

# Voltage Gradient Probe Operating Manual

The Voltage Gradient Probe is a robust, hand-held, subsea, unit used to give an easy interpretation and reliable indication of AC voltage gradients as part of a risk assessment and management scheme while working on or around subsea electrical equipment



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# 1. GENERAL DESCRIPTION

The Voltage Gradient Probe (VGP) is a robust, hand held, subsea unit used to give an easy to interpret, robust, and reliable indication of AC voltage gradients in sea water. The primary use is to provide a robust indication of the presence of any local AC voltage gradients as part of a risk assessment and management scheme while working on or around subsea electrical equipment. The VGP should never be touched against known or suspected "live" parts and comes pre-fitted with an insulating cap to prevent such accidental contact.

The VGP gives an indication of the presence and magnitude of the AC voltage gradients using a series of 6x LEDs, which illuminate progressively at clearly defined trigger voltages, in an easy to interpret 'traffic light' configuration.

A dedicated BATTERY STATUS LED provides a clear indication of the battery status and also provides confirmation that the unit is functioning.

The VGP comes with a dedicated TESTBOX which allows functionality to be tested prior to deployment by following a quick, simple, and intuitive procedure.

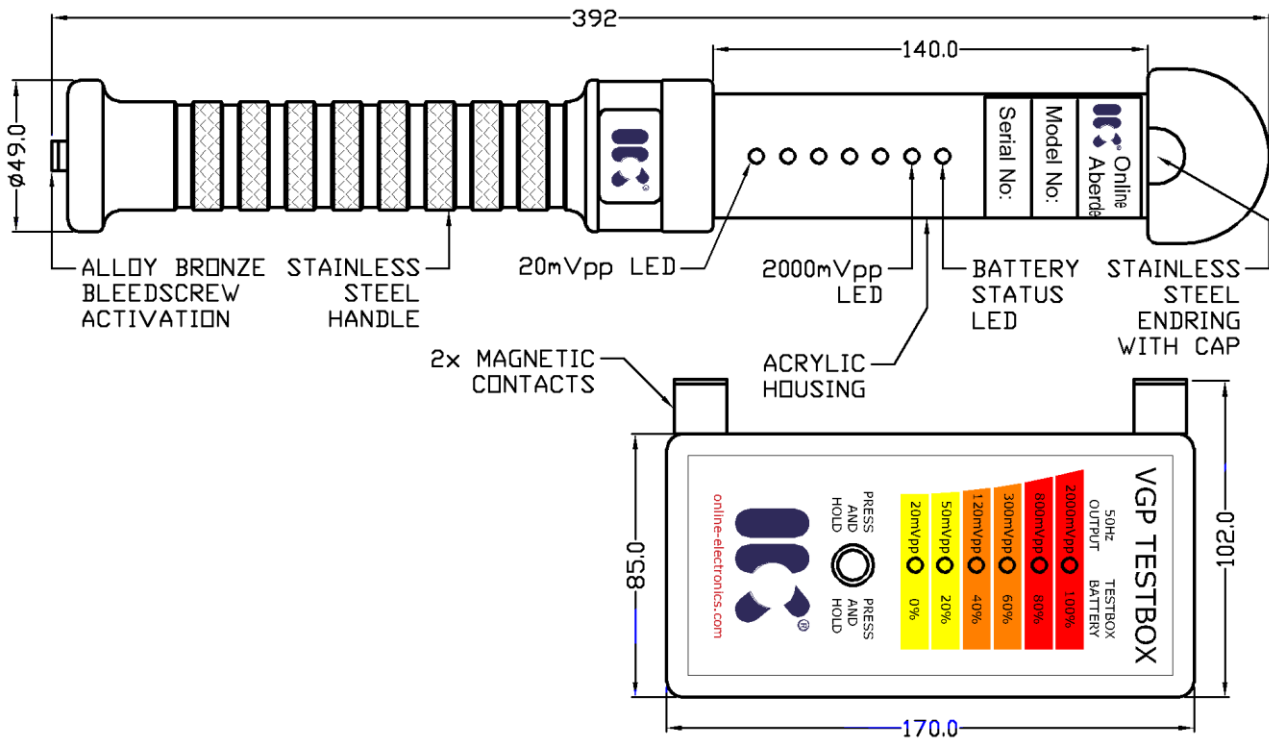


Figure 1: VGP PROBE AND TESTBOX

## 2. VGP PROBE SPECIFICATIONS

### GENERAL:

Minimum battery life at 5°C..... 2 days (10 days typical)  
Battery type ..... 3x Standard 1.5V 'AA' Alkaline cells (Duracell ID1500)  
Operating temperature range.....-5°C to +50°C  
External pressure rating ..... 300m / 30bar

### SENSOR:

Measurement gap (Between Handle and Endring)..... 140mm  
Measurement frequency range ..... 50Hz to 500Hz  
LED 1 illumination level .....20mVpp ±4mVpp (50mVrms/m\*)  
LED 2 illumination level ..... 50mVpp ±4mVpp (130mVrms/m\*)  
LED 3 illumination level ..... 120mVpp ±4mVpp (300mVrms/m\*)  
LED 4 illumination level ..... 300mVpp ±9mVpp (760mVrms/m\*)  
LED 5 illumination level .....800mVpp ±24mVpp (2020mVrms/m\*)  
