UNDERSIDE OF THE VEHICLE: PREPARATION AND PAINT RANGE

 **Note, one or more warnings are present in this procedure** 

WARNING

Always wear protective gear (gloves, goggles and breathing masks).

Use extra ventilation source.

Steps	Description	Special notes
1	Clean the subframe	Soapy water
2	Rinse / Blow	
3	Strip the PVC mastic from the subframe on the areas to be repaired	Tools for stripping very thick soft mastic: Use Tools for scraping rigid adhesives and paint: Use (40A, General information)
4	Wipe / blow	
5	Sand the PVC mastic remaining from the repair, slightly overlapping by 150to 200 mm	P180-P240 / Red pad
6	Wipe / blow	
7	Degrease	Lint-free cloth soaked in surface cleanerVehicle: Parts and consumables for the repair (04B, Consumables - Products). wipe with a dry lint-free cloth
8	Masking	Masking paper
9	Apply a pre-treatment primer	Vehicle: Parts and consumables for the repair (04B, Consumables - Products)
10	Remove solvent	
11	Apply a bi component primer	Vehicle: Parts and consumables for the repair (04B, Consumables - Products)
12	Remove solvent / dry	
13	Sand the primer	P400 to P500dry / P400 to P800water

14	Wipe / blow	
16	Degrease	Lint-free cloth soaked in surface cleaner Vehicle: Parts and consumables for the repair (04B, Consumables - Products). wipe with a dry lint-free cloth
17	Masking	Masking paper
18	Apply a sealing mastic	Anti-corrosion protection products after assembly: Use (40A, Generalinformation) Vehicle: Parts and consumables for the repair (04B, Consumables - Products)
19	Apply the paint finishing	

WHITE TECHNICAL NOTE

Edition Anglaise

FEBRUARY 2013
77 11 XXX XXX

6526A
Service 0465

Type *S/*Section

Electric vehicle

XXX X **24A**

24A INSULATION FAULT FINDING ON ELECTRIC VEHICLES

- Engine: **XXX**
- Gearbox: **XXX**

Basic manual: any Technical Note

This Technical Note concerns the operations to be performed when searching for an electrical insulation fault on a power circuit of an electric vehicle or hybrid electric combustion engine vehicle with a megohmmeter or insulation tester.

CONTENTS

1. GENERAL INFORMATION

1.1 Warnings

WARNING
It is prohibited to work alone in the workshop. Another person must be available nearby so that, in the event of a problem, they can help the person in danger.

WARNING
Any operation performed on the high voltage network of a vehicle involves the risk of death by electrocution. An operator is accredited by the company that employs him/her, provided that the mandatory training has been successfully completed and that he/she has the necessary skills.

WARNING
The procedures described below must be performed by a qualified employee authorised to work on a high voltage on-board network.
Operations on the vehicle's high voltage network present a risk of death by electrocution. The operator is trained and authorised by their employer, subject to certain mandatory conditions of skills and training.

WARNING
DANGER: VEHICLE UNDER HIGH VOLTAGE.

Risk of serious burns or electric shocks that may prove fatal.

Before any operation on the vehicle, it is essential that the lockout instructions for the vehicle are followed. This operation must be performed by a qualified employee authorised to work on a high voltage on-board network.

WARNING
Never use a voltage absence tester if the self-test is incorrect. It could give incorrect information which could put you in danger.

WARNING
To prevent damage to the systems, apply the safety and cleanliness instructions and operation recommendations before carrying out any repair operation:

- Technical Note 6037A: "Vehicle mechanical introduction: work procedure for electric vehicles"
- MR xxx: "Vehicle mechanical introduction: precautions for repair"
- MR xxx: "Battery: precautions for repair"
- MR xxx: "Wiring: precautions for repair"
- MR xxx: "Vehicle mechanical introduction: lockout – removal of lockout"

MR xxx: xxx corresponds to the number of the repair manual for the vehicle.

Note:

Remove any personal objects (jewellery, watches etc.).

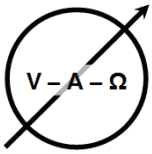
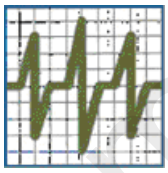
Note:
Check that the personal and collective protective equipment are in perfect condition.

1.2 Equipment required

This equipment is given as a reminder. To find the part numbers for each particular vehicle, refer to MR xxx: "Vehicle mechanical introduction: lockout – removal of lockout"

Special tooling required		
Ele. 1967, Ele. 2005, …		Safety locking plug for traction battery
Ele. 1980		Traction battery lockout padlock
Ele. 1993		Voltage Absence Tester

Equipment required	
	Face shield
	Safety helmet
	Safety shoes (electric class 00 or 0)

Equipment required	
	Protective overalls (mainly cotton)
	Boundary limit kit (posts, red and white chains, A4 sign)
	Electronic diagnostic tool
	Multimeter that meets RENAULT approved specifications (refer to the "garage equipment" catalogue)
	Megohmmeter that meets RENAULT approved specifications (refer to the "garage equipment" catalogue)
	The relevant FAULT FINDING REPAIR MANUAL for the vehicle and the system
	Connection to RENAULT.NET with access to the wiring diagrams for the vehicle being diagnosed

2. DEFINITIONS

2.1 Insulation tester or megohmmeter

Device used to measure very high electrical resistances, such as insulation resistance, expressed in megaohms. It also is called a "megohmmeter".
The insulation tester generates a high direct current voltage (from several hundred volts to several **kV**). The device generally limits the current to a few **mA**.
This device is used to measure the insulation of electrical equipment such as an electric machine, power cables, insulators and lightning arrestors, as well as any equipment or installation likely to present a danger to safety in the event of a fault.

2.2 Voltage detector – Voltage absence tester

This is a specific device designed to check that there is no nominal voltage on an electrical circuit.
The common terms "voltage absence tester", "voltage absence testing device" or "voltage absence controller" are applicable to "voltage detectors" that perform only this function, as defined in the standards in force. The term "voltage detector" has a wider meaning because it includes the "absence" and the "presence" of voltage.
Refer to Technical Note 6037: "Mechanical introduction: personal protective equipment for electric vehicles - **V** - VOLTAGE DETECTOR"

2.3 Multimeter

A device that is used to measure currents, voltages and electrical resistances.

