Repairing the Milwaukee SuperTough 12Volt Battery Pack
(Part # 48-11-0200)
Written by Bill Ashley

The report explains the step by step procedure required to replace the cells in the Milwaukee SuperTough battery pack. This procedure may be used as a general guide to repair other similar battery packs. The replacement cells are 10 pieces of Sub-C size 2100 mAHr NiCd batteries with tabs (10 pieces batteryspace Part#: CD-SC2100PTB). You might as well repair both battery packs (20 cells total), the second pack failure is usually close behind the first one. First I will cover a few general areas, then get to the specific cell by cell reconstruction.

NiCd Batteries:
There is a lot of information available about NiCd batteries and what occurs during charge, discharge, and over-discharge. Start with the information in batteryspace.com web site, there are links to web sites that go into even greater depth. I will hit just a few highlights specific for this type of battery pack.

1. Never replace 1 or 2 bad cells, always replace all 10. The batteries are connected in series, and the charger sends one current stream through this series. If one cell is not closely matched with the other 9, poor recharging and discharging performance will result. When one cell has higher resistance (bad cell) it will both choke off the recharging energy available and hog more than its fair share of the charge. Conversely, if a cell has lower resistance (new cell) than its neighbors, it grabs less than its fair share of the charge. Either way, sub-optimum performance results. When all cells are closely matched, they each grab an equal share of the recharging energy.
2. Use NiCd Cells, not NiMH. While you may be tempted to use NiMH cells because they do not have the charge memory of NiCds, you will probably have a short lived battery pack. The Milwaukee recharger was designed for NiCd cells and does not contain the special features required to properly recharge NiMH cells. Recharging NiMH in a NiCd recharger is a no-no (NiCds in a NiMH recharger is OK).
3. I had gotten 9 solid years of heavy do-it-yourself usage out of the original packs, not bad at all. I expect to get longer life out of these because of the following tip: Never force the drill once it has stalled (try to avoid stalling altogether). This is the one thing that degrades the NiCd cells more than anything else. Once the drill no longer has enough torque to spin, finish with a

hand driver. If the stall happens because the pack is nearly discharged, then swap packs now, not later.

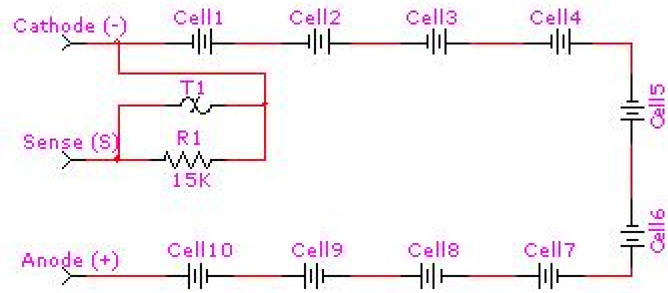
Soldering:
The most important skill required for this project is soldering. If you have no soldering experience, this project may not be the best choice to start. You must be able to solder well with no cold joints or the repair will be disappointing. The general steps when soldering the cells in this project:

1. Bend/fold the straps as required for the specific pair of cells to be connected. Because of the way that the electrical path winds and wends its way through the pack, the connections between any 2 cells is usually unique for that pair. Be sure that you have the “entrance” and “exit” straps pointed in the desired directions before the 2 cells are soldered together.
2. Tin the 2 strap surfaces that are to be joined together. Do not use an excess of solder, there is little room inside the pack for lumpy solder joints.
3. Tape the cells together in the desired orientation. This eliminates the need for a third hand.
4. Solder the 2 straps together by pressing down upon the top strap with the iron. Once the solder has melted and flowed, push the straps together with the point of a pencil or other suitable tool. Remove the iron and hold the straps perfectly still for about 10 seconds (until the solder has completely solidified). Failure to do this results in a cold solder joint that is mechanically weak and electrically unreliable.

