BUREAU VERITAS

SOLAR

WHOLE LIFE CYCLE SERVICE

MARCH 2024

Our mission
SHAPING A WORLD OF TRUST

CREATED IN 1828

190+ years in business

BUSINESS TO BUSINESS TO SOCIETY

Quality, health & safety, environmental protection & social responsibility

FACT BASED UNDERSTANDING

Testing, inspection, certification & technical consultancy

BUREAU VERITAS

YOUR TRUSTED PARTNER IN THE ENERGY TRANSITION

In power since around
1905

7,500+
Power experts

20
Global power centers of expertise

4,000+
Power clients

Power references in
100+
countries

BV CHINA HISTORY

195 YEARS

1828

Established

- First Entered in China

1920

The Modern Industrial Revolution

- Keeping up with the rapid growth and development of industry

1960

Technological progress

- Active role in ship classification and standards modernization
- Strengthen professional technical capabilities in the areas of building and energy efficiency

1990

Globalization

- Develop certification and government services
- Establish offices in Africa, China, the United States, and Europe to strengthen network coverage

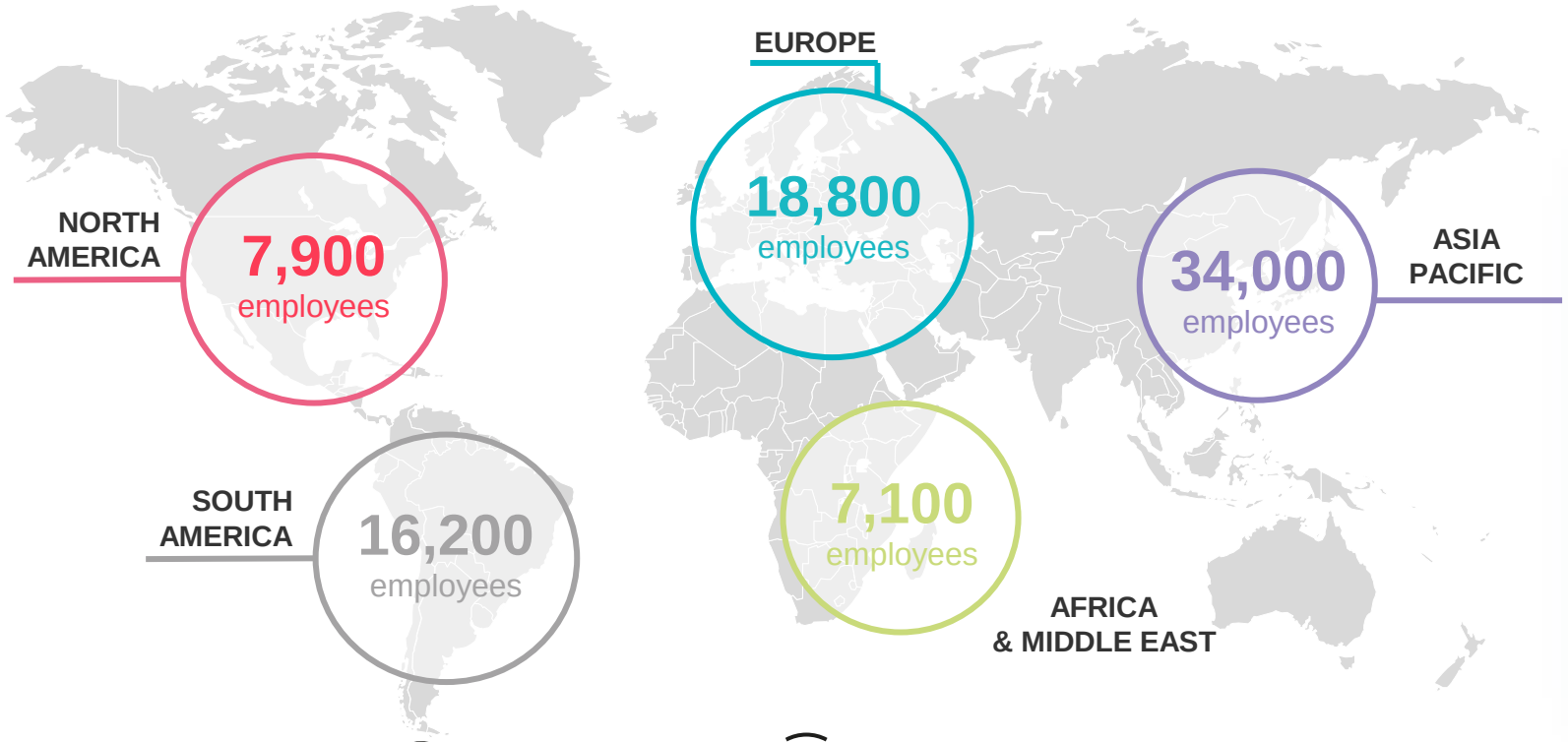
2010

Technological development

- Develop the commodities business and high-potential markets with Inspectorate and Maxxam joined
- Expand presence in China's construction and consumer goods industries

BUREAU VERITAS

BUREAU VERITAS: UNIQUE REACH, UNIQUE SCOPE
UNRIVALLED GLOBAL PRESENCE AND SERVICE PORTFOLIO



140+ Countries

84,000+ Employees

- EXPERTISE
- INDEPENDENCE
- IMPARTIALITY
- INTEGRITY

Testing, Inspection, Certification & Technical Services

KEY FIGURES

€5.9

billion

REVENUE IN 2023

84,000+

employees*

400,000+

clients

1,600+

offices & laboratories

140 COUNTRIES

* As of December 31, 2023

BUREAU VERITAS

BV CHINA KEY ACCOUNTS

SERVICE MENU FOR PV

01 Service for Development Period

02 Service for Purchasing Period

03 Service for Construction Period

04 Service for Operation Period

SERVICE FOR DEVELOPMENT PERIOD

1. Main supplier audit and management
2. Main equipment selection and optimize
3. Preliminary project feasibility study
4. Financing availability report

SERVICE FOR DEVELOPMENT PERIOD

01 Main supplier audit and management

BV carries out on-site audit and inspection on the production capacity, quality, new technology maturity and delivery situation for equipment potential supplier, and **provides technical support and decision support for supplier selection, product type selection and new technology application of customers** through the audit results of BV professional engineers.

