14000 Burn Rd
Arlington, WA 98223
USA
Ph (425)374-9060
www.midnitesolar.com

165 VDC ETL TEST STORY

Wow! In my 18 years in the Renewable energy industry as an engineer, I've seen a lot of cool blow ups, flames, sparks and such, but never anything as dramatic as the ETL test conducted on this little circuit breaker.

MidNite Solar orders custom made breakers for their PV applications from Circuit Breaker Industries in South Africa. These breakers come with a UL 489A listing of 125VDC with an interrupt rating of 10,000 amps. The UL voltage rating is not adequate for today's PV systems, so an additional agency listing is required.

I don't know where ETL cooked up the test requirements. They seem to go far beyond what we did at OutBack a few years ago, but we only tested a15 amp breaker back then. This new test we conducted was brutal to say the least, but it showed just how good these little breakers are.

The breaker pictured is the MidNite MNEPV series breaker with the proposed ETL label installed. As of this writing, the label has not yet been submitted to ETL for approval, so production breakers may be labeled differently.

There are several parts to the ETL test. Our test set up included thirteen 12V batteries in series, four really big DC power supplies, 18,000 watts of resistive loads, fuses, high voltage knife switches, lots of 6AWG wire and of course our MidNite CBI circuit breakers. Batteries were furnished by Dyno Battery

The first test consisted of applying 165 volts of DC to the 63 amp breaker while running 99 amps of current through it. The test was done turning the breaker on for one second and then off for 9 seconds. This was done successfully 35 times. That was **16,335 watts** of high voltage DC the little breaker had to switch on and off. The first time we ran this prior to ETL being there, all we got was a melted down breaker fused solid in the closed position! It's a good thing we keep a hand on the knife switch for cases just like this. The breakers are marked with words stating "+ for DC". Now we better understand why this marking exists. We had it backwards and that doesn't allow the breakers internal arc shute to work effectively. Engineers rarely read directions before applying power to equipment. The + wording on the breaker was added by CBI on my recommendation years ago.

The second part of the test was conducted directly after the first with no break or cool down period. It consisted of turning on the breaker and running 99 amps through it until it tripped on its own. Every third time, I was required to hold the handle on to make sure the trip free mechanism worked. This automatic tripping would take about 30 seconds and was done 15 times. A 1300 volt hi-pot test was conducted on the breaker after these 50 cycles of testing. After passing the second part I thought we were home free, boy was I wrong!

165 VDC ETL TEST STORY (continued)

The third and most terrible test was a short circuit test rather than merely an overload test. If we had an unlimited budget for power supplies and Grand Coulee Dam next door, we could have conducted this next test with as little as 200 amps being shorted to ground. The short was to be done while running 99 amps through the breaker. There is a 20 amp glass body fuse connected from the metal breaker box chassis to ground. The breaker box, battery negative and the short are also connected to ground, so a 6AWG wire and the fuse are in parallel from chassis to ground.

This test set up provided us with all sorts of problems. One of the problems was that I was not exactly excited about putting a direct short across the 13 batteries! If the breaker failed, we would have our own Chernobyl! Some other challenges were just how to accomplish the switching of power and then shorting to ground. We cured the hook up and switching dilemma and proceeded to apply power after which we immediately applied the short. Since we did not have 200 amps of power supplies available, we used the full force of the batteries. We estimate that the current was about two thousands amps!

The goal on this test is to prove that the breaker will not arc to the case which would blow the 20 amp fuse. Well, we blew the fuse numerous times and then called boB in to help figure out the problem. Sure enough we had something hooked up wrong and the short was being run directly through the 20 amp fuse. Has anyone ever seen what happens to a 3AG fuse after running two thousand amps through it? I'll save you the trouble. There is nothing left of the fuse. It exploded into a thousand little pieces. After hooking up the fuse correctly, it was now placed in parallel with a 6AWG wire both connected to the ground busbar inside the MidNite MNDC box and the other end to a conduit pipe in the building. We had better success, but on the second breaker we experienced a blown fuse again. This test requires three short circuit tests to be done on three separate breakers. The first passed just fine although I noticed the wires jumping off the floor during the short. boB pointed out that the fuse and the paralleled 6AWG wire was connected about 8 feet apart on the conduit. This provided just enough resistance and inductance to blow the 20 amp fuse. We passed with flying colors after moving all the grounds together. Lesson learned. Tie all grounds together with large wire and keep them as short as possible.

MidNite solar 150VDC **MNEPV** breakers are available in **10**,**15**,**20**,**30** and **63** amps.

Robin Gudgel

Pictured above, boB breaking 165VDC at 99 amps for the first test. This arc is the same arc that our little breaker must deal with internally. The arc is not only blinding, but also extremely hot. Pretty amazing huh! I also discovered the hard way that getting shocked with 165VDC feels pretty much the same as getting shocked with 120VAC.