LED 6 illumination level ..... 2000mVpp ±60mVpp (5050mVrms/m\*)

\*Assumes a sinusoidal waveform satisfying  $V_{pp} = 2.828 \times V_{rms}$  across the measurement gap.

### MATERIALS:

Handle material.....DUPLEX STAINLESS STEEL 2205  
Endring material.....DUPLEX STAINLESS STEEL 2205  
Cap material ..... BLACK ACETAL HOMOPOLYMER  
Housing material ..... ACRYLIC  
Bleedscrew material.....ALLOY BRONZE CA104 EN 12163  
Handle o-rings ..... 2x BS 50-220 NBR70  
Endring o-ring ..... 1x BS 50-213 NBR70  
Bleedscrew o-ring ..... 1x BS 50-008 NBR70

### DIMENSIONS:

Length .....392.0mm ±0.25mm  
Diameter ..... 49.0mm ±0.25mm  
Weight in air ..... 2.2kg  
Weight in water..... 1.8kg

### 3. VGP TESTBOX SPECIFICATIONS

**GENERAL:**

Minimum battery life at 20°C (Continuous Use) ..... 1 day  
Battery type ..... 1x Standard 9V 'PP3' Alkaline cell (Duracell ID1604)  
Operating temperature range.....-5°C to +50°C

**OUTPUT:**

Output waveform ..... 50Hz Sinusoid  
LED 1 level ..... 25mVpp ±1mVpp  
LED 2 level ..... 56mVpp ±2mVpp  
LED 3 level .....127mVpp ±3mVpp  
LED 4 level .....315mVpp ±6mVpp  
LED 5 level ..... 840mVpp ±15mVpp  
LED 6 level ..... 2100mVpp ±60mVpp

**DIMENSIONS:**

Length .....170.0mm ±0.25mm  
Width..... 85.0mm ±0.25mm  
Width (Including magnetic contacts) .....100.0mm ±5.00mm  
Depth ..... 35.0mm ±0.25mm  
Weight ..... 1kg

## 4. PROBE THEORY OF OPERATION

OEL recommend that the diver should withdraw if ANY AC voltage gradient is indicated by ANY of the VGP LEDs because this means that there may be live, un-insulated, conductors in the environment. The different LED levels can be used to help the diver determine the 'safest' direction in which to withdraw.

The VGP should never be touched against a known or suspected "live" part.

Note that the actual COLOUR of the VGP LEDs do not represent any specific information. The LOWEST, GREEN LED represents the lowest voltage gradient and the UPPER RED LED represents the highest voltage gradient. The voltage gradient represented by each LED may or may not be dangerous – this must be determined by the user as part of their risk assessment and management scheme. Depending on the environment/scenario all 6x LEDs may represent 'safe' levels.

