Annex 16

Provisional, Intermediate & Final Acceptance Tests

Macao Solar Installation

REVISION HISTORY

Revision Level	Change Summary	Elaborated by	Approved by	Date

1 Overview

The Contractor will be responsible for the Commissioning of the System and performing the Performance Tests.

The testing phases are divided as follows

1.1 Performance Tests

Tests carried out over specified time periods to verify that the Plant is achieving the Guaranteed Performance Ratio for that specific period.

1.1.1 Provisional Acceptance Test (PAT).

The Provisional Acceptance Test is performed over a 15 calendar day period. On satisfactory completion and issuance of the Provisional Acceptance Certificate (PAC), the 2 year guarantee comes into effect.

1.1.2 Intermediate Acceptance Tests (IAT)

Measures to verify the Performance Ratio of the Plant by measuring electricity production over a 12 month period starting from the date that the Provisional Acceptance Certificate was issued by the Owner.

1.1.3 Final Acceptance Tests (FAT)

Checks and Tests to verify the status of the Plant at the end of its warranty period of two
(2) years and to measure the Performance Ratio over a 12 month period commencing from the date that the Intermediate Acceptance Certificate was issued by the Owner.

2   General Requirements

2.1   Operation during Testing and Commissioning

During the Commissioning and the Provisional Acceptance Test, the Plant will be operated by the Contractor until PAC, with the O&M Contractor's staff in attendance under the direction and supervision of the Contractor.

After the issue of the Provisional Acceptance Certificate, the O&M Contractor shall operate the Plant in accordance with the O&M manuals provided by the Contractor. The Contractor shall remain responsible for the satisfactory performance of each test.

2.2   Procedures and Testing Equipment

The Contractor shall be responsible for providing all the necessary equipment, manpower, materials, consumables and services to meet his commitments with regard to this phase of the work.

The Contractor shall comply with all of the Distribution Network Operator (DNO from now on) safety procedures and be responsible for all coordination of installation and testing protocols including system and F21/F22 testing and commissioning. The Contractor shall liaise with the DNO and programme the DNO's commissioning engineer in sufficient time so that the testing proceeds without delay.

All tests and such activities may be witnessed by the Owner's agent or representative. Third parties may also witness some or all of the tests if and when required.

The Contractor shall make all necessary arrangements to obtain and record all test data as may be required while the Owner may check data as desired.

The contractor must send prior notification of the test to be performed to the client, if the client does not receive notification, the test carried out will not be valid and will have to be repeated.

All commissioning procedures should be in line with each equipment manufacturer's requirements.

2.3   Commissioning Plans, Procedures and Programme

The Contractor shall submit detailed commissioning and testing procedures to the Ownr for all commissioning activities and Performance tests to be carried out. The procedures shall cover all required safety measures together with all necessary inspections, adjustments and tests to achieve progress through operation from no load to full load capacity.

The Owner shall review the Contractor's submission and notify the Contractor in writing whether or not all test pre-requisites have been satisfied. If the Owner provides comments, then the Contractor shall revise the Test Protocol to address the Owner's comments and resubmit it for review and approval within two (2) business days thereafter.

If the Contractor fails to timely provide any of the required notices, such that the Owner or his Representatives are not able to witness the test then the Contractor may be required to repeat the tests at his own cost.

The procedures shall be divided into sections for each item of Plant or system and shall include:

- Documentation identifying the major components with references to the relevant instrumentation and interlocks.
- A description in the form of a list, table or similar or the design operating conditions with details of all restrictions, precautions and limits on Plant operation applicable to that section of the Plant during the pre-commissioning and commissioning periods and then to subsequent operation.
- A detailed program, for the activities to be carried out for the completion of its commissioning and performance trials.

2.4 Copies of the Contractor's check sheets for the pre-commissioning, commissioning and testing of each Plant item or system. Test Records

