

# STANDARD OPERATING PROCEDURE:

## Demonstrating the Van de Graaff generator

*Note: To be undertaken only by trained personnel in conjunction with a site-specific risk assessment.*

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### 1. Introduction

The Van de Graaff generator (VDG) is a device, which produces and stores a large electrostatic charge on a metal dome. It consists of a base, an insulating column (usually Perspex), a large metal dome and a smaller discharge sphere on an earthed and insulated handle. A nylon pulley in the base drives a belt (rubber or latex) over a metal pulley within the top dome. Negative ions jump from the belt to the earthed comb at the lower pulley and the positive charge is carried to the top where it is collected by the top metal pulley and comb and transferred to the dome. This charge can reach very high voltages but with low current and will discharge back to earth by sparking to the discharge sphere connected to earth. In ideal conditions, it can produce a voltage of 400,000 volts with a short circuit current of 20 micro-amps. The voltage of a spark is approximately 30,000 volts per centimetre. It can be used to demonstrate the presence and nature of static electricity and electric fields.

### 2. Context

- The Van de Graaff generator is to be used for demonstration purposes only.

### 3. Safety notes

- Ensure that any person, who may be pregnant, has a heart condition, metal plates, a pacemaker, cochlear implant(s), electronic insulin pump or similar electronic device is not in the vicinity of the Van de Graaff generator.
- Ensure that people in close vicinity to the unit remove personal metal objects or jewellery.
- Ensure that the earthing sphere remains connected to the unit and is between the operator and the main dome at all times.
- Always hold the discharge sphere support rod by the insulated handle and have the earth cable attached to the base. Do not touch the metal base of the unit while it is running.
- Approach the machine with caution at all times. The spark generated has a high voltage but a low current. A spark discharge to the hand, although harmless, is a little painful.
- Do not operate the generator near flammable liquids. Keep any computer, mobile phones or similar device away from operating unit.
- After switching off, always earth the large dome by touching the dome with the discharging sphere to discharge it before touching it with the hand.
- Avoid using unit on metal-framed tables/benches.
- **Science ASSIST strongly advises against the forming of a human chain in demonstrations using the Van de Graaff generator.**

### 4. Regulations, licences and permits

The Van de Graaff should have a regular electrical Portable Appliance Test.

## 5. Equipment

- Van de Graaff generator
- Hair dryer may help to dry the column in humid conditions
- Attachments i.e. lock of hair, small aluminium pie plates, polystyrene cup and beads
- Insulating platform such as block of polystyrene (e.g. a lid of a polystyrene crate), sturdy plastic crate or rubber mat
- Wooden ruler such as a metre rule (without metal tips)

## 6. Operating procedure

### General instructions:

- Be familiar with the safety notes and do not allow students to operate the generator unsupervised.
- Ensure that any person with who may be pregnant, has a heart condition, metal plates, a pacemaker, cochlear implant(s), electronic insulin pump or similar electronic devices is not in the vicinity of the Van de Graaff generator.
- Remove any jewellery or metal objects if in close proximity to the operating unit.
- Place the Van de Graff generator at least 1.5 metres from walls, plumbing and light fittings, away from computers, mobile phones and similar equipment. Best results are obtained in a darkened laboratory.
- Wipe the dome, the sphere and the Perspex column with a clean dry cloth to remove any dust particles. Occasionally polish the dome with metal polish.
- Allow time for the unit to warm up. The unit operates best on a dry day. A hair dryer may help to reduce the humidity of the air in the column and dome.
- Plug in the machine and if it has a variable speed (most new models do), adjust the speed to the maximum.
- Touch the dome with the discharging sphere and build up the capability of the machine in the following manner:
  - Position the discharge sphere just a few millimetres away from the charging dome and wait till there is a regular steady discharge of approximately one per sec.
  - Increase the distance and repeat the procedure.
  - The rate of discharge is a better indicator of the performance of the machine than the optimum voltage, because the optimum voltage is affected so greatly by the conditions of the atmosphere.
  - Leave the machine running, discharging regularly as described above, for 5–10 minutes before doing any demonstrations.
  - When finished earth the large dome and hold the sphere on the dome and switch off the Van de Graaff generator before touching it.
  - Wipe the dome before storing in a dry cupboard protected from light or cover with a dark plastic bag.

