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IPC-DRM-WHA

Rev. C • 05.17 1k
Rev. B • 04.13 2k
Rev. A • 04.11 2k
Rev. A • 11.06 2.5k

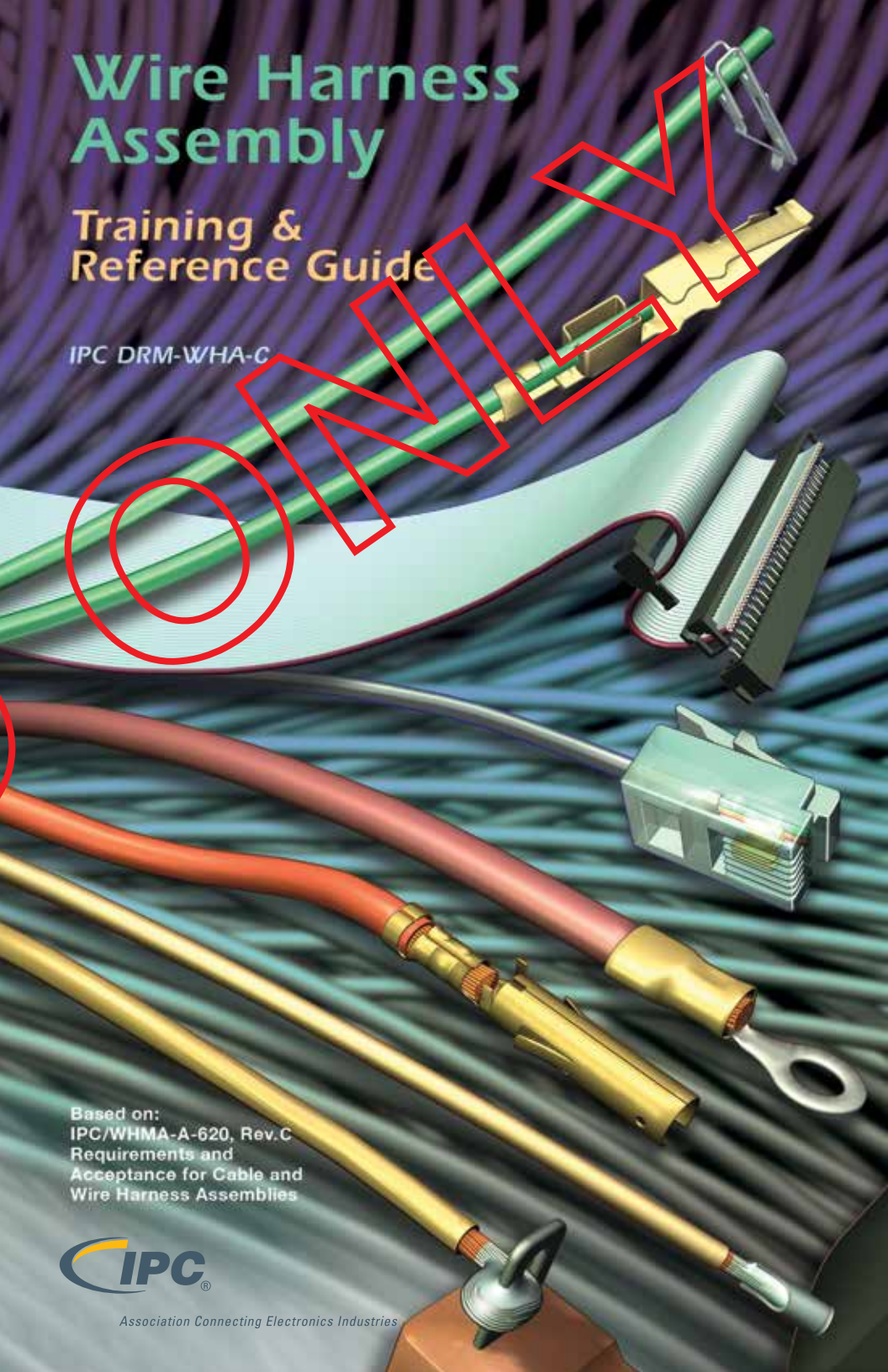
IPC-DRM-56

1st printing • 7.02 2k

Wire Harness Assembly

Training & Reference Guide

IPC DRM-WHA-C



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

IPC®

Association Connecting Electronics Industries

Wire Harness Assembly

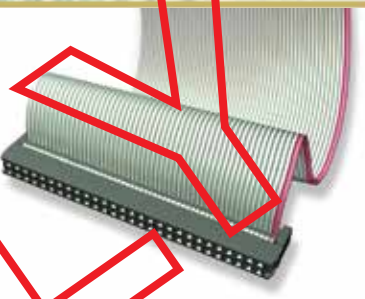
Training & Reference Guide
IPC DRM-WHA-C

Table of Contents page

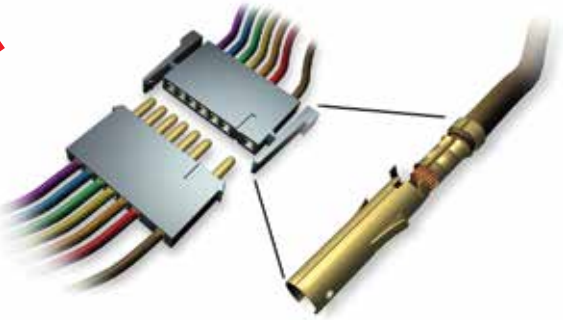
Based on: IPC/WHMA-A-620, Rev. C
Requirements and Acceptance for Cable and Wire Harness Assemblies

Introduction

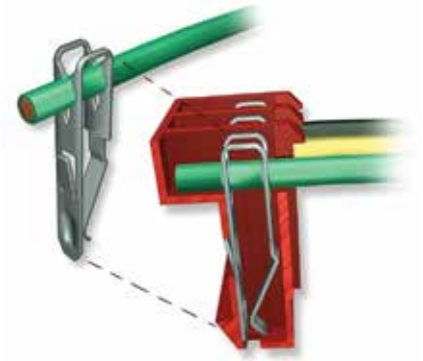
This reference guide provides the basic criteria for preparing and terminating wires and cables used in wire harness assemblies as defined in the **IPC/WHMA-A-620**.

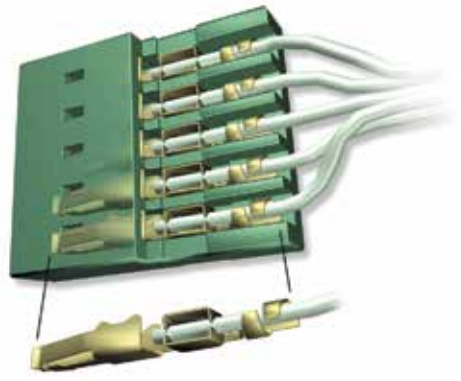


Each section of the manual presents the criteria for target, minimum acceptable and defect conditions for the most common of the wire harness assembly categories.



For a more technically comprehensive format, please use *IPC/WHMA-A-620, Requirements and Acceptance for Cable and Wire Harness Assemblies.*



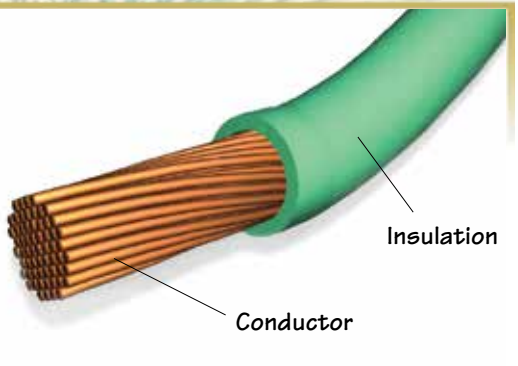


Wires

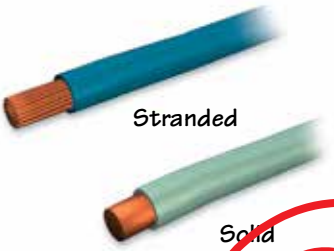
Wires typically consist of an electrical conductor such as copper, and an insulating material.

The *conductor* carries electrical current.

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



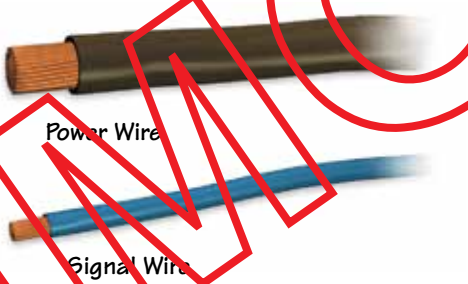
Conductors are either stranded or solid, and are usually copper or plated copper. Most of the wire used in wire harness assembly is stranded.



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

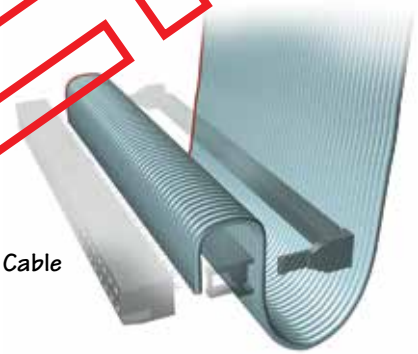
There are two different functions performed by wires.

Power wires distribute electrical current from the power supply to the rest of the device.



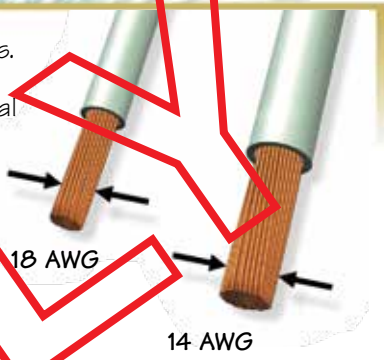
Signal wires are generally smaller than power wires. They carry the lower voltage signals that control the functional operation of an electronic device, or provide data input and output.

For example, ribbon cable is used for signals only.



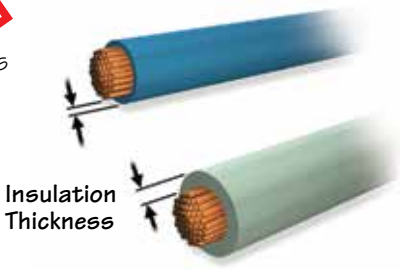
Wire Gauge

Wires may be of various gauges, or diameters. 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 to assist the flow.



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 10 AWG wire is smaller than a 14 AWG wire.

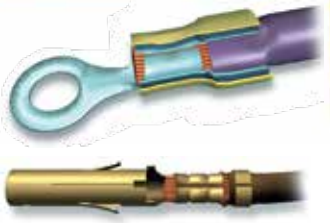
It's important to realize that the wire stranding and insulation type or thickness can vary within a particular wire size. This can be due to voltage, temperature and/or environmental requirements.



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

Prior to soldering, the stripped wire usually 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 terminations.

Crimped Contacts & Terminals

Both crimped *contacts* and *terminals* come in a variety of shapes and sizes, and in two types of *barrels* – ***open and closed.***

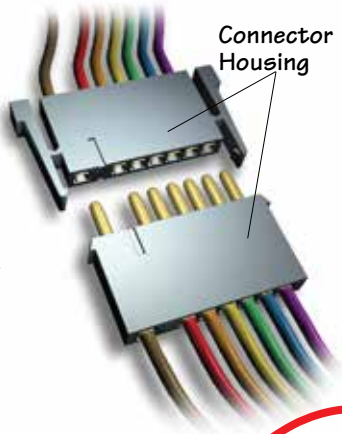
Contacts

Contacts are usually small and are designed to fit grouped into a connector 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.

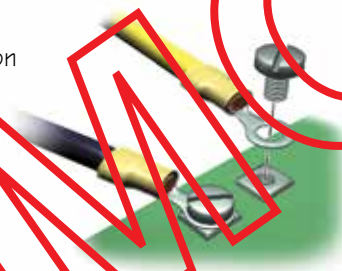
Ring

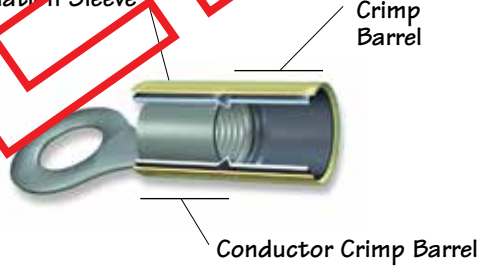
Fork

Male Spade

Female Spade

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

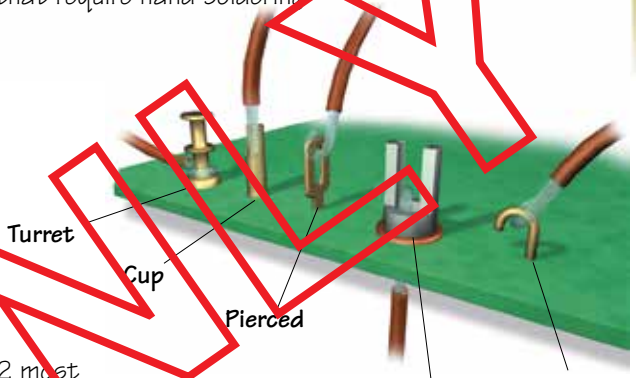




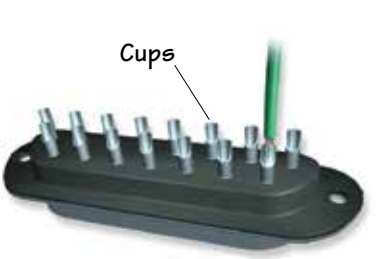
Soldered Terminals

Soldering is one method of terminating wires. Common terminals that require hand soldering include:

- Turrets
- Cups
- Pierced Tab
- Bifurcated
- Hook



This book covers the 2 most common soldered terminals: **Pierced & Cups**.



