# PD measurements with

# Pry-Cam™ Portable

REVISION HISTORY

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## Contents

# 1. Introduction

This document describes the procedure to perform Partial discharge (DP) measurements with Pry-Cam Portable instrument on high voltage (HV) and medium voltage (MV) electric components.

# 2. Prysmian Pry-Cam™ Portable

## 2.1 Introducing Pry-Cam™ technology

Pry-Cam™ is a breaktrough technology for PD diagnosis services. Pry-Cam instruments detect, acquire, processes and classify Partial Discharge (PD) phenomena without any contact with the equipment under test, allowing on-line measurements with the high accuracy and safety for operators.

## 2.2 Pry-Cam™ Portable description

Pry-Cam™ Portable is a small and rugged high performance PD acquisition system specifically designed for on-line in-field measurements. It is a highly integrated unit, including the Prysmian exclusive wireless electromagnetic sensor for PD signals detection and phase synchronization, a digital acquisition unit and a WiFi interface. It is powered by a Lithium battery that allows Pry-Cam operation without any wired connection. It is simply pointed or located near an electrical component (with the aid of a hook stick, if required) and it is immediately able to stream PD data to a PC via a WiFi link. The PDiscover software running on the PC is used to control the instrument, displaying, storing and processing PD data in real-time.

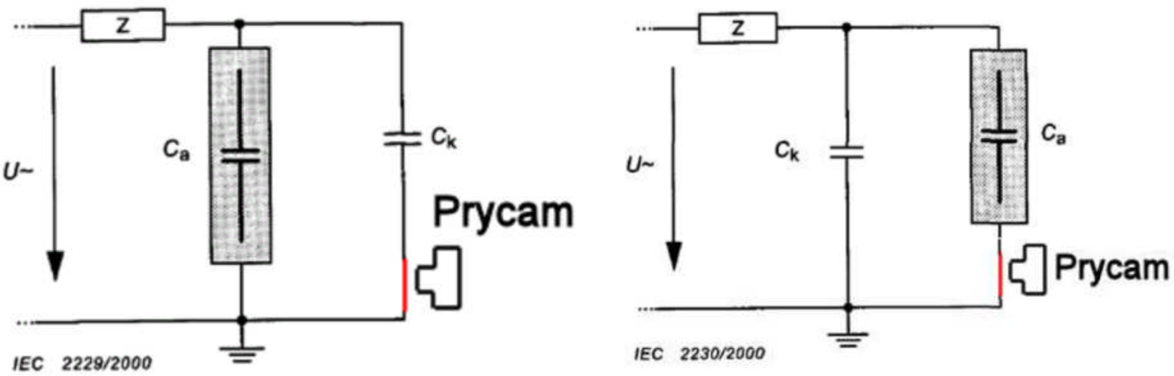

*The PryCam Portable unit: it is similar to a reflex camera in shape and dimensions.*

## 2.3 Hardware specifications

| Sensor | |
|---|---|
| Type: | Electromagnetic, based on a patented Ultra Wide Band antenna, also providing AC synch signal |
| Bandwidth: | 0.5 – 100 MHz |
| PD sensitivity: | Down to 1 pC |
| Synch sensitivity: | Down to about 150 VAC (at 10 cm) |
| Synch frequency: | From 10 Hz to 1 KHz |
| Working range: | From 1 cm up to 200 cm (depending on the PD activity level) |
| **Acquisition Unit** | |
| Sampling frequency: | 200 MS/s |
| Bandwidth: | 100 MHz |
| Gain: | From 0 dB to 40 dB |
| Trigger: | Digital, fully configurable |
| Synch resolution: | 16 bit (5 µs) |
| Timestamp resolution: | 5 ns |
| Processing: | Real-time filtering, high-speed pattern only, TDR |
| **Repetition Rate** | |
| Full pulse waveform: | Ethernet >10,000 pps, WiFi: >3,000-6,000 pps |
| Pattern only: | Ethernet >50,000 pps, WiFi: >10,000 pps |
| Interfaces: | Wireless 802.11b/g (WiFi), Optical Fiber Ethernet (100-Base FX, optional) |
| Remote Synch: | Wireless RF interface @ 868MHz |
| Working mode: | Local, remote and monitoring |
| Power supply: | 12 V, 200 mA |
| Backup battery: | Li-Po 7.4 V, 2200 mAh |
| Autonomy in battery mode: | About 5 hr |
| Weight: | About 400g (depending on options) |
| Working temperature: | From -25°C to 70°C |
| Dimensions: | 160 mm x 120 mm x 130 mm (LxWxH) |
| Case: | Rugged ABS plastic with IP67 protection rating |

## 3. Pry-Cam measuring circuits

Thanks to its electromagnetic sensing technique, PryCam can be used in the same configurations described in the IEC 60270 standard, but allowing to operate achieving full galvanic isolation. The two following configurations are usually adopted, guaranteeing the same high level of sensitivity and safety for the operators.