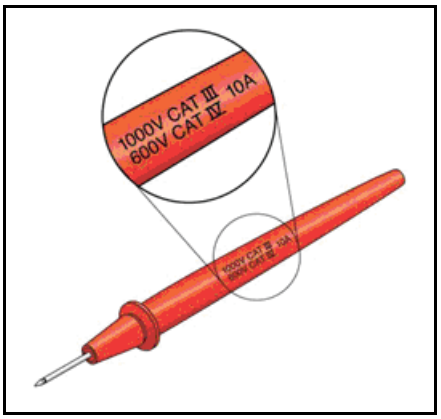
3. BASIC SAFETY RULES

All electricians are suspicious of components that may contain an electrical current. Important: emergency work and work performed under pressure can result in careless mistakes and serious errors being made, even by the most experienced electricians. The information below details a few rules that must be followed when taking electrical measurements.

- **Understanding the installation**
  Measuring range, voltage levels, excess voltage level (excess voltage categories), current values during normal use and in the event of a fault, installation wiring diagram, the capacitive effects of components etc.
- **Wear personal and collective protective equipment when taking measurements with a risk of voltage and electrical current**
- **Delimit the working area and perform the lockout procedures**
- **Whenever possible, switch off the voltage supply to the circuits to be measured.**
  If you have to work with a live circuit, use suitably insulated tools, wear personal and collective protective equipment, remove your watch and any other jewellery, and wear appropriate clothing.
- **Check that there is no voltage present before taking any measurements**
- Residual voltage may still be found on a component that has been removed or a faulty component, which must be eliminated before any measurements are taken with the electricity supply off
- **When working with live circuits, where possible, always keep one hand out of the range of the electrical circuit.**
  This reduces the possibility of creating a closed circuit that passes through one of your arms to the other via your chest and heart. Suspend or position the tester if possible; try to avoid holding it in your hands to minimise the risk of exposure to the effects of electrical transients, and avoid holding the two measurement leads at the same time etc.

- **When measuring current without using a current clamp, switch off the supply before connecting the multimeter to the circuit.**

- **Be familiar with and use a suitable measuring device for the measurement to be taken.**
  Check that it corresponds to the operating range (measurement level, voltage level, excess voltage level or installation level, current values during nominal usage and in the event of a fault).



- **Operating voltage range**
  The electrical work and installations are classified into voltage ranges. **Considering the voltages to be measured, the measuring device will be within the minimum low voltage range.**

Voltage ranges		**Alternating current**	**Direct current**
Very low voltage		**Un ≤ 50 V**	**Un ≤ 120 V**
Low voltage	**Range A**	**50 < Un ≤ 500 V**	**120 < Un ≤ 750 V**
	Range B	**500 < Un ≤ 1000 V**	**750 < Un ≤ 1500 V**
High voltage	Range A	**1000 < Un ≤ 5000 V**	**1500 < Un ≤ 7500 V**
	Range B	**Un > 5000 V**	**Un > 7500 V**

- **Excess voltage category**

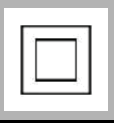
  The excess voltage category defines the excess voltage that a device can withstand (with or without damage), without posing a danger to the user.
  To limit the risks related to electric shock (human contact with voltage) and material projected through melting, standard IEC 61010 defines the measuring devices and their use depending on the voltage types, networks and measuring devices. **Considering the categories of use, the multimeter should be at least CAT III 600 V.**

Category	Symbol	Overvoltage	Description
4	CAT IV	**6000 V**	Primary source, aerial line and cable system, including distribution busbars and equipment associated with overcurrent protection
3	**CAT III**	**4000 V**	**Fixed installations related to industrial distribution and 230/ 400 V electrical maintenance input circuits for buildings (technical columns, lifts etc.)**
2	CAT II	**2500 V**	Portable or domestic devices and equipment, **230 V** single phase mains sockets.
1	CAT I	**500 V**	Special equipment or equipment that is part of category II, telecommunication, electronics, insulation transformer, **60 V** battery etc.

- **Insulation class**

  The insulation class defines the protection level against electric shocks during normal service and the protection level against electric shocks in the event of a fault. **In view of the requirements, the measuring device should be at least class 2.**

Class	Specifications	Use	Symbol
0	Basic insulation: the device has a functional insulation with no earth. It is not possible to connect the earths to each other or to ground The plugs of this equipment have no earth pin. The structure could have a potential that is dangerous to humans (due to an insulation fault for example) if the fault is not detected before contact is made.	Usage is forbidden on work sites. Note: The sale of class 0 equipment is forbidden in Europe.	No symbol

Class	Specifications	Use	Symbol
1	Basic insulation: the device has a functional insulation with an earth terminal and equipotential connection. The earths are connected to each other and to ground. This equipment has plugs with an earth, which is connected to the metallic parts.	Usage is possible on work sites for fixed machines	IEC 60417-5019 
2	**Reinforced insulation (or double insulation): the device has reinforced insulation without accessible metallic parts. The earths are not connected to ground. The equipment plugs do not have an earth pin.**	**Usage is possible on work sites for non-fixed machines**	**IEC 60417-5172** 
3	The device operates at a very low safety or protection voltage (TBTS) of a maximum of **50 Volts**. The voltage must be lowered using a safety transformer, which provides safe galvanic insulation between the primary and secondary circuits. The earths are not connected to ground.	Mandatory on mobile devices that are not fixed and in a confined environment that is humid or damp	IEC 60417-5180 

- **Protection index**

  This index classifies the protection level offered by a piece of equipment against solid body and liquid intrusions. **The multimeter must have a protection index at least equal to IP54.**

Index	1st number ➨ Protection against dust	2nd number ➨ Protection against water
0	No protection.	No protection.
1	Protected against solid bodies larger than **50 mm**.	Protected against vertically falling drops of water.
2	Protected against solid bodies larger than **12 mm**.	Protected against drops of water falling at up to **15°** from the vertical.
3	Protected against solid bodies larger than **2.5 mm**.	Protected against drops of rain water at up to **60°** from the vertical.
4	Protected against solid bodies larger than **1 mm**.	**Protected against projections of water from all directions.**

Suffix	1st number ➨ Protection against dust	2nd number ➨ Protection against water
5	**Protected against dust.**	Protected against jets of water from all directions.
6	Completely protected against dust.	Protected against jets of water of similar force to heavy seas.
7		Protected against the effects of immersion.
8		Protected against the prolonged effects of immersion under pressure.