Lead Free Soldering

The primary difference between the solder connections created with processes using tin-lead alloys and processes using lead free alloys is related to the visual appearance of the solder.

Acceptable lead free and tin-lead connections may exhibit similar appearances, but lead free alloys are more likely to have:

- Surface roughness (grainy or dull)
- Greater wetting contact angles*

All other solder criteria are the same.

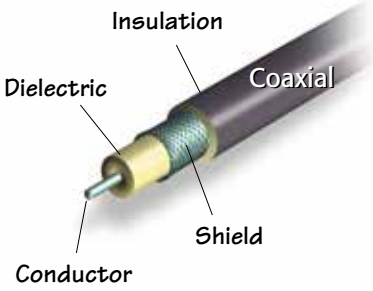
*Wetting cannot always be judged by surface appearance. The wide range of solder alloys in use may exhibit from low or near zero degree contact angles to nearly 90 degree contact angles as typical.

For information on lead forming, placement and soldering wires to turret, bifurcated and hook terminals, refer to: *IPC/WHMA-A620, Requirements and Acceptance for Cable and Wire Harness Assemblies.*

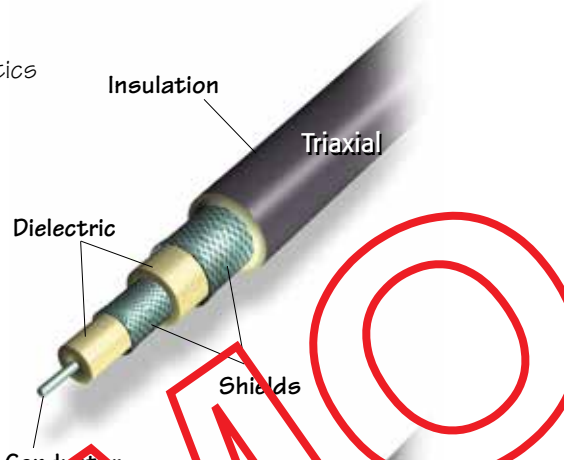
Coaxial, Triaxial & Twinaxial Cables

These types of electronic cables transmit radio frequencies for broadcast and other types of data transmissions that require stable, high frequency signals.

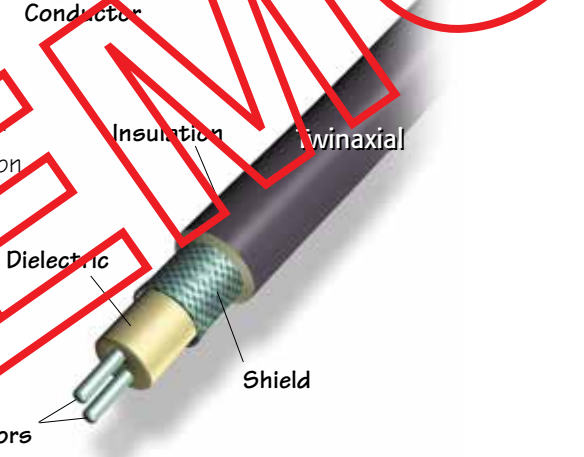
Coaxial cable consists of four basic parts: a center conductor that carries the electronic signal; an outer conductor that shields the center conductor from electronic noise; a dielectric made from foam insulation that separates the center and outer conductor; and an outer jacket that protects the parts 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, or Biaxial 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 twinaxial 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-A-620, Requirements and Acceptance for Cable and Wire Harness Assemblies.

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 **consumer** applications, where the major requirement is the function of the completed assembly, not necessarily for extended life, reliability of service, or cosmetic perfection.

Class 2 Dedicated Service Electronic Products

Includes **commercial** type 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 from such extremes as temperature or contamination.

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, such as for life-support, aerospace and other **high-reliability** systems.

Note: The inspector does not select the class for the part under inspection. Documentation which specifies the applicable class for the part under inspection should be provided to the inspector.

Acceptance Criteria

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

- Target
- Acceptable
- Process Indicator
- Defect

Below are the definitions for each condition level.

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

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 slightly 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 and function of a product. However, process indicators signal a lack of good workmanship to the customer and should be used to improve the manufacturing process – even though the product is considered fully usable.

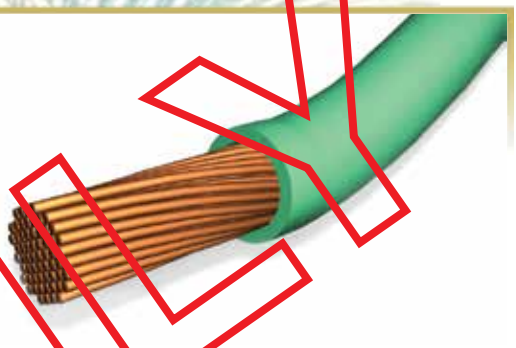
Class 1, 2, 3 Defect

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.

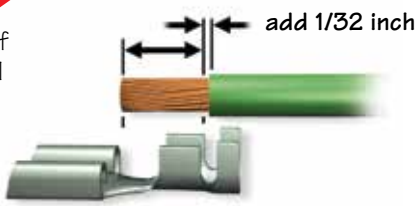
Wire Preparation

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.



Most 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. A typical rule for stripping wires that will be crimped is the length of the barrel – plus 1/32 inch (0.7938 mm).



Wire Stripping Criteria 3.2

Class 1, 2, 3 Target Condition

Wire conductor ends are cut perpendicular to the wire longitudinal axis.

All of the strands of the strand group are the same length.

Strands are not nicked, cut, flattened, scored or otherwise damaged.

Class 1, 2, 3 Acceptable

Strand groups cut approximately perpendicular to wire longitudinal axis.

All of the strands in the group are approximately the same length.

There are attached burrs that will not dislodge during process or use.

Strand Damage 3.2

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

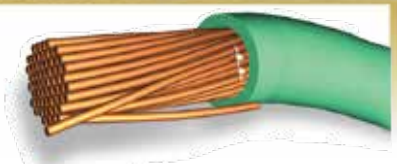


Table 3-2 Allowable Strand Damage[1,2,3]

Total number of Strands in the wire	Maximum number scraped, nicked or severed strands for: Class 1, 2 Crimped or Soldered	Class 3 **Crimped** Terminations	Class 3 **Soldered** Terminations
1 (solid conductor)	No damage in excess of 10% of conductor diameter		
2-6	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 1: No damaged strands for wires used at a potential of 6kV or greater.
Note 2: For plated wires, a visual anomaly that does not expose basis metal is not considered to be strand damage.
Note 3: Nicks or scrapes less than 10% of conductor diameter are not considered to be strand damage.

Reference: IPC/WHMA-A-620, Table 3-2.

Class 1, 2, 3 Defect

Damaged strands that are **scraped**, **nicked**, or **severed** become a defect when they exceed the typical limits specified in the Table above. Also a defect when variation in strand group prevents installation to full depth in crimp contact area.

Attached burrs that may be dislodged during process or operation.

Conductor Deformation -Loss of Spiral

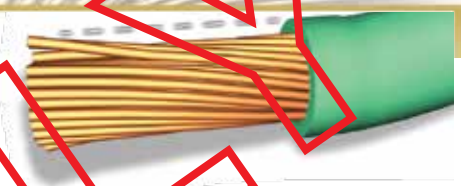
Class 1 Acceptable
Class 2, 3 Defect

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

Conductor Deformation 3.3

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.



If strands were straightened during stripping, they have been restored to approximate the original spiral lay of the wire.

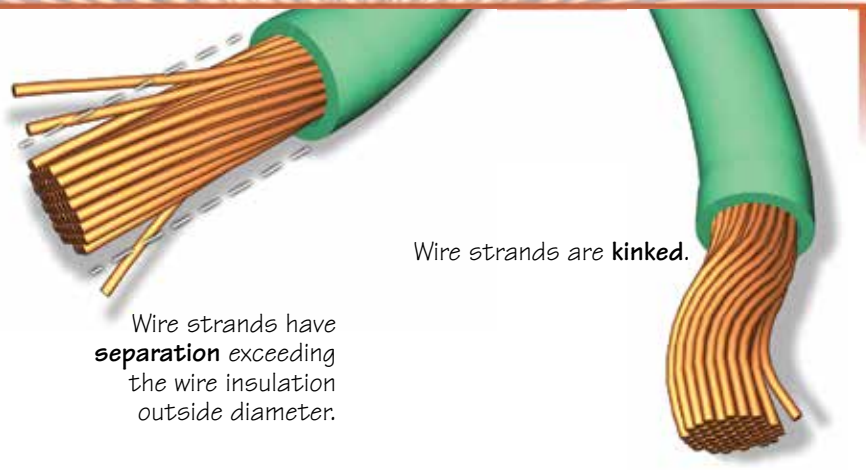
Wire strands are **not** kinked.

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 Acceptable
Class 2, 3 Defect

Class 1, 2, 3 Defect



Wire strands are **kinked**.

Wire strands have **separation** exceeding the wire insulation outside diameter.

Insulation Damage

3.5

Class 1, 2, 3 Acceptable

Slight uniform **impression in the insulation** from the gripping of mechanical strippers.

Slight **discoloration** of insulation from the thermal stripping operation is permissible, provided it is not charred, cracked or split.

Note: Acceptable to use chemical stripping agents on solid wires as long as no degradation is apparent to the wire.

Class 1, 2, 3 Defects

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

Uneven, or Ragged pieces of insulation "frays, tails and tags" are greater than 50% of the insulation outside diameter, or 1 mm, whichever is more.

Any **cuts, breaks, cracks** or **splits** in insulation.

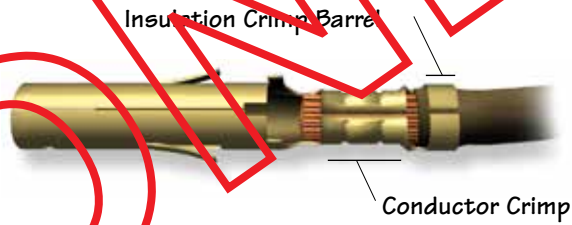
Insulation is **charred** or **blackened**, or melted into the wire strands.

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.

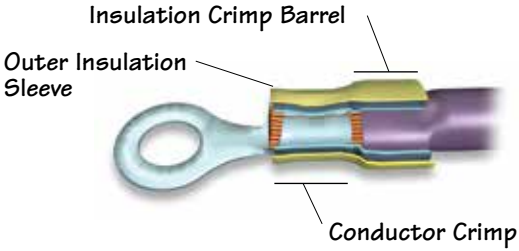
Open Barrel

Open barrel contacts and terminals 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

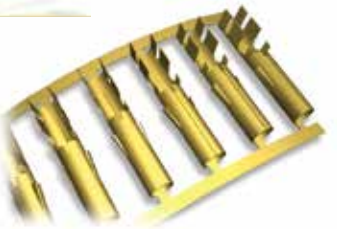
Closed barrel contacts and terminals have an "**O-shaped**" or closed area where the wire is inserted and crimped. This type may also have an insulation crimp and an outer insulation sleeve.



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 an 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 insulation surface.

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

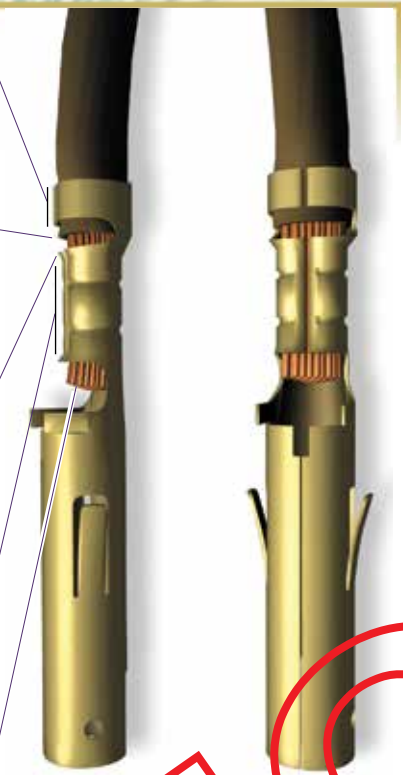
The bellmouth is the flare that is found on both edges of the conductor crimp, acting as a tunnel for the wire strands. This tunnel reduces the possibility that a sharp edge on the crimp will cut or nick the wire strands.