For an example let's assume that the users' risk assessment and management scheme has determined that the diver has a maximum 2m span, minimum body resistance of 750R and the safe body current is 10mA.

Note that to calculate body current RMS voltage values must be used. In this example if LED 5 is lit then there is between 2.02Vrms/m and 5.05Vrms/m being measured by the VGP. This would result in a body current of between 5.4mA and 13.5mA assuming a diver with 2m span and body resistance of 750R. Remember that it is the users' risk assessment and management scheme which must determine the safety parameters for each job.

In this example the lower 4x LEDs would represent 'safe levels' where the assumed body current would be below 5.4mA and the upper 2x LEDs would represent potentially 'dangerous levels' which may result in a body current above the 10mA safe body current determined by the users' risk assessment and management scheme. However OEL recommend that the diver should withdraw should ANY of the LEDs illuminate as there should never be live, un-insulated, conductors near the diver and there should therefore be no AC voltage gradient.

The VGP takes 5000 samples per second of the AC voltage present between the Handle and Endring which are 140mm apart. Every 0.2 seconds the VGP updates the LEDs with the highest peak to peak value seen between these two points since the last update. This means that if there is a sudden spike of voltage then the VGP will show it. If the VGP were displaying an Average or RMS (Root Mean Square) value then it may not have shown the spike at all, or at least not the true magnitude of the spike.

Most multimeters display an RMS measurement when measuring AC voltages. A multimeter can be used to check the output of the VGP TESTBOX by simply measuring the AC voltage between the 2x magnetic contacts but remember that the VGP TESTBOX output is specified in Vpp and the multimeter will be displaying Vrms.

### 4.1. CONVERSION FACTORS

Some important conversion factors to remember are shown below along with a table showing the equivalent mVrms, Vpp/m, and Vrms/m for the PROBE and TESTBOX mVpp levels.

**$V_{rms} = V_{pp} / 2.828$**  (for sinusoidal waveforms only)

**$V_{rms}/m = V_{rms} / 0.14$**  (for the VGP measurement gap of 0.14m only)

**$V_{pp}/m = V_{pp} / 0.14$**  (for the VGP measurement gap of 0.14m only)

<b>VGP PROBE</b> (mVpp)	<b>EQUIVALENT</b> (mVrms)	<b>EQUIVALENT</b> (Vpp / m)	<b>EQUIVALENT</b> (Vrms / m)
20 mVpp	7.07 mVrms	0.14 Vpp/m	0.05 Vrms/m
50 mVpp	17.7 mVrms	0.36 Vpp/m	0.13 Vrms/m
120 mVpp	42.4 mVrms	0.86 Vpp/m	0.30 Vrms/m
300 mVpp	106 mVrms	2.14 Vpp/m	0.76 Vrms/m
800 mVpp	283 mVrms	5.71 Vpp/m	2.02 Vrms/m
2000 mVpp	707 mVrms	14.3 Vpp/m	5.05 Vrms/m
<b>VGP TESTBOX</b> (mVpp)	<b>EQUIVALENT</b> (mVrms)	<b>EQUIVALENT</b> (Vpp / m)	<b>EQUIVALENT</b> (Vrms / m)
25 mVpp	8.84 mVrms	0.18 Vpp/m	0.06 Vrms/m
56 mVpp	19.8 mVrms	0.40 Vpp/m	0.14 Vrms/m
127 mVpp	44.9 mVrms	0.91 Vpp/m	0.32 Vrms/m
315 mVpp	111 mVrms	2.25 Vpp/m	0.79 Vrms/m
840 mVpp	297 mVrms	6.00 Vpp/m	2.12 Vrms/m
2100 mVpp	742 mVrms	15.0 Vpp/m	5.30 Vrms/m



## 5. RULES FOR SAFE OPERATION

**⚠ WARNING:** Any operation involving pressure is potentially hazardous. No person should use this equipment unless fully aware of the potential hazards of working with pressurised vessels. The purchaser of this equipment is responsible for the training and competence of operators and the manner in which it is used. This manual should be read through and understood before installation and commissioning so that the operator is familiar with the equipment. Contact Online Electronics Ltd immediately should any difficulty arise in the use of this equipment.