- **Be familiar with, use and check the leads suited to the measurement to be taken.**
  The measuring leads are an important component involved in the safety of your multimeter. Check that your measuring leads correspond to the measuring level to be taken. Choose leads with double insulation, shielded input connectors, finger guards and a non-slip surface.

- **Check and ensure that everything is in good condition and that the equipment works correctly. Only use devices and connection accessories that comply with the safety standards** (IEC 61010).
  In the event of a fault, invest in a new device as the cost will most certainly be less than that of hospitalisation. In the event of a fault, the devices are in direct physical contact with the user!

- **Check that your device has been certified by an independent test laboratory.**
  Something to consider to prevent you from choosing the cheapest multimeter: being the victim of an accident at work because the cheap tester did not actually have the safety specifications stated!

- **Use a multimeter equipped with overload protection in resistance mode**

- **Replace the melted fuse with a fuse that has the same specifications as the original fuse and meets the manufacturer's specifications.**
  Its rated silicon fuse has been specially designed to make your tester safe by preventing an overload from reaching your hand. Use a multimeter equipped with fuses at its current measurement inputs and check the fuses before taking any current measurements.
- **Use the multimeter to test the continuity of the test leads**
- **Only use test leads equipped with insulated terminals and finger guards**
- **Only use multimeters equipped with recessed inputs**
- **Select the function and the scale suited to the measurement beforehand**
- **Always disconnect the "hot" test lead first: the red lead.**

4. PRINCIPLES

In order to guarantee the safe operation of the devices and electrical installations, all conductors are insulated by a sheath for the cables and by varnish for the windings. When the quality of the insulation deteriorates, a leakage current can circulate from one conductor to the other. This is an electrical insulation fault.

This may cause:

- installation faults (risk of erratic stopping or starting)
- short circuits (risk of overheating or fire)
- personal protection faults (risk of serious burns or electric shocks that may cause death).

4.1 Cause of fault?

The quality of the insulation changes over time as a result of the stress to which this equipment is subjected. This causes a decrease in electrical resistance and an increase in leakage current.
This fault can generate incidents, the severity of which can have consequences in terms of personnel safety, the safety of goods, production downtime costs for professionals and customer immobilisation.
It is possible to classify these causes of insulation faults into several groups. These different causes combine together mutually in the absence of corrective measures.

Electrical stress:

- Mainly linked to excess voltage and under voltage

Mechanical stress:

- Starting and stopping sequences particularly when they are frequent
- Rotating machine balancing faults and
- All direct impacts to cables and installations affect the insulation performance of the materials.

Chemical stress:

- The proximity of chemical products, oils, corrosive vapours and dust affect the insulation performance of the materials

Stresses related to temperature variations:

- In combination with the mechanical stress caused by equipment starting and stopping sequences, the stress of expansion or contraction affect the characteristics of the insulating materials. Operation at extreme temperatures is also a factor that causes the materials to age

Environmental contamination:

- Development of mildew and particle deposits in hot and humid environments contribute to negatively affecting the insulation characteristics of the installation

Climatic environment:

- Humidity is a source of insulation faults. Take care when the vehicle is wet, damp or humid. When a vehicle enters and leaves a dealership, starting the vehicle can generate dew and condensation points, which can affect the equipment insulation

4.2 Preventive and corrective maintenance

Periodic insulation tests must be performed on the installations and new or renovated equipment. This makes it possible to avoid incidents and to detect ageing components.

The checks can be:

- manual using electronic and electrical diagnostic tools or
- automatic by means of an automatic check integrated into the vehicle.

In the event of an automatic check, a preventive check to verify the correct operation of the measuring sensors may be required.
For this, refer to the wear maintenance range and/or the electrical and electronic fault finding methods for the vehicle.

4.3 Measuring principle

An insulation check may be performed to earth, to "+ (plus)", "**–** (minus)" or between conductors using:

- an ohmmeter - installation with no voltage supply and locked out
- an insulation tester - installation with no voltage supply and locked out or
- a voltmeter - live installation.

The insulation tester is used to measure the resistance of the materials when the ohmmeter reaches these measurement limits. It is for this reason that it is not always possible to use an ohmmeter alone to measure the insulation resistance. In this case, an insulation tester is used.

Note:
An undefined resistance is indicated by "OL" (out of limits) on a device when the resistance is greater than the values measurable by the device.

It is necessary to refer to the technical specifications of the device to find out the measurement limits.

It is important not to mix up the dielectric strength tests, also called "flash test", which expresses the ability of an insulating material to withstand excess voltages of average duration without causing priming. The dielectric test is quite destructive in the event of a fault, depending on the test levels and the energy available in the device. The device required for this type of measurement is a dielectrometer. This is not the subject of this document.
Measuring the insulation resistance is not destructive under normal test conditions. It is performed by applying a known direct voltage and provides a result expressed in **k**Ω (kiloohm), **M**Ω (megaohm), **G**Ω (gigaohm). This resistance expresses the quality of the insulation between two conducting components. This measure is taken using an **insulation tester,** which is also called a **megohmmeter**.

4.4 Measuring principle of an insulation tester

The operating principle of an insulation tester is based on Ohm's law:

$$U = I \times R \quad \textbf{or} \quad R = \frac{U}{I}$$

(**R**: resistance in Ohms – **I**: current in amps – **U**: voltage in volts).

The insulation tester generates a known direct voltage (**50 V**, **100 V**, **250 V**, **500 V**) selected by the user, then measures the leakage current escaping from the conductor through the insulation. Once these values are obtained, it calculates the resistance and therefore the insulation. The lower the leakage current, the higher the resistance value displayed and therefore the better the insulation.

For example, if a voltage of **500 V** is applied between the earth and a conductor.

