

Van de Graaff generator – Fundamental Facts

2018-03-19 / HS

Standard setup

Use a **grounded** mains cord in order to have the base of the generator at ground potential. Place a **grounded** conductor sphere 8 to 10 cm from the dome in order to have a well-defined spark gap. Connect a 1 to 2 metre long lab lead to the base of the van de Graaff. Insert a blank metal crocodile clip at the other end of the lead.

Working procedures

Keep yourself grounded and only operate the generator buttons when the dome is shorted to ground:

Always hold the above mentioned grounded crocodile clip in your hand.

When you want to short-circuit the dome to ground, hold the end of the clip furthest away from the tip with your fingers and make the tip of the crocodile clip touch the dome. (While doing this, the metal tip must at all times be closer to the dome than any of your fingers.) Now you can e.g. shut off the generator.

Working principle of the van de Graaff

A van de Graaff generator is in fact a **current generator**, not a voltage generator. It charges the dome by moving electric charges on the belt. Charge moved per time equals current.

If no charge escapes the dome, its voltage will rise steadily, proportional to the charge accumulated. This situation (voltage growing towards infinity) can of course not continue in the real world. Sooner or later, some charge must leave the dome to balance the almost constant charging current.

The most dramatic way to reduce the charge on the dome is when the insulating air breaks down and a spark discharges the dome. The voltage drops almost to zero before rising once again.

Less spectacular is the possibility that charge escapes by so-called corona discharges. Edges or points are typical origins of these continuous discharges – even a small speck of dust or a little piece of hair can in certain situations lead to corona discharges that completely keep up with the charging current. This means that the voltage will more or less stabilize at a rather low value, often making the operator conclude that the generator is not working.

Typically, both kinds of discharges are at play; the corona discharges are not strong enough to balance the charging, letting more or less frequent sparks take care of the rest.

Why does the van de Graaff send sparks down the columns or along the belt?

As mentioned above: Have a grounded conductor sphere placed 8 to 10 cm from the dome in order to have a well-defined spark gap. Moving the conductor sphere too far away means that the voltage will rise until other discharge paths are found. If corona discharges are not dominating the situation, a spark will find its way from the dome to the nearest point at ground potential – which is often the base of the van de Graaff.

If you happen to have your hand placed between the dome and the base, **you** will be the nearest point at ground potential.

Sparking down to the base is simply an indication that your lab isn't too dusty for the van de Graaff to operate normally – and that you have forgotten the conductor sphere.

Some accessories remove sparks

In case an accessory produces sufficient corona discharges, the voltage never reaches a point where sparks are produced. The electric whirl is a good example, another is the famous “hair-rising” experiment.

In case you still experience unwanted sparks, you could try to turn down the motor speed. This reduces the charging current.

Isn't it dangerous?

The total energy in one spark from our van de Graaff is only around 70 mJ. This is not dangerous for a normal, healthy person. But it does sting unpleasantly and we do not encourage using any part of the body as a spark gap electrode.

Anyone with a heart condition should not operate a van de Graaff generator.

I touched the base, there was a spark and I got a shock!

This is even less dangerous than a direct “zap” from the dome. It happens because the instantaneous current in the spark is very high, leading to a voltage spike in any wire it goes through. This voltage can easily be high enough to be felt when you touch the base but lasts for a very short time.

When the van de Graaff is *too* tame

Sometimes you may experience that the problem is the opposite: No sparks when you want them. We have a separate troubleshooting guide for this situation. But start with a thorough wiping of the dome with a damp, *lint-free* cloth. As mentioned, a small speck of dust can ruin your day.