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.

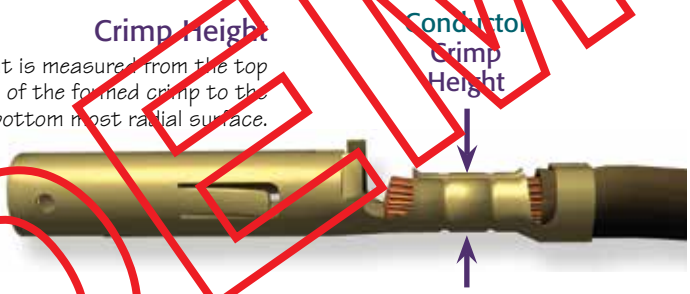
Conductor Brush

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



Crimp Height

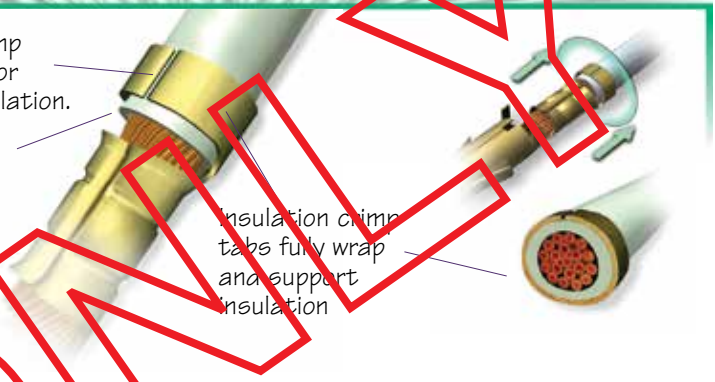
Crimp height is measured from the top surface of the formed crimp to the bottom most radial surface.



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.

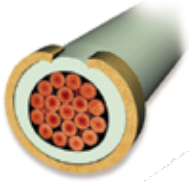
Insulation Support Crimp
5.1.1.2

Class 1, 2, 3 Target Condition

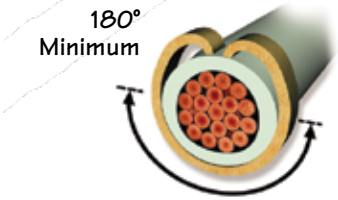


Class 1, 2, 3 Acceptable

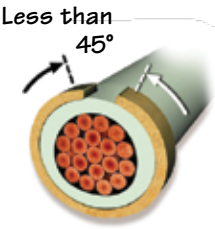
Minor deformation of the insulation surface as long as the crimp tabs do not cut, break, penetrate or puncture the surface of the wire insulation.



Crimp tabs provide a minimum **side support of 180°** to the wire insulation and at least one tab contacts the top of the wire insulation. The second tab must be within one material thickness of contacting the top of the insulation.



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

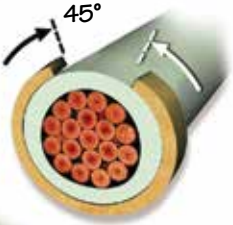


Insulation Support Crimp 5.1.1.2

Class 1, 2, 3 Defects

The insulation crimp **tabs pierce the insulation**.

More than 45°

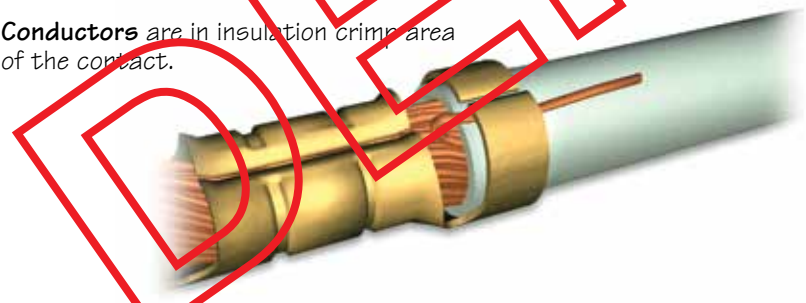


Crimp tabs that encircle the wire but leave an **opening of more than 45°** at the top.

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

At least one crimp tab **does not contact** the top of the insulation. If one tab makes contact, the second tab is **greater than** one material thickness of contacting the top of the wire insulation.

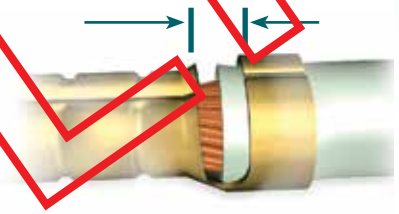
Conductors are in insulation crimp area of the contact.



Insulation Inspection Window
5.1.1.1

Class 1, 2, 3 Target Condition

Insulation and conductor transition line is centered within the **inspection window**.

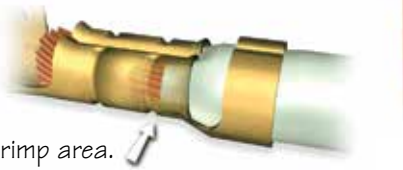


Class 1, 2, 3 Acceptable

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.

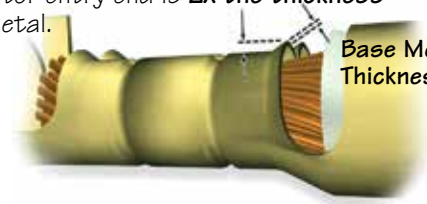
Insulation and conductor transition line is **not** visible within the inspection window.

Bellmouth
5.1.4

Class 1, 2, 3 Target Condition

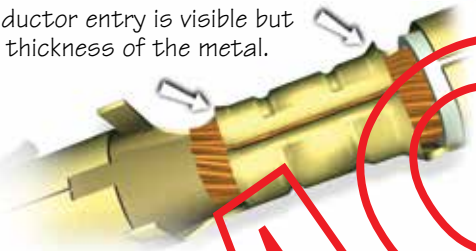
Bellmouth at each end of the conductor crimp area.

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

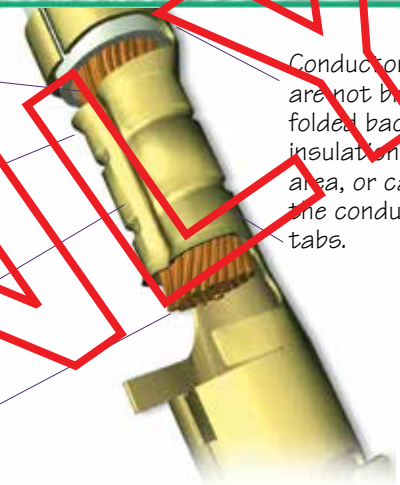
No visible bellmouth at the conductor entry end of the crimp.

Excessive bellmouth indicating over crimping or undersize wire gauge.

Conductor Crimp 5.1.3

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.

Conductor strands are not broken, or folded back into insulation crimp area, or captured by the conductor crimp tabs.

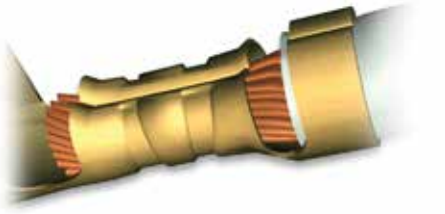
Class 1, 2 Acceptable
Class 3 Process Indicator

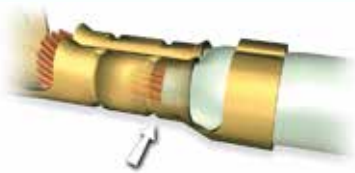
Minor **deforming** of the contact, such as a **banana shape**, that does not alter its form, fit, function or reliability.

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

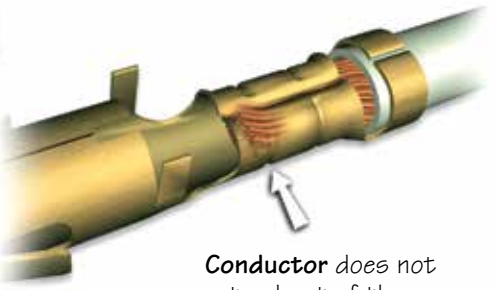
Class 1 Acceptable
Class 2, 3 Process Indicator

Crimp **indentations not uniform** but do not affect form, fit, function or reliability.



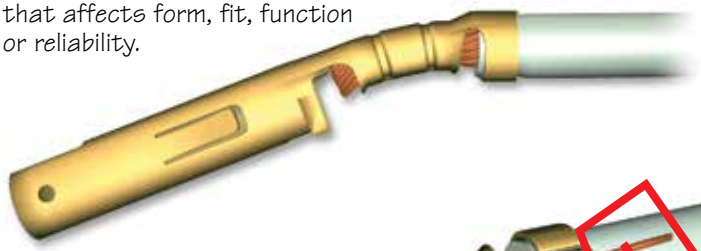


Insulation extends into conductor crimp area.

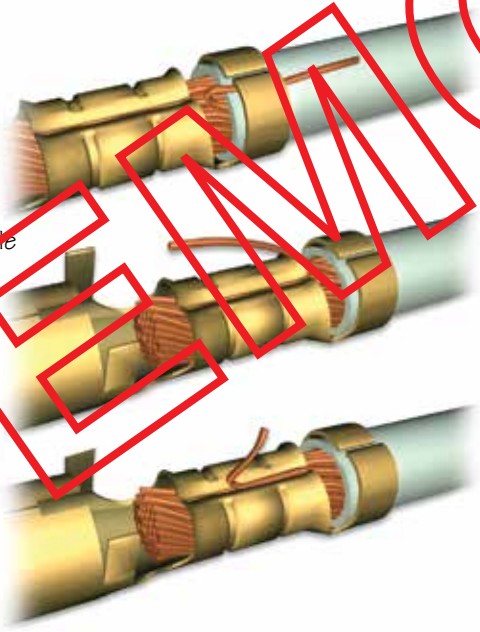


Conductor does not extend out of the crimp area.

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.

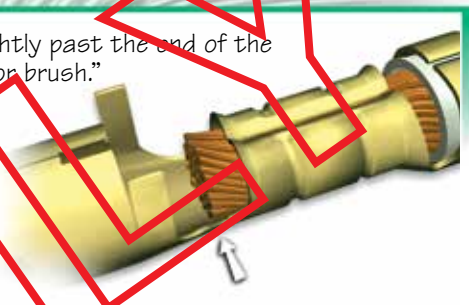


Conductor Brush 5.1.5

Class 1, 2, 3 Target Condition

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

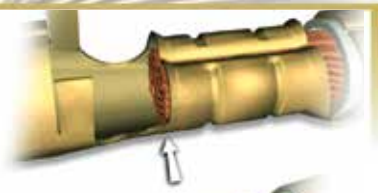
The conductor strands forming the brush are kept together as a group and are not flared out.



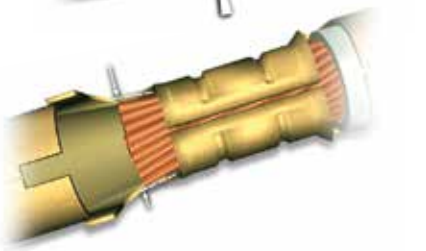
Class 1, 2, 3 Acceptable

Conductor strands **are flush with** the end of the conductive crimp area.*

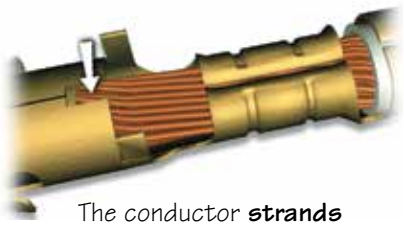
*Less than flush to end of bellmouth is a Defect, Class 1, 2, 3.



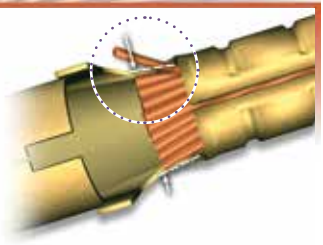
Conductor strands are flared but ***do not extend*** beyond rim of crimp barrel.



Class 1, 2, 3 Defect



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



Any conductor strands **extending outside of the crimp barrel**.

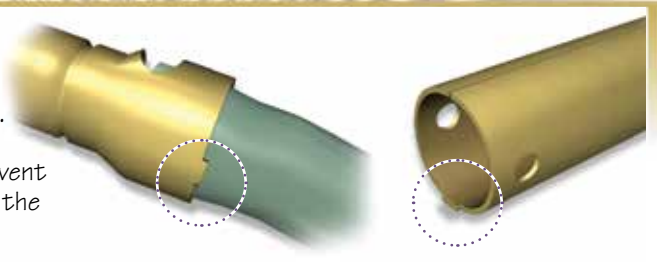
Carrier Cutoff Tab
5.1.6

Crimp
Open Barrel

Class 1, 2, 3 Acceptable

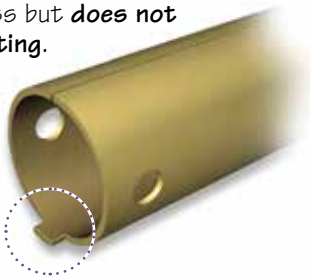
No damage to contact or terminal.