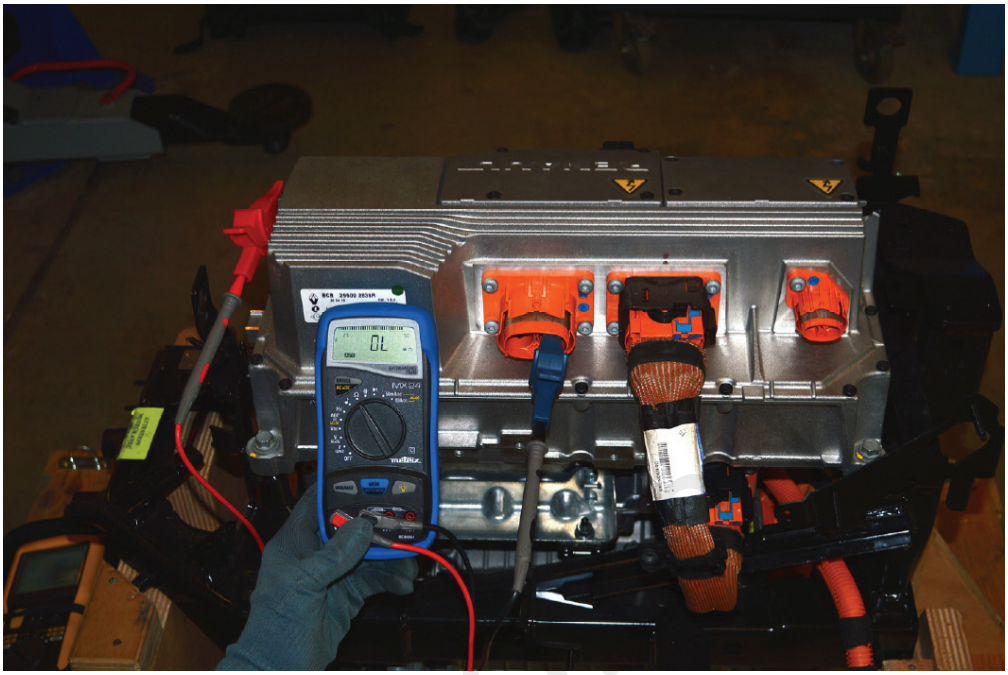
The current measured with the insulation tester has a current of **1 mA**.

$$R = \frac{U}{I} \Rightarrow R = \frac{500V}{0{,}001A} \Rightarrow R = 500\,000\,\Omega = 500\,k\Omega$$

If the current measured is hundred times lower, i.e. **0.00001 A** or **10 µA**.

$$R = \frac{500V}{0{,}00001A} = 50\,M\Omega$$

The example below shows a situation where the ohmmeter is no longer able to take the measurement. We want to check an insulation greater than **80 MΩ**.
After having checked that there is no voltage, we measure the resistance between a direct **400 V** phase and the earth. The ohmmeter displays out of limits "OL". It has reached its maximum measuring limit. We will therefore use an insulation tester.



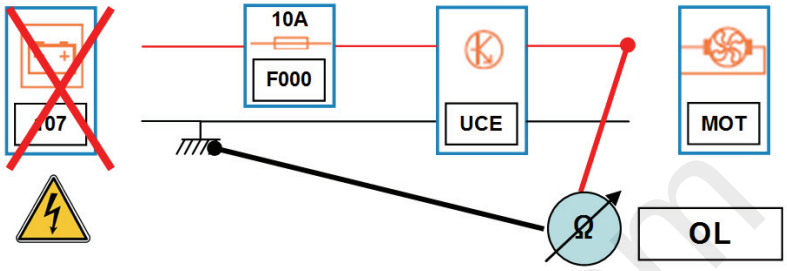
The insulation tester displays a resistance of **3324 M** when we measure the resistance between a phase and the earth on a component. In order to confirm that a part is compliant, the measured resistance must be greater than the minimum value given by the manufacturer in the fault finding manuals.

5. SEARCHING FOR A FAULT

5.1 Searching with an ohmmeter

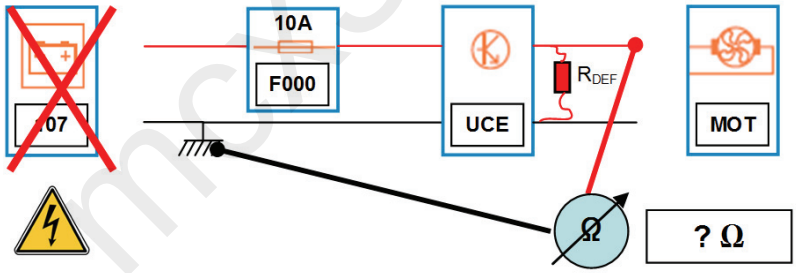
An earth insulation check consists of checking that a component, receiver or conductor does not touch the earth. Using an ohmmeter, we measure the following with no voltage:

- If **R = "OL"** (Out of limits: infinite) between the controlled line and the earth, the earth insulation check may be correct.
  Important: an out of limits resistance is indicated by "OL", which means that the resistance exceeds the measuring limits of the device. On circuits supplied by the traction battery of an electric vehicle, it is necessary to refer to the minimum reference resistance required in the fault finding manuals.



107: **12 V** battery
F000: fuse
UCE: computer – Electronic Control Unit
MOT: Electric motor

- If, for example, **R = ?** Ω (Ohm), there is a short circuit to "earth".



R_{DEF}: FAULT resistance

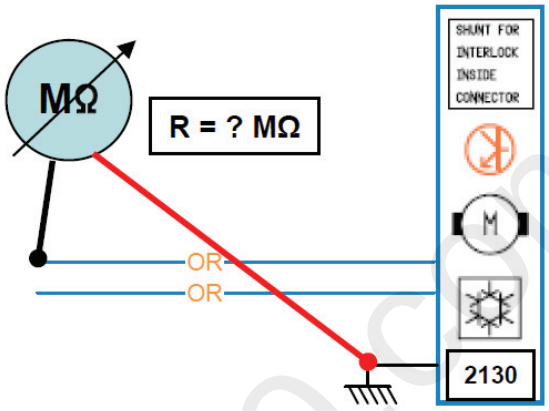
5.2 Searching for a mutual short circuit with an ohmmeter

A mutual insulation check consists of checking that two or more wires do not touch each other
The operation must be repeated as many times as there are wires in the wiring harness concerned.
Using an ohmmeter, we measure the following with no voltage:

- If **R = OL** (infinite) between these two wires, the circuit is correct
- If **R = ?** Ω (Ohm), there is a mutual short circuit.