- The Contractor shall be responsible for supplying to the Owner copies of all test documentation for the complete Plant. All original and signed test records sheets shall become the property of the Owner and shall be handed to the Owner following each test.
- Unless noted otherwise, the Contractor shall promptly prepare and submit a detailed test report to the Owner within 15 business days of completion of any test. The test report shall include the test procedure, description of any deviations from the test procedure of unusual event(s), which occurred during the test, copies of test data sheets, calculated results, copies of lab analyses, copies of instrument calibration records, technician name and supervisor.
- Test results should be recorded and submitted to the Owner, the forms should always provide a means for recording:
    - The equipment under test and expected results
    - Test equipment used and calibration certificates.
    - The name of the person(s) who performed the test & date/time the test was carried out
    - Details of the operational testing carried out, the results of the tests and of any adjustments necessary to enable the equipment to meet its specified requirements.
    - Confirmation of pass/fail or any remedial action
    - Relevant standards (e.g. IEC 61724, Photovoltaic systems performance monitoring - Guidelines for measurement, data exchange and analysis)
- The Contractor shall certify to the Owner in writing that the Test results and supporting data provided by the Contractor are complete, current and accurate.
- The Owner shall confirm his acceptance or rejection of the test reports within five (5) business days of receipt.
- If the Test results are rejected or incomplete, the Owner shall provide the basis for rejection and/or identify the missing information together with the necessary corrective action (which may include a repetition of the test).

2.5 In case of Dispute

- If the Contractor disputes the Owner's rejection of any Test results or other Owner determinations with regard to the Tests Protocol, Contractor shall follow the procedure for Determinations under the Contract and if no agreement is reached

the Disputes Resolution procedures set forth in the Contract.

3   Performance Ratio

The "Performance Ratio" (PR) is a measure of the quality of the design and the components of the PV Plant. It is the relationship between the actual produced Energy measured at the Plant's energy meter and Energy theoretically produced by the PV modules.

The Plant's Performance Ratio shall be calculated in accordance with IEC 61724.

All Performance Ratio calculations shall be based on, fifteen (15) minutes averaged readings taken throughout the measuring period,

The following data points shall be recorded and used to determine the System Performance meets expectations:

a.   In-plane Irradiance (W/m²) using a minimum of two (2) calibrated pyranometers with maximum measurement tolerance < 2 %.

b.   Cell temperature (⁰C) using a minimum of two (2) temperature sensors with accuracy of at least +/-1 ⁰C

c.   Ambient air temperature (⁰C) using a temperature sensor with accuracy of at least +/- 1⁰C

d.   Total Plant Energy Output (kWh) to the grid.

The data for items a-c above will be taken using the Plant's weather station sensors whereas the Total Plant Energy Output will be measured at the Plant's energy meter (for clarity this is the meter at which Plant output is measured for the purposes of receiving payments through the Power Purchase Agreement (PPA)).

The clock from the weather stations data logger/SCADA system will be synchronized before the test with the clock from the Plant energy meter.

The average data of the pyranometers and temperature sensors will be considered as input values for the Performance Ratio calculation. However, if some pyranometers and/or temperature sensors demonstrate incorrect behaviour then they will not be taken into account for the average.

After each of the Performance Ratio measurement (done during the Performance Test, the Intermediate Acceptance Test, the Final Acceptance Tests or any other phase) the Contractor shall provide to all parties the following documentation:

- Excel File with raw data in one single file containing all the data acquired synchronized and not manipulated.
- A comprehensible Performance Test-Calculation showing the formulas used.
- Short report about the Performance Test which includes a short summary on the following:
  - Testing conditions (minimum requirements e.g. irradiance, temperature, testing period, availability of monitored data, etc.)
  - Testing procedure
  - Testing equipment with the calibrated certificates.
  - Testing results

4 Performance Tests

The Performance Tests are designed to demonstrate that the Plant achieves the Guaranteed Performance Ratio set out in the Contract over a given period.

After completion of any of the Performance Tests, the Contractor shall not adjust the Plant, its control system or any equipment in any way which, in the opinion of the Owner, could: reduce output from that tested during the Performance Tests or any other parameter guaranteed or subject to an environmental condition such that the Works will not comply with the guarantees or conditions of consent.

The rate of change for many of the parameters of interest can be relatively high. Irradiance, for example, can change rapidly under partly cloudy conditions. While the intent is not to capture electrical transient-level detail, a sufficient sampling rate is necessary to characterize average performance over the averaging interval.

The sampling interval for all parameters shall be consistent with the capability of the instruments and shall be as close as practicable to the following intervals. For all parameters which vary directly with irradiance the sampling interval shall be 60 seconds or shorter. For all other parameters the sampling interval shall be no less than 5 minutes and in line with the recommendations of IEC 61724.

The processed data values for each parameter shall be recorded each 15 minutes or less. At each recording interval, the time and date at the end of the period in which measurements were taken shall be recorded. The time shall always refer to local time and all the variables will be registered at the same time.

All recorded data shall be checked for consistency, any gaps shall be identified and obvious anomalies recorded prior to any detailed analysis being conducted. A reasonable set of limits shall be defined for each recorded parameter, based on the known characteristics of the parameter, the Plant and the environment.

