

# Certificate in Installing and Testing Domestic Photovoltaic Systems (2372)



## Qualification Handbook

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## **2372 Certificate in Installing and Testing Domestic Photovoltaic Systems**

<b>Contents</b>	<b>Page</b>
1 Rationale	4
2 General information	5
3 Assessments	8
4 Syllabus	12
5 Further information	23

## **Certificate in Installing and Testing Domestic Photovoltaic Systems 2372**

### **Rationale**

This award is intended for qualified electricians who will be required to install grid connected domestic photovoltaic systems that are either integrated into, or retro onto, a domestic dwelling. It is concerned with domestic systems installation within prescribed specifications and therefore does not cover design or glazed or curtain wall systems.

It is expected that candidates will be practising electricians and have appropriate qualifications related to electrical installation such as an NVQ at level 3, knowledge of the IEE Wiring Regulations and inspection and testing. They will need to be employed within the electrical contracting industry. The award is designed to offer specific skills and knowledge to electricians to ensure they are conversant with Regulations and Code of Practice related to PV systems. The Department of Trade and Industry (DTI) supports the recognition of qualified personnel within this initiative and sees PV systems as an essential part of Government energy policy.

## General information

This award has been designed by City & Guilds to support Government initiatives in respect of providing training and assessment to support a competent workforce to meet the expected growth in relation to renewable energy sources.

## General structure

The award is made of two units. The first unit describes the underpinning knowledge that is required to understand the theory behind PV systems, related Regulations, safety requirements and installation and testing. The second unit is concerned with the application of practical skills in carrying out installation and testing.

## Assessment and quality assurance

National standards and quality assurance will be maintained by the use of

- City & Guilds written tests, marked by the centre to pre-set criteria
- Practical assessments marked by the centre according to externally set marking criteria with quality assurance assured by the centre and monitored by City & Guilds external verification system.

Quality assurance includes initial centre approval, scheme approval, the centre's own procedures for monitoring quality and City & Guilds' ongoing monitoring by an External Verifier. Details of City & Guilds criteria and procedures can be found in *Providing City & Guilds Qualifications – a guide to centre and scheme approval*.

External verifiers act on behalf of City & Guilds to ensure that national standards are maintained. Full details of their role can be found in the above document.

No higher grade than pass will be awarded for the assessment components.

For candidates with particular requirements, centres should refer to City & Guilds policy document *Access to assessment, candidates with particular requirements*.

## Course design

Teachers/assessors should familiarise themselves with the structure and content of the award before designing an appropriate course. City & Guilds does not itself provide course of instruction and teachers/assessors may design courses in any way that they feel best meets the needs of their candidates.

It is recommended that 30 hours should be allocated to deliver the course.

## Entry to the course

City & Guilds strongly recommends that candidates for the award should be practising qualified electricians. City & Guilds would also state that candidates should not be registered if they hold from City & Guilds or another awarding body a qualification of a similar level and within the same content area.

## Health and safety

The requirement to follow safe working practices is an integral part of all City & Guilds qualifications and assessments, and it is the responsibility of centres to ensure that all relevant health and safety requirements are in place before candidates start practical assessments. Should a candidate fail to follow health and safety practice and procedures during an assessment the test must be stopped and the candidate advised of the reasons why. The candidate should be informed that they have failed. Candidates may retake an assessment after remedial tuition in respect of the safety element.

## Centre and scheme approval

Any centre wishing to offer City & Guilds qualifications must gain approval. New centres must apply for centre and scheme approval. Existing City & Guilds centres will need specific scheme approval to run this award. **Centres must ensure that they can access the specific resources required for the practical assessment.**

Full details of the process for both centre and scheme approval are given in *Providing City & Guilds qualifications – a guide to centre and scheme approval* which is available from City & Guilds regional offices.

City & Guilds reserves the right to suspend an approved centre, or withdraw its approval from an approved centre to conduct a particular City & Guilds scheme or particular City & Guilds schemes, for reasons of debt, malpractice or for any reason that may be detrimental to the maintenance of authentic, reliable and valid qualifications or that may prejudice the name of City & Guilds.

External verifiers act on behalf of City & Guilds to ensure that national standards are maintained. Full details of their role can be found in *Providing City & Guilds' Qualifications - a guide to centre and scheme approval*.