02 Main Equipment selection and optimize

BV experienced professional engineers provide technical support and optimization Suggestions for equipment selection in the early stage of the project, **including technical maturity, equipment reliability, common equipment failure problems, etc., to help customers improve the project design scheme**

SERVICE FOR DEVELOPMENT PERIOD

03 Preliminary project feasibility study

Evaluate the light resources, access conditions, installed capacity and related construction conditions of the customer's intended project site, issue the feasibility proposal report of the photovoltaic power station, and help the customer to investigate the feasibility of the intended project.

SERVICE FOR DEVELOPMENT PERIOD

04 Financing availability report

Conduct third-party evaluation on the financability of different entities of customers, and submit financability reports, including photovoltaic power plant projects, related equipment factories (components, inverters, brackets, etc.), to help customers build confidence in cooperation at the financial end.

SERVICE FOR PUCHASING PERIOD

1. **Main supplier audit and management**
2. **Main Equipment supervision**
3. **FAT**
4. **Loading and unloading inspection**
5. **Lab test for PV module and Inverter**
6. **PV module product certification**

SERVICE FOR PURCHASING PERIOD

01 Main supplier audit and management

BV review the raw material preparation, process preparation and quality system of the supplier selected by the customer, and **check whether the products to be produced meet the customer and relevant standards.**

02 Main Equipment supervision

BV supervised the production process of the main equipment of PV station, including raw material audit, production process witness, process test witness, delivery test witness, expediting, etc., to ensure the production products meet the technical agreement and customer requirements.

Supervision Equipment
PV module
Module support
Inverter
Transformer
Switch Cabinet
Power Cable
GIS

SERVICE FOR PURCHASING PERIOD

03 FAT

According to customer's requirement, witness the delivery inspection of related equipment to ensure the product delivery performance meets the technical agreement and customer's requirement

04 Loading and unloading inspection

According to customer requirements, witness the loading and unloading of photovoltaic modules and other equipment. Inspection points include factory loading, dock loading, dock unloading, and project site unloading supervision. Provide customers with timely product information during the transportation process.

05 Lab test for PV module

BV samples photovoltaic modules and inverters for laboratory testing, according to the technical agreement or customer requirements, to complete the IEC related laboratory tests.

IEC61215 10.1-10.18 Tests	IEC61730 Tests
PID Test	Degree of cross linking test
Back plate stripping force test	

SERVICE FOR PURCHASING PERIOD

06 PV Module Product Certification

Scope of certification:

IEC 61215 and IEC 61730 require voluntary certification for PV module and accessory products.

Certification standard number to be determined (BV certification technical standard is being prepared): weatherability certification of photovoltaic modules in special environments (ocean, desert dry and hot environment, ecological lake environment, ice and snow polar environment)

Authentication mode:

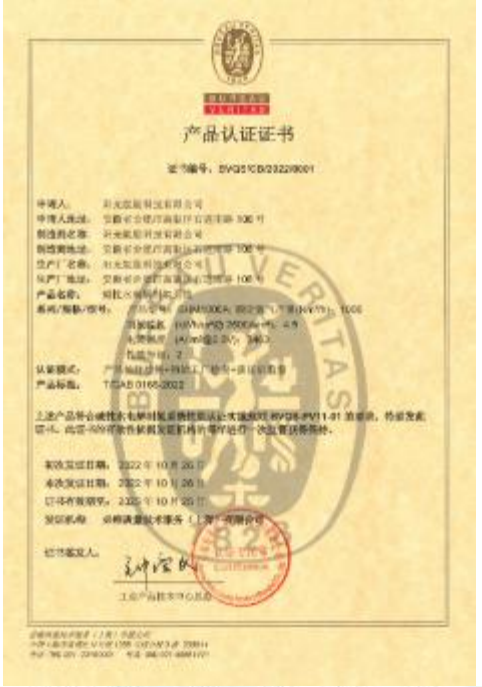
Type test + initial factory inspection + supervision after certification

Principle of certification unit:

In principle, PV module products shall apply for certification according to the product model.

The products of the same manufacturer and the same product model but produced by different factories shall be divided into different application units; the type test can be carried out on the samples of the same factory; However, if there is an OEM factory in the application, the OEM factory shall conduct a separate type test. Photovoltaic modules with the same material and the same packaging process can be used as an application unit.

The type test completed by the national laboratory approved by the China National Accreditation Committee for Laboratories may be exempted from repeated tests within one year before the application. If the items are incomplete, the test items shall be completed according to the corresponding standards.



Issuing period: about 2 weeks for type test report and about 3 months for no type test report (IEC61215 + IEC61730)

SERVICE FOR CONSTRUCTION PERIOD

1. **Receiving inspection for PV module on-site**
2. **Construction technical and quality support（on-site expert engineer）**
3. **PV project acceptance test**

SERVICE FOR CONSTRUCTION PERIOD

01 Receiving inspection for PV module on-site

After the photovoltaic modules arrive on-site, BV will carry out incoming acceptance sampling inspection on the PV modules, including appearance inspection, EL, IV test, etc., to check whether the modules are unqualified or damaged before installation.

02 Construction technical and quality support (on-site expert engineer)

BV provides professional technical experts, including electrical, civil, etc., to provide technical and quality supervision support in the construction stage for the customer's on-site project department.