*Typical PD measuring circuits including Pry-Cam Portable in parallel and in series to the equipment under test (Ca).*

The first one is equivalent to the classical technique employing a capacitive coupler and a sensing impedance. When using the PryCam this configuration is obtained by positioning the instrument near the HV side of the component under test (the distance between the sensor and the HV conductor acts itself as a capacitance). The second configuration is equivalent to the use of a HFCT in series with the component under test. In this case the PryCam is positioned near the earth conductor of the component (just like the HFCT) and exploit the capacitive coupling whit it (as opposed to the magnetic coupling of the HFCT) to sense the PDs.

## 4. Scope of measurements and basic requirements

PryCam Portable can used to perform PD measurements on most HV components by using the same setup and operating procedure. In particular the operating procedure described in this document addresses to two main situations: on-line measurement and commissioning. The former is performed during normal operating life of assets, with a regular frequency or on a spot basis, and is intended to assess or track the asset conditions. On-line measurements are performed with powered assets during their normal operations (no disconnection is required). Commissioning measurements are instead off-line measurements that are performed with assets disconnected from the grid, by using a resonant transformer generator to apply the test voltage to the circuit under test. In this case specific test standards and technical norms apply (such as IEC 62067, IEC 60840, etc.) and should be followed during operations with regards the voltage level applications, duration and timing when performing PD measures.

However the basic requirements to be considered for performing a PD measurement with PryCam are the same in both cases, and are much simpler than the average ones commonly required when using traditional instrumentations. They are summarised in the following points:

- Assets subjected to PD measurements have to be clearly identified either with a formal reference (name, code, serial number, etc.) either on the work site (known location and position);
- Assets subjected to PD measurements have to be reachable so that the instrument can be positioned in the correct measurement position;
- The area surrounding an asset subject to PD measurements should be as clear as possible form unrelated metallic objects (not grounded) and strong sources of electromagnetic emissions;
- Assets subjected to PD measurements have to be energised during all the measurements at the specified operating or test voltage;
- The work site has to be surveyed and organised as described in the “Work site organisation and preliminary checks” paragraph, and the measurement sequence has to be planned in order to allow a safe positioning and movement of operators during measurements.

## 5. Measurement procedure

PD measurements with the PryCam Portable are performed, as discussed in paragraph 3, by positioning the instrument close to the component under test, then by controlling the PD acquisition process from a nearby computer that is connected with the PryCam by a WiFi link. The PryCam is battery powered and completely isolated and autonomous (has no connection), so it can be positioned in the measurement points while components are energized yet maintaining a complete isolation and an excellent degree of safety for operators. In most cases the PryCam is attached at the end of an insulating hook stick and is positioned and kept in place by one operator, while another operator controls it by a laptop computer or tablet running the control and acquisition software.

The following paragraphs describe the standard operations, comprising the location where to place the instruments for every component category as well as the connection of the PD calibration device when required for the calibration procedure. The standard positioning of the PryCam is essential in obtaining reproducible and referenced measures. The word “facing” means that the sensor is directed toward the specified object and it is in contact or in close proximity with the object (within 1 cm).

## 5.1 Calibration procedure

Calibration procedure is performed prior to actual PD measurements, mainly during commissioning, and it is intended to measure the scale factor between the apparent charge (in pC) according the IEC 60270 standard and the detected signal (in mV). Generally, the calibration procedure with PryCam closely follows the IEC 60270 prescriptions, due to the equivalence described in paragraph 3, with only one additional requirement imposed by the portable nature of the instrument (that is also valid but implicit for traditional sensors): **during the entire calibration measure the PryCam have to be held in a fixed position and orientation**.