**⚠ WARNING:** Always use caution when opening equipment which has been in a pressurised environment. It is possible for pressure to leak into the equipment and remain there even after external pressure has been removed. ALWAYS point the end to be opened towards a safe area and away from yourself or others. Contact Online Electronic immediately if there is a suspicion that the equipment has become pressurised.

**⚠ WARNING:** Always loosen the probe bleedscrew to relieve any internal pressure prior to opening.

**⚠ WARNING:** Replace all batteries at the same time. NEVER install used batteries. NEVER install a mix of new and used batteries. USE ONLY new batteries from the same package or manufacturing batch. DO NOT mix different brands or types of batteries. ALWAYS observe correct battery polarity. New batteries should be installed before each deployment.

**⚠ WARNING:** Ensure the insulating cap is fitted. DO NOT TOUCH KNOWN OR SUSPECTED "LIVE" PARTS WITH THE VGP.

**⚠ CAUTION:** Always complete a 6.4 VGP PROBE FUNCTION TEST before deployment.

**⚠ CAUTION:** Do not expose to aggressive solvents or chemicals which could be harmful to the acrylic probe housing, ABS testbox enclosure or nitrile rubber o-rings.

**⚠ CAUTION:** Opening of the equipment should take place in a clean laboratory environment.

**⚠ CAUTION:** To prevent the formation of condensation within the transmitter, allow the transmitter temperature to stabilise within the laboratory environment for a minimum of 6 hours prior to opening.

## 6. OPERATION

Familiarise yourself with all of the rules for the safe operation of this equipment as described in Section 5 RULES FOR SAFE OPERATION.

### 6.1. TURNING ON

1. To turn the VGP PROBE unit ON, fully engage the BLEEDSCREW. The GREEN BATTERY STATUS LED should begin to flash every 2 seconds indicating that the VGP PROBE is functioning. Confirm that the remaining battery lifetime indicated by the GREEN BATTERY STATUS LED is sufficient.
2. The VGP PROBE may be shipped with a plastic washer under the BLEEDSCREW to prevent accidental activation during transit, if fitted, this washer must be removed to allow the BLEEDSCREW to fully engage.

### 6.2. TURNING OFF

1. To turn the VGP PROBE unit OFF simply loosen the BLEEDSCREW 4 full turns. The GREEN BATTERY STATUS LED should stop flashing after approximately 2 full turns. Apply some tape over the BLEEDSCREW to prevent it turning and causing accidental reactivation.

### 6.3. VGP PROBE BATTERY STATUS LED

While ON, the VGP PROBE GREEN BATTERY STATUS LED flashes 4, 3, 2, 1, or 0 times every 2 seconds indicating that battery lifetime remaining is 100%, 75%, 50%, 25%, or 0% respectively. It is recommended that the batteries be replaced at 50%.

The VGP PROBE GREEN BATTERY STATUS LED flashes also give a visual indication that the VGP PROBE is functioning - **if the LED is not flashing then the VGP PROBE may not be functioning and must be recovered and inspected immediately.**

