

Technical Reference

| General Application Notes |

There are common considerations when using APP® connectors. Additional considerations may apply based on the particular connector being used, the application, and conditions in which the connector is being used. This information is intended to provide a basic understanding and is provided for reference only. APP® connectors should be assembled and used according to the equipment manufacturer's instructions, as well as in compliance with local and international electrical codes.

The maximum amperage ratings provided in the specifications are based on use of APP® recommended assembly tooling and the maximum wire size for the connector being used. Amperage ratings are based on not exceeding the maximum operating temperature of the connector housing, factoring in an ambient temperature of 25°C or 77°F. A wire with an appropriate insulation temperature rating should be selected to meet or exceed the total connector temperature (heat rise + ambient).

As an example: if the maximum operating temperature for a connector operation is 105°C and the ambient temperature is 25°C, the maximum heat rise attributable to the connector is $105^{\circ}\text{C} - 25^{\circ}\text{C} = 80^{\circ}\text{C}$. The expected heat rise based on the connector and wire size used can be estimated using the heat rise charts, but should be confirmed by testing in the specific application with the specific wire to be used.

Connector devices are rated or derated by the wiring configuration and the environment. Factors to be considered include: enclosure characteristics, connector housing and wire insulation characteristics, number of wires in an enclosed area such as a raceway or conduit, as well as the ambient temperature.

Underwriter Laboratories Inc. amperage ratings are based on not exceeding the maximum operating temperature of the connector housing. This means connectors can be extremely hot when used at the UL amperage ratings. For this reason UL amperage ratings should only be applied to connectors when they are used inside an enclosure not accessible to untrained persons. Canadian Standards Association ratings are based on not exceeding a 30°C temperature rise above ambient temperatures. For this reason CSA amp ratings are a good point of reference for connectors that are user operated. APP® does not recommend exceeding a 30°C temperature rise above ambient temperatures for connections accessible during operation to untrained persons.

| How to Read Temperature Charts |

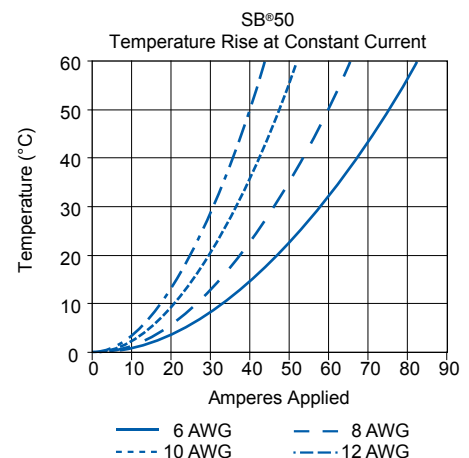
Temperature Rise at Constant Current Charts

Temperature Rise at Constant Current charts show the associated heat rise as a result of applied current to the connector. An example of the SB®50 Temperature Rise chart is included to follow along with this explanation.

The chart is based on an ambient temperature of 25°C (77°F room temperature). Accordingly if the temperature °C on the Y axis of the chart is at 30°C, the expected total connector temperature would be 55°C.

Separate curves are shown for #6, #8, #10, and #12 AWG wire. Interpreting the curves, if 50 amps are applied continuously to the connector, the heat rise will be 23°C for #6, 35°C for #8, 55°C for #10, and #12 wire is not suitable for this amperage.

Where T = Temperature, heat rise is expressed as a $\Delta T^{\circ}\text{C}$.
 $T_{\text{ambient}} - T_{\text{ambient}} + \text{heat from applied current} = \Delta T^{\circ}\text{C}$.

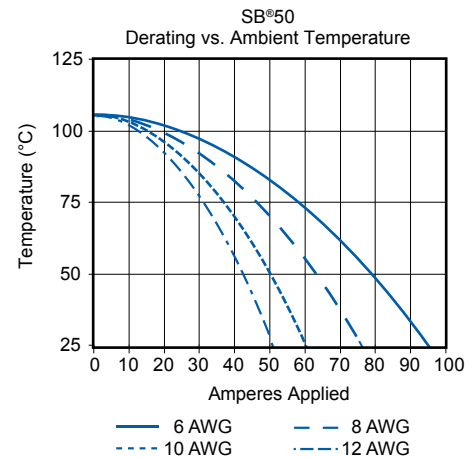


Derating vs. Ambient Temperature Charts

Derating vs. Ambient Temperature charts show the maximum amperage capability of a connector at a given ambient temperature. An example of the SB®50 chart is included to follow along with this explanation.