SERVICE FOR CONSTRUCTION PERIOD

03 PV project acceptance test

According to the on-site acceptance requirements, BV carry out acceptance test for PV plant, including electrical performance, construction quality inspection, electrical safety performance, etc.)

No.	Project	Test Item	Description
1	PV Module	Visual	Doing the inspection of the module to check if there is any quality problem for the PV modules.
		EL test	Use a portable EL device to scan for potentially problematic components in the field to rule out whether the power of the component has decreased due to battery problems, moisture ingress, etc
		IR test	Use the infrared camera to check the square array of the photovoltaic power plant and display the performance of the photovoltaic system equipment under the infrared image(UAV is available)
2	PV string	Power test (IV curve test)	Perform IV curve measurements on components, strings, etc. outdoors, and analyze problems(Irr.>400w/m2)
3	PV array	Grounding continuity test	Verify the safety performance of the power station
		Insulation test	
4	Inverter	Efficiency test	Test the power quality and conversion efficiency of the inverter to ensure that the requirements of the on-site inverter comply with the technical specifications of the factory
		Power quality test	
		IR test	
		Function test	
5	PV station	PR test	The data collected every 15 minutes during the test cycle is integrated into a data point, which includes the theoretical power generation amount and the actual power generation amount. Then through the theoretical formula, the final efficiency of the whole power station is calculated
		Construction quality inspection	Evaluate the surrounding environment of the entire photovoltaic power plant
		Power generation evaluation	The collected meteorological data is input into the model in the modeling software to calculate the expected power generation of the photovoltaic power plant
		Conformance assessment(Equipment)	The comparison between the design of photovoltaic power station and the products in actual use

SERVICE FOR OPERATION PERIOD

1. **PV project annually test**
2. **PV project Due diligence**
3. **Safety risk assessment for photovoltaic power plants**
4. **Accurate simulation and forecasting of power generation**

SERVICE FOR OPERATION PERIOD

01 PV project annually test

BV carry out annual routine tests for client PV power stations, checks the operation of PV power stations, provide improvement Suggestions, and helps client to increase electricity generation.

02 Due diligence

BV provides due diligence services for Client PV power plant transactions, comprehensively investigates the administrative procedures, construction quality and power generation performance of the purchased power station, and provide due diligence reports，including risk assessment

03 Safety risk assessment for photovoltaic power plants

The ultimate outbreak point of OPEX Solar photo voltaic power plants photovoltaic power plant safety hazards: fire

Fire not only affects the safety of photovoltaic power plants, but also causes harm to the surrounding facilities, plants, buildings and personnel of the power plants, which has attracted global attention.

2015.05

Photovoltaic arrays catch fire at Apple's Mesa, Arizona, plant.

Apple Factory Photovoltaic Power Station Fire Scene Map

Map of fire scene in Wal-Mart store

Fire scene map of roof power station in Zhejiang

2016.07

Photovoltaic panels caught fire in Taipei Natural Water Park, resulting in a loss of 3 million yuan.

2019.03

A power station in northern China caught fire without effective fire fighting measures, causing losses of more than 30 million.

2019.06

Photovoltaic modules on the roof of a factory in Zhejiang caught fire, causing the collapse of 10000 square meters of factory buildings and the loss of more than 100 million yuan.

2019.08

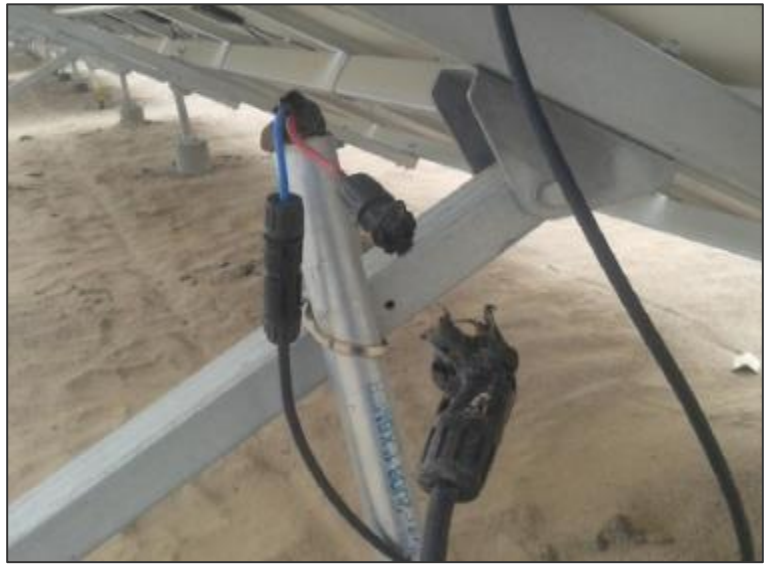
Wal-Mart Files Lawsuit, Tesla Solar Panel Causes Fire in More Than 7 Wal-Mart Stores

2019.09

Solar panels on the water in Chiba Prefecture, Japan, were blown over by strong winds, causing the components to overheat and cause fires.