## Entry for assessment and certification

Candidates must be entered through an approved centre. Full details will be found in the *Directory of Vocational Awards* published by City & Guilds. This information also appears on City & Guilds Web site <http://www.cityandguilds.com>

## Appeals and Equal Opportunities

Centres must have their own, auditable, appeals procedure. If a candidate is not satisfied with the assessor's judgement of his/her competence during the assessment process, or a candidate feels that the opportunity for assessment is being denied, the internal verifier and centre co-ordinator should, in the first instance, address the problem. If, however, the problem cannot be resolved, City & Guilds will arbitrate and the external verifier may be approached to offer independent advice. All appeals must be clearly documented by the centre co-ordinator and made available to the external verifier or City & Guilds if advice is required. Should occasions arise when centres are not satisfied with any aspect of the external verification process, they should contact City & Guilds regional or national office.

## The provision and conduct of assessments

- 1
  - a For the purpose of this scheme assessments are made available to centres along with answers and marking guidelines. Centres must apply to City & Guilds in writing to receive the test papers and answers.
  - b Centres are responsible for the marking of the question papers and the entry of the appropriate grade on Form S.
- 2
  - a Centres must adhere to the conditions laid down for examination paper security.
  - b Scripts should be retained by the centre for at least 18 months from the completion of the examinations. Failed candidates may retake an assessment at any time.
- 3
  - a Test papers must be kept under secure conditions at all times and only assessors may have access. They must only be issued to candidates for the duration of the examination and no unauthorised person should be able to obtain or remove a copy of a test
  - b The test should be marked by the centre as soon as possible after examination. When the marking is complete the assessor should indicate the grade for each candidate
  - c Candidates who fail a test may retake it at any time at the discretion of the test centre. A new test paper must be used.

## Assessments

### The award

For the award of a certificate candidates must successfully complete both assessments.

Unit 1	Knowledge of photovoltaic systems	2372-001	Written-short answer
Unit 2	Practical applications	2372-002	Practical assessment

### Test specifications

**2372-001** Knowledge of photovoltaic systems

Written paper of 20 short answer questions and 1 long answer question 1 1/2hours

Section	Topic	Weighting %	No of Questions
1	Photovoltaic systems	10	2
2	Standards and Regulations/Guidelines and Codes of Practice	15	3
3	Safety	15	3
4	PV systems components	30	6
5	Approvals	5	1
6	Installations	5	1
7	Commissioning and testing	15	3
8	Customer care	5	1
Total		100	20

### **2372-002** Practical applications

Practical assessment based on the installation commissioning and testing of a simulated domestic PV system. Details of the practical assessment outcomes are contained within the Assessment Material

## Results

For both assessment units there are two grades, **pass** and **fail**.

All candidates for City & Guilds certificates and assessments receive a Notification of Candidate Results giving details of their performance. Candidates who successfully complete both the assessment units will automatically receive a City & Guilds Certificate.

Centres will receive Notification of Candidate's Results and Certificates for their own candidates. Any correspondence is also conducted through the centre.

Centres will receive consolidated results lists detailing the performance of all the candidates they enter, whether they are successful or not.

## Test Rig Specifications

These specifications state the minimum requirements which must be met by organisations who wish to offer the City & Guilds course in the installation of domestic grid connected PV systems. The aim of the specification is to ensure uniformity throughout the delivery of the practical element of the course. Any deviation from this specification would render practical elements of the course invalid.

The following specification may be implemented in a number of ways and can involve a number of test rigs or one single test rig. The specifications have taken into account the likely resources available to institutions wanting to deliver the course.

### 1. Roof requirements

The roof used for training can be a real roof at height, or alternatively an indoor or outdoor mock-up roof at ground level may be used. Training on and experience of working at height will be included in the course, but will not form part of the final practical assessment.

The roof must have the following specification:

- A slope of at least 25° pitch from the horizontal.
- The roof must be covered with tiles, slates or interlocking tiles.
- The sub-frame of the roof must be similar to that of a conventional roof and constructed from wood and include felting/sarking and battening.