Tools Required:

1. #10 torx driver
2. wooden pencil
3. Soldering iron with electrical grade solder (do not use plumbing solder)
4. Hole punch or razor knife
5. Volt-Ohm meter (VOM, DVM, VTVM, etc)
6. Diagonal wire cutters
7. Needle nose pliers

Battery Pack Schematic:



The schematic only show electrical connection information, the mechanical information is contained in photos that follow. Studying the schematic shows that there are 10 NiCd cells, that are named Cell1 through Cell10 in this report. There is also a 3 contact connector, a thermostat, and a resistor. The thermostat and resistor notify the charger when the cells are too hot, so that the charger will back off until they are cool enough to continue recharging. The three contacts, in counter clockwise order are: Cathode (-), Sense (S), and Anode (+) (with the center contact pointed towards you).

Step by Step instructions:

Figure 1 shows the battery pack prior to disassembly. There are 4 torx screws to remove. Once the screws are removed, the top part of the case can be slid off of the rest of the pack (press both buttons). You may have to press one of the metal contacts with the eraser end of a pencil to help slide the contacts out of the top. Remove the 2 buttons and their springs. Finally remove the cells from the case.

Figure 1

Figure 2. Disassembled Pack

Figure 2 shows the disassembled pack. This view, with the 7 cells on the bottom is the normal view (right side up) for this report. Some photos will show the cells in an upside down position. Note that the thermostat sets in the void between Cell2, Cell6, Cell7, and Cell8. The contacts are taped and one contact is welded to Cell10 and some wires are soldered to Cell1. Figure 3 shows the cells slightly separated to view the thermostat.

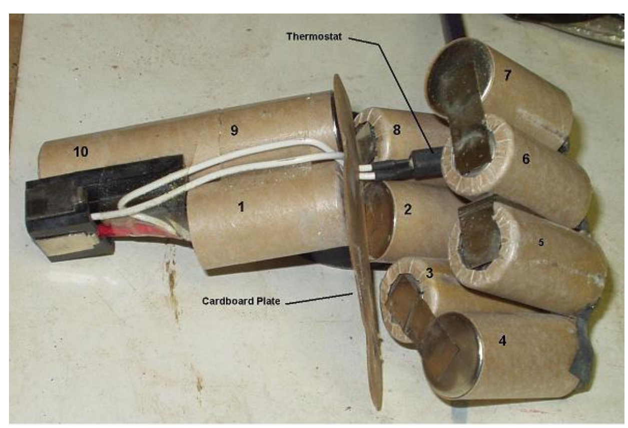
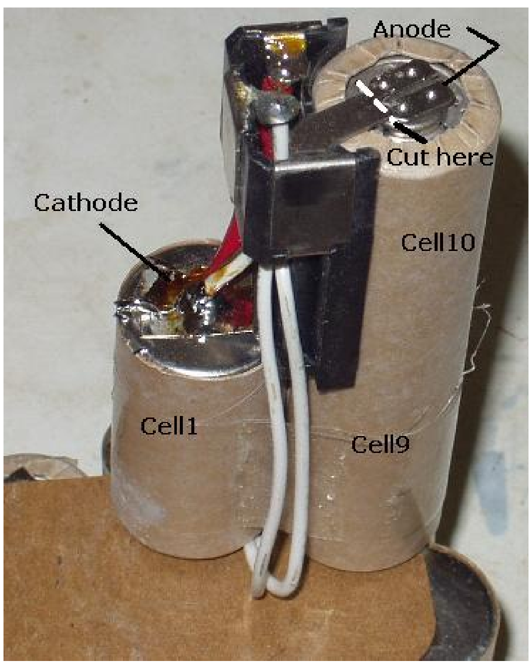


Figure 3.

Figure 4 shows the detail of the connector. The white wires go to the thermostat, the red wire to the Cathode; the Anode is direct welded to its cell. Milwaukee used a red wire for the cathode which goes against all standards (normally the cathode is black or green, the anode is red). They figured that if we can't see it, it doesn't matter. Just don't get fooled into connecting the red wire to the anode. Unsolder the wires connected to Cell1 cathode. Score the anode contact near the Cell10 button with the wire cutters. Use the needle nose pliers to flex that part back and forth until it snaps loose.