Final outbreak point of potential safety hazard of OPEX photovoltaic power plant: fire

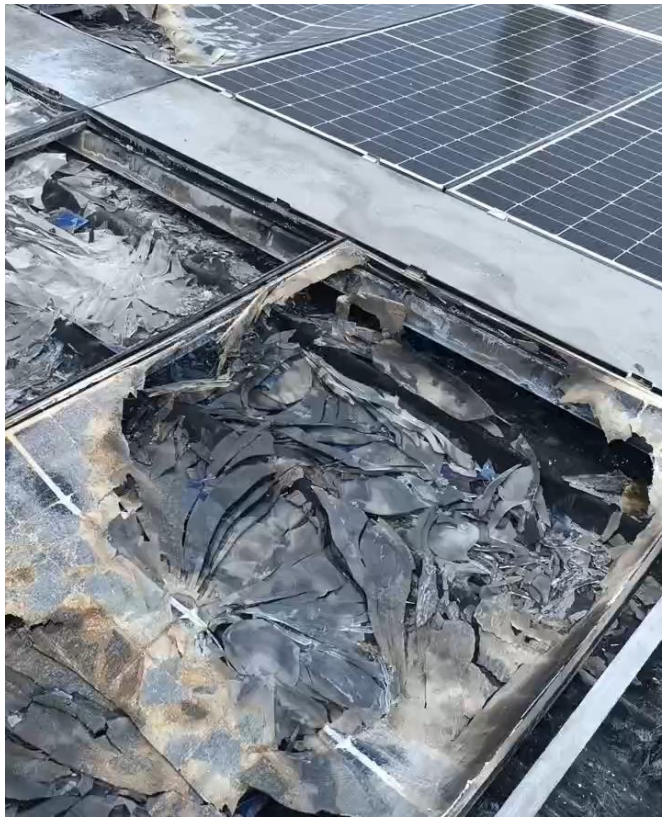
The PV system is composed of PV module, combiner box and inverter in series and in parallel. The DC line is from the PV module to the DC input side of the inverter. In DC transmission lines, arc discharge is easy to occur due to loose joints, poor contact, component fragments, insulation decline and other reasons. Because the direct current has no zero crossing point, the arc can not be extinguished automatically, and the high temperature of continuous arc discharge ignites the surrounding materials, thus causing the accident to expand.



MC4 head burned

Internationally accepted MC4 plug (more than 8,000 MC4 interfaces for 1MW power station, and the occurrence rate of DC arcing hazard: 1/10,000)

DC combiner box is burnt



SAFETY RISK POINTS OF PV POWER PLANT ASSETS

- Abnormal grounding of components and electrical equipment
- Component abnormal hot spot
- Abnormal hot spot of electrical equipment
- Insulation problems of components and cables
- DC arc discharge

A. Insulation test

Insulation test: Use a special insulation resistance test meter to conduct an insulation test between the negative pole of the string and the ground, and then conduct an insulation test between the positive pole of the string and the ground to verify the insulation performance of the photovoltaic string and prevent the risk of discharge to the ground caused by insulation damage.

Recommended ratio: GB2828.1 Level II, test standard, IEC62446.

B. Component and array continuity test

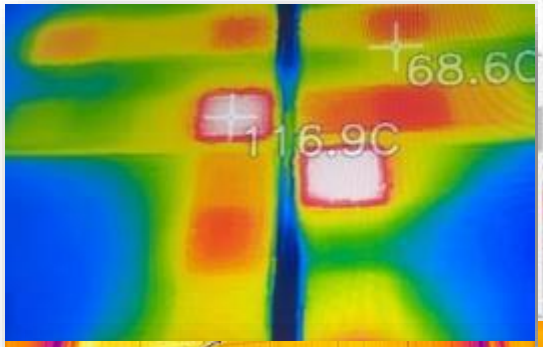
Grounding continuity test: Use the grounding resistance tester to measure the grounding resistance between the frame of the component and the grounding point, the inverter and the grounding point, and the bracket and the grounding point, and prove that there is a conductive path between all exposed conductor surfaces, and the grounding is sufficient to reduce the risk of electric shock to personnel.

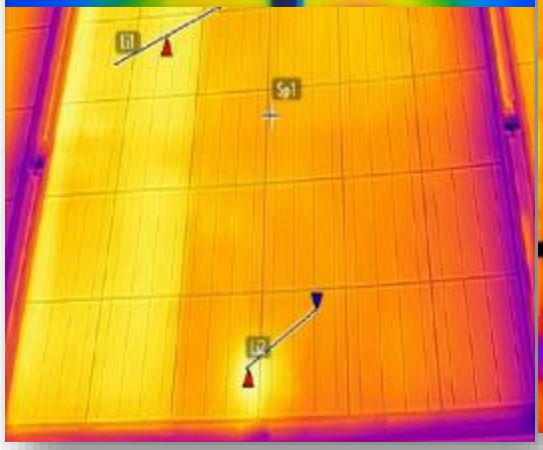
Recommended ratio: GB2828.1 Level II, test standard, IEC62446.

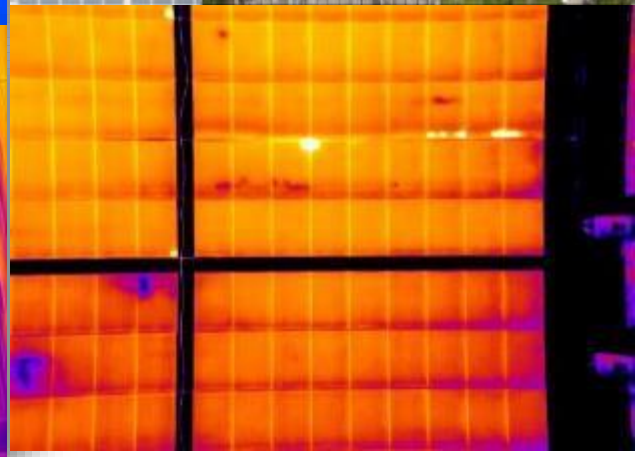
C. Thermal imaging test of photovoltaic modules and electrical equipment

Thermal imaging test: Scan the connection points of photovoltaic modules and electrical equipment through the thermal imager to check whether there are hot spots, so as to reduce the risk of thermal breakdown and fire. At the same time, BV can use infrared UAV to scan the whole station of distributed projects.

