# What Forges High Reliability

----Endurance Tests of Huawei Inverters

PV system is normally installed outdoor,exposed to hash environment, like extreme high or low temperature, high humidity, strong wind, dust, rain or salt. Huawei endurance test lab invents a complex test machine combining temperature, humidity and corrosive dust together. Huawei inverter passes these tests, proving excellent endurance to hash environment. For outdoor use, the lab would speed up tests of high temperature, rain, power and temperature cycling and field exposure to verify the long-term reliability, so as to ensure its stable performance in the long run.

## 1 What Temperature influences

At different temperature, molecular in the material will move at a different speed; the different expansion coefficient and thermal transfer between different materials will result in a loose connection between joint parts of components. Either a thermal mismatch of IGBT modules and radiator, or different compression or expansion rates of different materials could all trigger the material deformation, break, crack of surface coating, bad air seal, leakage or failure of insulation protection. Normally, a slow change of temperature will not influence the device, but a sharp change will temporarily or permanently influence the device.

Meanwhile, a sharp change of temperature will leave condensation, water or even ice on PCB board or cabinet, which is a great risk to inverter performance.

## 2 Cases on Temperature Influence

Change of inverter temperature mainly comes from temperature variation of territory, day/night, seasons or climate change like sun, wind and rain. Meanwhile, in the natural cooling system, temperature variation will exist between heat source and components or cabinets. Finally, temperature varies among inverter components. In the north area, the winter temperature is very low, some places even blow -20℃; the summer temperature will be above 40℃ ; the day/night difference could be 20℃ and climate temperature variation is up to 60℃. The temperature rise of inverter cabinet is around 20~30℃ while that of internal IGBT is 40~50℃. Therefore, there would be a temperature variation both inside and among components at a frequent pace. It is a great challenge for material choice.

Moreover, the start output in the early morning and late evening, a sudden storm or climate change will make increase the temperature variation rate, resulting in condensation in some parts, and finally influencing the inverter safety.

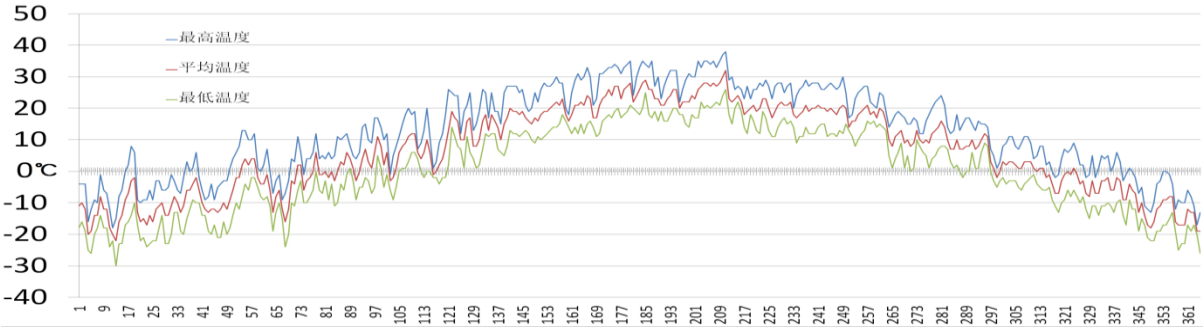



**Photo 1 Year Temperature Variation Curve in Northwest Area**

**Photo 2 Icing**

**Photo 3 Simulation of Rain**

**Photo 4 simulation of corrosive dust**

## 3. Solution

From the product design phase, temperature variation and risks of condensation should be taken into considering. Meaures like PCB board concentration, coating, or internal fan for cooling could be taken. At test verification phase, high temperature water spray test and PTC (power and temperature cycling) test chould verify the overall performance and look for vulnerable points. Meanwhile, the field exposure can be a supplimentory test to verify the endurance capacity in tough environment.

Product design should consider temperature balance and continuous distribution of temperauture variation and avoid obvious temperature difference in the cabinet in order to balance the temperauture of internal PCB board and improve its endurance capability to temperature variation. Thermal simulation is to analyze heat data on radiator, internal power pipe and PCB board and then ensure temperature balance in the product design.

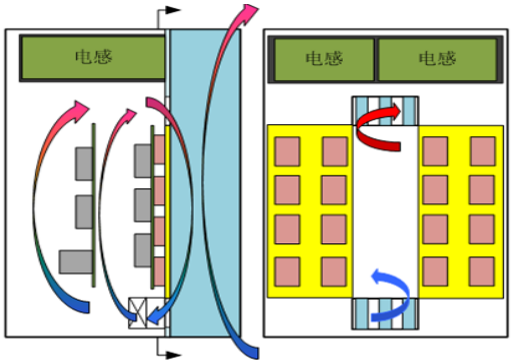



Photo 5 Internal & External air tunnel

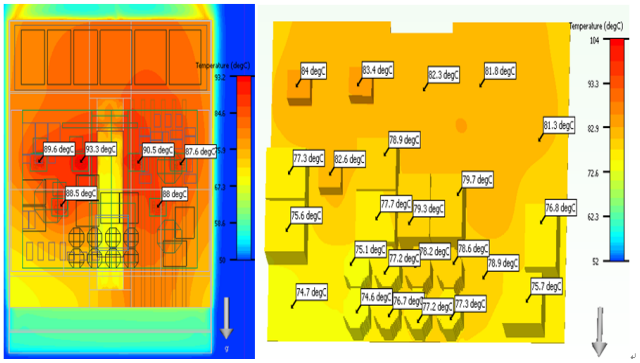


Photo 6 Overall thermal simulation

# 3 Test Method

## 3.1 High temperature water spray test

### 3.1.1 Test senarios analysis

Water spray test is to spray cold water on the sample product in a high temperature and humidity cabinet. The external temperature drops rapidly. This test could verify not only the IP protection class, but also the risks of internal condensation. The common method is to place humidity test paper in the cabinet to check if there is any condensation. At the same time, it could be tested with power so as to check if the inverter could endure the high temperature water spray.

