

Solution to Practice Problem of the Day #10:

My first impression was that there was some sort of short or power drain in the system that was causing the battery to discharge. This was not true. I should have guessed the answer sooner.

The key measurement is the resistance between the negative pole of the battery and the negative terminal lug. Ideally, this should have been very low correspond to a good “conductor-to-conductor” contact between the metal (lead) pole of the battery and the metal (copper) terminal lug. This is what I saw when I measured the resistance at the positive terminal to be about 0.2 Ohms – practically almost too small to measure. In contrast the measured resistance at the negative terminal was found to be 20 Ohms – about 100 times greater.



Why was it greater? Two reasons: First there was corrosion in and around the terminal lug. Corroded surfaces are comparatively poor conductors compared to pristine metal. More importantly, since the bolt on the terminal lug was frozen, I could not tighten the terminal onto the battery pole, resulting in relatively poor contact. A good tight terminal with the copper of the terminal biting into the lead of the battery pole would have ensured a good low-resistance connection.

Now 20 Ohms may now sound like a lot, but that's all it takes to ensure that the starter motor will not turn over. The starter motor needs to pull 100's of Amps to have enough power. But if I have a resistance of 20 Ohms in **series** with the starter motor, then power from the battery will go into the resistance, not the starter motor. Think about it: if I try to put even as little as 20 Amps through a 20 Ohm resistor the power will be $P = IV = IR^2 = 8$ kilowatts. Think 80 light bulbs. No wonder there was a puff of smoke! Basically I was toasting the high-resistance corrosion at the negative battery terminal.

Note that the power draw required by the interior lights is much less. If I only draw a fraction of an amp through the 20 Ohm corrosion on the battery, the voltage drop across the corrosion is not enough to influence the performance of the lights.

The intermittent nature of the problem can also be explained by the relatively loose terminal lug. When I first installed the battery, having pushed the terminal down on the pole, I probably had

a pretty tight fit, so a good connections between conductors. But after driving around for a while, the vibrations loosened up the terminal and the resistance went up. Next time I try to start the car, it won't start.

Note that the problem was not simply an intermittent "open circuit" where the terminal lug completely loses electrical contact with the pole of the battery. If this was the problem, I would have lost all electrical power in the car, including the interior lights. The light worked fine because 20 Ohms is a "small" resistance for a few watts of power but it is a very large resistance for kilowatts of power.

Once we know the problem, a "quick fix" workaround is simple. To get the car started we "jiggle the cable" connected to the negative terminal to break up the corrosion and push the terminal firmly back onto the pole for a good connection. This won't last long eventually coming loose again due to the vibrations as we drive the car, but it's just fine for getting the car started in the parking lot.

The long-term fix is to replace the corroded terminal lug. This is just a simple piece of standard hardware than anyone with a decent set of tools can install. Prices for these on the internet range from a low of about \$5 to a high of about \$40 for (literally) gold-plated terminals. So compared to other possible car problems, it's not going to be a very expensive fix.



**Gold-plated
battery
terminals!**