According the IEC 60270 standard the calibration is done by applying a known charge, by means of a charge calibrator, to the component under test and measuring the signal level (usually in mV) detected by the PD sensors. The ratio between the two measures is used as a scale factor for the conversion of mV to pC for the given component. It is important to note that this scale factor takes into account how charge distributes within the component and how it give rise to a voltage signal in the sensor, but does not directly relate with the true charge associated with PD phenomena occurring in the same component. For this reason it is called “apparent charge” by the standard. Also, the scale factors is only determined by the physical characteristics of the component (materials, geometry, etc.) and the position of the calibrator and sensor. The calibration procedure has so an important role in making repeatable and comparable measures, but has a limited diagnostic value *per se* with respect to the magnitude of the degenerative phenomena.

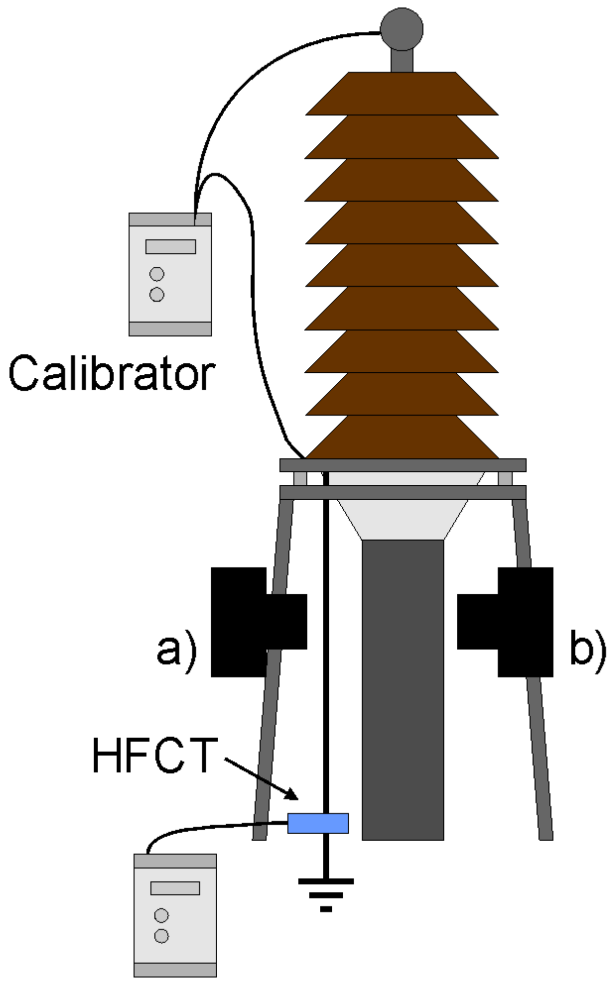
Calibration procedure requires the direct connection of the calibration device to the component under test: this can be done only when components are disconnected or not energised (not powered). For this reason calibration is commonly used during commissioning but is not performed during on-line spot measurements. In many cases however, considering the dependence of the calibration factor from the physical characteristics of components, **the same calibration factor can be measured once (for example during commissioning) and then properly used for subsequent measurements on the same componen**t. The same expedient can be safely used when performing measurements on three-phase systems due to the fact that components in each phase and their connections are physically identical (by design and implementation): **in this case the calibration can be optionally performed on only one phase and assumed to be valid (same calibration factor) also for the other two**.

The following paragraphs illustrate the standardized (preferred) connections of the calibration device to different classes of components.

### 5.2 Outdoor terminations

The PryCam should be positioned below the base of the termination (within about 1 m from the base), with the sensor facing the termination earth connection cable (a) or the HV cable sheath (b) (both measurements should be taken for a better diagnosis). In case of the termination base is at a significant height an hook stick can be used.

Calibration device, when used, should be connected between the HV termination end and its earth connection at its base when the component is not energised, otherwise the calibration device can be connected to an HFCT positioned around  the termination earth connection cable.