## 6.4. VGP PROBE FUNCTION TEST

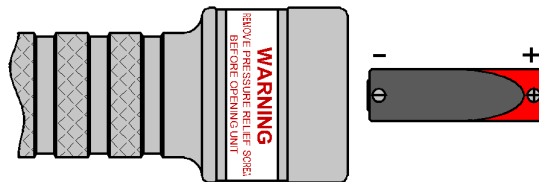
1. Connect the VGP TESTBOX to the VGP PROBE using the TESTBOX MAGNETIC CONTACTS and place on a dry, non-conducting surface. The TESTBOX can be connected either way round but ensure that the LEDs on both the PROBE and TESTBOX can be viewed simultaneously. The TESTBOX magnetic contacts will normally be shipped with thin, mild steel discs fitted, ensure these are removed and that the contact faces are **clean and free from corrosion**. They should be lightly greased to prevent corrosion.
2. Ensure that the VGP PROBE is turned ON, the GREEN BATTERY STATUS LED should be flashing every 2 seconds.
3. Press and hold the VGP TESTBOX button.
4. **(6 – 2000mVpp)** After approximately 1 second the TESTBOX shall output a 50Hz, 2100mVpp sinusoid for the next 5 seconds. Confirm that all TESTBOX LEDs and the first 6x PROBE LEDs illuminate for this period. After 5 seconds the TESTBOX output shall turn OFF for 1 second. Confirm that all LEDs on the TESTBOX and all LEDs on the PROBE turn OFF during this time.
5. **(5 – 800mVpp)** The TESTBOX shall now output a 50Hz, 840mVpp sinusoid for the next 5 seconds. Confirm that the first 5x TESTBOX LEDs and the first 5x PROBE LEDs illuminate for this period. After 5 seconds the TESTBOX output shall turn OFF for 1 second. Confirm that all LEDs on the TESTBOX and all LEDs on the PROBE turn OFF during this time.
6. **(4 – 300mVpp)** The TESTBOX shall now output a 50Hz, 315mVpp sinusoid for the next 5 seconds. Confirm that the first 4x TESTBOX LEDs and the first 4x PROBE LEDs illuminate for this period. After 5 seconds the TESTBOX output shall turn OFF for 1 second. Confirm that all LEDs on the TESTBOX and all LEDs on the PROBE turn OFF during this time.
7. **(3 – 120mVpp)** The TESTBOX shall now output a 50Hz, 127mVpp sinusoid for the next 5 seconds. Confirm that the first 3x TESTBOX LEDs and the first 3x PROBE LEDs illuminate for this period. After 5 seconds the TESTBOX output shall turn OFF for 1 second. Confirm that all LEDs on the TESTBOX and all LEDs on the PROBE turn OFF during this time.
8. **(2 – 50mVpp)** The TESTBOX shall now output a 50Hz, 56mVpp sinusoid for the next 5 seconds. Confirm that the first 2x TESTBOX LEDs and the first 2x PROBE LEDs illuminate for this period. After 5 seconds the TESTBOX output shall turn OFF for 1 second. Confirm that all LEDs on the TESTBOX and all LEDs on the PROBE turn OFF during this time.
9. **(1 – 20mVpp)** The TESTBOX shall now output a 50Hz, 25mVpp sinusoid for the next 5 seconds. Confirm that the first 1x TESTBOX LEDs and the first 1x PROBE LEDs illuminate for this period. After 5 seconds the TESTBOX output shall turn OFF for 1 second. Confirm that all LEDs on the TESTBOX and all LEDs on the PROBE turn OFF during this time.
10. **(BATTERY)** The TESTBOX shall now give an indication of the TESTBOX BATTERY STATUS by illuminating 1, 2, 3, 4, 5, or 6 of the TESTBOX LEDs representing 0%, 20%, 40%, 60%, 80%, or 100% TESTBOX BATTERY life remaining respectively. Ensure that at least 3x LEDs remain illuminated (40%) otherwise replace the TESTBOX battery and restart the test. All PROBE LEDs should remain OFF during this time. After 5 seconds all TESTBOX LEDs shall turn OFF for 1 second.
11. The VGP PROBE FUNCTION TEST has now been PASSED if all results were as described. The VGP TESTBOX button can now be released however if it remains held then the test shall simply repeat until the button is released.
12. Lightly grease the magnetic contact surfaces if necessary to prevent corrosion.

## 7. MAINTENANCE

Familiarise yourself with all of the rules for the safe operation of this equipment as described in Section 5 RULES FOR SAFE OPERATION.