5.3 Searching with an insulation tester

An insulation check consists of checking that a component, receiver, conductor or earth is not in direct contact.
With an insulation tester, we measure the insulation between a supply cable and the earth or two supply cables with no voltage supply to check for short circuits and insulation faults.



2130: air conditioning compressor

To interpret the measurement, it will be necessary to refer to the minimum reference value required in the fault finding manuals.

- If **R** > "reference value" **M**Ω, the circuit is correct
- If **R** ≤ "reference value" **M**Ω, the circuit is incorrect.

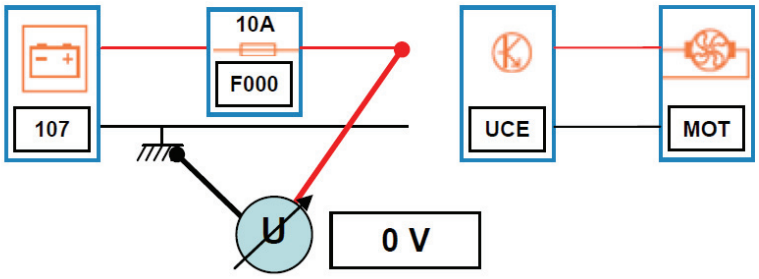
5.4 Searching with a voltmeter

WARNING

DANGER: LIVE INSTALLATION

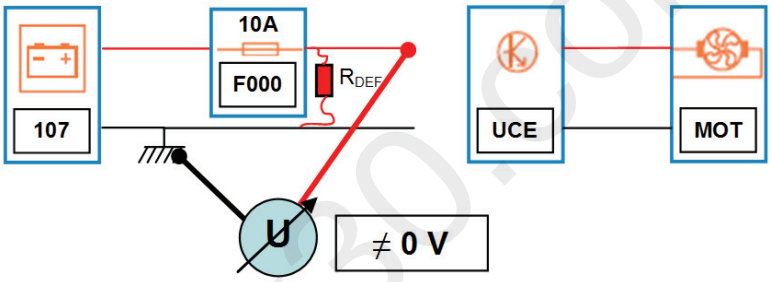
Risk of serious burns or electric shocks that may prove fatal.
Do not do perform this check using an ohmmeter, an insulation tester, an ammeter or devices other than a voltage absence tester or voltmeter.

With the voltmeter or voltage absence tester, we measure the following with a voltage supply:



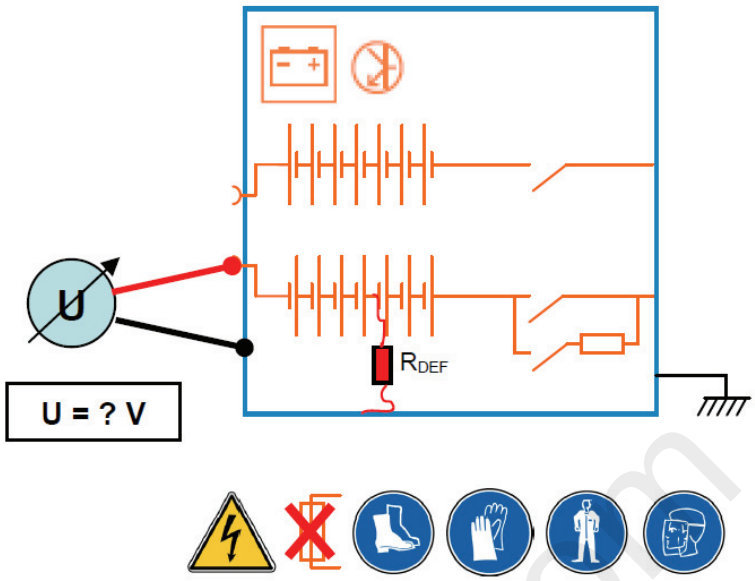
107: battery
F000: fuse
UCE: computer – Electronic Control Unit
MOT: Electric motor

• If **U =** 0 V between the checked line and the "+ battery", the earth insulation check is correct.
Important: a circuit can be cut. In this case, the voltage measured will also be equal to zero volts



• If **U ≠ 0 V** non permanent, there is a capacitive discharge effect
• If **U ≠ 0 V** permanent, there is a short circuit to "± battery".

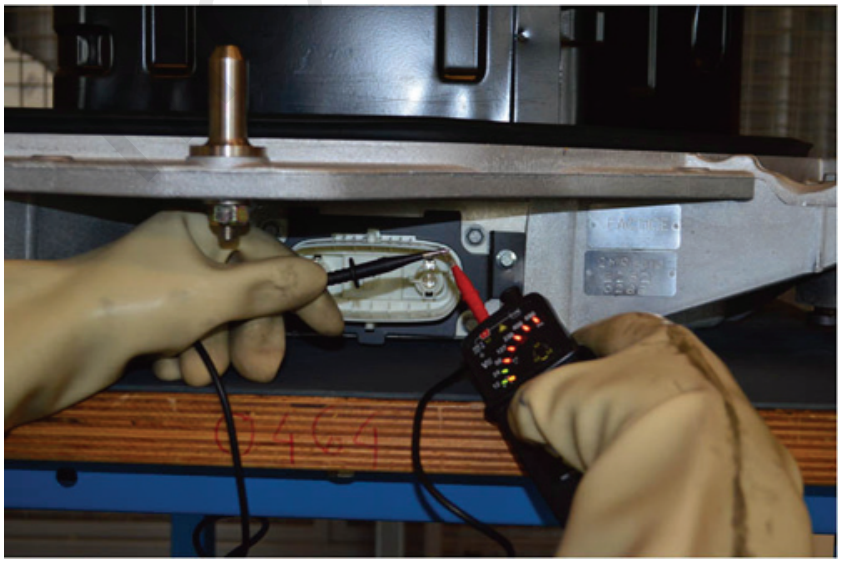
5.5 Measuring insulation on a voltage generator



- If **U = 0 V** between the checked line and the "+ battery", the earth insulation check or internal circuit check is correct
- If **U ≠ 0 V non permanent**, there is a capacitive discharge effect
- If **U ≠ 0 V permanent**, there is a short circuit to "± battery" or an insulation fault between at least one phase and the earth.