All data points are based on the maximum operating temperature of the connector, most often 105°C or 221°F. Accordingly if the temperature °C on the Y axis of the chart is at 105°C, there is no amperage capability because the connector housing is already at the maximum operating temperature.

Separate curves are shown for #6, #8, #10, and #12 AWG wire. Interpreting the curves, at a 75°C ambient temperature the maximum amperage capability that can be applied continuously to the connector is: 58A for #6, 46A for #8, 37A for #10, and 31A for #12 wire.

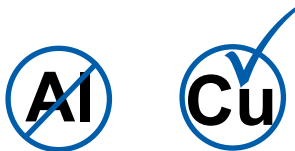


Notes on Temperature Rise Charts

Note that these charts are constructed using calculations based on actual test data. For this reason the chart information may vary slightly from the safety agency ratings. Safety agency ratings and compliance with electrical codes take precedent over these charts. The charts are designed to provide a guideline as to the connectors' capability. Actual results can vary based on the specific wire used, crimp tooling and assembly, as well as the environment the connector is used in.

CSA ratings are based on not exceeding a 30°C temperature rise above ambient or a total temperature of 55°C. This is considered the maximum temperature to safely handle a connector at. UL ratings can be based on the operating temperature limit of the connector. Often for APP® connectors this is 105°C or an 80°C temperature rise above an ambient temperature of 25°C. To provide a margin of safety, the heat rise charts are limited to a 60°C temperature rise.

| Compatible Wires |



APP® connectors are designed to be crimped and/or soldered to multi-stranded copper conductor wires only. Alternate conductor materials including aluminum should not be used. Aluminum conductors crimped into APP® contacts can result in a galvanic reaction occurring between the aluminum wire and the more cathodic metals used in APP® contacts including copper, tin, silver, and gold. Additionally softer metals like aluminum flow or loosen from crimps much easier than copper.

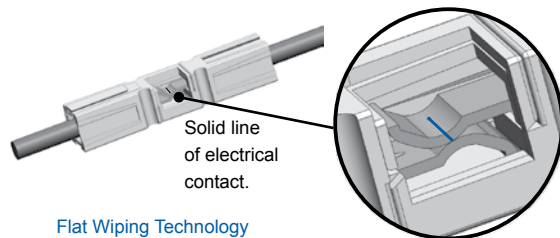
Multi-stranded wire is recommended for all APP® connectors and is required when crimp terminating wires or when a connector with flat wiping contact technology is used (such as Powerpole® and SB®). Solid wires do not adequately compress and retain in crimp barrels after being crimped. For this reason if solid wire is used, it should be with solder termination only.

Solid wires also do not flex and bend as easily as multi-stranded equivalents and can act as a lever arm and impede or alter the natural state of a flat wiping contact in the housing. This impediment or alteration to the flat wiping contact's natural state can cause intermittency and shorts as well as higher resistance and temperature at a given amperage than is shown in APP® specifications. Mating and unmating forces may also be impacted.

| Different Contact Technologies |

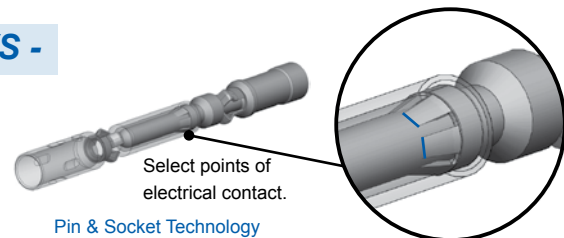
Flat Wiping:

- Same contacts on the “male” and “female” side reduce inventory costs and increase ease of assembly.
- Low resistance connection has a large conducting surface and a high normal force in comparison to typical pin and socket contacts.
- Sacrificial tip confines damage to non-conducting area when mating or breaking under load.
- Raised surface on the mating side of the contacts secures the connector in the mated condition, limiting the need for latching on outer housings.
- Over wiping design cleans the mating surface when mating and unmating.



Flat Wiping Technology

- VS -



Pin & Socket Technology

Pin & Socket:

- Different contacts on male and female sides. Female socket contacts are typically more expensive than the simple geometries of the pin contacts.
- Often higher resistance than flat wiping connectors of the same wire size and plating due to the reduced mating surface area and lower normal force. Gold plating often used to compensate and minimize resistance.
- Best for compact connection needs such as signal and low power due to static position in housings and symmetrical shape.
- Socket contacts can catch and hold debris inside the socket body causing mating problems.

| Use of APP® Connectors in Applications Exceeding 600V |

The approved voltage ratings for APP® connectors are usually limited by the category under which a safety agency such as UL approves our connector for use. UL typically defers to National Electric Code (NEC) on the voltage limitations for any given device our connector could be used in. For most common applications NEC restricts voltage to a maximum of 600V AC or DC which is what our connector voltage ratings are based on.

