

## Short-Course

# Solar PV System Installation and Maintenance

## NTQF Level III

### Learning Guide -23

<b>Unit of Competence</b>	<b>Diagnose, Repair and Maintain PV System</b>
<b>Module Title</b>	<b>Diagnose, Repair and Maintaining PV System</b>
<b>LG Code</b>	<b>EIS PIM3 M15 0120 LO5-LG23</b>
<b>TTLM Code</b>	<b>EIS PIM3 TTLM 0120v1</b>

### LO 5: Test PV system-23

This learning guide is developed to provide you with the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:

- Using tools and measuring instruments.
- Checking PV system for any more defects.
- Testing PV system parameters comply within the nominal range.
- Performing rectification of any malfunctions/deficiencies.
- Observing safe working practices throughout the task.
- Accomplishing and recording in accomplishment report form

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to: -

- Use tools and measuring instruments.
- Check PV system for any more defects.
- Test PV system parameters comply within the nominal range.
- Perform rectification of any malfunctions/deficiencies.
- Observe safe working practices throughout the task.
- Accomplish and recording in accomplishment report form

### Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below:
3. Read the information written in the information Sheet 1 (page: 103), Sheet 2 (page:110), Sheet 3 (page: 112), Sheet 4 (page: 115), Sheet 5 (page: 117), Sheet 6 (page:120)
4. Accomplish the Self-Check 1 (page:109), Self-Check 2 (page: 111), Self-Check 3 (page: 114), Self-Check 4 (page: 116), Self-Check 5 (page: 119), Self-Check 6 (page: 121)

## LO5. Test PV system

Information Sheet 1	Use tools and measuring instruments
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### 1 Use tools and measuring instruments











The following tools and measuring instruments can be used for diagnosing and repairing of PV systems:

#### 1.1 Tools

##### 1.1.1 Hand tools

**Table 2: Hand Tools etc.**







Hand Tools	
Measuring tape	
cutter knife	
Set of open-end wrenches (spanner) As a minimum, the sizes required for the mounting system(s) used will be required.	
Permanent marker	
Chalk Line	
Brick laying cord or Fish Line	

Hand Tools	
hexagon socket screw keys (Socket set and ratchet spanner) As a minimum, the sizes required for the mounting system(s) used will be required.	
Crimping tool MC4	
Crimping Tool (Lobster)	
Set of screwdrivers (flat and cross-headed)	
Set of socket wrench As a minimum, the sizes required for the mounting system(s) used will be required.	
Torx bit set As a minimum, the sizes required for the mounting system(s) used will be required.	
Nutsetter (8 and 10mm)	
Gripper/pincer (set)	
Side cutting pliers	
Set of pliers	

Hand Tools	
Folding rule	
Set Square	
Spirit Level	
Hand Files Required if rails will be cut	
Hack Saw Required if rails will be cut	
Utility Knife	
Torque Wrench (10-25Nm) Optional if the drilling machine/cordless screwdriver have reliable torque settings	
Lockout/Tagout kits	

### 1.1.2 Electrical Tools

**Table 3: Power Tools**

Electrical tools	
Cordless screwdriver with bits Optional – the cordless drilling machine can also perform this functionality	
Drilling machine cordless (with spare battery)	
Drilling machine	
set of drilling bits wood, steel, stone	
Hole saw set (or 20mm hole saw minimum)	
Flex (metal/stone plate) Saw or angle grinder  alternatively, a milling machine)	

### 1.2 Measuring Instruments

- Multimeter

- Current clamp meter
- PV analyser
- Hydrometer
- Thermal imager

**Table 4: Measuring Instruments**

Test Equipment	
Multimeter (the measurement of voltage and amperage as well as resistance)	
DC Clamp meter for current measurements non-invasive	
PV Analyser to measure open circuit voltages, short circuit currents, IV curves, insulation resistances etc.	
Hydrometer to measure Lead Acid battery acid levels. Testing for the specific gravity of electrolyte in the battery is an accurate way to measure and compare the state of charge of each individual cell.	
Thermal imager to find bad connections and problems on PV modules	

<b>Self-Check - 1</b>	<b>Written Test</b>
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**Instruction: Follow the below selected instruction**

Answer all the questions listed below.

N°	Questions and answers
<b>1</b>	<b>Name 3 measuring instruments and what it is used for: (6)</b>

**Note: the satisfactory rating is as followed**

Satisfactory	4 points
Unsatisfactory	Below 4 points

**Answer Sheet**

Score = _____
Rating: _____

Name

Date



## 2 Checking PV system for any more defects

When you are on site to do a repair on the PV system, it will be the ideal time to also inspect and check the complete system problems or defects.

It will also be a good opportunity to engage with the client on the use of the system i.e.:

- Does it perform according to the original design?
- Are there any additions or enhancements that can be done e.g. maybe the client wants to run additional equipment requiring a bigger inverter and/or more batteries (upsell)?
- Check the battery logs if available. It will be a good indication to see if the batteries and PV system are sized correctly.

