

## Workmanship Standards for Pronto4 System Installations

### Introduction

This bulletin documents minimum basic workmanship practices used by Kairos Autonomi personnel and contracted labor. To ensure proper performance, these practices are expected to be employed during the installation of any Kairos hardware and any other associated hardware, such as customer additions or modifications. Some workmanship practices are included in multiple categories.

This bulletin is designed to augment, but not replace, Pronto4 installation documents. The bulletin provides an overview of basic, industry-standard, prerequisite information. For example, the first section of this document highlights the importance of using the correct tool; when a specific tool needs to be used during installation, installation documentation states what the correct tool is.

Additionally, because of general applicability, this document restates some aspects of the installation process (e.g., always disconnect the vehicle battery before working on any vehicle's electrical system).

### General Practices

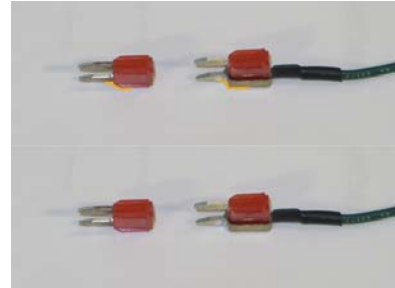
- Always use the correct tool for the job; if in doubt - ask. For example,
  - Do not use a Phillips driver on a hex socket head; use the correct type of tool.
  - Do not use a #1 Phillips driver on a #2 Phillips head screw; use the correct size tool for the component.
  - Use the correct crimp tool and die for the crimp termination contact being crimped.
  - Do NOT force hardware together. Doing so can cause cross-threading, bending of pins, stripping of screw heads, etc. If pieces do not fit together without force, separate them and then carefully try again. For example, instead of forcing a screw, back it all the way out, realign the screw with the pieces being connected, and then carefully drive in the screw.

### Vehicle Battery, Battery Cable, and Battery Connections

- Disconnect the vehicle battery before performing any work on the vehicle, to include installation of a Pronto4 Series 4 (P4S4) unit.
- Ensure the battery posts and terminals are clean and secure.
  - If battery posts are not clean, use a battery post and terminal cleaner or a wire brush to clean the posts and terminals.
  - If there is still obvious corrosion then use a cleaning compound according to package instructions (e.g. NOCO E404 Battery Cleaner and Acid Detector) to perform a chemical cleaning.

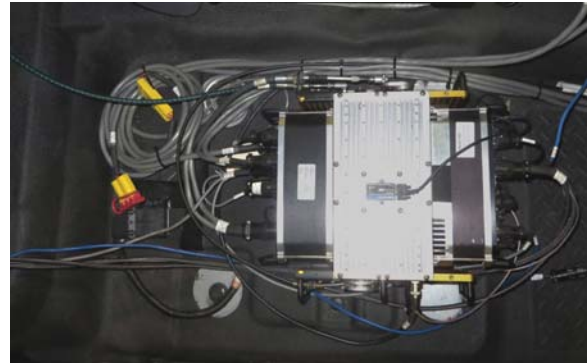


- Once the posts are clean, apply neutralizer to each post according to package instructions (e.g., NOCO NCP-2 Battery Savers).
- If battery post terminals are still not clean, replace the battery terminals.
- Ensure battery cable terminal post connections are tight and secure.
- When practical, the battery cable should be run with other cables along the center of the vehicle. If not practical the shortest route should be used.
- Ensure all fuse taps are fully seated. When a mini fuse is tapped, the shape of the fuse is changed enough that the mini fuse holders may need to be trimmed (e.g. using a rotary tool, such as a Dremel) in order for the fuse tap to fully seat.