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



Class 2, 3 Process Indicator

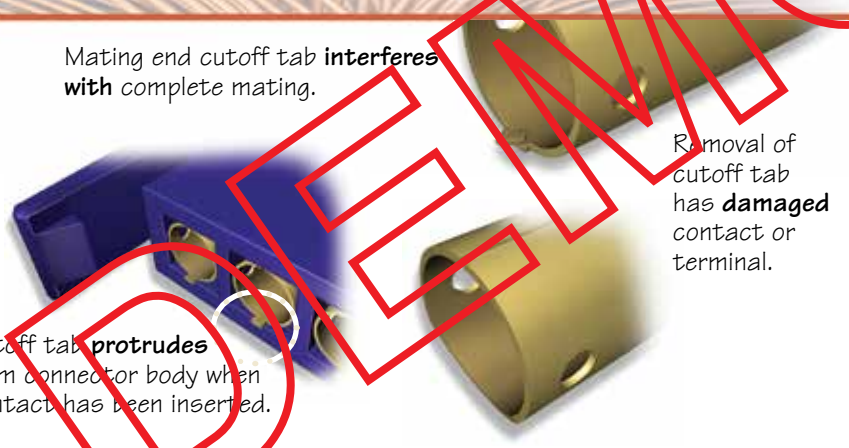
Cutoff tab length at mating end is greater than twice its thickness but **does not impede mating**.



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 **interferes with** complete mating.



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

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

Contact/terminal is otherwise **damaged** and does not meet form, fit, function or reliability requirements.

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

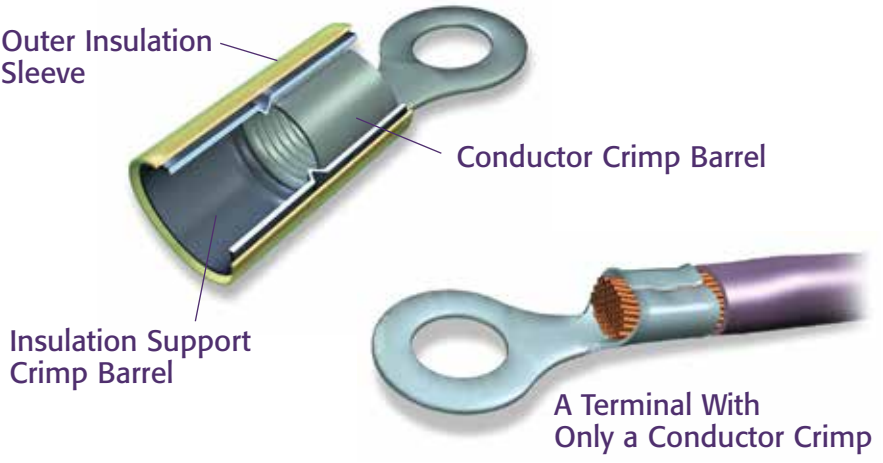
refers to the mechanical compression of the metal contact around the conductor. This is what creates the continuous conductive electrical path.

Bellmouth

is the flare that is found on both edges of the conductor crimp, acting as a tunnel for the end of the wire strands. This funnel 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
5.2.2

Crimp
Closed Barrel

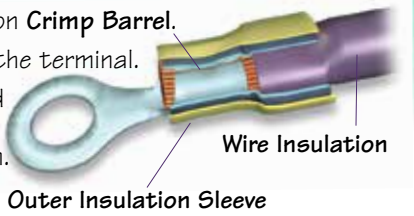
Class 1, 2, 3 Target Condition

Wire insulation extends into the Insulation **Crimp Barrel**.

Outer (terminal) insulation is secure to the terminal.

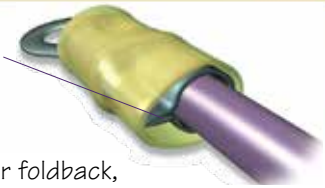
The insulation crimp is evenly formed and contacts the wire insulation providing support without damaging the insulation.

Terminal insulation is not damaged.



Class 1, 2, 3 Acceptable

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



No damage to terminal insulation.

Terminal insulation is secure (centered) on the terminal.

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

Class 1, 2, 3 Defect

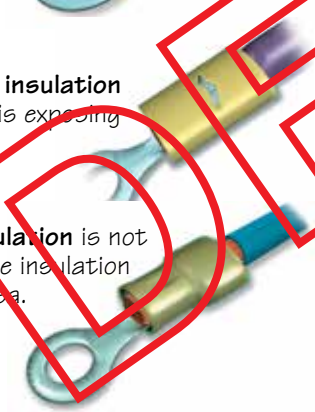
Outer insulation of terminal is not secure on the terminal.

Filler wire extends beyond edge of the terminal insulation.

Terminal insulation damage is exposing metal.

Wire Strands folded back or visible in the insulation crimp.

Wire insulation is not within the insulation crimp area.



Insulation **support crimp** does not support the wire.

Conductor Crimp
5.2.3

Class 1, 2, 3 Target

Conductor strands (and filler if specified) protrude slightly past the end of the conductor crimp.

All conductor strands are contained in the conductor crimp area.

Crimp centered on the conductor crimp area.

Bellmouth is evident at each end of the conductor crimp area.

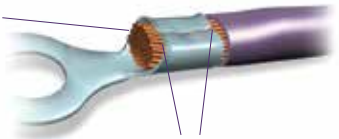
No damage to terminal insulation. Multiple leads extending past the bellmouth are even.

Conductor Crimp

Class 1, 2, 3 Acceptable

Multiple leads extend past the bellmouth but may not be equal in length.

Conductor strands do not extend into the mating area of the terminal and are flush with the end of the bellmouth.



Bellmouth is evident at each end of the conductor crimp area.

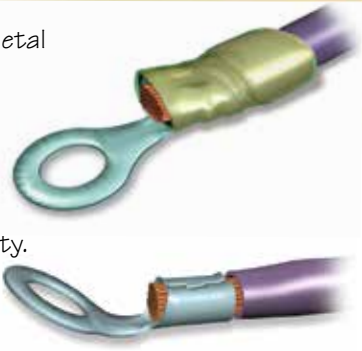
Class 1, 2 Acceptable
Class 3 Process Indicator

Terminal insulation damaged not exposing metal nor affecting its intended application.

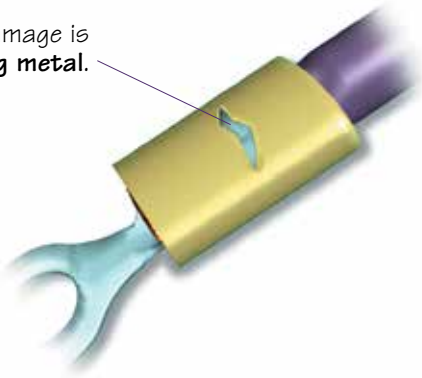
Conductor crimp not centered but located on crimp barrel.

Crimp indentations not uniform, but does not effect form, fit, function or reliability.

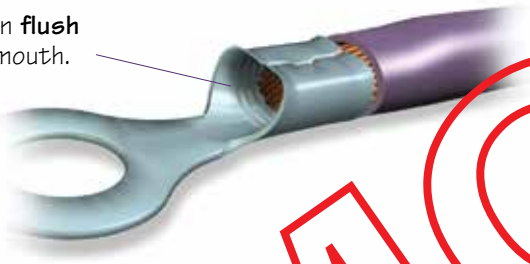
Minor deforming of the terminal does not alter its form, fit, function or reliability.



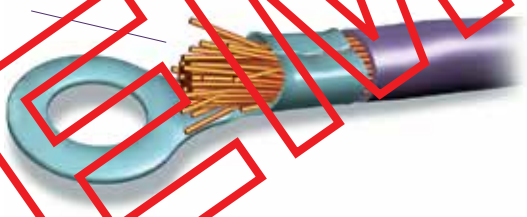
Terminal insulation damage is **exposing metal**.



Wire end is less than **flush** with end of the bellmouth.



Conductor **extends** into mating area of the terminal.



Bellmouth not evident at each end of conductor crimp area when tooling is intended to form a bellmouth (not shown).

Carrier Cutoff Tab
5.1.6

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**.

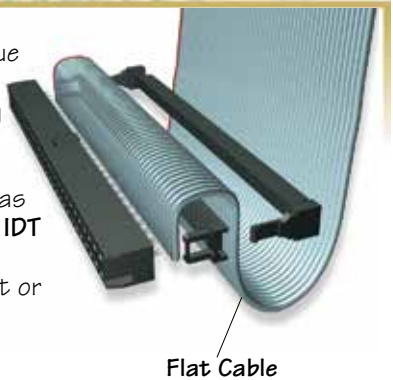
Removal of cutoff tab has **damaged terminal**.

No carrier cutoff tab visible and terminal is damaged

Insulation Displacement

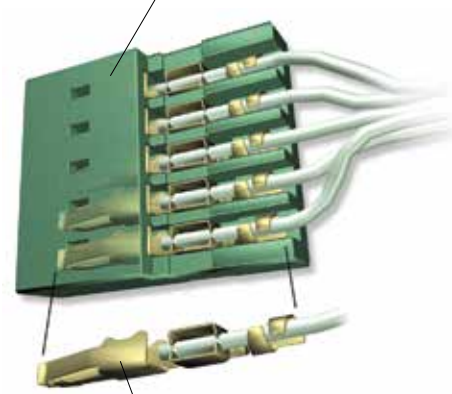
Insulation displacement is another technique for terminating an insulated wire to a connector or terminal without pre-stripping the insulation from the conductor.

Insulation displacement is also referred to as **IDC** (insulation displacement connector) or **IDT** (insulation displacement terminal), and is primarily used for mass terminations of flat or ribbon cable, as well as for individual wires.



Flat Cable

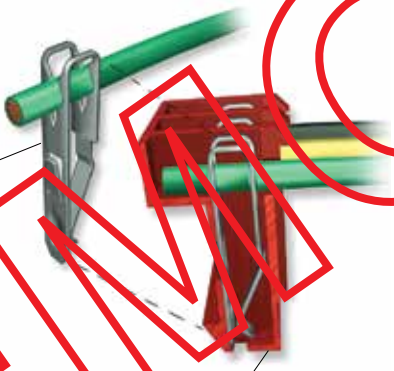
Connector Housing



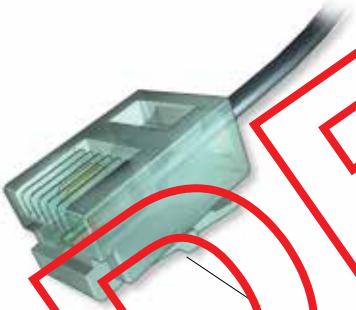
IDT contact for individual wires

The connection is made by cutting through the insulation and making contact with the conductor.

The individual IDT contact is often grouped within a connector housing, as in these examples below.



Connector Housing

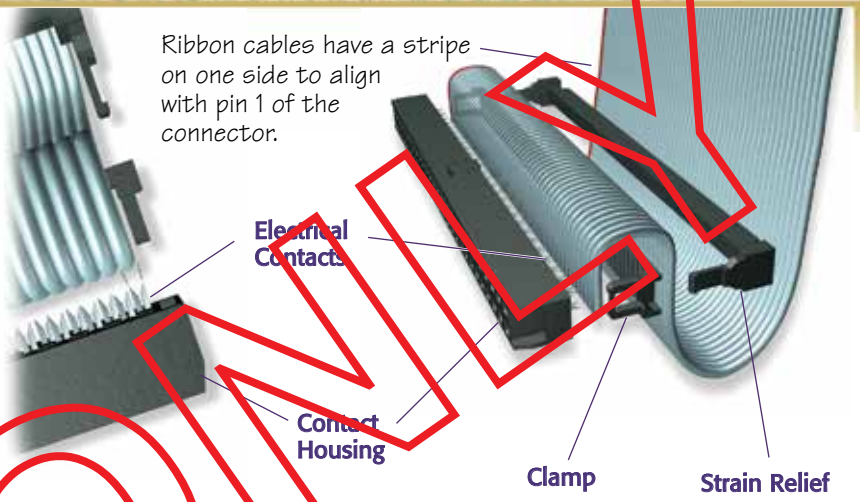


Modular Telephone Jack

This section provides the criteria for insulation displacement.

Included are mass termination of flat or ribbon cable and individual termination of discrete wires.