To achieve UL 1977 approval for a 600V rating, we test our connectors for dielectric withstanding voltage. The connector is tested at 2 times the rated voltage of 600V plus 1000V or 2200VAC for 1 minute. For applications exceeding 600V, UL / NEC / IEC may require application specific review for creepage and clearance resistance.

| Frequently Asked Questions |

Q: Can I cross mate low and high mating force contacts?

A: Yes, however this would not be a connection solution we have tested for safety agency approval. Additionally the contacts may wear at an accelerated rate causing the mating cycle rating to be reduced. The mating and unmating force expected would be somewhere in between the high and low mating force specification.

Q: Can I crimp multiple wires into 1 crimp barrel?

A: Yes, however this would not be a connection solution we have tested for safety agency approval. Particular care should be used that the bundle of wires do not interfere with the movement of the contact in the housing during mating and unmating (see maximum wire O.D. specification). The total circular mils of all conductor strands should be within + or – 5% of the wire size the contact is intended for. Twist the conductor strands together and crimp using APP® tooling with range taking capabilities such as the 1368 series. To crimp with other APP® recommended tools, contact customer service for the recommended setting or die and locator combination.

Q: Will the crimp tool I have for standard color-coded lugs, Mil Spec contacts, or another connector manufacturer, work for crimping APP® contacts?

A: No. APP® contacts generally do not conform to standard crimp barrel dimensions used for lugs, Mil Spec contacts, or other connector manufacturers. The tooling recommended by APP® must be used to ensure the performance designed by APP® is achieved. Alternate tooling will void APP® warranties and can affect safety agency approvals. In some instances Mil Spec tools are approved for crimping contacts with the dies and locators recommended by APP®. See tooling charts for specific instances, or contact customer service for more information.

Q: Can metric sized wires be used with APP® contacts?

A: Yes. The majority of our crimp tooling recommendations are based on testing and verification we have performed with AWG sized cables. Metric cables of the same or slightly smaller circular mils equivalent to the AWG wire recommended can typically be successfully terminated in APP® contacts. There is a wire conversion chart at the end of this catalog section that can be used as a reference when converting AWG to mm² sizes. The 1368 series crimp tooling has a range taking capability that produces a reliable crimp with metric equivalents of AWG cables. Please contact customer service for metric tooling recommendations for other APP® crimp tools.

Q: Are APP® connectors suitable for use in applications where the voltage exceeds 600V AC/DC?

A: Possibly. See “Use of APP® Connectors in Applications Exceeding 600V”, contact customer service with further questions.

Q: How do Powerpole® and Multipole connectors stay securely mated without latches?

A: The proven flat wiping technology used in these connectors features a detent or bump in the contact surface along with powerful stainless steel springs that hold the connectors in the mated position. High mating force contacts have a detent that is raised higher than low mating force contacts. The higher the detent, the more force is required to mate and unmate the contacts. In many applications the detent and spring force is enough to securely hold the connectors in the mated position without the need for latches. Latching shells, clips, or other external devices can be used to secure flat wiping connectors in applications where shock, vibration, or cable strain may overcome the inherent force holding the connectors together.

Q: How does APP®'s genderless connector design work to make a mated pair.

A: Genderless Powerpole® and Multipole housings do not have a male(pin) and female(socket) side. For wire-to-wire applications the exact same housings and contacts are used on both sides of the mated pair. If your application calls for wire-to-PCB or wire-to-busbar connections then different contacts and possibly housings will be required on each half (similar to male and female connectors).

To make a mated pair of Powerpole® or Multipole connectors simply assemble the connectors closely following the assembly instructions. After each connector half is fully assembled take one half and flip it over. The two halves will mate together. Multi-row Powerpole® assemblies will need to be stacked in mirror images of each other to properly mate the correct circuits. This information is detailed at the beginning of the Powerpole® section.

| Touch Safety & Ingress Protection (IP) |

UL 1977 Section 10.2:

Typically required for applications where the connector is external to the end device and operating over 30V or 200A, where wet conditions may be present (600V category).

Testing is performed using a probe that mimics a child's finger. All features of the connector are tested for live parts in the unmated state (no pressure applied). A smaller 3 mm probe is then applied in the mated state to test for live parts. Note that some applications may require the connector to not expose live parts to the 3 mm probe in the mating interface.