Getting feedback on the performance of the system is a good way to close the loop on the design process and valuable lessons can be learned for future projects.

<b>Self-Check - 3</b>	<b>Written Test</b>
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**Instruction: Follow the below selected instruction**

Answer all the questions listed below.

N°	Questions and answers
<b>1</b>	<b>Why is it important to check the entire system for more defects? (2)</b>

**Note: the satisfactory rating is as followed**

Satisfactory	2 points
Unsatisfactory	Below 1 point

**Answer Sheet**

Score = _____
Rating: _____

Name

Date

<b>3</b>	<b>Testing PV system parameters comply within the nominal range</b>
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### 3 Testing PV system parameters comply within the nominal range.

Being on site is a good opportunity to test the PV system according to the original design specifications and commissioning values. If a PV analyser was used when installing the system, the stored data can be compared with the current system values in terms of open circuit voltages, short circuit currents and IV curves. Battery voltages and for open lead batteries specific gravity should also be checked.

This will give a good indication of the current state of the system.

When doing these measurements, bear in mind that the PV module currents will be influenced by the radiation while the voltages will be influenced by temperature. The measurements should however give an indication if the module's output is still within range.

State of Charge	Specific Gravity	Voltage - 12V
100%	1.265	12.7
75%	1.225	12.4
50%	1.190	12.2
25%	1.155	12.0
Discharged	1.120	11.90

**Figure 40: Example of battery voltage and specific gravity measurements**

#### 3.1 Switching on the system

The following paragraphs were adapted from (Mayfield, 2010).

The process for re-commissioning a battery-based system is explained in general terms below. Always follow the manufacturer's instructions to ensure proper operation:

- Visually inspect the entire system.
- Lock out and tag all the disconnects for the AC and DC conductors in the PV system.
- Go to the PV array and open the junction box or combiner box.
- Put on your high-voltage gloves and safety glasses and then use your DMM to verify that the voltage and current levels in each circuit equal zero. After you know that none of the strings have voltage or current present, open any fuse holders and make sure the fuses aren't in them.

- To prevent that the system is switched back on by anyone accidentally, attach a warning sign or put the fuses in your pocket and take them with you until the work is finished.
- Proceed to the array and connect the home-run cables from the array to the junction box or combiner box.
- Return to the junction box or combiner box, check the strings individually for voltage and polarity, and record the voltage values for every string. If after conducting this check you find that you have more than a couple of volts difference between strings, you need to investigate the series string connections to verify that you didn't make a mistake along the way.
- Insert the fuses (when present) and close the fuse holders.
- In systems with only one or two strings, you may not have fuses installed.
- Because you've locked all the disconnects below the array, the system won't turn on and put you at risk. All the PV conductors after the junction box or combiner box will have voltage present, but until a load is introduced, there won't be any current flow.
- Check the voltage and polarity from the battery bank to the battery disconnect(s).
- If the voltage and polarity values are correct, apply DC power from the battery to the inverter by turning on the inverter's DC disconnect.
- Connect the charge controller to the battery bank by turning on the charge controller's output disconnect.
- Refer to the charge controller's manual and make any adjustments to the controller that are necessary for proper operation.
- At the PV array disconnect(s), verify the voltage and polarity from the array to the disconnect(s).
- Connect the PV array to the charge controller when you're satisfied with the voltage and polarity values.
- Connect the AC power to the MDP.
- Each panel will be connected via a dedicated circuit breaker.
- Verify the voltage to and from the MDP (and subpanel) before flipping the disconnects.

<b>Self-Check - 3</b>	<b>Written Test</b>
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**Instruction: Follow the below selected instruction**

Answer all the questions listed below.

N°	Questions and answers
1	<b>Why is it good to check if a PV system complies within the nominal range? (2)</b>

**Note: the satisfactory rating is as followed**

Satisfactory	2 points
Unsatisfactory	Below 1 point

**Answer Sheet**

Score = \_\_\_\_\_

Rating: \_\_\_\_\_

Name

Date

<b>Information Sheet 4</b>	<b>Performing rectification of any malfunctions/deficiencies</b>
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#### **4 Performing rectification of any malfunctions/deficiencies**

In section LO3, the rectification of malfunctions and deficiencies are handled in detail. In summary, the following tasks need to be performed:

- Confirm required isolations with site requirements.
- Undertake appropriate repair procedures.
- Replace & repair faulty, worn, damaged or unsecured components.
- Select and replacing parts and components.
- Reconnect the disconnected components for testing.
- Check all terminations are electrically and mechanically sound.
- Repair or rectifying all faults with the work plan.
- Perform and permit final job inspection.

Self-Check - 4	Written Test
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**Instruction: Follow the below selected instruction**

Answer all the questions listed below.