Mass Termination of Ribbon Cable



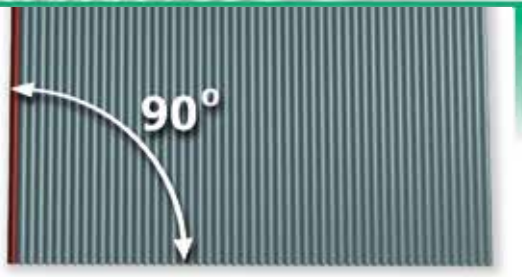
Cable End Cutting
6.1.1

Class 1, 2, 3 Target Condition

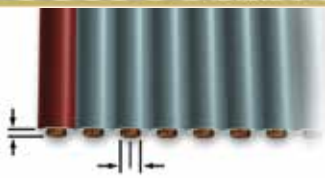
The cable is cut perpendicular to the cable edge.

Cable is cut straight with no visible variation such as waviness or unevenness.

No conductor strands protrude beyond the insulation of the cable.

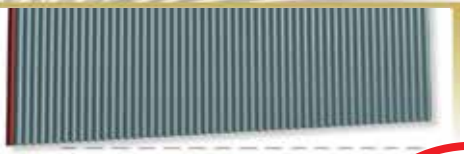


Class 1 Acceptable
Class 2, 3 Process Indicator



Conductor strand protrusion from the end of the cable **is less than or equal to** half the cable thickness.

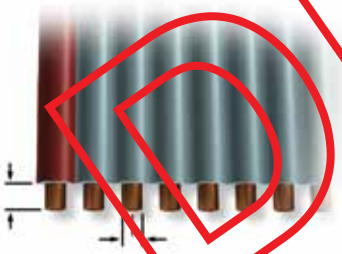
Class 1, 2, 3 Acceptable



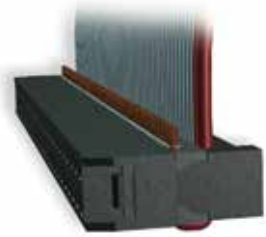
The cable end is cut so that it allows compliance to all other assembly requirements.

Class 1, 2, 3 Defects

There is **uneven or wavy cutting** of the cable end so that it does not comply to any other assembly requirements.



Conductor strand protrusion from the end of the cable is **more** than half the cable thickness, or violates **minimum electrical clearance** when assembled.



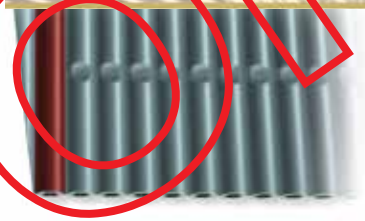
Cable Notching 6.1.2

Class 1, 2, 3 Target Condition

Notches are cut parallel to the conductors and do not reduce the wire insulation.

The notch length and width allows correct connector mounting including strain relief clips or covers if used.

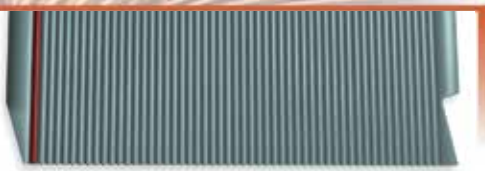
Class 1, 2, 3 Acceptable



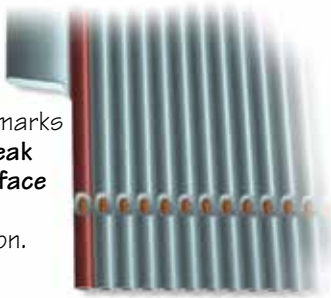
Tooling marks that ***do not break*** the surface of the insulation.

Variations in the notch cuts ***do not interfere*** with the mounting and crimping of the connector or reduce conductor insulation.

Class 1, 2, 3 Defects



Variations in the notch cuts interfere with the mounting and crimping of the connector or reduce conductor insulation.



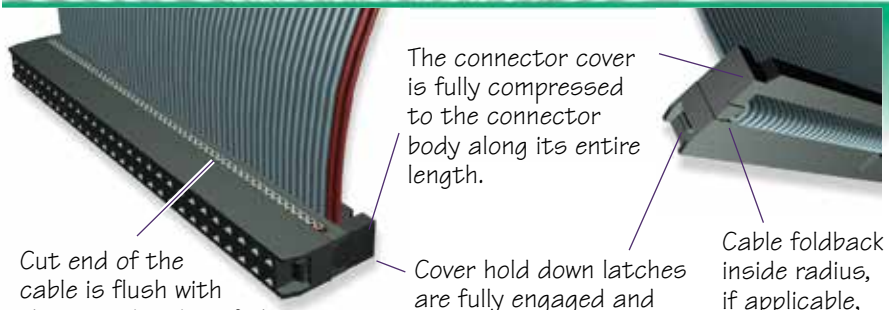
Tooling marks that ***break the surface*** of the insulation.

Notching that ***cuts, nicks or exposes*** the conductors.

Connector Position 6.1.4

Insulation Displacement Mass Termination, Flat Cable

Class 1, 2, 3 Target Condition



The connector cover is fully compressed to the connector body along its entire length.

Cut end of the cable is flush with the outside edge of the connector body.

Cover hold down latches are fully engaged and latched.

Cable foldback inside radius, if applicable, is two cable thicknesses.

Ribbon cable wires are aligned with the center of the piercing terminals.

Color reference stripe (or lowest number conductor) on flat cable is aligned with pin one.

Class 1, 2, 3 Acceptable

The cable end is flush or extends beyond the outside edge of the connector one cable thickness or less and does not violate minimum electrical clearance.

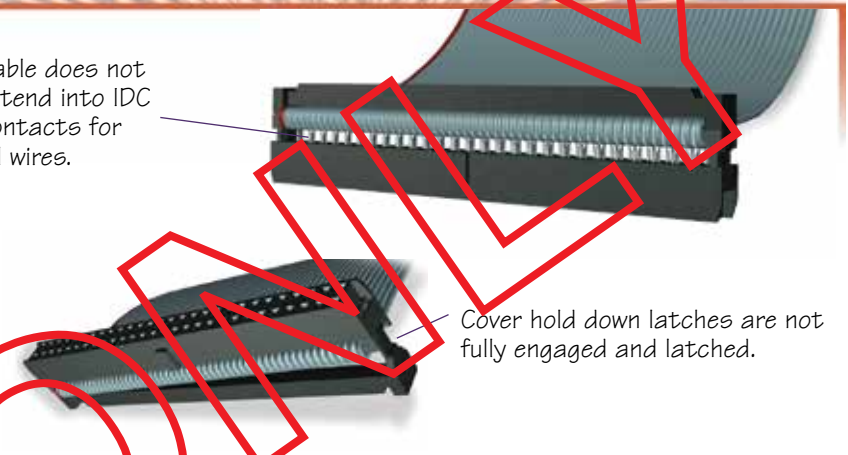
Cable foldback inside radius, if applicable, is flush with connector body and does not interfere with installation of the connector.

Minor tooling marks that do not break the surface of the insulation material of the conductor or cable.

Class 1 Acceptable
Class 2, 3 Defect

Cable extends beyond the edge of the connector greater than one thickness of cable.

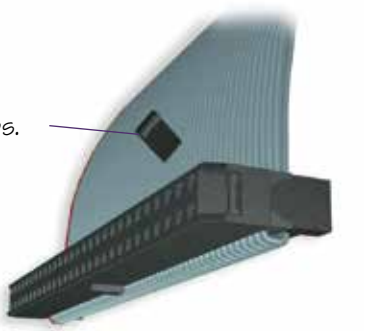
Cable does not extend into IDC contacts for all wires.



Cover hold down latches are not fully engaged and latched.

Exposed wires violate minimum electrical clearance (not shown).

Any broken cover hold down latches or barbs.



Ribbon cable wires are misaligned with the piercing terminals, or shorted together via the piercing terminals (not shown).

Cable foldback, if applicable, interferes with the mechanical fit of the connector.

Color reference stripe on ribbon cable not aligned with pin one (not shown).

Connector Skew 6.1.5

Class 1, 2, 3 Target Condition

Connector is aligned perpendicular to the edge of the flat cable.

Cable end is flush along the entire length of the outside edge of the connector.

All conductors are centered within the v-notch of the connector contacts.

Class 1, 2, 3 Acceptable

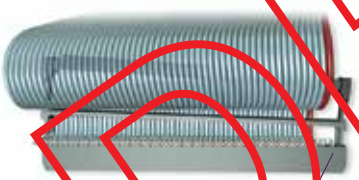
Connector **is aligned** so that all conductors are centered in their respective v-notches of the flat cable.

Shown here before final assembly

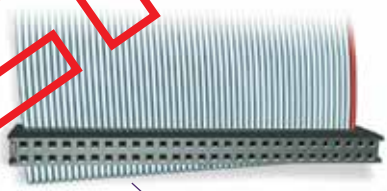
Class 1, 2, 3 Defects

Connector **misalignment** prevents contact of all wires to the IDC contacts, or permits shorting of conductors in the IDC contact area, or causes wire damage during crimping.

Connector misalignment permits **shorting of conductors** in the IDC contact area.



Connector **misalignment** prevents assembly of connector cover.

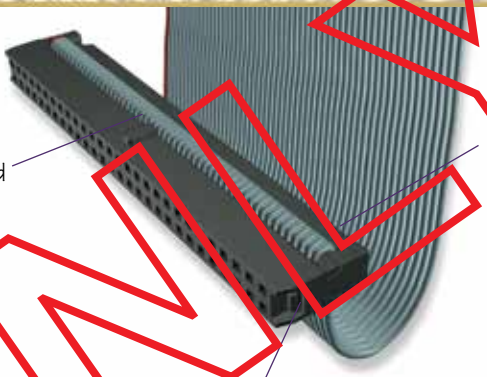


Edge of the cable is **not parallel** to the connector.

Connector misalignment causes **wire damage** during crimping.

Connector Retention
6.1.6

Class 1, 2, 3 Acceptable

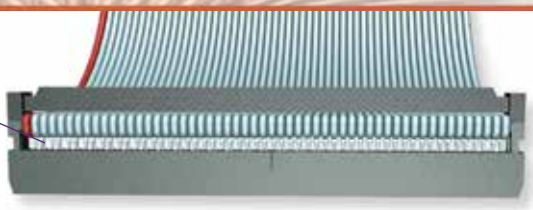


Wires are retained in the connector.

Strain relief features of the connector, if applicable, are utilized.

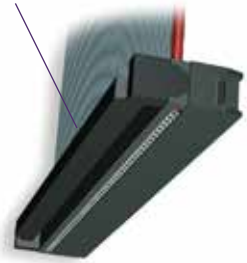
Where present, connector locking tabs are properly engaged.

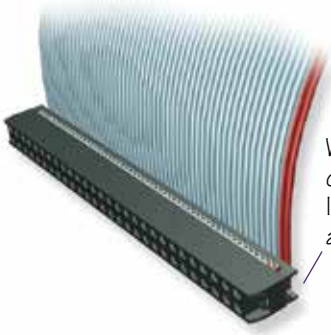
Class 1, 2, 3 Defects



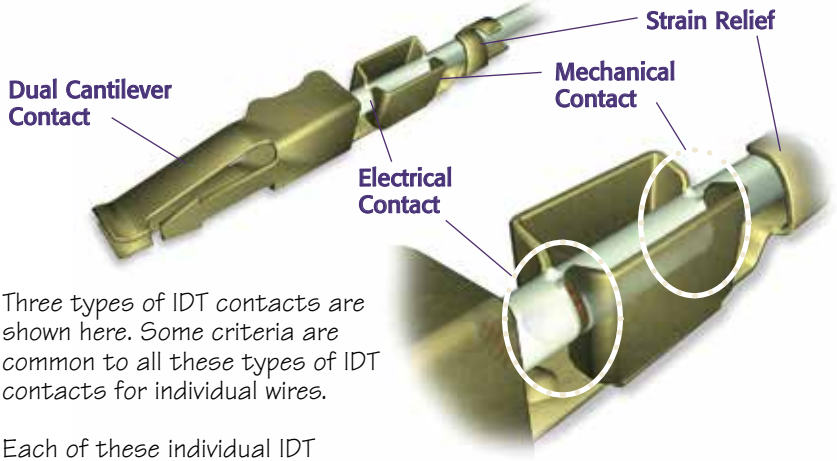
Wires are **not retained** in the connector.

Strain relief features of the connector, if applicable, are **not utilized**.



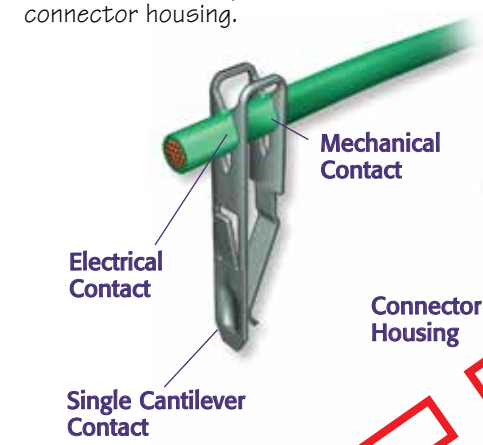


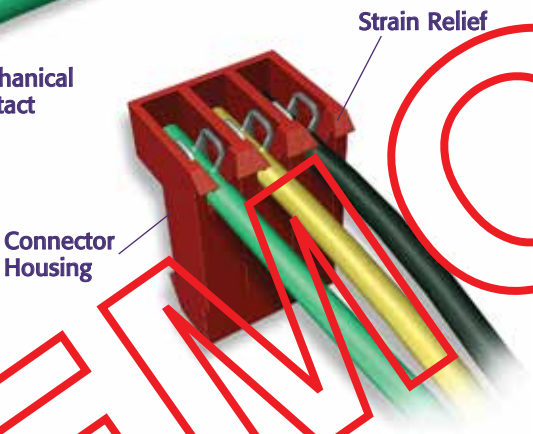
Where present, connector locking tabs are **not engaged**.