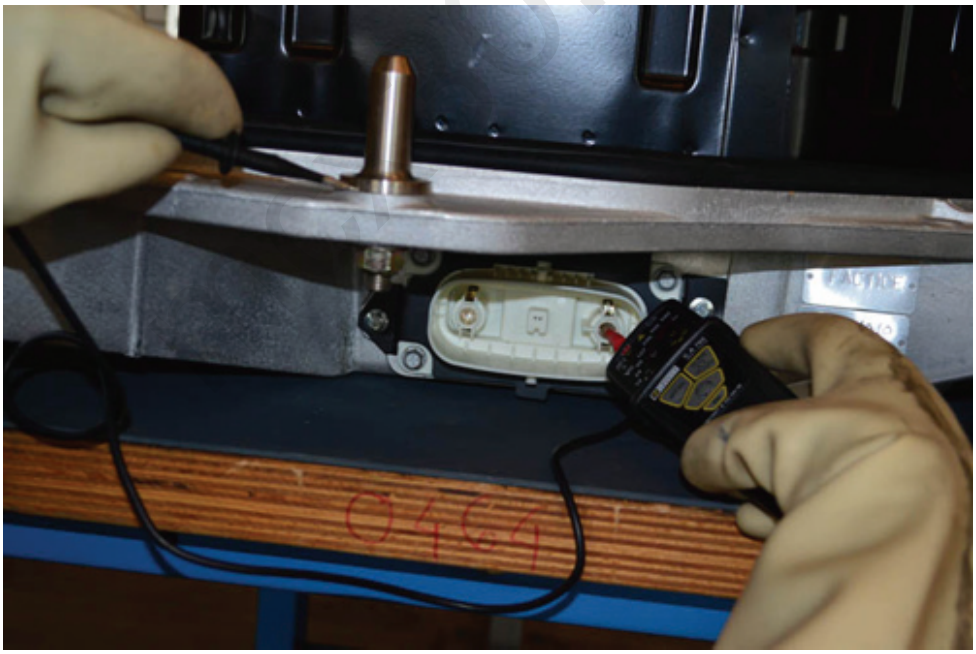
Example of the principle of checking a traction battery using the base of the traction battery safety circuit breaker of a FLUENCE vehicle.

- Check that your voltage absence testing device operates correctly

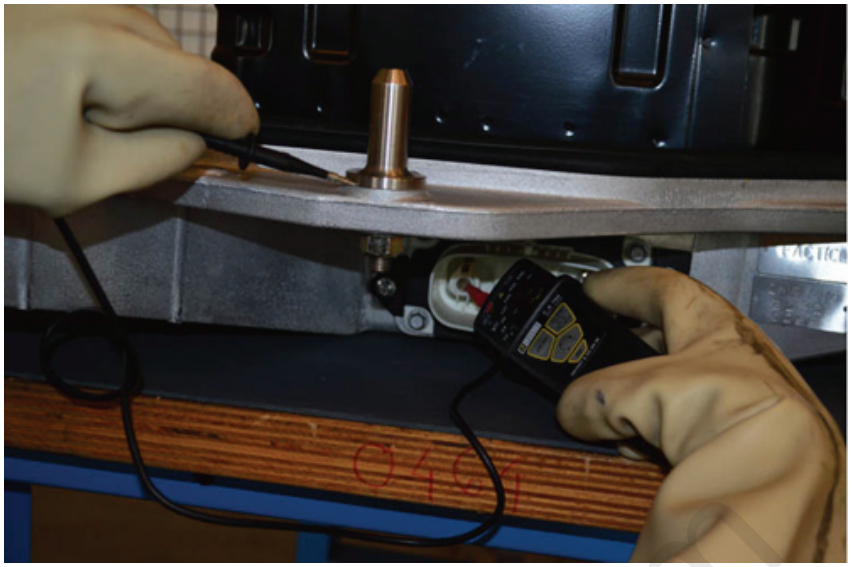


- Check that there is no voltage between the phases and earth and between the phases (3 measurements to be performed).
    - Measurement between phase

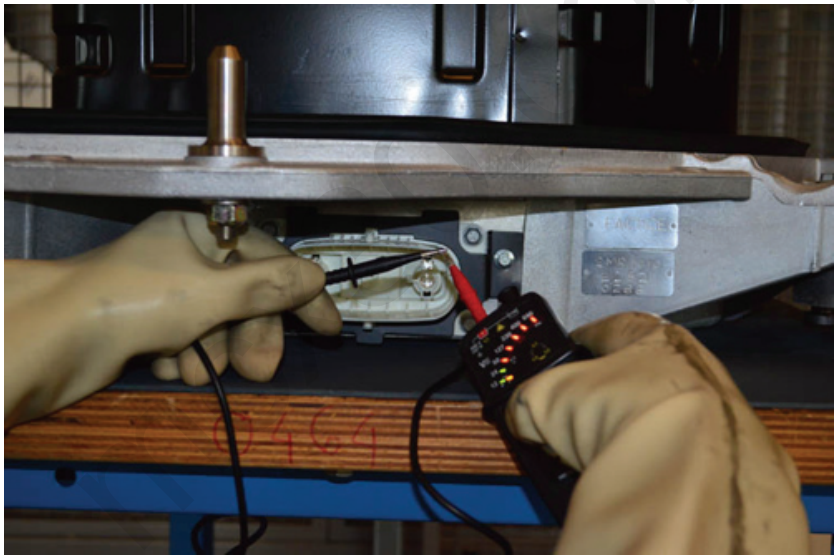
    - First measurement between phase and earth



- Second measurement between the other phase and earth



- Check that your voltage absence testing device operates correctly after the measurements.



Values measured	Possible interpretation
U = 0 V	The earth insulation check or internal circuit check is correct.
U ≠ 0 V non permanent	There is a capacitive discharge effect. Discharge the circuit before carrying out any operations.
U ≠ 0 V permanent	Short circuit to the "± battery" or insulation fault between at least one phase and the earth.