The functioning PV system can be used as a test rig for practising the installation of a PV mounting system as long as it meets the roof specification given above. The functioning PV system may also be removed to allow the installation of a different type of PV mounting system in the same place and to allow roof access and roofing skills to be practised. Due to the cost of PV modules, institutions may wish to undertake these activities on a separate test roof as the working PV modules may be damaged accidentally by students. If a separate test roof is to be used then the functioning PV system does not have to follow the roof specification given above.

The institution may opt to have a number of test rigs, and to demonstrate several mounting systems. However it is imperative that there is at least one functioning PV system and a roof meeting the above specification for the installation of non-integrated and integrated PV mounting systems.

#### 1.1 Dummy Modules

Given the cost of PV modules institutions may opt to use factory rejects or dummy modules for students to practice system installation.

The specification for dummy modules is given below:

- Dummy modules must be a minimum size of 0.5m x 1m.
- Dummy modules must be constructed from glass of similar weight to that of conventional PV modules. The aim is to ensure students are aware of the fragile nature of PV modules and their weight.
- Dummy modules must be framed in metal similar to that of typical modules.
- Connection boxes or leads must be fixed to the back of the dummy modules to allow student to wire up modules into an array.

**Note:-** A working PV system is still required to demonstrate a working array. Dummy modules are only to be used to demonstrate fixing methods and wiring. The dummy array must be installed on a roof of the same specification as that given above.

## **2. Functioning PV System**

A fully functioning PV system that operates in parallel with the electricity distribution network must be installed. The system operator must have a connection agreement from the local Distribution Network Operator and the system must be installed in accordance with relevant regulations and standards. In particular the system must comply with G83/1 and BS7671.

The minimum requirements of the system are:

- A G83/1 compliant string inverter, NOT module inverters.
- Minimum of 6 modules in series.
- Array configuration must match the inverter input range.
- The inverter must be located close to the array.
- The array must be positioned to maximise sunlight gain and have no or minimal shading.
- Appropriate DC and AC isolators must be installed adjacent to the inverter to enable isolation from the array and the electricity network.
- The system must be connected to a dedicated miniature circuit breaker (MCB).
- A lockable AC isolator must be installed adjacent to the consumer unit/distribution board.
- The system must be labelled in accordance with G83/1.

Access for students is required to the main array cables from the array (but not necessarily to the connections between modules at the back of the array), inverter, and DC & AC isolators to enable this part of the system to be dismantled, reconnected and commissioned.

# Syllabus Unit 1 Knowledge of Photovoltaic Systems

The candidate will be able to

## 1 Photovoltaic systems

- 1 Identify typical photovoltaic (PV) installations
  - a grid connected
  - b building integrated
  - c non-integrated
- 2 State typical expected outputs of a domestic PV system and its proportion relative to typical domestic electricity consumption.
- 3 Describe the major components and system layout of a grid connected PV system

## 2 Standards, Regulations, Guidelines, Codes of Practice

- 1 Identify relevant statutory regulations
  - a Electricity at Work Regulations 1989
  - b Building Regulations 2000
  - c Health and Safety at Work etc Act 1974
  - d Control of Substances Hazardous to Health Regulations 1988
- 2 Identify and apply guidelines and Codes of Practice
  - a Engineering recommendations G83/1 and G59/1
  - b Department of Trade and Industry guidelines '*Photovoltaics in Buildings: Guide to the installation of PV systems*' and '*Photovoltaics in Buildings: Testing, Commissioning and Monitoring Guide*'
  - c BS 7671 IEE Wiring Regulations for Electrical Installations
  - d HSE Guide GS38 Electrical test equipment for use by electricians

### 3 PV safety

- 1 Describe methods of verifying and securing (locking off) circuit isolation.
- 2 Describe precautions to be taken and procedures to be followed to prevent electric shock
  - a identify hazards arising from the use of electrical equipment
  - b apply general safety rules in respect of checking of cables, leads and plugs, earthing and use of portable equipment and reduced voltage equipment
  - c recognise that PV cannot be switched off and that measures are necessary to ensure contact cannot be made with live connections.
  - d recognise that voltage is generated at low light levels and can lead to risk of electric shock
  - e identify PV modules as current limiting devices not damaged by short circuits and therefore not liable to be protected by fuses.
- 3 Describe the characteristics of d.c. wiring
- 4 State the requirements for the correct use of circuit identification, notices and labelling
- 5 List the general rules for observance of safe practices including
  - a being alert
  - b maintaining personal hygiene
  - c protecting oneself and other people
  - d knowing emergency and site evacuation procedures to cover
    - i fire
    - ii explosion
    - iii toxic atmosphere
    - iv security alerts
    - v reporting all hazards and notifying appropriate authority
- 6 Identify suitable access equipment for working at height and on roofs
  - a appropriate staging and trestles
  - b safe angles for ladders
  - c methods of securing ladders
  - d safety requirements for tower scaffolds
  - e guard rails and toeboards
  - f personal safety equipment when working on roofs
- 7 Recognise safe practices for handling, moving and storing PV modules.