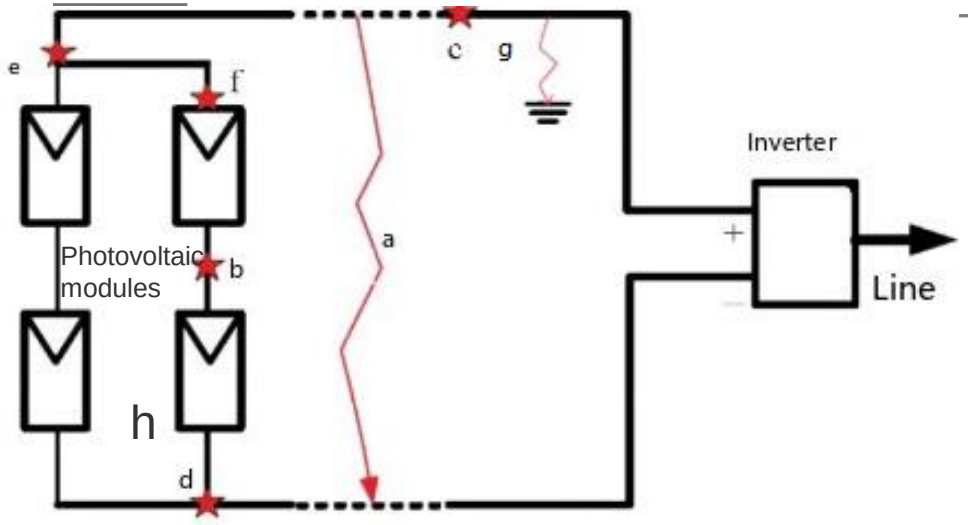
Recommended proportion: GB2828.1 Level II or UAV total station scanning, test standard, CNCA/CTS 0016



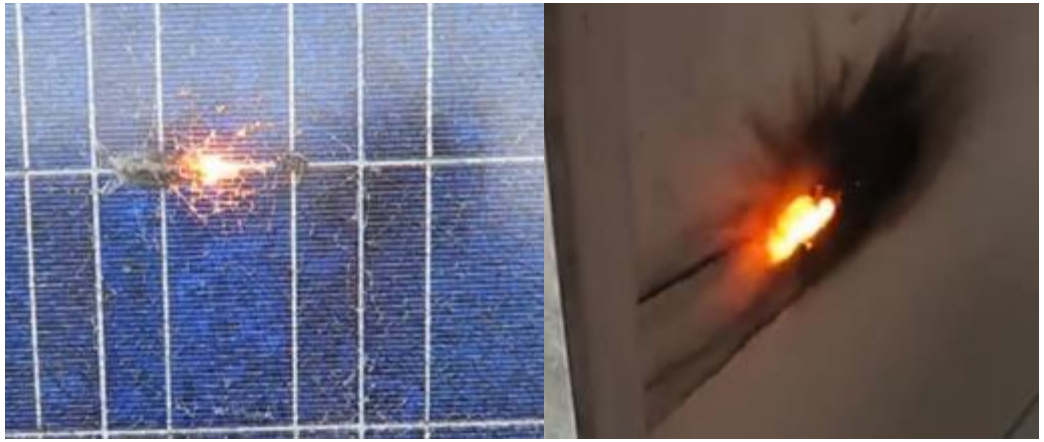




D. Fire Arcing Hazard Assessment



1: Series DC fault arc	Small distance deviation caused by loose connection terminal and PV module debris
2: Parallel DC fault arc	It is caused by insulation failure introduced by abnormal conditions such as animal bite and line aging.
3: Earth DC fault arc	Short circuit fault (such as insulation failure of DC input line)



Arcing Fire Caused by Photovoltaic Module Debris

Hazard: HVDC fault arcing can cause high temperatures above 1000 ° C, resulting in EVA and backplane burning, and igniting surrounding facilities.

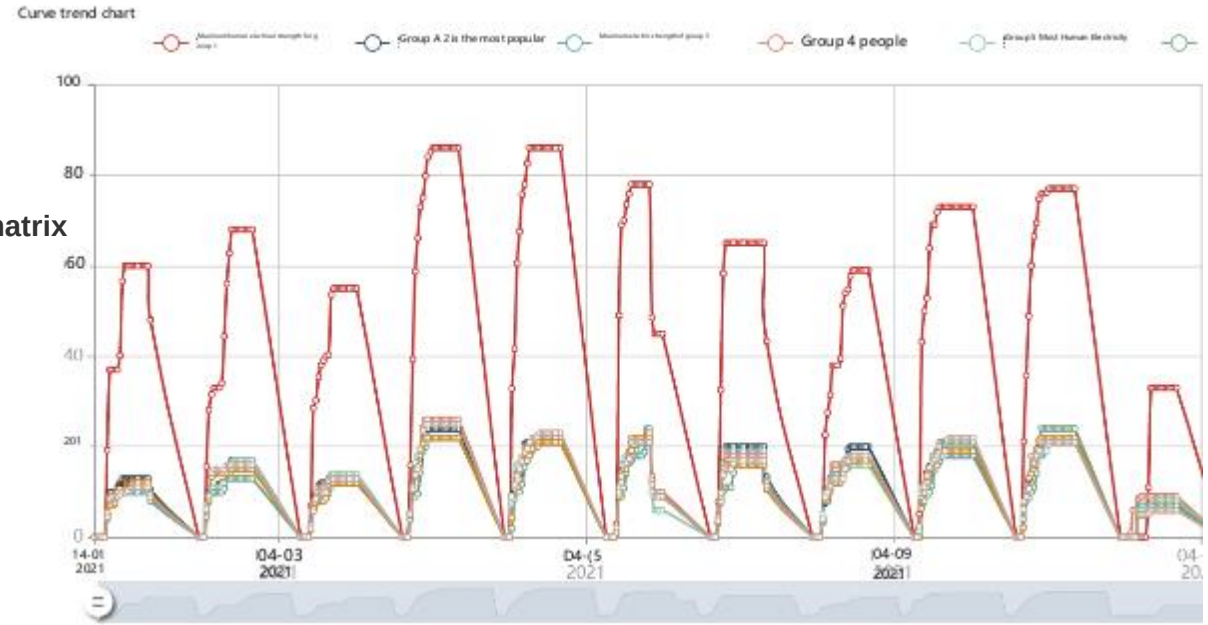
DC fault arcing due to loose terminals (simulation)

Harm: The maximum temperature can reach 4000 ℃. Compared with AC arc discharge, there is no zero crossing point and the duration is longer. Because of the high-frequency noise interference of the inverter, the traditional detection can not accurately judge the arc.