## All Cables

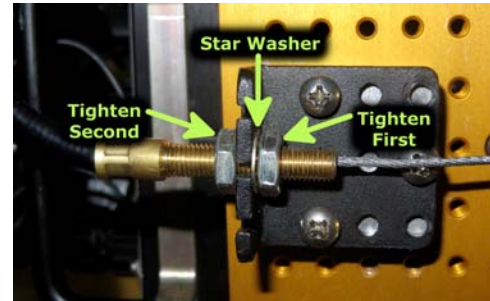
- As much as reasonably possible, all cables should be run along the center of the vehicle.
- When two or more cables are run adjacent to each other:
  - Multiple cables should be zip-tied together approximately every 6" and at any bends.
  - Excess cable loops should be aligned and zip-tied together.
- When a cable is run through the engine compartment or along an underside, the cable needs to be secured to the vehicle with a zip-tie approximately every 6" and at any bends.



- Pass-through holes in sheet metal should have edges eased and there should be either a grommet in the pass-through hole or an abrasion resistant loom, wrap, sleeve, or tube surrounding cables and wires that pass through the hole.

## Mechanical Cables

- When mechanical and electrical cables are run through the same area, the mechanical cables should be run on top of the electrical cables.
  - When routing mechanical cables, ensure they do not have any sharp angles (i.e. use wide turn radiuses).
- Manually push and pull the throttle and transmission cables to ensure there is no binding.
- Ensure there is no binding on any mechanical cable.
- For bracket nuts (i.e. a pair of nuts that secure each mechanical cable to a mounting bracket):
  - Ensure the nut with the star washer is positioned correctly and snug against the mounting bracket before securing the nut without the star washer.
  - Once the nut with the star washer is positioned correct and snug, tighten the nut without the star washer until the star washer firmly connects with the mounting bracket.



## Electrical Cables

- Excess cable should be carefully looped, with an approximate 6"-8" diameter. If the cable is not adjacent to any other cables, the loop should be zip tied in at least one point, ideally in two opposite points.
- Once the electrical integration has tied into the vehicle's enable and start functions, either a Vehicle Integration Module (VIM) or a VIM Bypass connector must be connected in order for the vehicle to be driven.



## Crimps

- Use the correct crimp connector for the job:
  - There are three types of insulation for quick disconnect crimp connector terminals: non-insulated (i.e., no insulation at all), barrel insulated (i.e., only the barrel over the wire is insulated), and fully-insulated (i.e. insulation covers the barrel and spade or coupler. Only fully-insulated disconnecting crimp terminals should be used.
  - Crimp connector terminals may or may not have heat shrink. Terminals that do have heat shrink also have adhesive inside the crimp that adheres to the cable jacket during the heat shrink process. Such terminals are referred to in this document as “environmental”.
  - Kairos recommends:
    - Molex Perma-Seal Series 19164 for environmental connectors:
      - Environmental 18-16 AWG ring terminal connectors (KA p/n CON-00434; Molex p/n 191640034)
      - Environmental 12-10 AWG ring terminal connectors (KA p/n CON-00422; Molex p/n 191640066)
      - Environmental 22-18 AWG disconnect male (KA p/n CON-00431; Molex p/n 191640015)
      - Environmental 22-18 AWG disconnect female (KA p/n CON-00432; Molex p/n 191640017)
      - Environmental 16-14 AWG disconnect male (KA p/n CON-00429; Molex p/n 191640048)
      - Environmental 16-14 AWG disconnect female (KA p/n CON-00430; Molex p/n 191640050)
      - Environmental 12-10 AWG disconnect male (KA p/n CON-00427; Molex p/n 191640075)
      - Environmental 12-10 AWG disconnect female (KA p/n CON-00428; Molex p/n 191640076)
      - Environmental 12-10 AWG splice barrel connector (KA p/n CON-00423; Molex p/n 191640056)
    - Kairos recommends Gardner Bender for non-environmental connectors:
      - Standard 22-18 AWG disconnect female (KA p/n CON-00339; Gardner Bender p/n 151F)
      - Standard 22-18 AWG disconnect male (KA p/n CON-00290; Gardner Bender p/n 151M)
      - Standard 16-14 AWG disconnect female (KA p/n CON-00338; Gardner Bender p/n 153F)
      - Standard 16-14 AWG disconnect male (KA p/n CON-00188; Gardner Bender p/n 153M)
  - Connecting crimp connectors should be of the same color and style (e.g. male and female red standard, or male and female blue environmental).