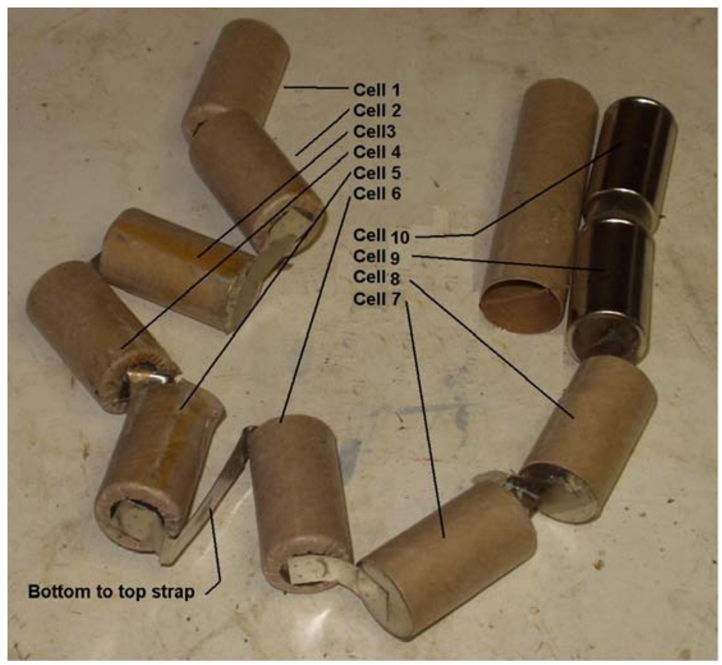


Figure 4. Connector

Figure 5. Cells pulled apart

Figure 5 shows the cells pulled apart into a string. Do not do this with your pack, this is only to show the special connection between Cell5 and Cell6. You will want to keep your cells relatively intact to use as a mechanical reference. Since the cells are connected in series, the anode (button) of one cell will connect to the cathode (flat) of the next, except for the two ends that connect to the contacts. Most of the cell connections go flat across from the one cell to the next. Cells 5 and 6 are an exception, the strap goes from the bottom of Cell5 to the top of Cell6. You will need to salvage and reuse a portion of this strap to rebuild the pack.

Figure 6 shows Cell2 and Cell3 soldered together (bottom view). Note that Cell2 anode is pointing up while Cell3 cathode is pointed 45 degrees down and to the right. See how the 2 straps are folded so that they meet neatly and are flat against the cells. Be sure that you “dry fit” the two cells together prior to soldering. Once your satisfied with the straps positions, flatten them against a solid surface. Remember, the case has no room for bulky solder joints or strap folds.

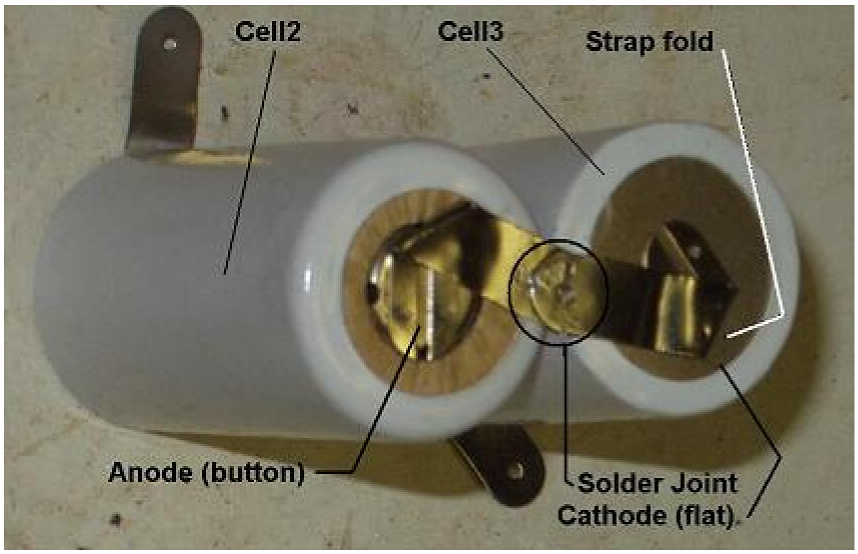


Figure 6. Cells 2 and 3, detail of solder joint

Figure 7 shows Cell4 and Cell5 (bottom is left). Two things happen here, Cell4 is the “corner” where the pack turns around, Cell5 is where the bottom to top strap starts. Note how the strap on Cell5 cathode folds back upon itself to reach Cell4 anode (mirror view). The Cell5 anode folds up its own side, the Cell4 cathode bends at a 90 degree angle from its anode strap. Test fit Cell4 and Cell5 with each other and with Cell2/Cell3 before pressing straps flat and soldering.