### 7.1. PROBE BATTERY REPLACEMENT

1. Loosen the BLEEDSCREW 4 full turns to relieve any internal pressure.
2. Stand the PROBE HANDLE upright on a table then, with clean hands, grip the ACRYLIC HOUSING in one hand and the HANDLE in the other, unscrew the HOUSING from the HANDLE (a regular Right Hand thread has been used). DO NOT GRIP THE CAP otherwise the ENDRING may unscrew from the HOUSING and become damaged.
3. Carefully withdraw the HOUSING from the HANDLE and set aside. Ensure that the Oring seals and surfaces are protected from damage and contamination while the unit is open.
4. Observing the battery polarity shown in the figure below, replace all batteries.



5. Examine the Oring seals for any signs of damage or contamination. Replace and/or lubricate if necessary.
6. Reassemble the unit following the above instructions in reverse. Stand the PROBE HANDLE upright on a table while engaging the HOUSING threads, **do not over-tighten or force the threads otherwise damage may occur, they should be finger tight only.**
7. Tighten the BLEEDSCREW to turn the unit ON and confirm that the BATTERY STATUS LED is flashing 4 times every 2 seconds indicating 75-100% lifetime remaining.
8. Loosen the BLEEDSCREW 4 full turns to turn the unit OFF if the VGP PROBE is not going to be used immediately.

### 7.2. TESTBOX BATTERY REPLACEMENT

1. Remove the sliding door on the rear of the TESTBOX to reveal the PP3 battery.
2. Carefully remove the battery from its compartment and replace.

### **7.3. ROUTINE CALIBRATION AND INSPECTION**

Online Electronics Ltd recommends that the VGP PROBE and TESTBOX be returned to our manufacturing facility in Aberdeen once per year for inspection, overhaul, and calibration. During this procedure the following actions will be completed:

1. Full inspection of VGP PROBE.
2. Replacement of all VGP PROBE Orings.
3. Recalibration of all VGP PROBE levels.
4. Replacement of all VGP PROBE batteries.
5. Full inspection of VGP TESTBOX.
6. Recalibration of all VGP TESTBOX levels.
7. Replacement of VGP TESTBOX battery.

### **7.4. ROUTINE MAINTENANCE AND STORAGE**

All Online Electronics Ltd products are designed to require minimum maintenance. The housing should be cleaned using fresh water as necessary. Do not use chemicals which could be damaging to the ACRYLIC HOUSING, the NITRILE RUBBER O-RINGS, or the ABS TESTBOX ENCLOSURE.

If the unit is to be placed in storage for a long period of time ensure the unit has been cleaned and dried, and remove the batteries.

## **8. DISPOSAL OF UNIT**

Online Electronics Ltd takes its responsibilities under the WEEE Regulations extremely seriously and has taken steps to be compliant in line with our corporate and social responsibilities. In the UK, Online Electronics Ltd has joined a registered compliance scheme WeeeCare (registration number **WEE/MP3538PZ/SCH**).

Electrical and electronic equipment should never be disposed of with general waste but must be separately collected for the proper treatment and recovery.

The crossed out bin symbol, placed on the product, reminds you of the need to dispose of it correctly at the end of its life.

When buying a new product you will have the possibility to return, free of charge, another end of life product of equivalent type that has fulfilled the same functions as the supplied equipment. These items may be deposited at:

Online Electronics Ltd  
Online House  
Woodburn Road  
Blackburn Business Park  
Blackburn  
Aberdeen  
AB21 0PS  
UK

Alternatively, to arrange a collection of any waste electrical equipment, obligated to Online Electronics Ltd please telephone WeeeCare on **0844 800 2004**.

## **9. WARRANTY**

Online products are guaranteed for one year from the date of purchase. Goods should be returned transportation prepaid to Online Electronics Limited.

There is no charge for parts or labour should any product require repair due to a manufacturing deficiency during the guarantee period.

In the event of a manufacturing deficiency the inward transportation costs will be repaid to the client.