(Operating procedure cont...)

### **Demonstrations:**

When ready for operation there are a range of demonstrations that can be performed. Here are a few examples:

(Note: Ensure that the dome is 'discharged' prior to adding any attachments, attach the item to the top of the dome prior to switching the unit on)

- Flying pies – stack some small aluminium pie plates onto the top and watch them fly off one by one.
- Sit a polystyrene cup full of polystyrene balls on top on the unit and watch them fly off.
- Light a fluorescent tube – hold the tube with a non-conducting holder (glove) and bring one end of the tube towards the dome. The glass surface of the tube nearest the dome acquires a negative charge by induction. The charge builds up on the glass surface to discharge intensity. As discharge occurs negative charges run through the entire tube lighting it up for the duration of the discharge.
- Hair-raising – attach a lock of hair and watch it rise. Discharge it with the sphere and watch the hair fall.

**If a student or other volunteer is to be used to see the hair raising demonstration a risk assessment should be performed.**

The recommended procedure is:

- a) Ask for a volunteer – a person with fine hair gets the best results.
- b) Check with the person that they are not pregnant, have a heart condition, metal plates, a pacemaker, cochlear implant(s), electronic insulin pump or other similar electronic devices.
- c) Ask the person to take off any jewellery or metal objects.
- d) Ensure that the generator is turned off and discharged before approaching.
- e) Have the person stand on the insulating platform.
- f) Get the person to run their hands through their hair and shake their hair.
- g) Have the person place both hands on the large dome BEFORE switching on the Van de Graaff generator.
- h) Switch on the generator, being careful to keep below the dome level so that the dome does not discharge.
- i) Hair should be seen to rise.
- j) When finished, earth the large dome by touching the discharge sphere to the dome on the opposite side to their hands and hold the sphere on the dome and switch off the Van de Graaff generator.
- k) Discharge the person by touching them with a wooden ruler.
- l) Ask the person to take their hands off the dome and jump from the insulating platform onto the floor, hitting the floor hard. The person can discharge any remaining static by shaking their hands.

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## **7. Trouble shooting/emergencies**

- Do not operate the generator in humid conditions.
- Allow time for the unit to warm up. A light or hair dryer can be used to warm and dry the air inside the unit.

- Wipe dome and insulating tube with a soft cloth before use.
- Avoid getting fingerprints on the insulating tube.
- Polish dome periodically with metal polish (such as Silvo® or similar).
- Remove the belt for storage. The nylon or rubber belt loses its efficiency if it is stretched for long periods of time. (See below for link to manufacturer's instructions).
- Remove and clean the belt with warm soapy water periodically.
- Check belt for wear or fraying.
- Adjust the tension on the belt, if this an option.
- Lubricate pulleys occasionally.
- Clean top metal pulley with alcohol.

## 8. Waste disposal

- Not applicable

## 9. Related material

- Manufacturer's instruction manual.
- Risk Assessment
- Van de Graaff information sheet [http://www.iecpl.com.au/z\\_pdfs/em4133-101.pdf](http://www.iecpl.com.au/z_pdfs/em4133-101.pdf)
- Van de Graaff attachments EM4144-001 [http://www.iecpl.com.au/z\\_pdfs/em4144-001.pdf](http://www.iecpl.com.au/z_pdfs/em4144-001.pdf)
- Van de Graaff belt Information [http://iecpl.com.au/z\\_exp/em4137belt.pdf](http://iecpl.com.au/z_exp/em4137belt.pdf)

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