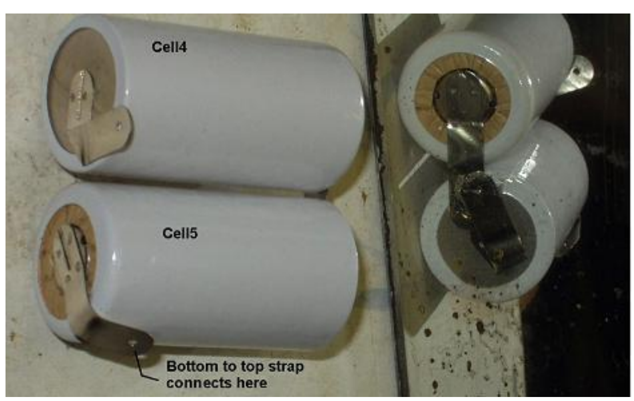


Figure 7. Cells 4 and 5

Figure 8 shows Cell6 and Cell7. Cell6 cathode strap bends up its side in preparation for the bottom to top strap. The strap on Cell7 anode makes a 90 degree turn compared with the Cell6 cathode. When joining Cell6 to Cell7, bend the straps in a manner that will not intrude into the void where the thermostat sets. Again, test fit prior to pressing straps and soldering.

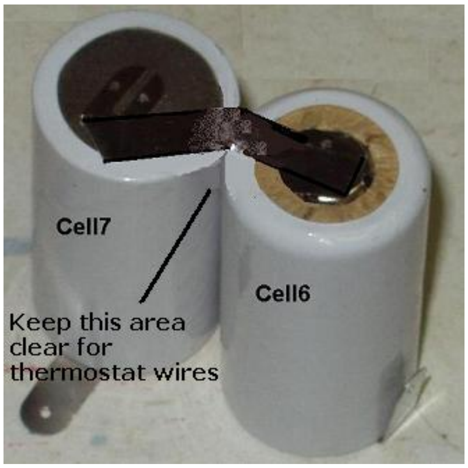


Figure 8. Cells 6 and 7

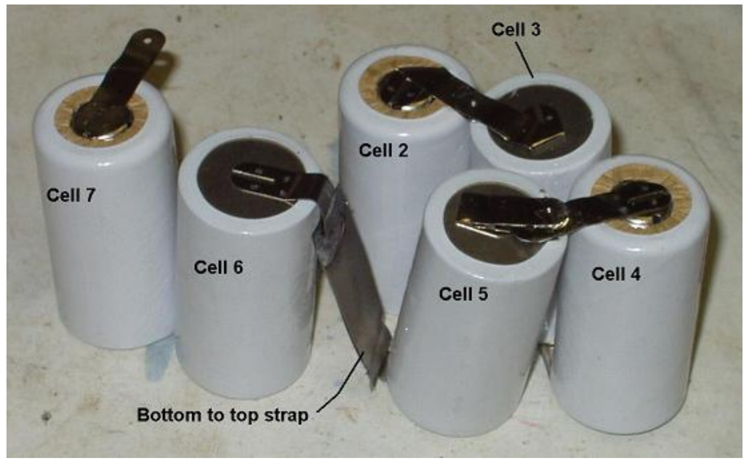


Figure 9. Cells 2 through 7

Figure 9 (batteries upside down) shows Cell2 through Cell7. We join the 3 pairs we've made so far. This is when we install the Cell5 to Cell6 strap. These pairs should fit right together because of the test fit operations that were performed earlier.