6. EQUIPMENT RECOMMENDATION SHEET

6.1 Voltage Absence Tester

6.1.1 Main functions

Used to check that there is no voltage on an electrical installation.

6.1.2 Main specifications

- In accordance with the current standard IEC/EN 61243-3
- Excess voltage category: **600 V** CAT III minimum
- Insulation class: class 2 minimum
- Self-test function: it must have a self-test function to check correct operation before and after using the function
- Must have an audible and visual warning to indicate the presence of voltage
- Must have a diode in the event of the presence of a dangerous voltage level (> **50 V)** even if the batteries are drained or removed. This device is called a "Redundancy circuit"
- Must automatically detect the type of current (direct or alternating)
- Must include a device designed to ensure the operator's safety and must not be equipped with fuses

6.2 Multimeter and current clamps

6.2.1 Main functions

Used to measure the electrical values of all internal combustion vehicles and electric vehicles in the RENAULT group.

6.2.2 Main specifications

- Excess voltage category: **600 V** CAT III minimum
- Insulation class: class 2 minimum
- To protect against incorrect connections, the multimeter must have a protection circuit with automatic resetting. This circuit detects overload conditions and protects the device until the risk has disappeared. In automatic resetting mode, the multimeter is ready to operate once the incorrect connection has been corrected
- TRMS device (AC + DC)
- Voltage measurement function
  ➔ AC and DC voltage range: **0 to + /- 600 V**
- Current measurement function
  ➔ AC and DC current range: **0 to 1000 A**
- Resistance measurement function
  ➔ Measurement range: **0 to 10,000 Ohms**
- Capacity measurement function
  ➔ Measurement range: **30 nF to 5 mF**
- Bandwidth: **10 Hz – 10 Khz**

6.3 Insulation tester

6.3.1 Main functions

Used to measure the insulation resistance of two conductors in order to assess the insulation quality and therefore to anticipate the risk of leakage currents.

6.3.2 Main specifications

- Excess voltage category: **600 V** CAT III minimum
- Insulation class: class 2 minimum
- To protect against incorrect connections, the insulation tester must have a protection circuit with automatic resetting. This circuit detects overload conditions and protects the device until the risk has disappeared. In automatic resetting mode, the multimeter is ready to operate once the incorrect connection has been corrected
- Detection of live circuits to prevent any insulation tests in the event of a direct or alternating current above **25 V**
- An "electrical danger" pictogram or warning is displayed as soon as the voltage generated is likely to be dangerous
- The insulation tester must have internal circuits that discharge the voltage in the circuits automatically and in complete safety
- Insulation resistance measurement function:
  ➔ Measurement range: **0 to 20 GΩ**
- Test voltages:
  ➔ **50 V**, **100 V**, **250 V**, **500 V**
- As an option, the device will be able to be supplied with a remote control sensor.

7. USING THE MEGOHMMETER

Note:

Before any operation, refer to the user manual for your measuring device.

7.1 Prerequisites

Before taking the measurements, check that the vehicle is dry and at ambient temperature.

7.2 Pre-test safety

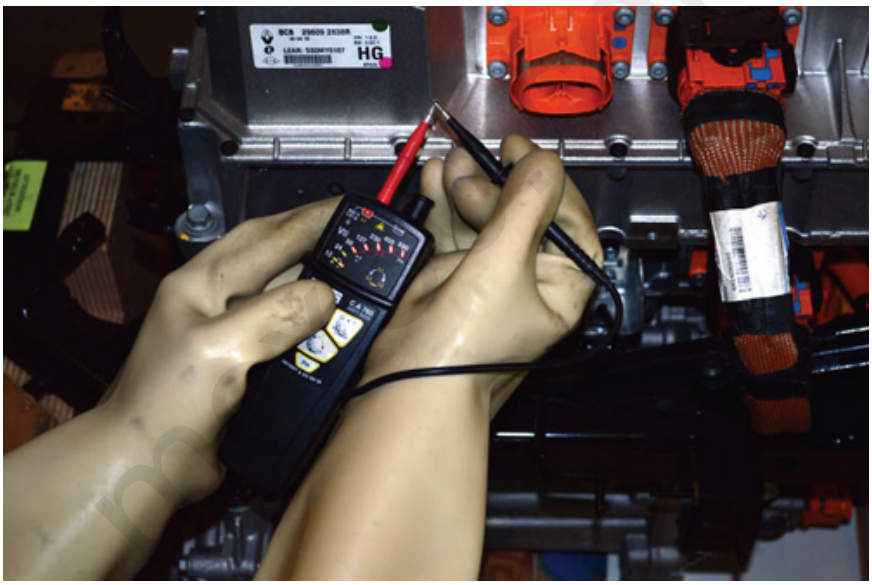
1. The test must be performed on an installation WITH THE ELECTRICITY SUPPLY OFF and disconnected in order to ensure that the test voltage will not be applied to other equipment that could be electrically connected to the circuit to be tested.

   Ensure that the circuit is discharged. The discharge can be performed by short circuiting the equipment terminals and/or connecting them to earth for a long enough period of time using the insulation tester.

- Check that your voltage absence testing device operates correctly

- Check that there is no voltage between the phases and earth and between the phases (3 measurements)

