

CCC: What is it and Why is it Important to Your Test Outcomes?

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According to the McGraw-Hill Dictionary of Architecture and Construction Engineering, Current-Carrying Capacity (CCC) can be technically defined as the maximum current which an electric device is rated to carry without excessive overheating and consequent premature breakdown or combustion. In the test contactor industry, CCC is a measure of the amount of current passing through a metal contact pin or circuit trace that will raise the temperature of the contact by 20°C. There is nothing magic about this number, it could just as well be 30°C or 40°C, but convention dictates that 20°C is a safe and reasonable temperature rise. By definition, it has become the unofficial *de facto* standard. Let's take a closer look at CCC using basic principles of physics.

All metal elements and their alloys are comprised of atoms arranged in the particular crystal lattice structure that their nature demands. An atom has a nucleus and electrons. It is the valence electrons that are the most free to move about in the electron "sea" or "wind" and by doing so, they constitute a current flow through the material when a voltage (forcing function) is impressed across the metallic material.

Now, this flow of electrons comes at a price. The path of the flow is dependent upon several factors, including the inherent conductivity of the material, its temperature, and the magnitude of the forcing function (voltage). In simple terms, the current flow obeys Ohms Law, which states that current flow is equal to the magnitude of the applied voltage divided by the inherent resistance of the contact itself. This resistance is due primarily to three things namely, the resistivity, length, and area of the contact. We can express this by the following equation.

$$R = (\rho * L)/A$$

Where:

ρ is the resistivity of the material

L is the length, and

A is the cross-sectional area normal to the flow of current

Since there is resistance to the flow of current, there will be internal heating ($I^2 * R$ losses) of the contact. If the current flow is dense enough, the temperature of the contact may rise significantly. In a suitable test fixture, we can measure this rise (via a thermocouple affixed to the side of the contact pin) and determine the CCC.

Why is CCC important? It is a measure of the "goodness" of the contact to current flow. For instance, if it takes several amperes of current to raise the temperature 20°C, then the contact is a good conductor of electricity and will draw heat quickly from the device under test (DUT) and divert it into the ambient environment. This effect will protect the dies in the DUT and prevent damage to them. Conversely, a contact that has a CCC with less current flow is not such a good conductor of current and heat. Consequently it will not dissipate as much heat energy away from the DUT. A corollary to this fact is that for every 10°C rise in junction temperature within the DUT, there is a corresponding decrease in its semiconductor life by 50%.

In the semiconductor test industry, CCC can be stipulated under steady-state or pulse current conditions. Steady-state typically means a duty cycle of 100%, such as would be prevalent in a circuit where direct current (DC) was applied to the DUT. This is a "worst case" situation with maximum temperature rise across the die in the device. Under pulse current application, the current applied to the DUT is turned on for a limited time period, then turned off for the remainder of the cycle. This may be a single-shot pulse or

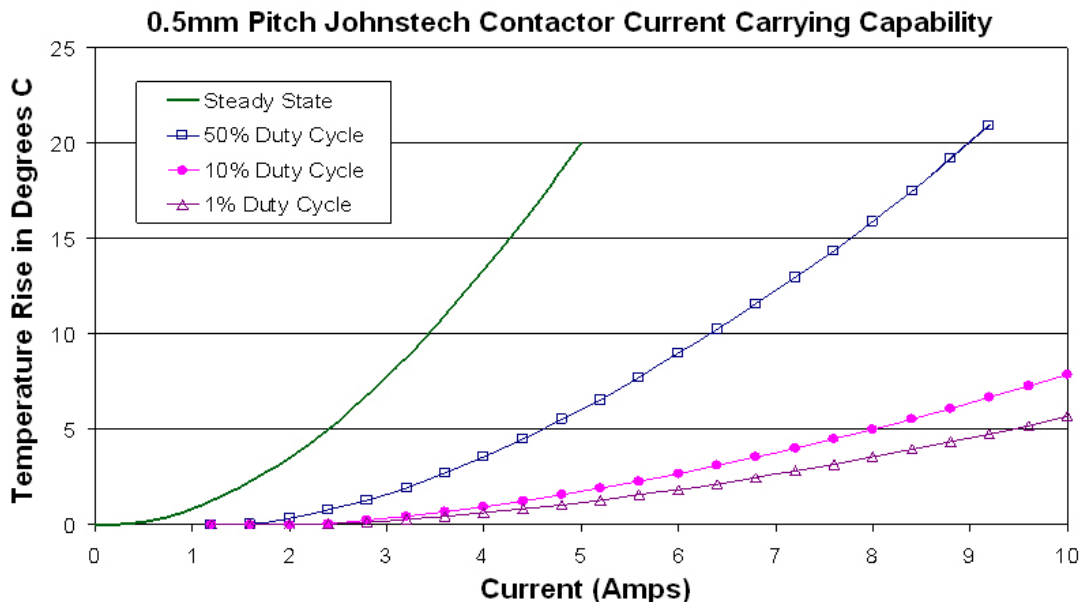
a string of pulses in a prescribed cycle. In many instances, CCC under these conditions may be much greater than CCC for the DC case. This is particularly true if the applied pulse of current is of short duration (heating part of the cycle), is turned off and the remaining time frame (cooling part of the cycle) is long. This is not too atypical and is happening more frequently with devices used in switching regulators and certain aspects of automotive electronics. With respect to CCC under pulse conditions, one could say that frequently encountered duty cycles are 50%, 10%, and 1%. By way of illustration, we submit a chart (Figure 1) showing the CCC for a Johnstech test contactor product with a 156296-0001 BeCu fine-tip contact, at various duty cycles, with an applied pulse width of 300 milliseconds. This data presented is measured, not calculated.

Figure 2 shows a graph of the CCC for a Johnstech test contactor product under steady state conditions then plotted out at 50%, 10%, and 1% duty cycles for a 300ms pulse, which is similar to the length of test time for many parts. If the customer can handle a larger than 20°C temperature rise, CCC will also increase. A 20°C rise is specified in case customers are testing at high temperatures (+155°C) and don't want their chip die temperature to exceed 175°C. If the pulse width is shorter, more current can be handled for each duty cycle, but the device may need to be turned on multiple times to finish the testing, which will allow for contact and contactor to cool down. This could increase the test time. At very low pulse widths, CCC can exceed 120 amps for a rigid contactor. A rigid, one-piece contactor will always be able to handle more current than an option that includes multiple moving parts creating more C_{res} and IR voltage drop. This is essential for devices handling moderate to high current levels since Matte Tin is a standard plating for devices and the softening voltage of Matte Tin is only 0.07V.

Figure 1 CCC vs. duty cycle for 156296-0001 contact pin

Duty Cycle	DC (100%)	50%	10%	1%
I_{MAX} (Amps)	3.19	5.26	7.19	8.40

Figure 2



In summation, CCC is a measure of the “goodness” of a contact pin or ground insert because it denotes the ability of a contact to safely function as a conduit for current and heat under normal operating conditions. CCC applies to steady-state and pulse current conditions alike. It is up to the user to assess the data according to the situation at hand.

If you have any comments or questions regarding CCC or any other kind of engineering data around final test, please don't hesitate to contact a Johnstech representative. You can find the Johnstech rep for your area by visiting www.johnstech.com or by calling 612-378-2020.

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