N°	Questions and answers
1	Name 4 steps in Performing rectification of any malfunctions or deficiencies (4)

**Note: the satisfactory rating is as followed**

Satisfactory	3 points
Unsatisfactory	Below 3 points

Answer Sheet

Score = \_\_\_\_\_

Rating: \_\_\_\_\_

Name

Date






<b>Information Sheet 5</b>	<b>Observing safe working practices throughout the task</b>
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## 5 Observing safe working practices throughout the task


It is very important to observe safe working practices throughout. This includes:

- Wearing appropriate PPE.
- Following working at heights procedures.
- Follow required isolation and lock-out procedures before measurements.
- Keep workplace clean and tidy.
- Use the proper tool properly.
- Follow manufacturer's safety instructions for all equipment.

**Table 5: PPE**

No	Equipment	Description	Picture
1	Hard hat	Used in workplace environments such as industrial or construction sites to protect the head from injury due to falling objects	
2	Safety shoes	Protective, safety footwear is essential to ensure safe and healthy feet.	
3	Gloves	Are rubber insulating gloves worn by hands to provide the mechanical protection needed against cuts, abrasions, punctures and electrical injuries	
4	Safety belt	A belt is used to protect from the probability of falling from higher working position/height	
6	Eye glass	Eye protection is a type of personal protective equipment (PPE) designed to prevent injury to the eye. Eyes are easily injured by many things such as small particles, chemicals, biological agents, strong visible light and non-visible rays. Eyes should be protected by using appropriate eye protection.	



<p>7.</p>	<p>Electrician safety cloth</p>	<p>The main hazards that electrical worker safety clothing needs to protect against are arc flash and electric shock, but also visibility hazards when work involves construction sites.</p>	
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<b>Self-Check - 5</b>	<b>Written Test</b>
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**Instruction: Follow the below selected instruction**

Answer all the questions listed below

N°	Questions and answers
<b>1</b>	<b>Why is it important to observe safe working practices throughout the task (4)</b>

**Note: the satisfactory rating is as followed**

Satisfactory	3 points
Unsatisfactory	Below 3 points

**Answer Sheet**

Score = \_\_\_\_\_

Rating: \_\_\_\_\_

Name

Date

<b>Information Sheet 6</b>	<b>Accomplishing and recording in accomplishment report form</b>
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## 6 Accomplishing and recording in accomplishment report form

All maintenance activities should be documented and stored for future reference, but also to give to the client as proof of work performed.

Note down all measurements taken, measurements, equipment replaced with serial numbers and results. Keep report central for other technician or for the next maintenance.

A copy of the maintenance record should be handed over to the client and the client should sign the original.

<b>INVERTER</b>				
PV array isolator mounted adjacent to the inverter (Rating:.....Vdc, .....A dc)		<input type="checkbox"/> Isolator is mounted on output of the inverter (where required) <input type="checkbox"/>		
Lockable AC circuit breaker mounted within the switchboard to act as the inverter main switch for the PV/inverter system (Rating ..... A )		<input type="checkbox"/> Inverter is installed as per manufacturer's specification <input type="checkbox"/>		
Inverter ceases supplying power within two seconds of a loss of AC mains		<input type="checkbox"/> Inverter does not resume supplying power until mains have been present for more than 60 seconds. <input type="checkbox"/>		
<b>CONTINUITY CHECK</b>				
Circuit checked (record a description of the circuit checked in this column)				
Continuity of all string, sub-array and array cables				
Continuity of all earth connections (including module frame)				
<b>SYSTEM CHECK</b>				
WARNING:				
<ul style="list-style-type: none"> <li>• IF A STRING IS REVERSED AND CONNECTED TO OTHERS, FIRE MAY RESULT.</li> <li>• IF POLARITY IS REVERSED AT THE INVERTER DAMAGE MAY OCCUR TO THE INVERTER.</li> </ul>				
	Polarity	Voltage	Short Circuit	Operating Current
String 1		V	A	A
String 2		V	A	A
String 3		V	A	A
String 4		V	A	A
Sub-arrays where required		V	A	A
PV array at PV array switch-disconnector		V	A	A
Irradiance at time of recording the current			W/m2	W/m2
<b>INSULATION RESISTANCE MEASUREMENTS (see table 12.3.1 for minimum values of insulation resistance)</b>				
Array positive to earth				MΩ
Array negative to earth				MΩ
<b>INSTALLER INFORMATION</b>				
CEC Accredited installer's name:				
CEC Accreditation number:				
I verify that the above system has been installed to all relevant standards				
Signed:		Date:		
CEC Accredited Designer's name:				
Licensed electrician's name: (where applicable, e.g. LV work)				
Electrician's licence number:				
Signed:		Date:		

Figure 41: Sample maintenance report form (<http://pvsystemsomahoso.blogspot.com/>)

<b>Self-Check - 6</b>	<b>Written Test</b>
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**Instruction: Follow the below selected instruction**

Answer all the questions listed below

N°	Questions and answers
1	<b>What should be noted on the accomplishment report form? (2)</b>

**Note: the satisfactory rating is as followed**

Satisfactory	2 points
Unsatisfactory	Below 2 points

**Answer Sheet**

Score = _____  Rating: _____
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Name

Date