

Minor deforming of the contact does not alter its form, fit, function or reliability.

Class 1 Acceptable
Class 2, 3 Defect



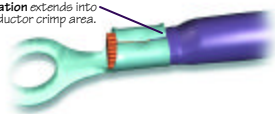
Filler wire extends beyond edge of the terminal insulation.

Conductor Crimp

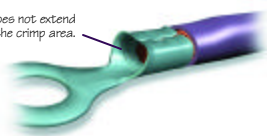
Crimp
Closed Barrel

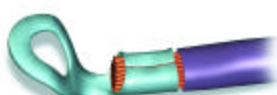
Class 1, 2, 3 Defects

Insulation extends into conductor crimp area.



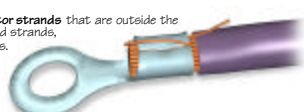
Conductor does not extend out of the crimp area.





Deformation of the contact/terminal that affects form, fit, function or reliability.

Any **loose conductor strands** that are outside the crimp area, trapped strands, folded back strands.

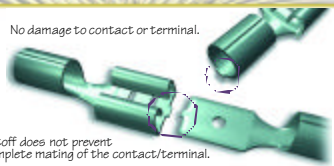


Carrier Cut-off Tab

Crimp
Closed Barrel

Class 1, 2, 3 Acceptable

No damage to contact or terminal.



Cutoff does not prevent complete mating of the contact/terminal.

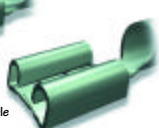
Class 2, 3 Process Indicator

Cutoff tab length at mating end is greater than twice its thickness but does **not impede mating.**

Class 1, 2, 3 Defects

Mating end cutoff tab **prevents complete mating.**

Removal of cutoff tab has **damaged terminal.**



No carrier cutoff tab visible and terminal is damaged

Glossary

Appendix

AMERICAN WIRE GAUGE (AWG): A standard numbering system for designating wire diameter. Primarily used in the United States.

BANANA TERMINAL: A termination that has excessive bending, making it difficult to insert into a connector housing.

BELLMOUTH: The raised portion at the front and/or back of the wire barrel crimp that provides a gradual entrance and exit for the wire strands without causing damage.

BRAID: Woven bare metallic or tinned copper wire used as shielding for wires and cables.

CABLE: A group of individually insulated conductors in twisted or parallel configuration under a common sheath.

CABLE ASSEMBLY: A cable with plugs or connectors attached.

CIRCULAR MIL AREA: Cross-sectional area of a current carrying portion of a conductor expressed in circular mils.

CLOSED BARREL: A contact or terminal with an O-shaped barrel.

COAXIAL CABLE: A cable consisting of a center conductor that carries the electric signal; an outer conductor that shields the center conductor from outside noise; a dielectric that separates the center and outer conductor; and an outer jacket to protect the parts inside.

CONDUCTOR: An uninsulated wire or the conductor of an insulated wire suitable for carrying electrical current.

CONDUCTOR BRUSH: The wire strands that extend past the conductor crimp on the conductor side of the termination.

CONDUCTOR CRIMP: Refers to the mechanical compression of the metal contact around the conductor. This is what creates the continuous conductive electrical path.

CONNECTOR: A device used to physically and electrically join two or more conductors.

CONTACT: The conducting part of a connector that acts with another such part to complete or break a circuit.

CONTACT SIZE: Defines the largest size wire that can be used with the specific contact.

CRIMP: The final configuration of a terminal barrel formed by the compression of terminal barrel and wire.

CRIMP HEIGHT: A measurement taken of the overall wire barrel height after the terminal has been crimped.

CUT OFF TAB: The small tabs that remain on the front and back of a terminal after it has been applied.

DIELECTRIC: Any insulating medium that intervenes between two conductors.

FLAT CABLE: Any cable with two smooth or corrugated but essentially flat surfaces.

HARNESS: A group of wires and cables, usually made with breakouts, which are tied together or pulled into a rubber or plastic sheath. A harness provides interconnection of an electric circuit.

INSULATION: A material that offers high electrical resistance making it suitable for covering components, terminals and wires to prevent the possible future contact of adjacent conductors resulting in a short circuit.

INSULATION DISPLACEMENT: A technique for terminating an insulated wire to a connector or terminal without pre-stripping the insulation from the conductor. The termination is made by cutting through the insulation to the conductor.

INSULATION SUPPORT CRIMP: Provides strain relief for the wire by holding the insulation firmly without cutting the conductor strands.

INSULATION THICKNESS: The wall thickness of the applied insulation.

INTERCONNECTION: Mechanically joining devices together to complete an electrical circuit.

LEAD: A wire, with or without terminals, that connects two points in a circuit.

LUG: A wire terminal.

OPEN BARREL: A contact or terminal with two U-shaped areas – one for crimping the conductor and one for crimping the insulation.

PLUG: The part of the two mating halves of a connector that is free to move when not fastened to the other mating half.

PULL TESTING: A destructive test where the terminal and wire are pulled until the termination pulls apart or the wire breaks. Pull testing is used to determine the strength of the crimp.

RIBBON CABLE: A flat cable of individually insulated conductors lying parallel and held together by means of an adhesive film laminate.

Glossary Appendix

SHEATH: The outer covering or jacket of a multi-conductor cable.

SHIELD: A metallic layer placed around a conductor or group of conductors to prevent electrostatic interference between the enclosed wires and external fields.

SOLDER TERMINALS: Electrical/mechanical connection devices that are used to terminate a discrete wire or wires by soldering. The shapes of these terminals include turret, bifurcated, cup, hook and pierced.

STRAIN RELIEF: A technique or item that reduces the transmission of mechanical stresses to the conductor termination.

STRIP LENGTH: A specific length of insulation removed from the wire before it is crimped or soldered to a terminal or contact.

TERMINAL: A device designed to terminate a conductor that is to be affixed to a post, stud, chassis, another conductor, etc., to establish an electrical connection. Some types of terminals include ring, tongue, spade, flag, hook, blade, quick-connect, offset and flanged.

TINNING: The application of solder to the stripped wire to assure the wire to be soldered has a uniform and solderable surface – and that there is no separation of the individual strands.

TRIAXIAL CABLE: Similar to coaxial cable, but consisting of two outer conductors, or shields separated by a second dielectric layer.

TWINAXIAL CABLE: Similar to coaxial cable, but consisting of a pair of insulated conductors enclosed in a common outer conductor, or shield.

WETTING: The formation of a relatively uniform, smooth, unbroken and adherent film of solder to a basis metal.

WIRE: A wire is a slender rod or filament of drawn metal.

WIRE DIAMETER: The overall conductor plus insulation thickness.

WIRE WRAP: The connecting of a solid wire to a square, rectangular or V-shaped terminal by tightly wrapping a solid-conductor wire around the terminal with a special tool.

If you have comments or suggestions regarding this Desk Reference Manual, please contact:

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