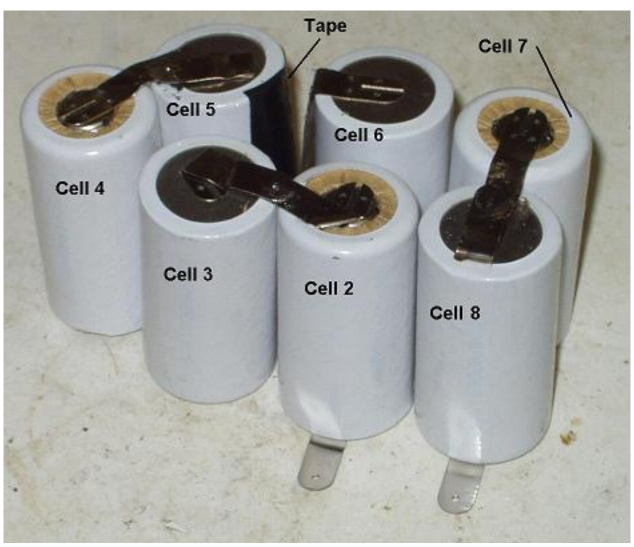
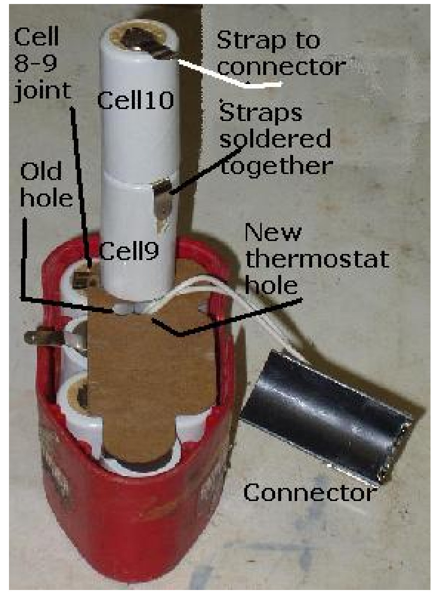


Figure 10 (batteries upside down) shows that we've added Cell8 to the block and its anode strap lies parallel to Cell2 cathode strap. Also note that I added a strip of tape between Cell5 and the strap. The batteries are double insulated (shrink wrap plastic over cardboard tube) but I added one more layer of insulation here just to be safe.

Figure 11 shows the 7 cells being test fitted into the case. This is a good time to tape the cells together, similar to how the factory did it. Use cellophane tape and be sure to leave the clearances needed at the 4 torx screw posts.



Figures 11 and 12

Since the replacement cells were just a smidgen larger than the originals, I relocated the thermostat so that Cell1 and Cell9 would not be on top of the white wires. Cut or punch the thermostat hole in the cardboard further over towards Cell6 and Cell7. This lets us keep the thermostat wires next to but not under Cell1 and Cell9.

Figure 12 shows the result of these steps. You can see the modified thermostat hole here. Also see how we join Cell9 to Cell10, with the straps angled 30 degrees to the right. This angle lets the Cell9 – Cell10 joint happen in a void part of the case and also aligns the Cell10 anode with the anode contact. Bend/fold the Cell9 strap to meet the anode strap from Cell8.

Figure 13 shows that we added Cell1 and the connector. Cell1 anode points directly out to join Cell2 cathode strap. Bend Cell1 cathode strap to meet with the wires from the connector (red connector cathode wire, 15Kohm (1502) resistor lead, and one wire from the thermostat). Tape the connector into position before soldering. Solder the Cell10 anode to the connector anode, (the connector strap that you snapped loose from the old cell10).