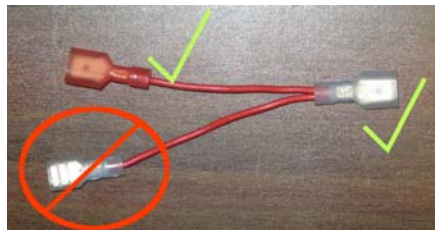
- The wire gauge determines the color of the crimp contacts:
  - 22-18 AWG wires require RED crimp contacts
  - 16-14 AWG wires require BLUE crimp contacts
  - 12-10 AWG wires require YELLOW crimp contacts

**NOTE**  
Wire color does NOT matter; only wire AWG determines the correct crimp contact.

Wire 1	Wire 2	Crimp Contact
22	none	Red
22	22	Blue
22	20	Blue
20	none	Red
20	20	Blue
20	18	Blue
18	none	Red
18	18	Blue
18	16	Blue
16	none	Blue
16	16	not recommended
16	14	Yellow
14	none	Blue
14	14	Yellow
14	12	not recommended
12	none	Yellow
12	12	not recommended
12	10	not recommended
10	none	Yellow
10	10	not recommended

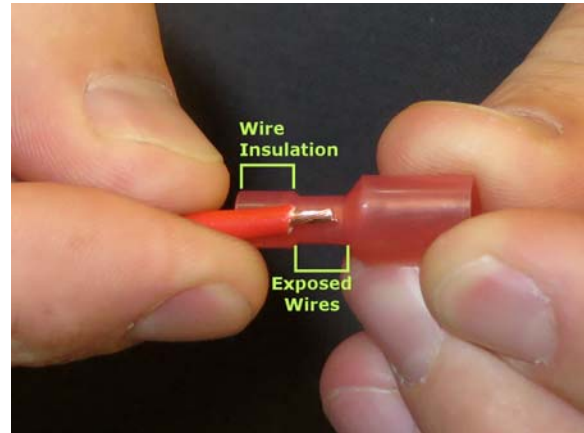
- If two wires are to be inserted into a single crimp connector, use the table to the right to determine the correct crimp connector color.

For example, when two 20AWG wires are connected into a single crimp connector, then they require a blue crimp connector.



- All of the crimp connectors should be environmental in the engine compartment or other areas where the crimp connectors may be exposed to environmental elements. If windows are removed from the vehicle then all crimp connectors should be environmental.
- Ensure the crimp connectors are in good condition:
  - No cracks in the plating or base metal.
  - No tarnishing, discoloration, or flaking of the plating
  - No base metal exposed
- Only stranded wire is to be used in crimp connectors; i.e. solid core wire is NOT to be used.
- Use the appropriate wire strip tool and strip the wire insulation according to IPC-A-610 standards. The IPC-A-610 standard can be obtained via: [https://portal.ipc.org/Purchase/ProductDetail.aspx?Product\\_code=02136f31-3a38-df11-aa66-002219545fd5](https://portal.ipc.org/Purchase/ProductDetail.aspx?Product_code=02136f31-3a38-df11-aa66-002219545fd5)
- Recommended strip tools are:
  - Klein 1011 (for 10-20 AWG)
  - Klein 11045 (for 12-20 AWG)
  - Ideal T®-7 T®-Stripper 45-125 (for 24-32 AWG)
  - Ideal Stripmaster 45-091 with L-4420 (for 10-16 AWG)

- Ensure the wire to be connected has enough insulation removed to expose wires to be crimped into the connector when the insulation is fully inserted into the crimp connector.