IEC 60950:

From the standard for Information Technology Equipment Safety, the requirements are harmonized with UL1950. Typically required for commercial and industrial applications where operators may need some degree of protection while accessing or servicing equipment.

Testing is performed using a probe that mimics an adult finger. All features of the connector are tested for live parts in the unmated state with 30 N of force applied to the probe.

IEC 60529:

Standard for Degrees of Protection Provided by Enclosures is harmonized with EN 60529.

Protection degree number is assigned to both solids and liquids in that order. For example: a connector with an IP20 rating is protected against fingers, but has no protection against ingress of liquids. APP® takes a conservative approach in rating our connectors against liquid ingress and consider any meaningful water ingress to have a harmful effect.

Protection Degree	Solids (First Digit)		Liquids (Second Digit)	
	Description	Protected Against	Description	Protected Against
0	Not Protected		Not Protected	
1	> 50 mm	Large body part such as back of hand	Vertically dripping water (no harmful effect)	Duration: 10 minute Water: 1 mm / minute rainfall Pressure: N/A
2	> 12.5 mm	Adult fingers or similarly sized objects	Tilted 15 degrees up dripping water (no harmful effect)	Duration: 10 minute Water: 3 mm / minute rainfall Pressure: N/A
3	> 2.5 mm	Typical screw drivers or large wires	Water spray up to 60 degree angle (no harmful effect)	Duration: 5 minute Water: 0.7 liter / minute Pressure: 80-100 kN/m ²
4	> 1 mm	Small pointy tools and small wires	Water splash from any direction (no harmful effect)	Duration: 5 minute Water: 10 liter / minute Pressure: 80-100 kN/m ²
5	Dust protected	Complete physical protection, no functional interference from dust	Water jet from any direction (no harmful effect)	Duration: 3+ minute Water: 12.5 liter / minute Pressure: 30 kN/m ² @ 3 m distance
6	Dust sealed	Complete physical protection and sealed from dust ingress	Strong water jet from any direction (no harmful effect)	Duration: 3+ minute Water: 100 liter / minute Pressure: 100 kN/m ² @ 3 m distance
7	N/A		No ingress of water in harmful quantity when immersed up to 1 m depth	Duration: 30 minute Water: Immersion Pressure: 1 m depth
8			No ingress of water in harmful quantity when subject to tests in excess of condition 7	Duration: Mfg. specified Water: Immersion Pressure: 1+ m depth. Mfg. specified

| Preventative Maintenance |

Damaged connectors, contacts and cables may present hazards, resulting in inefficient battery and charger operation. To avoid these problems, conduct the following maintenance checks at least once annually. When you see a problem, take corrective action immediately.

1. Dirty Connectors

When engaged and disengaged, the contact surfaces of Anderson SB® Connectors “over wipe,” thus providing a self cleaning action. To ensure the continued benefit of this feature, clean the contact surfaces and lubricate the connector. Use a “white” lithium grease, which may be obtained from hardware stores and automotive parts suppliers.

2. Melting Connectors

Connector housings overheat and melt for many reasons. To prevent this:

- A. Examine the crimp between cable and contact. Ensure the crimp tooling recommended by APP® has been used. Improper crimping, corrosion, and broken wires result in unnecessary resistance causing the contact to heat up.
- B. Check contact surfaces for signs of “pitting” caused by dirt or disengaging connectors under load. One badly pitted contact, particularly in a connector attached to a battery charger, can lead to pitting on surfaces of other contacts. If not corrected, this can result in an epidemic of bad connectors throughout a fleet of electric vehicles and in chargers and batteries.
- C. Check to see if batteries are being disconnected while the charger is still on. This causes the contacts to arc at the tips, resulting with progressive pitting and silver removal from tip to crown. If this practice is occurring, discontinue it now to avoid major repairs in the future.

3. Other Conditions

If any of the following conditions exist, the connector housing, contact and/or cable should be replaced immediately.

- A. **Housing:** Cracks, missing pieces, evidence of excessive heat, discoloration. You may consider replacing the existing housing with a Chemical Resistant equivalent for improved durability against UV rays and common solvents and hydrocarbons.
- B. **Contacts:** Pitting, burns, corrosion, excessive wear, cracked crimp barrels, discoloration.
- C. **Cable:** Exposed copper near housing, cracked cable, peeling or frayed insulation.
- D. **Handles:** Loose attachment and signs of damage as missing or loose hardware and cracked or broken plastic (Handles should be used for connectors that are hard to reach or move.)
- E. **Cable Clamps:** Loose attachments, signs of abraded cable jacket, missing or loose hardware. (Cable clamps should be used to relieve strain on unmounted cable.)



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