## 4 System components

### PV Modules and Array

- 1 Recognise the main PV cell technologies and their characteristics
  - a types
    - i Monocrystalline
    - ii Polycrystalline
    - iii Thin film
  - b characteristics
    - i PV cell
    - ii module
    - iii string
    - iv array
- 2 Describe the following in respect of a photovoltaic module
  - a  $I/V$  (current/voltage) curve
  - b open circuit voltage and short circuit current ( $V_{oc}$  and  $I_{sc}$ )
  - c maximum power current and voltage ( $I_{mpp}$  and  $V_{mpp}$ )
- 3 State the significance of standard test conditions and recognise that actual power output in real conditions can vary substantially.
- 4 State the international standards with which PV modules should comply
  - a BS EN 61215, IEC 61215
  - b BS EN 61646, IEC 61646
- 5 State the factors effecting the installation of a PV array
  - a inspection and storage of modules
  - b siting of modules (orientation, angle of inclination, free from shade)
  - c load bearing capacity
  - d configuration of modules
  - e fixing methods, integrated and non-integrated
  - f alignment and levelling of secondary structures to minimise stress on modules
  - g maintaining the integrity of the roof (weather seal)
  - h aesthetic considerations
  - i environmental conditions

## Roofing

- 6 Describe the following roof terminology
  - a types of roof: flat, with gable ends, hipped and half-hipped
  - b trusses, rafters, struts, ridge board, wall plate, tie beams, purlins, counter battens and battens
  - c ridge, eaves, gable end, flat
  - d roof flashing
  - e roof coverings: flat/plain tiles, slates, pantiles/interlocking tiles, felt roofing, standing seam metal roofing, clay/concrete tiles

## D.C. System

- 7 Calculate recommended minimum voltage and current ratings for d.c. components and cable
  - a plugs
  - b connectors
  - c switches
  - d minimum cable sizing for main and string d.c. cables ( $V_{oc}$  and  $I_{sc}$ )
- 8 State that the PV array must be isolated from the inverter by a double pole switch
- 9 State the class of protective insulation recommended for PV modules including systems with high open circuit voltages.
- 10 Describe short circuit proof installation
- 11 State the requirements for d.c. cabling in respect of
  - a minimum temperature rating requirements for string cables
  - b ultra violet (UV) and weather resistance requirements for d.c. cables
- 12 Describe the labelling requirements for a d.c. system
- 13 Describe the use of string fuses and blocking diodes with reference to
  - a type of system
  - b fuse ratings
  - c point of installation
  - d selection factors for a blocking diode
  - e potential problems

## Inverter and Electrical Protection

- 14 State the function of inverters and the factors which influence selection
- a type of inverter
    - i string
    - ii a.c. module
    - iii single phase
    - iv 3-phase
  - b location
    - i effect of weight
    - ii length of d.c. cable
    - iii environment
    - iv inverter sizing
    - v compliance with G83/1
- 15 Describe protection types for small PV systems
- a anti-islanding protection
  - b over and under voltage protection
  - c over and under frequency protection
- 16 State G59/1 requirements for large PV systems

## Earthing and Lightning Protection

- 17 State earthing requirements in BS 7671 and BS 7430 with reference to
- a array frame earthing
  - b d.c. conductor earthing
  - c inverter earthing
- 18 State lightning protection system requirements in BS 6651 with reference to
- a type of system
  - b connection to array and mounting
  - c surge protection

## A.C. System and Metering

- 19 State grid connection requirements in BS 7671 with reference to
- a meter installation
  - b a.c. cabling

- 20 State a.c. switch disconnecter requirement in accordance with BS EN 60947-3 and G83/1
- 21 State a.c. fault current protection requirements