- Ensure the correct crimp tool is used and used properly:
  - Use only crimp tools specified in the corresponding crimp connector packaging and datasheets, for example:

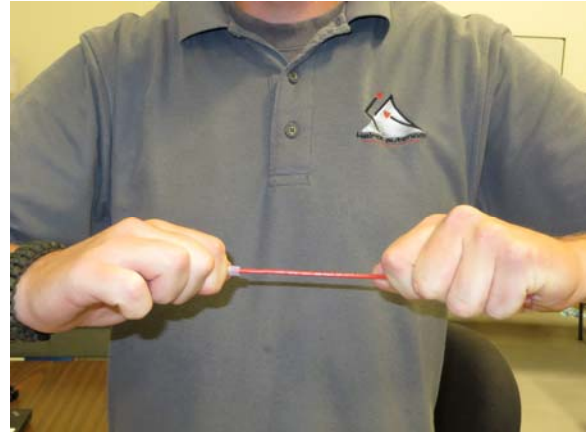
- The datasheet for Molex's 16-14 AWG environmental disconnect terminals (Mouser p/n: 538-19164-0050) specifies four crimp tools that can be used on those crimp contacts ([http://www.mouser.com/ds/2/276/0191640050\\_QUICK\\_DISCONNECTS-161446.pdf](http://www.mouser.com/ds/2/276/0191640050_QUICK_DISCONNECTS-161446.pdf)). Kairos recommends the Molex 64016-0041 ServiceGrade Hand Crimp Tool – Ratchet, with die number 4100-40.
    - The packaging and datasheet's for Gardner Bender's disconnect terminals specify a non-existent crimp tool (i.e. GRC-1610FM). A Sargent Super Crimp Tools 4100 Frame Assembly should be used for the Gardner Bender quick disconnect terminals.



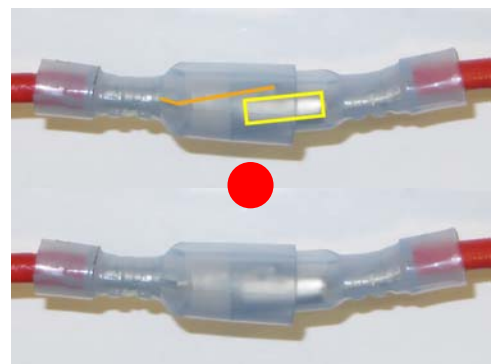
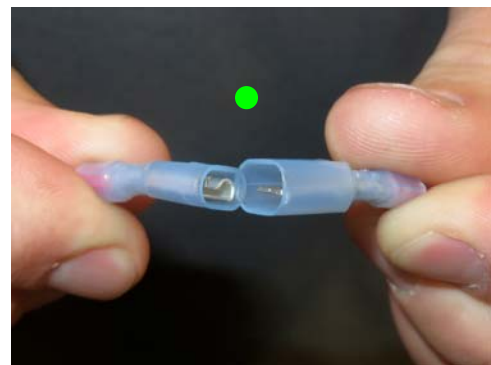
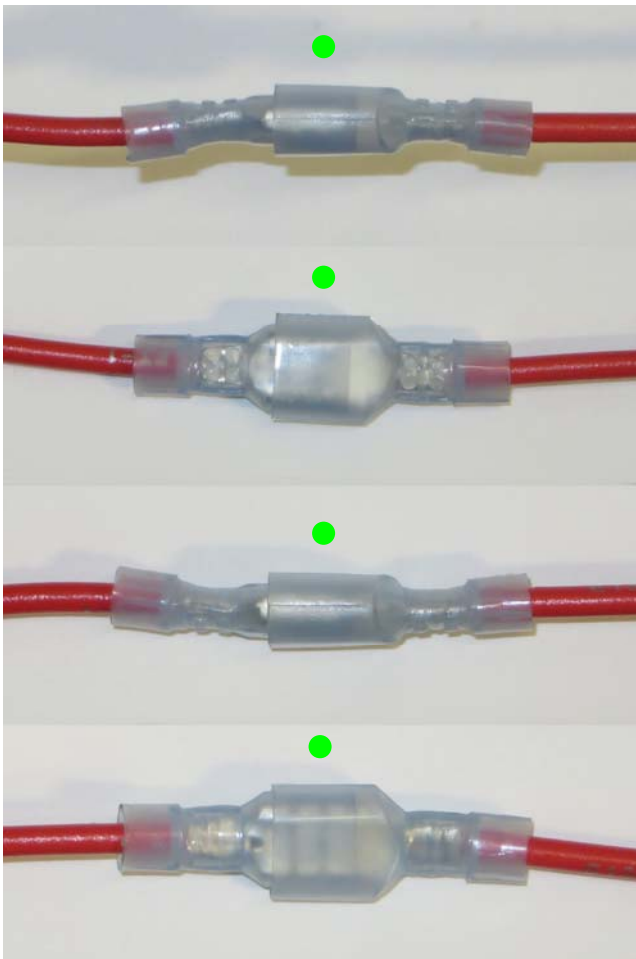
- Use the correct die for the crimp connector (e.g., the red die should be used for the red crimp terminal, the blue die for the blue crimp terminal, etc.).