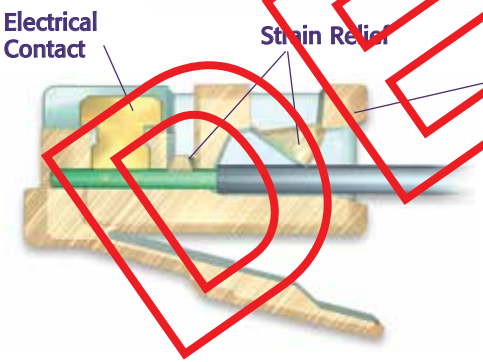


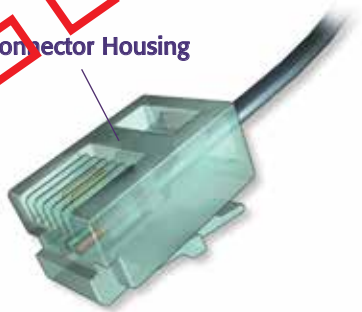
Three types of IDT contacts are shown here. Some criteria are common to all these types of IDT contacts for individual wires.

Each of these individual IDT contacts are grouped within a connector housing.





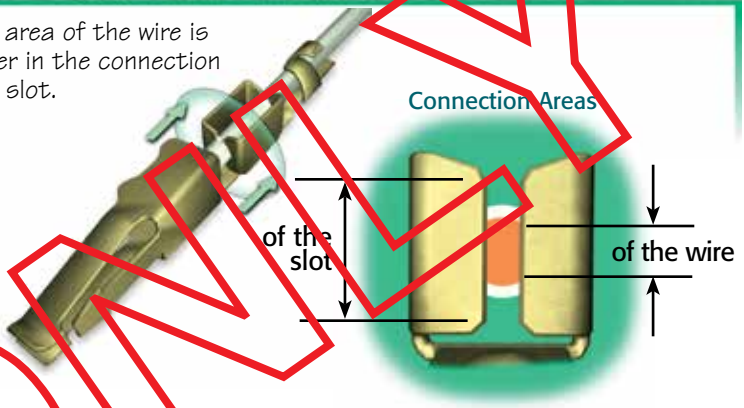




Position of Wire on Contacts
6.2.2

Class 1, 2, 3 Target Condition

Connection area of the wire is in the center in the connection area of the slot.

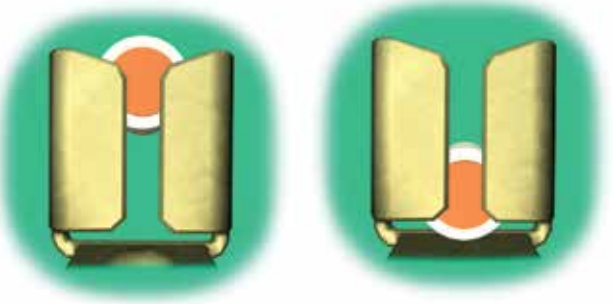


Class 1, 2, 3 Acceptable

Connection area of the wire is completely in the connection area of the slot.

Class 1, 2, 3 Defects

Conductor is not completely within the connection area of the slot.*

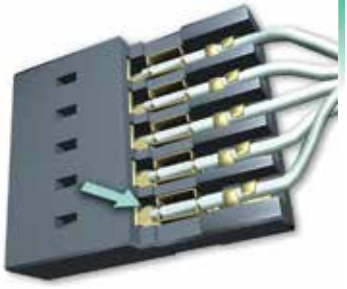


*Also applies to front and back wire slots of a dual slot contact.

Overhang of Wire
6.2.3

Class 1, 2, 3 Target Condition

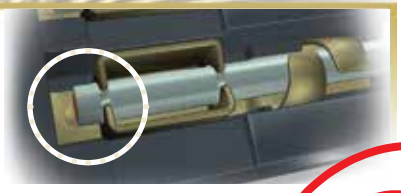
Overhang of the wire extends to the far edge of the IDC connectors.



Class 1 Acceptable

Wire end is **flush** with electrical (second) contact.

Class 2, 3 Acceptable



Overhang of the wire is ***equal or greater than*** half the overall wire diameter.

Class 1, 2, 3 Defects

Wire ***does not pass through*** both IDC contacts.

Exposed conductors violate minimum design electrical clearance.

Class 2, 3 Defects

Overhang of the wire is **less than** half the overall wire diameter.

Wire is deformed and ***extends out*** of the connector.

Wire Holder
6.2.4

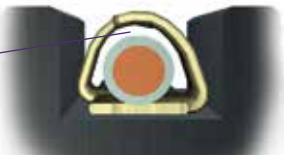
Class 1, 2, 3 Target Condition

Both holders are bent snug to insulation.

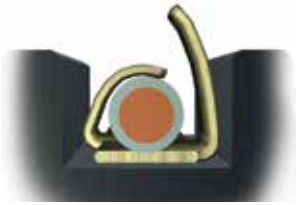
Maximum height of the holders is below the top of the housing.

Class 1, 2, 3 Acceptable

Wire is **contained** (space is permitted between insulation and holders).



Class 1, 2, 3 Defects



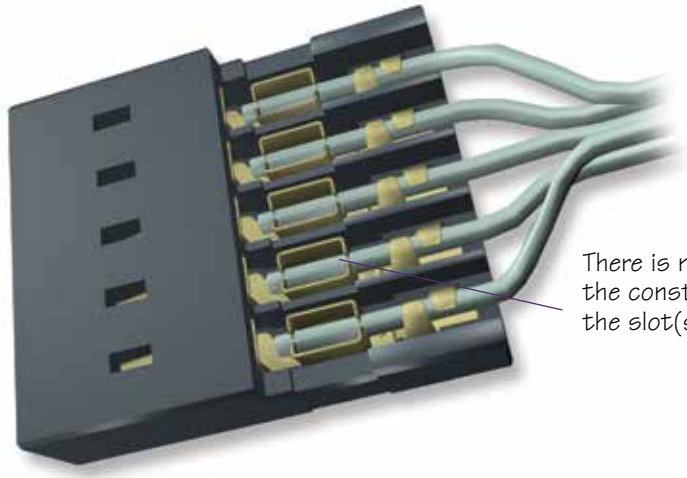
Both insulation crimp tabs are **not crimped** to prevent the wire escaping the holders.

Insulation crimp tabs violate electrical isolation distance.

Insulation crimp tabs **pierce insulation**.

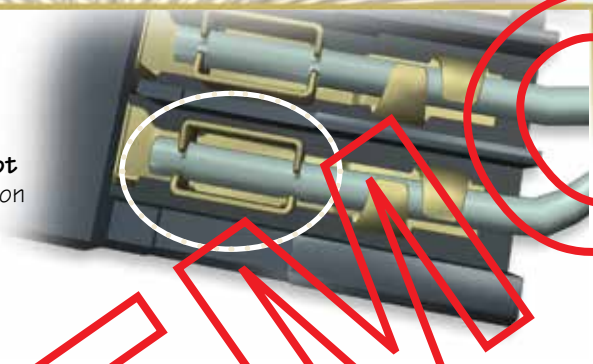
Damage in Connection Area

Class 1, 2, 3 Target Condition



There is no damage in the construction of the slot(s).

Class 1, 2, 3 Acceptable

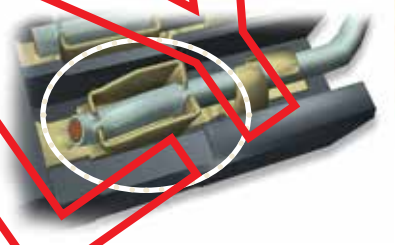


Minor deformation is **not piercing** wire insulation on both sides of the slots.

Minor damage in the holder tabs **does not affect** functionality.

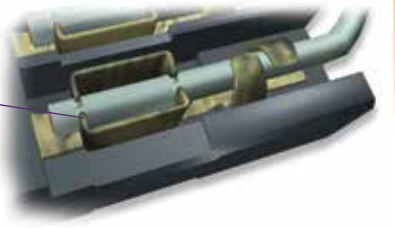
Damage in Connection Area
6.2.5

Class 1, 2, 3 Defects



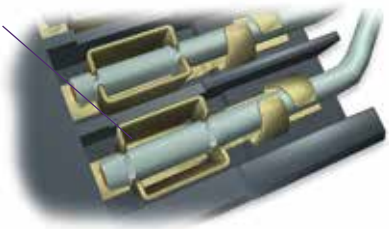
Slot(s) **twisted, bent** or otherwise damaged.

Class 2, 3 Defects



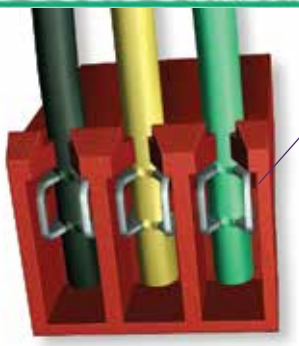
Corrosion damage or other detrimental impurities on the surface of the slot, or exposed basis metal.

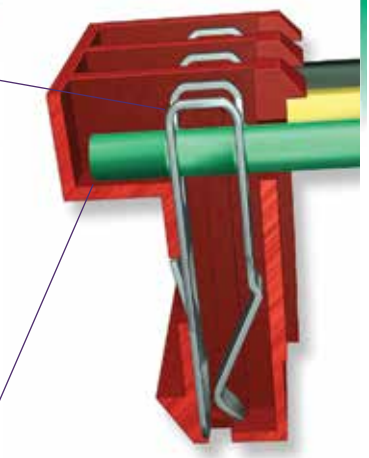
Contact damage that causes the side beams of the wire slot to **not be parallel** with each other.



End Connectors
6.2.6

Class 1, 2, 3 Target Condition

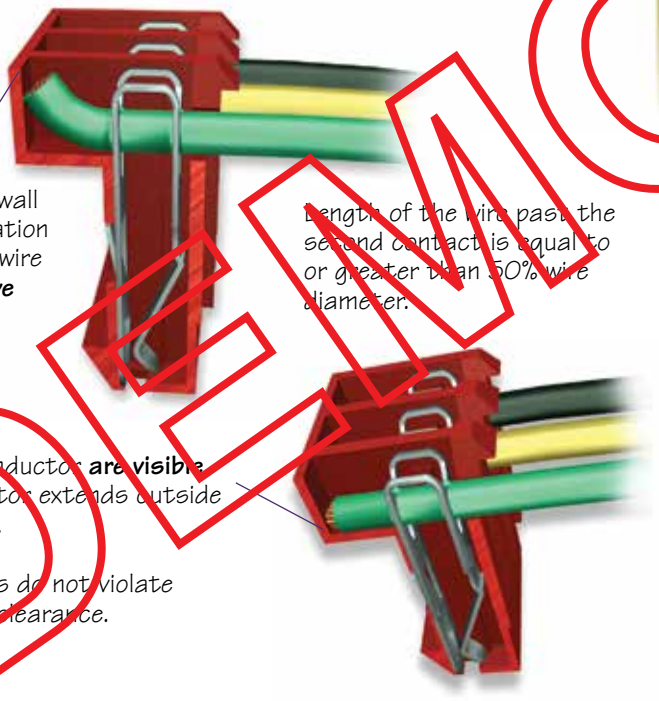




Wire is fully seated into the contact and extends to the back wall of the connector.

cut away view

Class 1, 2, 3 Acceptable



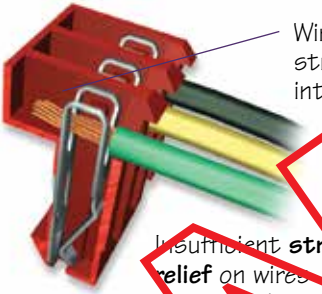
Wire touches back wall with slight deformation but the top of the wire ***does not rise above*** the back wall.

Length of the wire past the second contact is equal to or greater than 50% wire diameter.

Portions of bare conductor **are visible** but no bare conductor extends outside the connector body.

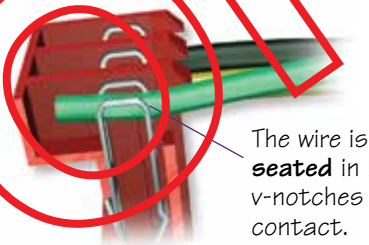
Exposed conductors do not violate minimum electrical clearance.