## Performance Monitoring

- 22 List methods of performance monitoring

## 5 Approvals

- 1 State planning and approval requirements with reference to
  - a local authorities
  - b conservation areas and listed buildings
- 2 Describe the approval necessary for grid connection by a distribution network operator (DNO)
  - a installation certificate as per BS 7671
  - b Stage 1 and 2 of G83/1
- 3 State that systems must comply with Building Regulations with respect to
  - a strength of supporting structure and fixing method for modules
  - b fire regulations and PV modules
  - c weatherproofing of modules

## 6 Installation

- 1 Select tools and equipment required for undertaking installation
- 2 Describe sequence of operation for undertaking installation
- 3 State factors which effect the installation costs
  - a type of system, roof integrated/mounting
  - b cable routing
  - c access to site/roof
  - d equipment costs
  - e component breakage through poor storage/handling
  - f labour costs
  - g commissioning costs

## 7 Commissioning and testing

- 1 State the completion requirements with reference to
  - a cleaning of array
  - b operational status of the inverter
  - c checking of module fixings
  - d general visual inspection of the system
- 2 State requirements for visual inspection for
  - a fixing and positioning of array
  - b connectors and junction boxes
- 3 State the testing requirements for weather sealing and structural integrity
- 4 Describe methods of connecting and commissioning monitoring systems.
- 5 State basic principles of diagnostic testing as
  - a knowledge and understanding of relevant system
  - b optimum use of resources expertise and experience
  - c use of a logical approach
- 6 Describe safety inspection and DNO witnessing
- 7 State principles of commissioning in accordance with inverter instructions
- 8 Identify appropriate documentation necessary for testing.
- 9 Describe handover procedures and customer information requirements
- 10 State the commissioning and testing requirements with reference to
  - a G83/1
  - b G59/1
  - c BS 7671
  - d DTI document *'Photovoltaics in Buildings: Testing, Commissioning and Monitoring Guide'*
- 11 State the safety precautions to be taken when carrying out commissioning

## **8 Customer care**

- 1 Recognise the importance of checking the awareness of customers for installation services
- 2 Describe the types of information which can be provided to customers through
  - a installation specifications
  - b manufacturers data
  - c user instructions
- 3 Describe the following in relation to a Code of Practice
  - a sales and promotion
  - b warranties
  - c service and repairs
  - d installation
  - e customer complaints

## Syllabus Unit 2 Practical Applications

The candidate will be able to under real or simulated conditions install and commission a basic grid connected PV system. Details of the tests are contained within the Assessment Materials.

- 1 Ensure work area is safe before work commences
  - a identify possible sources of hazard
  - b ensure tools and equipment are fit for purpose
  - c ensure circuit isolation
  
- 2 Carry out basic roofing techniques
  - a battening
  - b levelling of systems
  - c tiling (plain tile and interlocking tile)
  - d install flashing
  - e position array on a sloping roof
  
- 3 Position fix and install at height
  - a support structures
  - b modules
  - c cables
  - d d.c connectors
  - e isolation switches
  - f earthing protection
  - g lightning protection
  
- 4 Position fix and install
  - a inverter
  - b meter
  - c customer display panel
  
- 5 Label in accordance with G83/1 and G59/1
  - a junction boxes
  - b switches
  - c distribution board

- 6 Connect system to the grid through a domestic distribution board
- 7 Carry out measurement of open circuit voltage and short circuit current for modules, strings and array both at end of installation and during installation process
- 8 Undertake fault diagnosis on modules and array
- 9 Undertake operational testing for an inverter

## Further information

Further information regarding centre/scheme approval or any aspect of assessment of the scheme should be referred to the relevant City & Guilds regional/national office:

<b>Region</b>	<b>Telephone</b>	<b>Facsimile</b>
City & Guilds Scotland	0131 226 1556	0131 226 1558
City & Guilds Newcastle	0191 402 5100	0191 402 5101
City & Guilds Warrington	01925 897900	01925 897950
City & Guilds Leeds	0113 380 8500	0113 380 8525
City & Guilds Wales	02920 838700	02920 838725
City & Guilds Birmingham	0121 359 6667	0121 359 7734
City & Guilds Derby	01773 842900	01773 842940
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