D. Fire Arcing Hazard Assessment

Arcing measurement channel

Cloud arc drawing analysis curve



Real-time monitoring of DC arc strength of each string (millisecond level)

- Arc strength value 30: micro arc (1 ~ 3mm)
- Arc strength value 50: obvious arc (5mm)
- Arcing strength value 70: the interface and cable can be burned
- Arc strength value of 100 and above: may cause fire

Recommended test and evaluation ratio: GB2828.1 S-1 ~ S-2

SERVICE DURING THE OPERATION PERIOD

04 Accurate simulation and prediction of power generation

Current pain point: the owner is unable to reasonably estimate the future income of the power station, and the forecast deviation of the feasibility study is large.

Cause analysis:

- Meteorological resources, array orientation, key equipment performance parameters and so on are different from the actual situation.
- The parameters of external characteristics and attenuation characteristics of key equipment are not quoted, and the deviation of simulation results is large

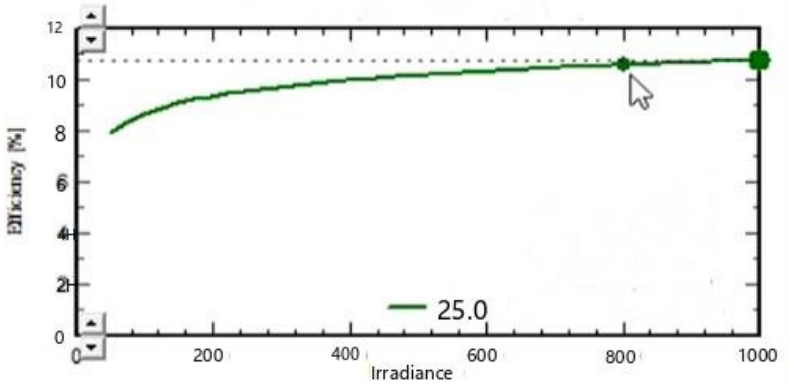
Features of BV:

- Field measured meteorological data + latest database combined correction of meteorological resources;
- A nonlinear correction model is adopted for the external characteristics of the assembly, and temperature and irradiation are combined for correction;
- The external characteristics of the inverter are based on the on-line monitoring data, and the "voltage + power" two-parameter model is selected.
- Comprehensive loss evaluation: near shadow, far shadow, direct, scattering, reflection, etc.

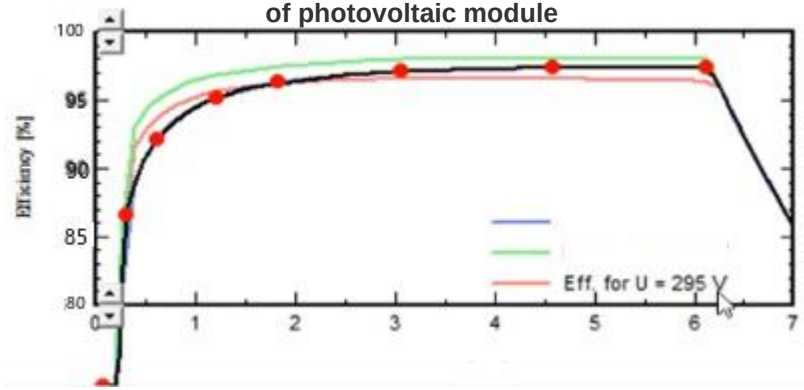
Report results, value enhancement

- Power generation prediction and evaluation to improve the accuracy of power station benefit prediction
- Power generation production rate evaluation to guide power generation production scheduling
- Comprehensive PR compliance rate evaluation to guide power station operation and maintenance to eliminate defects

Multi-orientation photovoltaic array simulation



Non-linear correction model of photovoltaic module



Two-parameter efficiency curve of PV inverter

REFERENCES

ASSIST YOUR PHOTOVOLTAIC PROJECT

Before 2014

Thailand Future Energy, Atlas PV Module Inspection

PV module inspection of Biya Solar Co., Ltd.

Alstom PV module inspection

Westinghouse Solar PV Materials Inspection

Spain PV Caposele photovoltaic inspection

Portugal Tianwei PV module inspection

AGRAVIS Raiffeisen AG PV Module Inspection

Nextera PV Control Module Inspection

2014

Shandong Taikai Photovoltaic Electrical Equipment Inspection

Youtai International Photovoltaic Equipment Inspection

Technical consultation and inspection of China Power Dali (Xicun) PV Power Station

Algeria 233MW PV inspection by China Water Resources 13th Bureau

BYA Solar PV Module Inspection

OPED Yingli PV module inspection

2015

Procurement and Construction Consulting Management of CMIC 1G/W Photovoltaic Power Plant Project

Inspection of 50 MW PV equipment of Youtai International Boya Kiniz Power Co., Ltd.