- Check that your voltage absence testing device operates correctly



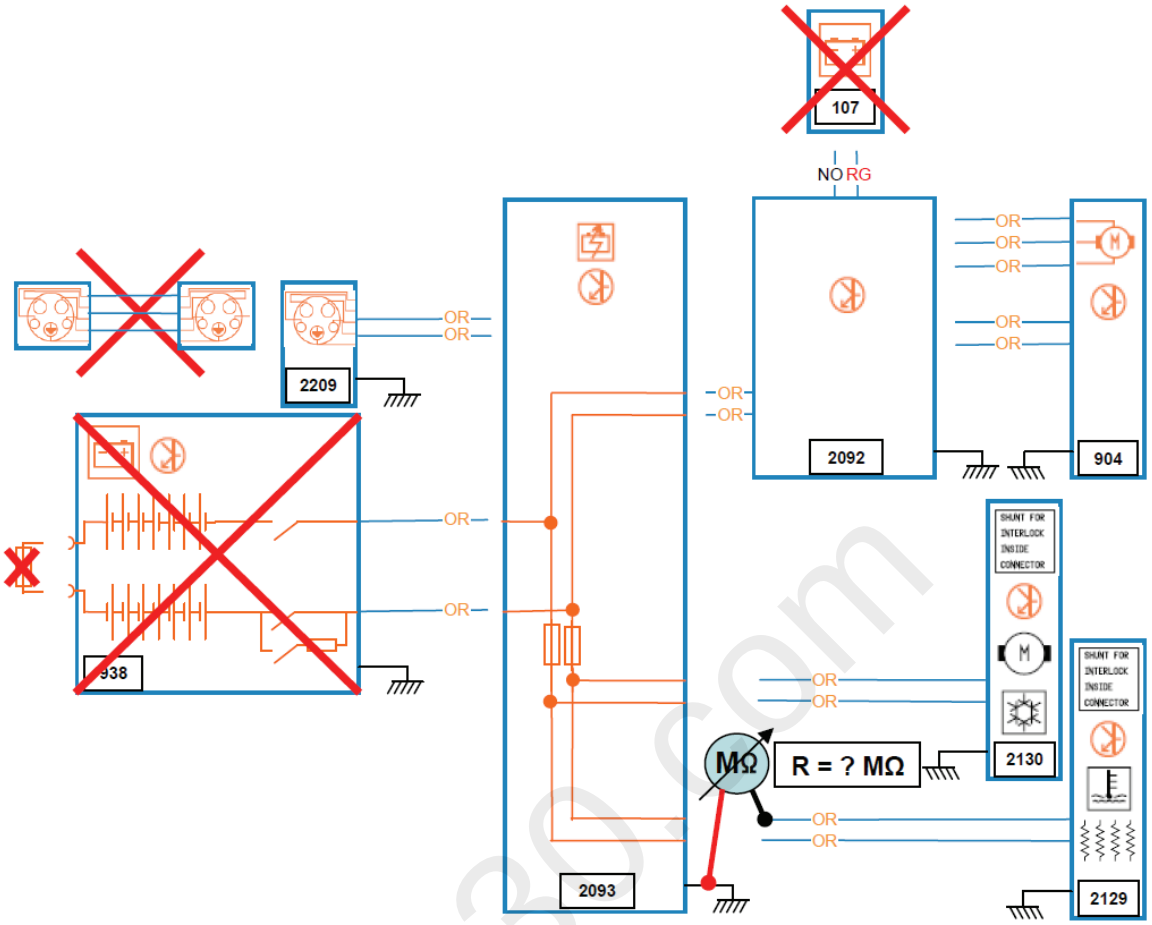
2. Do not test the vehicle or equipment when it is located in a flammable or explosive environment. In the event of an insulation fault, sparks can occur during insulation discharge before and after the test or during the test.
3. Minimise personnel access by delimiting the area and wear electrical personal protective equipment. When taking measurements, there may be high measurement voltages that are greater than the safety voltages to which people can be exposed.
4. Only use appropriate connection cables for the test to be performed and ensure that they are in excellent condition. Inappropriate cables will cause measurement errors and may be dangerous.

7.3 Measuring

5. Switch on the device by positioning the switch in position **M** and choosing the desired voltage (**50 V**, **100 V**, **250 V** or **500 V**).
6. Check that all the displays are operational and that the battery charge level is correct.
7. The test voltage is determined according to the service voltage of the devices. The table below gives the recommended test voltages according to the service voltages of the installations and equipment.

Service voltage cable/equipment	Direct current test
24 to **50 V**	**50** to **100 V**
50 to **100 V**	**100** to **250 V**
100 to **240 V**	**250** to **500 V**
240 to **550 V**	**500 V**

It is advisable to use the electrical and electronic fault finding manuals in order to establish the recommended test voltages to be applied.



Example of electrical layout

107: **12 V** battery
904: traction motor
938: traction battery
2092: electronic power unit
2093: battery charger unit
2129: passenger compartment heater
2130: air conditioning compressor
2209: charging socket

8. Check between a conductor and the electrical earth or physical earth. To do this, connect the lead of the "+" (plus) terminal of the insulation tester to the cold point and the lead of the "-" (minus) terminal of the insulation tester, or the remote control sensor, to the hot point. Crocodile clips are preferable to manually-held test probes.

   The following is understood:

   - Cold point: neutral, electrical earth, physical earth
   - Hot point: a phase.

   The insulation tester measures and displays the presence of voltage between its terminals as soon as it is switched on. Before you begin to measure the insulation, check that there is no voltage present on the terminals to be checked.

   - If the voltage on the vehicles is greater than **25 V**, a warning is displayed and/or a discontinuous signal is emitted; it is not possible to take the measurement. Do not measure the insulation or resistance when the presence of voltage is reported
   - If the voltage present on the vehicles to be checked is less than **25 V**, it is possible to the measure the insulation, but it is vitiated by an error that is progressively bigger the lower the test voltage. The voltage should be close to **0 V**
   - If there is no dangerous voltage, the user can then measure the insulation.

9. Press and hold the "TEST" button so that the measurement is taken over 30 to 60 seconds.

   The measurement voltage is generated between the terminals (marked "+" and "-").

   The value of the measurement is shown on the logarithmic scale of the bargraph and on the digital display, with the corresponding **M**Ω or **G**Ω symbol.

   If the numerical value varies significantly in the values above **500 M**Ω, this means that the charge is extremely capacitive. In this case, read the measurement on the bargraph.

10. Note the value displayed.

11. At the end of the measurement, release the "TEST" button and wait until the device tested is discharged to a voltage below **25 V** before disconnecting the leads. As soon as you release the measurement request "TEST" button, the insulation tester switches back to measuring the voltage.

    The insulation tester performs a capacitive discharge of the circuit. These insulation testers must have internal circuits that ensure this discharge occurs automatically and in complete safety.

    When a generated voltage is likely to be dangerous, the "electrical danger" symbol is displayed.

12. Wait until the voltage reaches **0 V**. At the end of the test, the installation has accumulated a quantity of energy, which must be discharged before any other operation is performed.

13. When you have finished taking your measurements, switch off the device by turning the switch to the OFF.