End Connectors
6.2.6 Class 1, 2, 3 Defects

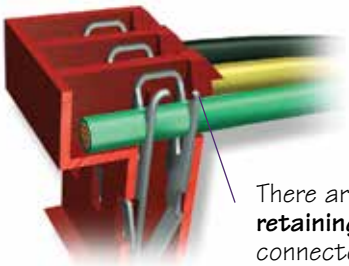


Wire is **stripped** or partially stripped before being inserted into the connector.

Insufficient **strain relief** on wires entering the connector.



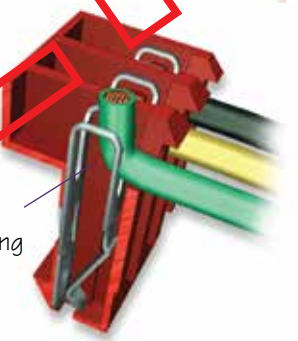
The wire is **not fully seated** in both sets of v-notches of the IDC contact.



There are **broken retaining tabs** on the connector.

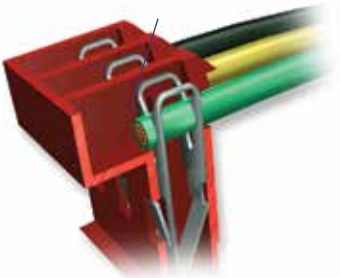
Wire size does not meet connector parameters.

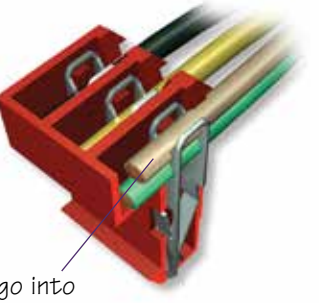
Deformation of the connector body is due to wires with oversize insulation.



The wire is **not within** the retaining tabs.

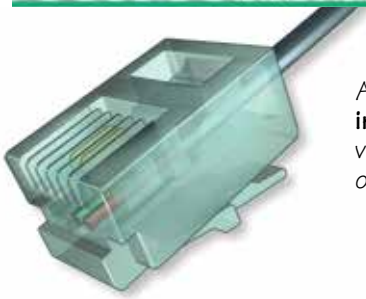
The wire extends **less than** 50% of the wire diameter past the second contact.



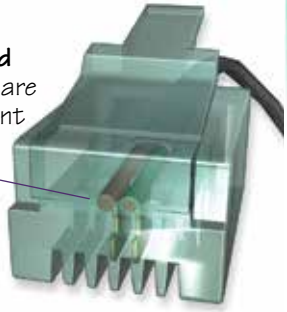


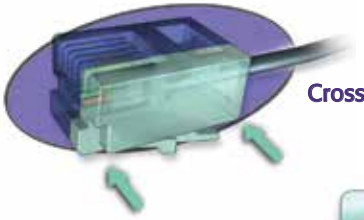
Two wires go into a single contact unless the specifications indicate that this is acceptable.

Class 1, 2, 3 Target Condition



All wires are **bottomed in the connector** and are visible through the front of the connector.

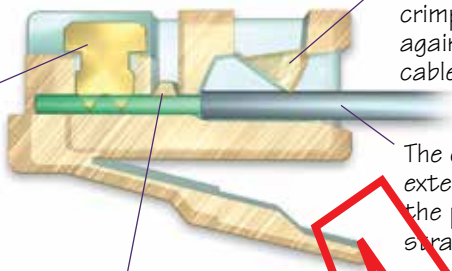




Cross-Section View

The **primary strain relief** is crimped tightly against the cable jacket.

The **terminals** are crimped so that no part of the contacts are above the top of the plastic dividers between the contacts.

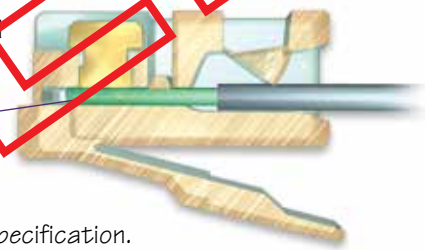


The **cable jacket** extends past the point of the strain relief.

The **secondary strain relief** is crimped so that it is in contact with the insulation.

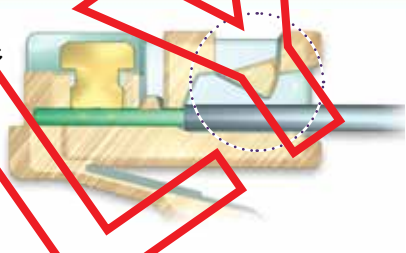
Class 1, 2, 3 Acceptable

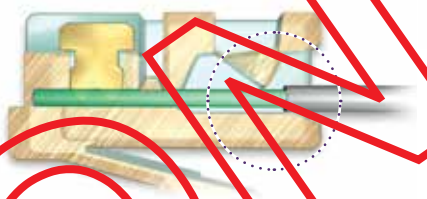
Wires are not bottomed but all are within 0.5 mm [0.02 in] or less of the end wall but all are **inserted at least past** the terminal.



Terminals meet the connector manufacturer's crimp height specification.

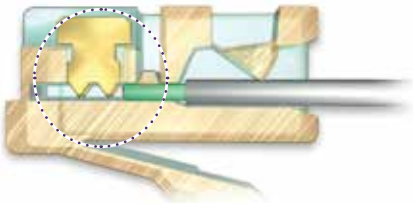
The primary strain relief is **not in tight contact** against the cable jacket or is not latched.

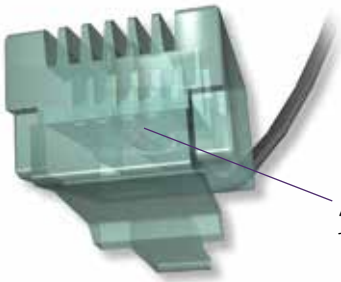




The cable jacket **does not extend past** the primary strain relief.

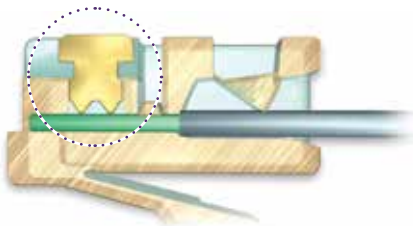
Wire ends are not within 0.5 mm [0.02 in] or less of the end wall, or are **not inserted past** the terminal.

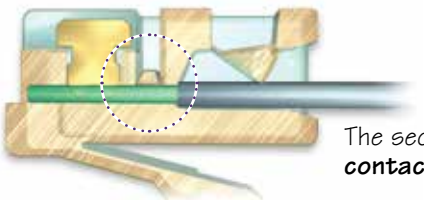




All wire ends are **not visible** through the face of the connector.

The terminals are **not crimped sufficiently** and extend above the top of the plastic dividers between the contacts.



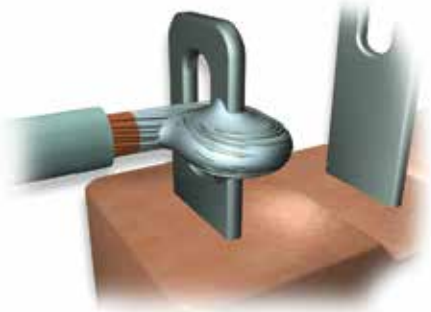


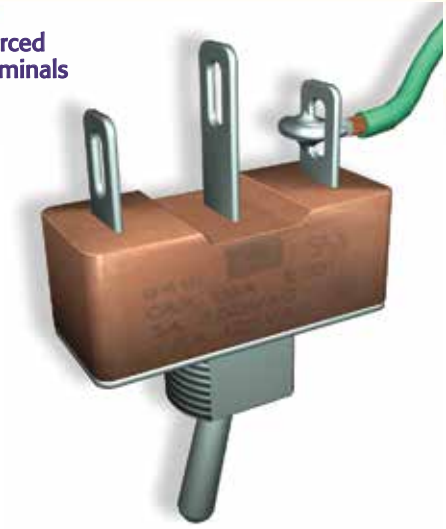
The secondary strain relief is **not in contact** with the wires or is not latched.

Soldering Terminals

This section provides the criteria for lead tinning, forming, placement and soldering wires to the two most common terminals – cup and pierced.

Pierced Terminals

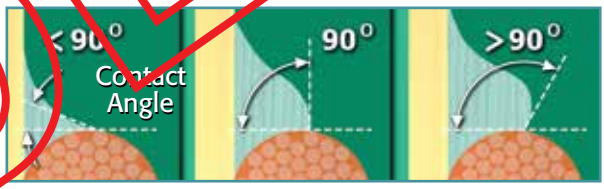




Cup Terminals

Class 1, 2, 3 Acceptable

The acceptable solder connection must indicate evidence of wetting and adherence where the solder blends to the soldered surface, forming a **contact angle of 90° or less.**



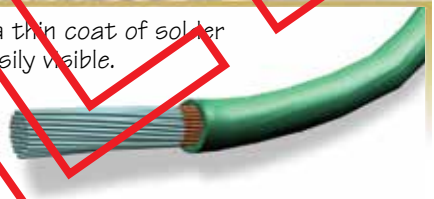
Exception:
Wetting angles exceeding 90° are acceptable when created by the solder contour extending over the edge of the solderable termination area.

Wire Tinning
4.4

Wires used for soldering terminals require *tinning*. Tinning assures that the wire to be soldered has a uniform and solderable surface. Tinning also fuses the wire strands together so they can be formed without the separation of the individual strands.

Class 1, 2, 3 Target

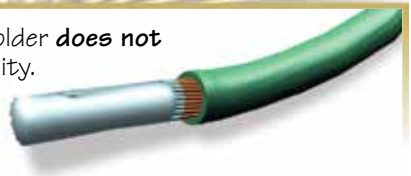
Stranded wire is uniformly coated with a thin coat of solder with the individual stands of the wire easily visible.



Class 2, 3 Process Indicator

Strands are not discernible but excess solder **does not interfere** with form, fit, function or reliability.

Solder **does not penetrate** to the inner strands of the wire.

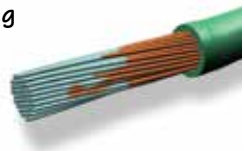


Class 2, 3 Defect

Stranded wire is **not tinned** prior to attachment to terminals or forming splices.

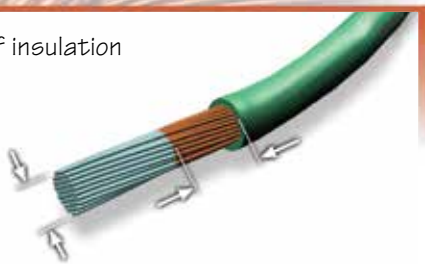
Solder does not wet the tinned portion of the wire.

Tinned wire has **pinholes, voids** or **dewetting/nonwetting** exceeding 5% of the area required to be tinned.



Class 1 Acceptable
Class 2 Process Indicator
Class 3 Defect

Length of **untinned strands** from end of insulation is **greater than** one wire diameter.

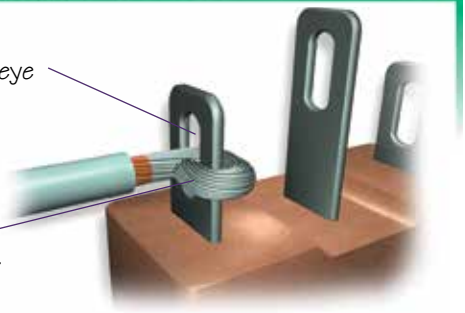


Wire Wrap
4.8.4.1

Class 1, 2, 3 Target Condition

Wire passes through the eye of the terminal.

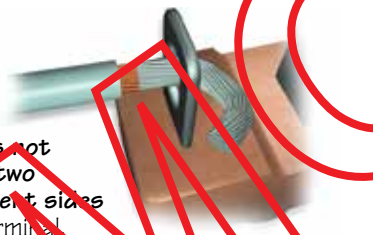
Wire is wrapped to at least two nonadjacent sides of the terminal.



Class 1 Acceptable
Class 2, 3 Defects

Wire **does not pass through** the eye of the terminal.

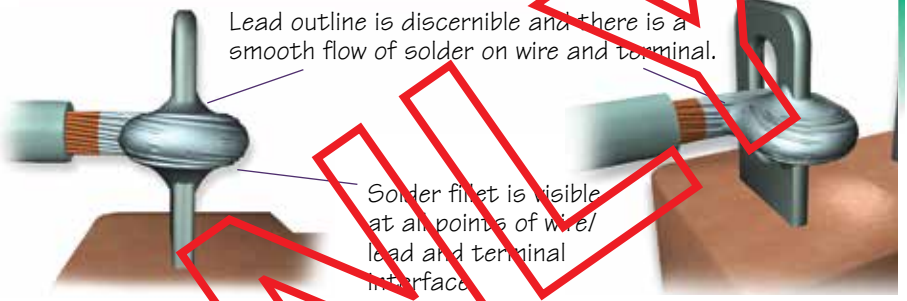
Wire **does not contact two nonadjacent sides** of the terminal.