*Measurement and calibration points for outdoor terminations.*

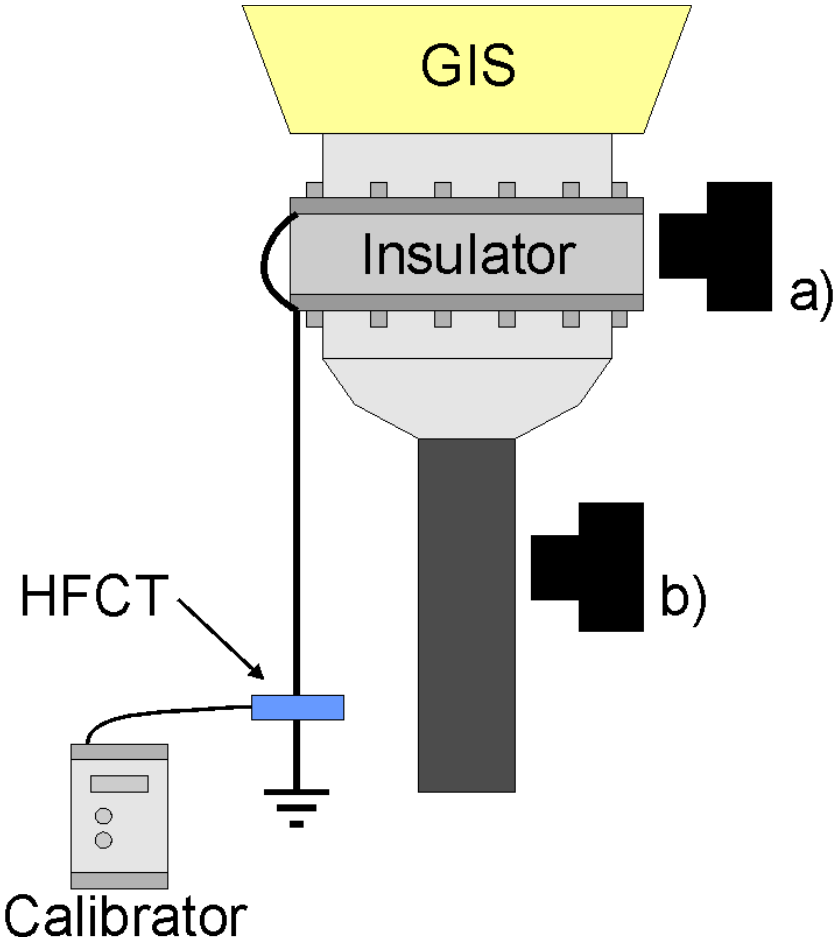
*Example of measurement on an outdoor termination (termination earth cable).*

*Detail of a  measurement on an outdoor termination (cable sheath).*

## 5.3 GIS terminations

The PryCam should be positioned below the base of the termination (within about 1 m from the base), with the sensor facing the epoxy insulating ring (a) or the cable sheath (b) (both measurements should be taken for a better diagnosis). In case of the termination base is at a significant height an hook stick can be used.

Calibration device, when used, should be connected to an HFCT positioned around the earth connection cable.



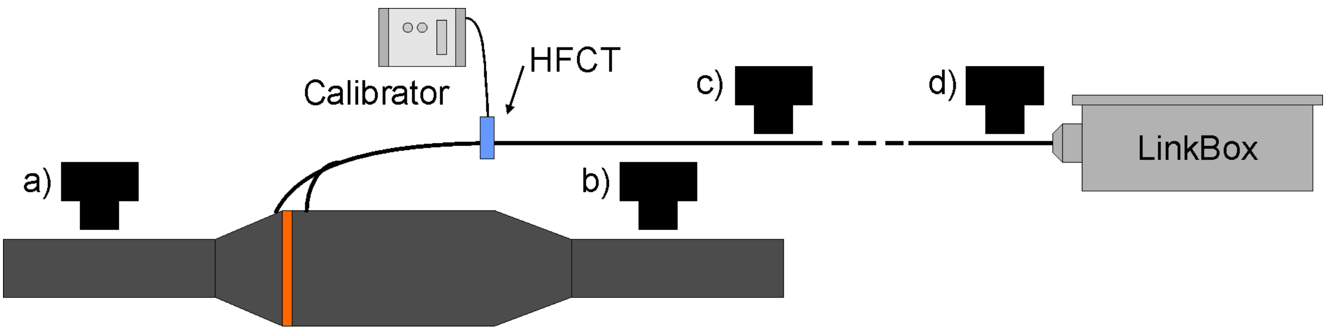

*Measurement and calibration points for GIS terminations.*

*Example of measurement on a GIS termination (insulator ring).*

### 5.4 Cable joints

In case of joints the position of the PryCam may vary according to the specific situation, i.e. if the joint is buried or not. Four measurement points are usually considered: a) with the sensor facing the cable sheath before the joint (within about 1 m from the joint end), b) with the sensor facing the cable sheath after the joint (within about 1 m from the other joint end), c) with the sensor facing the joint screen earthing cable (within about 1 m from the joint), d) with the sensor facing the joint screen earthing cable at the nearest link box (either straight earthing or cross bonding). The latter is the preferred method for measures on buried or unreachable joints. If position a) or b) can be adopted, both should be taken in case of joints with separated screens for a better diagnosis. In case of only measure near link boxes (position d) ) are possible, it is necessary perform the same measure on all the three phase incoming earthing cables in order to perform a correct diagnosis.