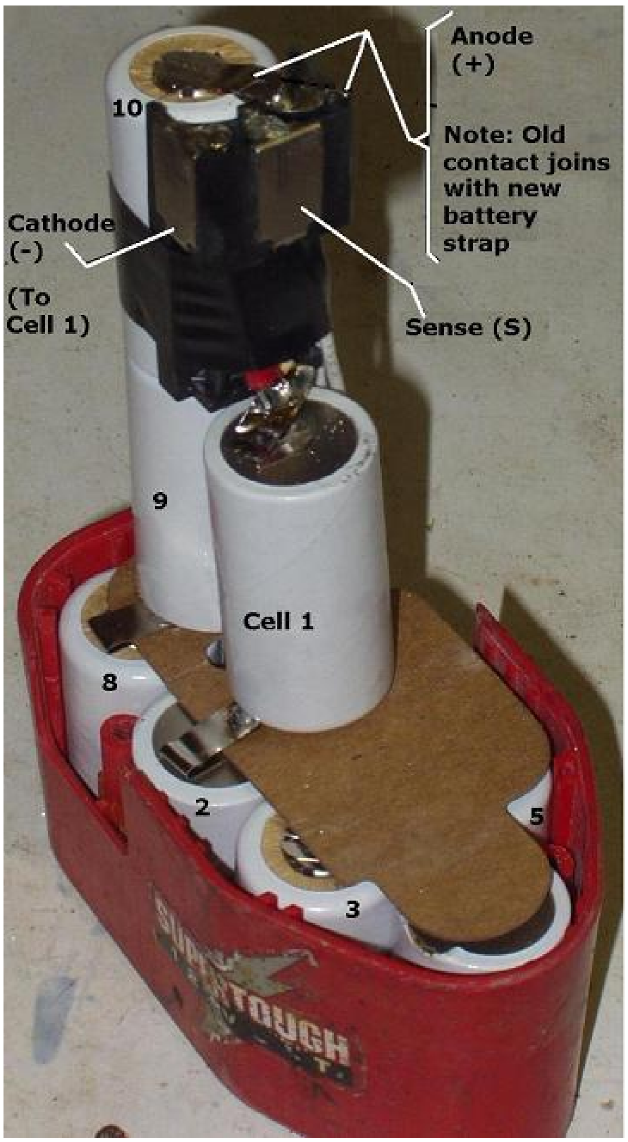
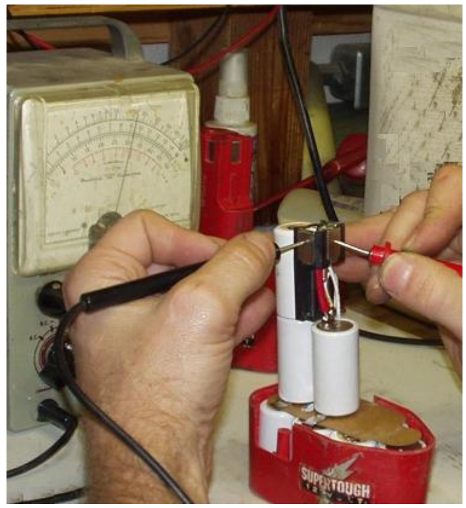


Figure 13. Add Cell1 and connector

Now you can test the pack. The first test (Figure 14) connects the voltmeter leads on the connector Anode (+) and Cathode (-). You should have a reading between 9 and 12 volts. If the batteries have been on the shelf for a long time they may read lower. Just be sure that you haven't connected any of the cells backwards (this will cause a low voltage reading and not operate). Each cell's anode connects to the cathode of the next higher cell (cell10 anode connects to anode contact). A freshly charged set of cells can read up to 12.6 volts or so.



Figures 14 Voltage test

Figure 15 Ohms test

The second test (Figure 15) measures the resistance between the Cathode (-) and the Sense (S) contacts. The reading should be about 15 Kohms (15,000 ohms). If it reads near zero, the thermostat needs replacement or has been miswired. If it reads way high, the 15K resistor is improperly connected.

When the pack passes the tests, you can try a quick check in the recharger. Just slip on the case top and plug it into the recharger. If the green light changes to a red light, its good. If both lights go out the charger has detected an error. Recheck and repair your connections until the pack operates properly in the recharger.

Now that the pack operates, you can close it up. First lift up the top (Figure 16). Then put the springs in, the forked end faces down, the curl arches outward. Now slip on the gray buttons. When you slide the top back down, push both buttons in until the top has completely seated. Now close with the torx screws. Try to drop the screws into the original threads. Haphazardly cutting in a new set of threads will weaken the case.

Figure 16. Add Springs and Buttons

Plug the pack into the recharger. The red light should be blinking within approximately 45 minutes. Your battery is ready to use.