This Actual Measured Performance Ratio ("PR_{ACTUAL}") will be the measure to determine whether the Guaranteed Performance Ratio has been achieved.

4.1 Provisional Acceptance Test (PAT)

Before starting the Provisional Acceptance Test the Contractor will deliver the necessary information (login and password) to allow remote access to the Monitoring System to the Client and

- Verify that the positioning and angle of the Pyranometers is correct.

- Ensure that the Pyranometers are clean (in accordance with the to manufacturer's instructions) and not shaded at any of the day.

Throughout the PAT, the data to determine system performance must be continuously monitored. The PAT will continue until a minimum of 15 days, with irradiation levels greater than 400 W/m², for at least 2 hours a day, are achieved.

In the event that the Plant operation is interrupted due to non-operation of the equipment within the plant and it is evident that the required availability over the test period cannot be achieved then the results will be discarded and the test will be suspended and re- started (from day 1) when the problem has disappeared.

If the Performance Test is disrupted due to Force Majeure events or due to theft,

vandalism, Substation, Grid failure or instability (including when the Grid is out of bounds) it will be suspended and re-started when the problem has disappeared.

<u>Data delivery format</u>

Once the 15 days Test Period has finalized the Contractor will send to the Owner all the data collected inside a unique Excel file including all the samples registered from all the variables monitored including:

- Meter
- Pyranometers
- Reference cells
- Thermometers
- Inverters
- Stringboxes

4.1.1 Actual and Adjusted Performance Ratio Calculations

Once the data points have been completely logged, the validated dataset will be used to calculate the Actual and Adjusted Performance Ratio.

PR calculation methodology

Formula below provides method for condition checking for each period (PAT):

$$PR_{ACTUAL} = \frac{\sum_i E_{ac-i}}{P_{STC} \cdot \sum_i (1 - L_{t-i}) \cdot G_{dg-i} \cdot \left(\frac{1kW}{m^2}\right)^{-1} \cdot A_0}$$

Levels of irradiation lower than 50 W/m² will not be taken into account. Measurements will be recorded every 5 minutes (*"i"*).

Where:

E_{ac-i} indicates energy production in each period "I" in the counter installed at the POC.

P_{STC} indicates nominal power of the Plant in kW. Sum of the individual module power of all installed modules at STC conditions.

L_{t-i} indicates temperature losses in each period "i".

$$L_{t-i} = \beta \cdot (T_{mod} - T_{meas-i})$$

where,

β indicates the temperature coefficient of Pmax from the module´s data sheet (in 1/°C).

T_{mod} indicates the average monthly cell temperature during daylight hours computed from the project PVSyst model as per Annex 18 (°C).

T_{meas-i} indicates the average module temperature measured in each period "i" This value shall be calculated using the temperature sensors placed on the reverse side of the modules (°C).

G_{dg-i} indicates the irradiation (kW/m^2) in each period "i" measured with an on-site pyranometer with the same inclination as the modules. If the modules are tracked, also the pyranometers has to be tracked the same way.

A_0 indicates the agreed maximum availability of the plant during the period of the PAT.

4.1.2 Passing the Performance Tests and Liquidated

Damages The Performance Tests shall be passed only

if:

- **Plant's Availability is equal to 100% during the tests, according to Annex 23.**
- **Monitored Data Availability is equal to 99% during the tests.**
- **Actual Performance Ratio calculated in paragraph 4.2 is greater than or equal to the Guaranteed Performance Ratio corresponding to the month in which the Provisional Acceptance Tests are performed.**
- **Registered amount of days with an irradiation level greater than the minimum specified.**

If the Actual Performance Ratio is above the Minimum Performance Guarantee but below the Guaranteed Performance Ratio, the Contractor shall identify and remedy the cause and restart the Provisional acceptance test within fourteen (14) days.

If the Actual Performance Ratio is below the Minimum Performance Guarantee, the Performance Tests shall be considered as failed.

4.1.3 Provisional Acceptance Certificate (PAC)

The Owner will proceed to the issuance of the Provisional Acceptance Certificate on the satisfactory conclusion of the PAT once all of the following requirements are achieved:

- all works described in the contract have been finished and,
- all the required documentation has been provided and successfully checked and,
- the security and surveillance system operation has been fully checked and,
- the keys and security codes of the plant have been provided.

4.2 Intermediate Acceptance Tests

The procedure for data collection will match the procedure described in Section 4 above but will be extended to cover a full 12 month period commencing at the issue of the Provisional Acceptance Certificate.