Longyuan 30 MW PV equipment witness

Kenli New Energy Shenzhou 40MW PV Power Station Consultation

Supervision and Inspection of CLP Dali (Xicun) Phase II Photovoltaic Power Generation Project

Ningbo Huashun PV module inspection

2016

Yunnan Electric Power Design Institute, manufacturing supervision of photovoltaic modules of Jingao and Tianhe

Guohua Power 50 MW Photovoltaic Project Supervision

Italy Ennai PV Module Procurement Inspection

Nanjing Zhongjian Jiangxi Panyang Lake PV Module Inspection

Guohua Ordos 30MW PV Project Supervision

Swiss Re PV Module Plant Risk Assessment

2017

Guohua Kailu Photovoltaic Module 9.678 MWp Photovoltaic Project Phase II

Yangde New Energy PV Module Inspection

CGN Delingha PV module testing

Guangdong Electric Power Design Institute 50MW Taishan Photovoltaic Project Supervision

CPI Finance and PV Module Inspection

HECIC PV module frame inspection

2018

2019

Huzhou Port Energy PV Module Inspection

Swiss Re Overseas PV Module Factory Audit

Longyuan Youyu 28 MW Photovoltaic Project Supervision

2020~2023

Supervision Framework Agreement of East China Survey and Design Institute:

Oman 500 MW PV Project

Vietnam Luhe Photovoltaic Project

75MWFAS PV Project in Ukraine

Chile CEME1 450MW PV Project

Indonesia Crtia Floating Photovoltaic Project

Hyundai MEM Vietnam 75 MW PV Project

Shanxi Institute Xiyang 100MW Photovoltaic Project Supervision

Equipment Supervision of Saudi Arabia PIF 2.6G W PV Project

Supervision of Erdafra 2.1G W PV Project

Supervision of Rabigh300 MW PV Project in Saudi Arabia

Supervision of Vale VALE 766 MW PV Project

Procurement Management of URE United Renewable Energy Photovoltaic Module

CNBM Myanmar Minbu 250 MW PV Project Management

Inspection of electrical equipment for Qatar 800 MW PV project of Guizhou Power Construction

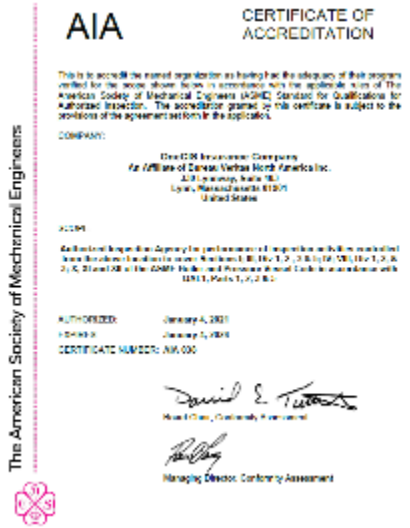
BUREAU VERITAS

QUALIFICATIONS

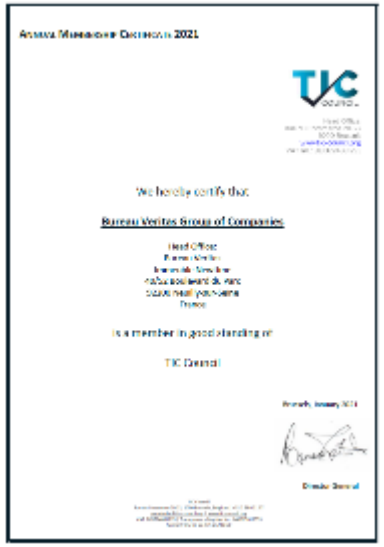
BV has a large number of professional technical and management personnel in the field of inspection and testing, covering all regions of the country, while BV has relevant inspection capabilities in 140 countries and regions overseas, and can provide inspection services for global customers.

BV China has more than 270 professional technical and management talents in the photovoltaic field, including more than 40 inspectors of photovoltaic modules and related photovoltaic equipment, and more than 200 professional electrical and structural inspectors. At the same time, BV has a large number of advanced testing equipment and testing teams in the evaluation and testing of photovoltaic systems to protect the quality, safety and risk of customer projects.

Qualification of CNAS Inspection Agency



ASEM Authorized Inspection Agency



International TIC Membership Certificate

Certificate of Class A Equipment Supervision Unit

CMA Qualification Certificate

QUALIFICATIONS

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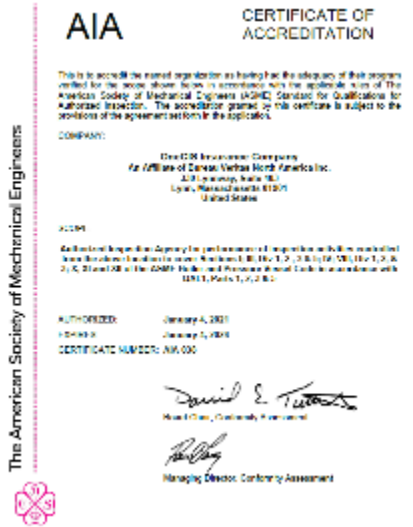
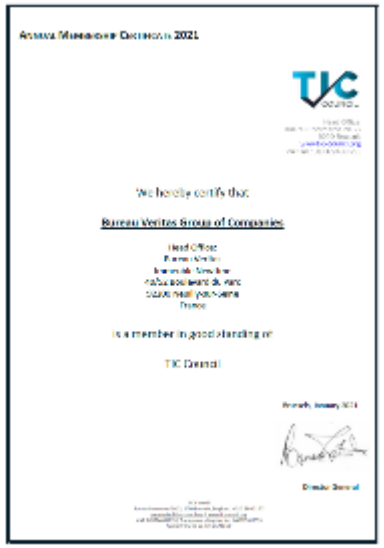


ASEM Authorized Inspection Agency



International TIC Membership Certificate

Certificate of Class A Equipment Supervision Unit

CMA Qualification Certificate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1828
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TESTING LAB

LAB OVERVIEW

- Bureau Veritas Photovoltaic Product Testing Center is located in the Future Energy Valley of Huinan Town, Pudong New Area. It covers an area of about 1800m^2.

- It is committed to building a new generation of photovoltaic testing center with high technology content, high innovation drive, high comprehensive ability and high data AI, aiming at the pain points of customers in the industry.