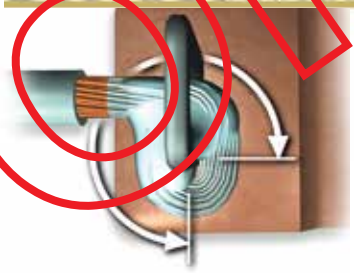
Class 1, 2, 3 Defects

Wire end **violates minimum electrical clearance** to non-common conductor.

Solder Connection
4.8.4.2



Class 1, 2, 3 Acceptable



Solder fillet joins the wire to the terminal for **at least 75%** of the wire and terminal interface for wraps of 180° or more.

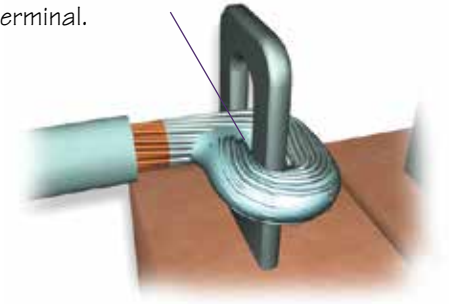
Solder fillet joins the wire to the terminal **for 100%** of the wire and terminal interface for wraps less than 180°.

Class 1, 2, 3 Defect

Less than 100% wetting of the lead to terminal contact when wrap is less than 180°.

Less than 75% wetting of the lead to terminal contact when the wrap is 180° or more.

Solder is **not wetted** to the terminal.



See IPC-A-610 for additional requirements on solder fillet depression.

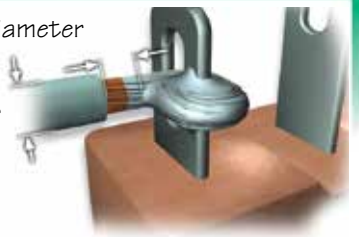
Insulation Clearance 4.5.1

Soldered Pierced Terminal

Class 1, 2, 3 Target Condition

There is an insulation clearance of one wire diameter between the end of the insulation and the top of the solder fillet.

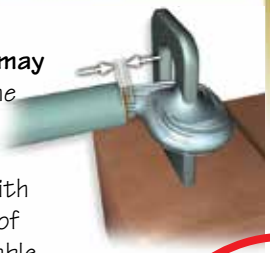
One Wire Diameter



Class 1, 2, 3 Acceptable

The insulation clearance is two wire diameters or less including insulation or 1.5 mm [0.060 in] (whichever is greater), but **does not permit** violation of minimum electrical clearance to adjacent conductors.

The wire insulation **may contact** the solder, but does not interfere with formation of an acceptable connection.



Class 1 Acceptable
Class 2 Process Indicator
Class 3 Defect

The insulation clearance is greater than two wire diameters or 1.5 mm [0.060 in], whichever is greater, but **does not permit** shorting to adjacent conductor.

Class 1, 2, 3 Defect

Insulation clearance **permits shorting** to adjacent conductors.

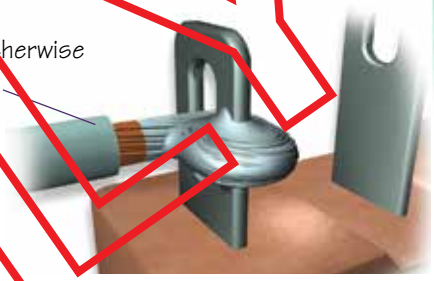
Insulation interferes with formation of solder connection.
Insulation is embedded or covered with solder (Acceptable, Class 1.)

Insulation Damage
4.5.2

Soldered Pierced Terminal

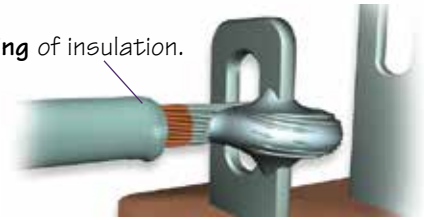
Class 1, 2, 3 Target Condition

Insulation is not melted, charred or otherwise damaged from the soldering process.



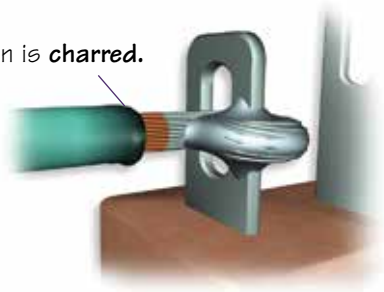
Class 1, 2, 3 Acceptable

Slight melting of insulation.



Class 1, 2, 3 Defects

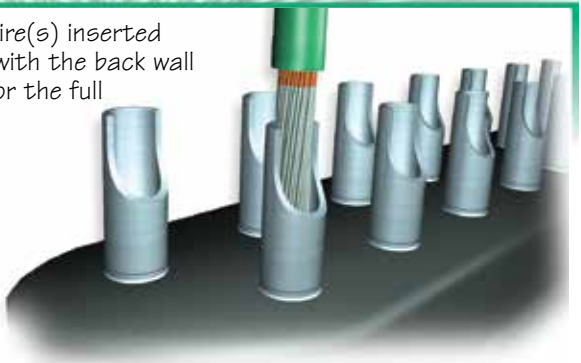
Insulation is **charred.**



Wire Position
4.8.6.1

Class 1, 2, 3 Target Condition

Solder cups having the wire(s) inserted straight in and contact with the back wall or other inserted wires for the full depth of the cup.



Class 1, 2, 3 Acceptable

Wire(s) inserted for full depth of cup, in some contact with back wall* and **does not interfere** with subsequent assembly operations.

Conductor strands **not cut** or modified to fit in terminal.

Multiple conductors are **not twisted** together.

*Class 2, 3 Process Indicator.

Class 1, 2, 3 Defects

Multiple conductors are **twisted** together.

Wire placement **interferes** with subsequent assembly operations.

Wire strands outside of the cup.

Wires not inserted to the full depth of the cup.* (Not visually inspectable, determined through process control).

*Acceptable Class 1.
Process Indicator Class 2.
Defects Class 3.

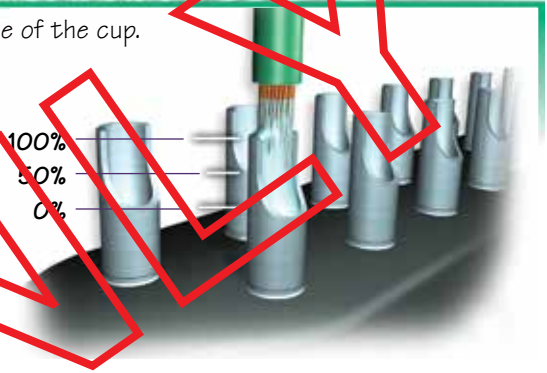
Solder Connection 4.8.6.2

Class 1, 2, 3 Target Condition

Solder wets the entire inside of the cup.

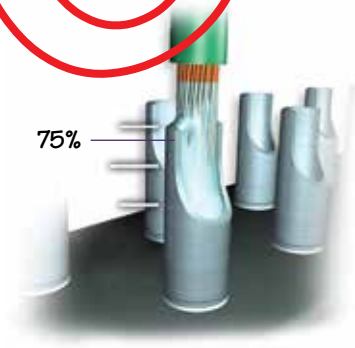
Solder fill is **100%**.

Outside of cup is free of solder.

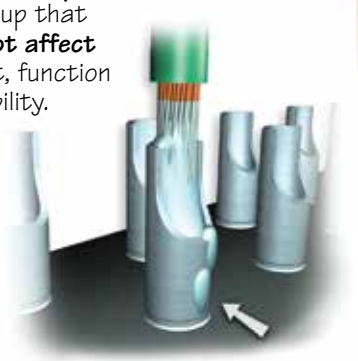


Class 1, 2, 3 Acceptable

Solder fill is **75% or more**.

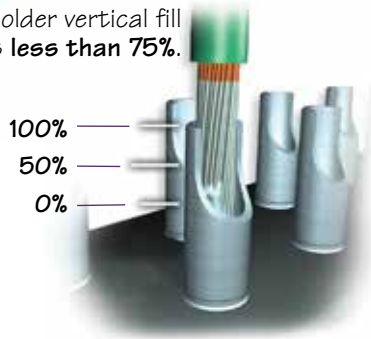


Solder **buildup** on the outside of the cup that ***does not affect*** form, fit, function or reliability.

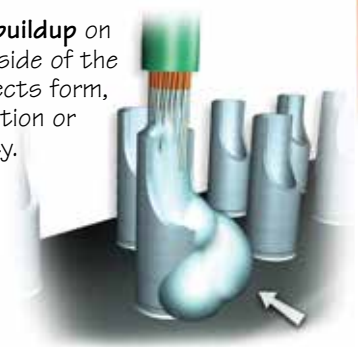


Class 1, 2, 3 Defects

Solder vertical fill is **less than 75%**.



Solder **buildup** on the outside of the cup affects form, fit, function or reliability.



See IPC-A-620C Section 4.8.62 for more information on solder fillet depression.

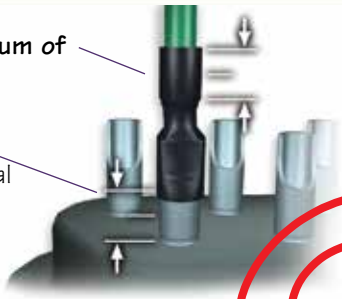
Insulation Sleeving 4.6

Class 1, 2, 3 Target Condition

Insulation sleeving overlaps the connector terminal and extends over the wire insulation four wire diameters.

Insulation sleeving is one wire diameter from the point where the connector terminal enters the connector insert.

Class 1, 2, 3 Acceptable



Insulation sleeving overlaps the connector terminal and the wire insulation by a **minimum of two** wire diameters.

Insulation sleeving is more than half the wire diameter and **not more than** two wire diameters from the point where the terminal enters the connector insert.

Multiple pieces of sleeving overlap each other by at least 3 wire/lable diameters.

Class 2, 3 Defects

Insulation sleeve is **damaged (split or charred)**.

Sleeving overlaps the wire insulation by **less than two** wire diameters.

Insulation sleeving is **more than two** wire diameters from the point where the connector terminal enters the connector insert.

Insulation sleeve prevents movement of floating contact (when movement is required).

Multiple pieces of sleeving overlap less than 3 wire/cable diameters.

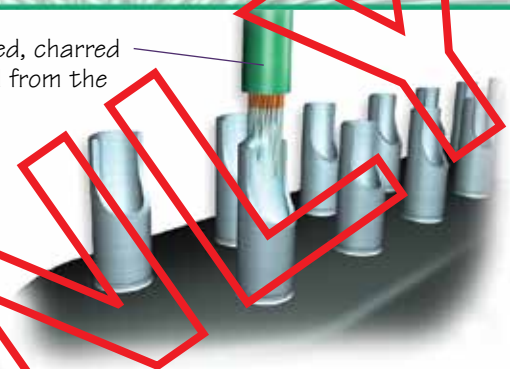
Insulation sleeve is **loose** on the terminal

Insulation Damage
4.5.2

Soldered Cup Terminal

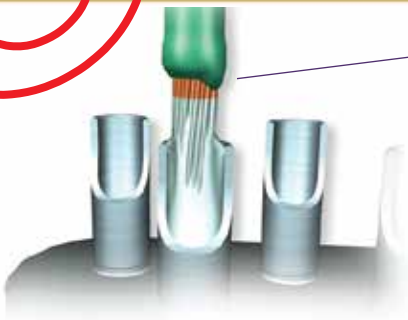
Class 1, 2, 3 Target Condition

Insulation is not melted, charred or otherwise damaged from the soldering process.



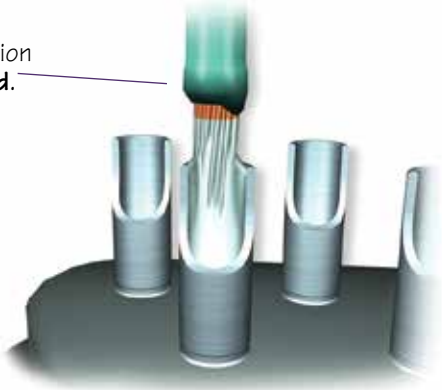
Class 1, 2, 3 Acceptable

Slight melting of insulation.



Class 1, 2, 3 Defects

Insulation **charred**.



Glossary

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 electronic 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.

Glossary

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

CUTOFF 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 from 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. Pulling 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.

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.

This reference guide does not take precedence over, or replace the requirements from any IPC Standard or Specification. While every effort has been made to represent applicable portions of the IPC-A-620 document, this manual may not cover all related requirements and is not intended for use as an industry consensus standard. IPC disclaims any warranties or guarantees, expressed or implied, and shall not be held liable for damages of any kind in connection with the information set forth in IPC-DRM-WHA.

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