4.2.1 Actual Intermediate Performance Ratio Calculations

Once the data points have been completely logged, the validated dataset will be used to calculate the Actual Intermediate Performance Ratio ("PR_{I_ACTUAL}").

PR calculation methodology

$$PR_{I\_ACTUAL} = \frac{\sum_i E_{ac-1}}{P_{STC} \cdot \sum_i \cdot (1 - L_{t-i-1}) \cdot G_{dg-i-1} \cdot \left(\frac{1kW}{m^2}\right)^{-1} \cdot A_1}$$

Where:

E_{ac-1} indicates the total energy production in the counter installed at the POC during year 1.

P_{STC} indicates nominal power of the Plant in kW. Sum of the individual module power of all installed modules at STC conditions.

L_{t-i-1} indicates temperature losses in each period "i" during year 1.

$$L_{t-i-1} = \beta \cdot (T_{mod} - T_{meas-i-1})$$

where,

β indicates the temperature coefficient of Pmax from the module´s data sheet (in 1/°C).

T_{mod} indicates the average monthly cell temperature during daylight hours computed from the project PVSyst model, as per Annex 16 (°C).

$T_{meas-i-1}$ indicates the average module temperature measured in each period "i" This value shall be calculated using the temperature sensors placed on the reverse side of the modules (°C) during year 1.

G_{dg-i-1} indicates the total irradiation (kW/m²) in each period "i" during year 1 measured with an on-site pyranometer with the same inclination as the modules. If the modules are tracked, also the pyranometers has to be tracked the same way. Levels of irradiation lower than 50 W/m² will not be taken into account.

A_1 indicates the availability of the plant during year 1, as defined in the O&M Contract.

4.2.2 Intermediate Acceptance Tests Pass Criteria and Compensation Payments

The Intermediate Acceptance Tests shall be passed if Actual Intermediate Performance Ratio is higher than the Guaranteed Performance Ratio.

If Actual Intermediate Performance Ratio is below the Minimum Performance Ratio, the Intermediate Acceptance Tests shall be considered as failed.

If Actual Intermediate Performance Ratio is above the Minimum Performance Ratio but less than the Guaranteed Performance Ratio then Performance Liquidated Damages will be applied in accordance with the Contract.

4.3   Final Acceptance Tests

The procedure for data collection will match the procedure described in Section 5 above but will be extended to cover a full 12 month period commencing after the issue of the Intermediate Acceptance Certificate.

4.3.1 Actual Final Performance Ratio Calculation

Once the data points have been completely logged, the validated dataset will be used to calculate the Actual Final Performance Ratio ("PR$_{F\_ACTUAL}$").

PR calculation methodology

$$PR_{F\_ACTUAL} = \frac{\sum_i E_{ac-2}}{P_{STC} \cdot \sum_i (1 - L_{t-i-2}) \cdot G_{dg-i-2} \cdot \left(\frac{1kW}{m^2}\right)^{-1} \cdot A_2}$$

Where:

E_{ac-2} **indicates the total energy production in the counter installed at the POC during year 2.**

P_{STC} **indicates nominal power of the Plant in kW. Sum of the individual module power of all installed modules at STC conditions.**

L_{t-i-2} **indicates temperature losses in each period "i" during year 2.**

$$L_{t-i-2} = \beta \cdot (T_{mod} - T_{meas-i-2})$$

    where,

    β **indicates the temperature coefficient of Pmax from the module´s data sheet (in 1/°C).**

    T_{mod} **indicates the average monthly cell temperature during daylight hours computed from the project PVSyst model (°C).**

    $T_{meas-i-2}$ **indicates the average module temperature measured in each period "i" This value shall be calculated using the temperature sensors placed on the reverse side of the modules (°C) during year 2..**

G_{dg-i-2} **indicates the total irradiation (kW/m^2) in each period "i" during year 2 measured with an on-site pyranometer with the same inclination as the modules. If the modules are tracked, also the pyranometers has to be tracked the same way. Levels of irradiation lower than 50 W/m^2 will not be taken into account.**

A_2 **indicates the availability of the plant during year 2, as defined in the O&M Contract.**

4.3.2 Passing the Final Acceptance Tests and Compensation Payments

The Final Acceptance Tests shall be passed if Actual Final Performance Ratio is higher than the Guaranteed Performance Ratio.

If Actual Final Performance Ratio is below the Minimum Performance Ratio, the Final Acceptance Tests shall be considered as failed.

If Actual Final Performance Ratio is above the Minimum Performance Ratio but less than the Guaranteed Performance Ratio then Performance Liquidated Damages will be applied in accordance with the Contract.