In case of joints calibration device, when used, should be connected to an HFCT positioned around the earth connection cable.




*Measurement and calibration points for a cable joint.*

*Example of measurement on a cable joint (joint end).*

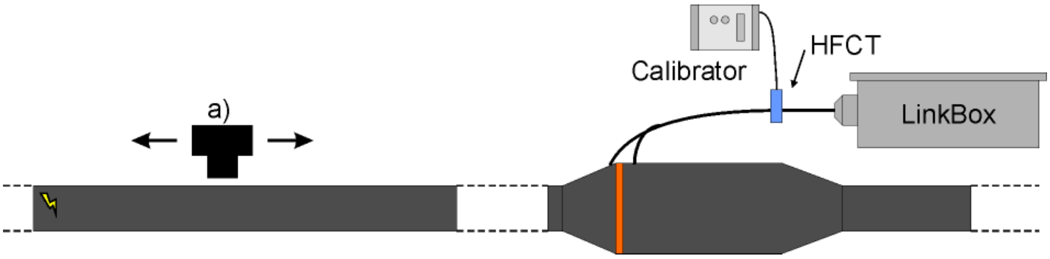
*Example of measurement on a cable joint (screen earth).*

*Example of measurement on a cable joint (screen earth near linkbox).*

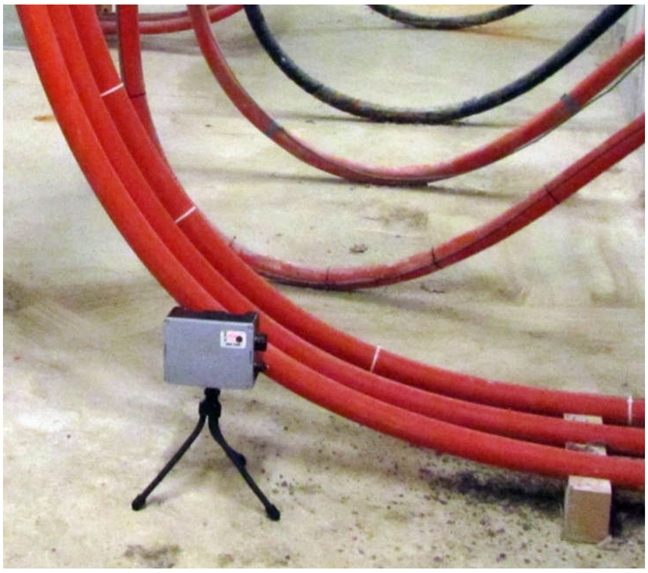
## 5.5 Cables

Direct measurements on cables are not very common, since the cable itself is less subject to dielectric defect or spontaneous degradation compared to other components. However in some cases (e.g. special cable technologies, mechanical damages, etc.) it is needed to perform PD measurement on it. The greatest advantage of the PryCam in this case is the possibility to precisely localise the defect. The measure is simply done by positioning the PryCam in front or on of the cable sheath. The measure can be repeated at several points (or by moving the instrument) along the cable, according to the specific needs. The exact position of the defect is found by searching for the location where the largest PD signal with the highest frequencies are detected.

Calibration, when required, can be done by connecting a calibration device to an HFCT positioned around the nearest screen earth connection (e.g. nearest joint or link box).