- Once environmental connector have been crimped to their wire and quality checked with a manual pull test, then they can be sealed with either a heat gun or lighter.
- After crimping a connector onto a wire, perform a manual pull test. To perform a manual pull test, use average human strength to try and pull the connector from the wire. If a more precise test is desired, use a fish scale and verify the connection remains secure with 25 ft/lbs weight. If the connector is separated from the cable, discard the used contact and secure another, new contact, to the cable.



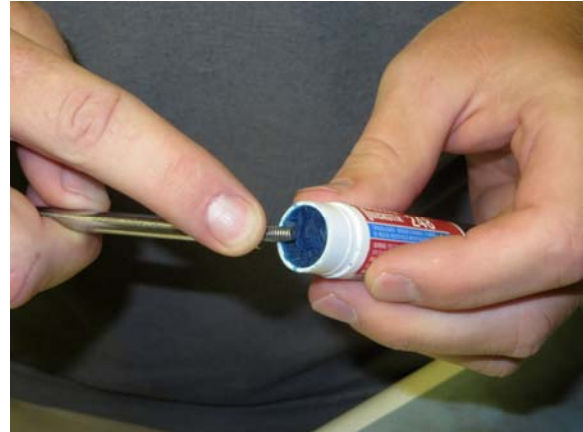
- Environmental connectors should be heated until they are fully sealed to the wire insulation.
- Ensure the male connector fully and properly seats into the corresponding female connector.





## Mechanical Connections

- When applicable use Loctite in addition to a lockwasher and Nylock nut on threaded components (e.g. screws, bolts). This includes Phillips panhead screws.
- Use Loctite with button head and flat head screws, but do NOT use lockwashers.
- Kairos recommends Loctite 248 Semi Solid Stick Medium Strength Blue Threadlocker to provide vibration resistance (<http://www.henkelna.com/product-search-1554.htm?nodeid=8797953851393>).
- All threaded components (e.g. screws, bolts), at a minimum, require the use of Loctite or a Nylock nut with a lock washer.
- Magnetic mount surfaces should be free of debris and smooth prior to application of the magnetic mount.



## Post-installation Quality Checks

- Ensure all connections are correct (i.e. connector with corresponding port) and secure (e.g., no bent pins, not at an angle, click heard/felt on connectors with click-indication, no cracks in connectors).
- Ensure no wires or cables are pinched.
- Ensure there are no nicks or other damage to wires and cables insulation.
- Ensure all pre-operational checks have been completed.

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### Contact Information

Kairos Autonomi  
498 West 8360 South  
Sandy, Utah 84070 USA  
801-255-2950 (office)  
801-907-7870 (fax)  
[www.kairosautonomi.com](http://www.kairosautonomi.com)