LAB TEST CONTENT

There are 5 standards involved in the construction of detection capability, including IEC61215-1: 2021/IEC61215-1-1: 2021/IEC61215-2: 2021/IEC61730-1: 2023/IEC61730-2: 2023, involving 69 detection items. It covers the testing capability of photovoltaic module performance and safety.

Type of detection	Test items
Routine testing	Identification
	Paper
	Visual inspection *
	Marking durability test
Safety/Safety Test	Insulation test *
	Wet leakage current test *
	Insulation thickness test
	Accessibility test
	Earth continuity test *
	Impulse voltage test *

IEC 61215-1: 2021 Terrestrial photovoltaic modules-Design qualification and type approval-Part 1: Test requirements
IEC 61215-1-1: 2021 Terrestrial photovoltaic modules-Design qualification and type approval-Part 1-1: Particular requirements for the testing of crystalline silicon photovoltaic modules
IEC 61215-2: 2021 Terrestrial photovoltaic modules-Design qualification and type approval-Part 1: Test procedures

IEC 61730-Photovoltaic (PV) Module Safety Qualification-Part 1: Construction Requirements
IEC 61730-Photovoltaic (PV) Module Safety Qualification-Part 1: Test Requirements

LAB TEST CONTENT

Type of detection	Test items
Safety/Safety Test	Reverse overcurrent test *
	Hot spot durability test *
	Bypass Diode Thermal Performance Test *
	Sharp edge test
Environmental simulation test	UV Pretreatment Test *
	Thermal cycling test *
	Wet and cold test *
	Damp heat test *
	Potential Induced Decay (PID) Test *
	Creep testing of materials *
	Dry heat test *
	Cold test *

LAB TEST CONTENT

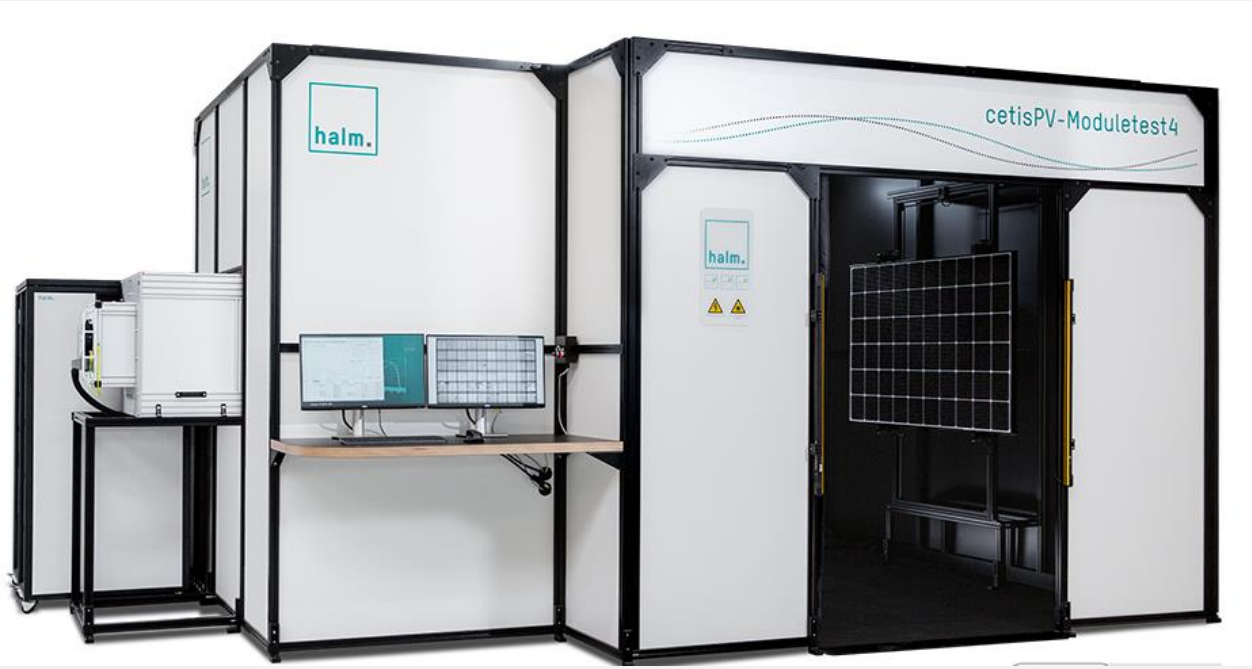
Type of detection	Test items
Performance testing	Maximum power determination *
	Performance Test at STC and NMOT *
	Performance Test at Low Irradiance *
	Temperature coefficient measurement *
	Stability test *
Mechanical test	Lead-out end strength test *
	Static mechanical load test *
	Dynamic mechanical load test *
	Hail Test *
	Scratch resistance test
	Component breakage test
	Screw connection test

LAB TEST CONTENT

Type of detection	Test items
Mechanical test	Peel test
	Lap Shear Strength Test

PARTS OF LAB EQUIPMENT

Long-pulse transient solar simulator



Equipment imported from Germany

$A^+A^+A^+$Grade

Pulse width 70ms

Equipped with a temperature control device to accurately measure the temperature coefficient

Comprehensive test environment box

Net height of inner box 2800 mm
16 components can be placed
The cooling rate can reach 200 ℃/H, far exceeding the level of the same industry

PARTS OF LAB EQUIPMENT

Dynamic/static load test device

104 cylinders for better uniformity

Hail testing machine

Simulate the test of 25mm and 35,35 mm diameter ice ball

PARTS OF LAB EQUIPMENT

Leading-out end strength testing machine

Customized fixture can realize the test of more than 90% of the mainstream components in the market

Impulse test device

The range of pulse voltage is up to 40 kV, far exceeding the standard requirement of 16 kV, which can provide customized and strict services for customers.

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