*Measurement and calibration points along a cable.*

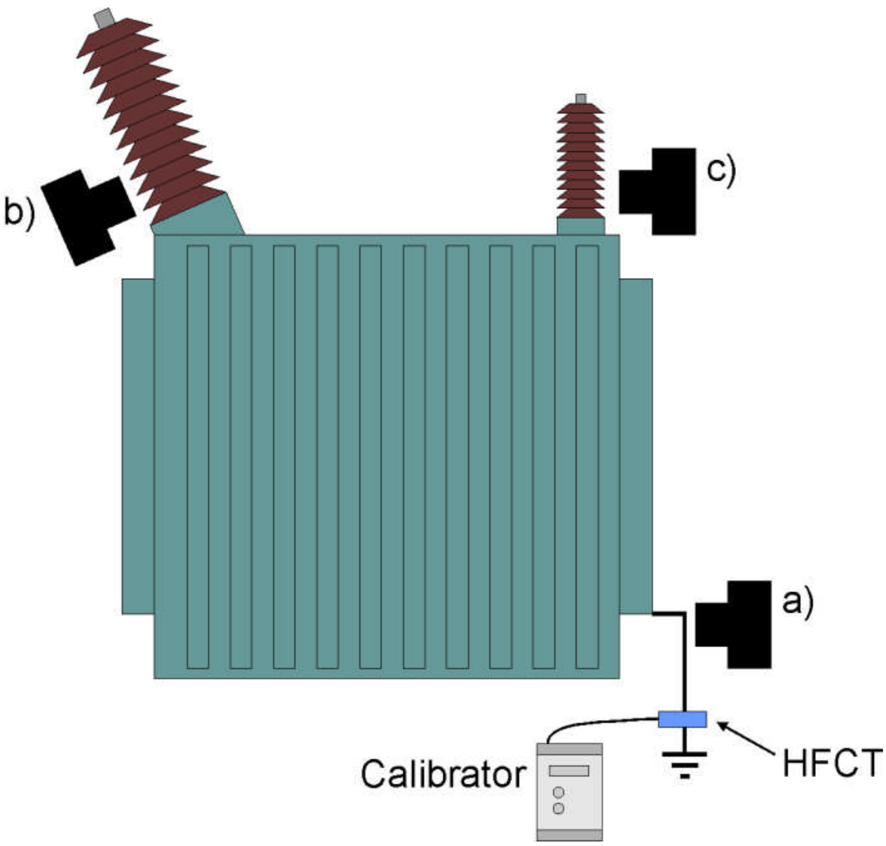


*Example of measurement on a cable.*

## 5.6 Power transformers

In case of power transformers the basic measure is done by positioning the PryCam in front of the transformer earth connection (a). For a more accurate diagnosis however a measure should also be taken at the base of each of the primary (b) and secondary terminations (c).

Calibration device, when used, can be connected to an HFCT positioned around the earth connection of the transformer.




*Measurement and calibration points for a power transformer.*

*Example of measurement on a power transformer (transformer earth).*

*Example of measurement on a power transformer (secondary terminations).*

## 6. Work site organization

Before starting the measurements is it essential to survey the site in order to:

- identify and verify the location of each component to measure;
- verify that all components are accessible and reachable with the PryCam;
- evaluate the available clearance spaces for operators in each measurement location (usually two operator are involved), the distances and the safest path to follow to reach all components;
- identifying all the necessary auxiliary items to carry or position during measurements (hook stick, remote synchronizer unit, computer with related devices, etc.);
- verify the preliminary checklist items.

The maximum suggested distance between the operator controlling the PD acquisition with the computer and the PryCam should not exceed about 20 m, with a free line of sight (i.e. no solid obstacles should be present between the operator and the PryCam). A maximum distance of about 50 m should be considered as well from the PryCam and the remote synchronization unit (when used).

The remote synchronisation unit is used to transmit to the PryCam a valid phase reference signal when it is not possible to reliably detect the AC signal phase in the measurement location. The remote synchronisation unit is placed in location where the AC electric field is higher so that a robust signal can be detected, or near a cable carrying a current in phase with the component under test (detected with the external current probe). In general both method can be used during on-line measures, while only the first is recommended during commission measures, since resonant transformers does not supply an adequate current and may work in a frequency range very different from the standard 50-60Hz. The minimum recommended current is 0.1 A. A good electric field in case of resonant transformer can be detected near termination ends or beneath the metallic tubes screening the HV leads. Also the synchronising unit is an autonomous and isolated device, so it can be placed near energised components if required.

## 7. Checklist

The following checklist has to be performed by operators when going to perform PD measures with PryCam:

**1)** Prior to go to the site check the following:
   a. battery charge level for all the instruments and the PC is full;
   b. the PryCam has been loaded with the correct WorkOrder and is able to start the acquisition;
   c. all instruments and accessories are packed and ready to be carried out;

**2)** On site turn on the instrumentation and make an acquisition to evaluate the environmental noise level;

**3)** Evaluate the radio (WiFi) channel: put the PryCam at 20 m from the PC and run an acquisition with the trigger set to zero. Check that at least 2000 pulse per seconds are acquired;

**4)** At each measurement location verify that the synchronization signal is stable before starting the acquisition. If not, employ the remote synchronization unit;

**5)** When using the remote synchronization unit verify that the distance with the PryCam is less than 50 m (free line of sight) and the received signal is stable. If using a current probe, measure the current and verify that it is greater than 0.1 A;

**6)** Before leaving the site, review the measures and check that all the listed components have been measured.