In the summer at some places of high humidity especially tropical areas, condensation is easily to be found on the power modules. The water spray test could verify IP65 protection class for anti-condensation and optimize internal PCB design. Normally, the absolute humidity change in the modules is very small. However, in the rainy day the average temperature variation rate exceeds 4 degrees per minutes and the rate would be faster if there is wind.

### 3.1.2 Test method

First, place the inverter in a water spray cabinet for 10H. The water will be turned on automatically and at the same time, the temperature starts to drop and the power starts to turn off. After 0.5H water spray, turn on the power output. After 10min, turn off the spray. During water spray and temperature drop, turning off the inveter output can speed up temperature variation and show the internal consumption. The above process should be carried out for 10 times in a total 168H period. During the test, the power output of the inverter will be checked from time to time. At completion, the inverter cabinet will be open to check the test paper.

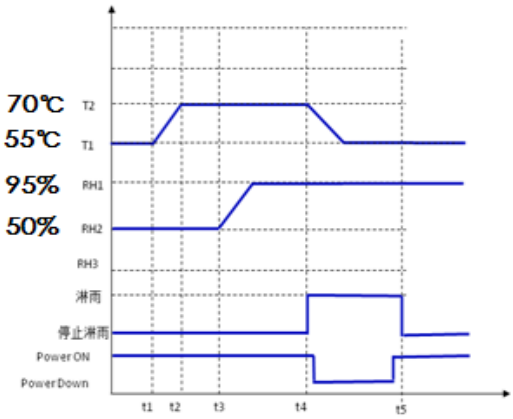
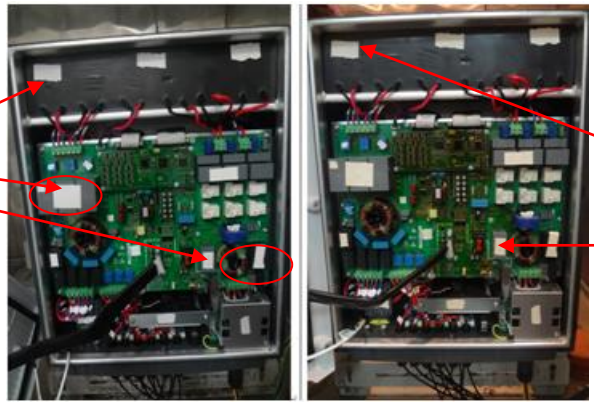



**Photo 7 Time interval of water spray test**

**Photo 8 Water spray test photo**

Before test, place the humidity test paper in different places. Condensation or excessive humidity will make paper red.



After test, check the test paper. No color change means no condensation. The performance is compliant to the requirements.

**图9 Test paper comparison before and after test**

## 3.2 PTC Test

### 3.2.1 Test scenario analysis

PTC (Power and Temperature Cycling) Test

PTC Test is to reveal the potential defects after product long-term operation under different temperature. Through cycling and fast temperature variation, it can speed up the actual low/high temperature change. It is a main test method to verify the endurance capability and long-term reliability, especially the heat match of the materials. Through power operation, it could very the status of the inverter at real time.

### 3.2.2 PTC test method

Most test in the industry will be no more than 300CYCLE. However, inverter temperature will change everyday, just the number of only day/night temperature variation in its life span will reach 365*25=9125 times; therefore, 1000CYCLE speed-up test is necessary. The lowest temperature is set to be -40℃ and highest to be 80℃; the deviation is 15℃/min. The detailed process is shown in the below curve.

Duration of high and low temperature depends on heat capacity of the product. For a large sealed sample, it is suggested to be more than 1H. During high and low temperature cycling, multiple power on and off tests could be carried out to verify the start performance at high and low temperature. It is suggested to add more power on and off test at high temperature (time between should be longer than the minimum feed-in off-time of the inverter).

After completion, it is required to inspect internal PCB board and power tube for any cracks, bad soldering or sealing, any cracks in the cabinet and any deformation of plastics, etc. Afterwards, a power feature test is done to analyze if there is any obvious degradation.

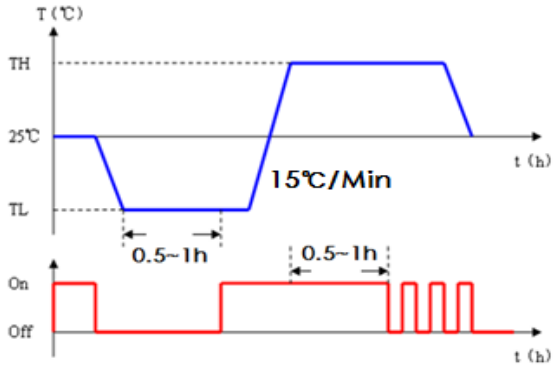



**Photo 10 PTC Test Time interval curve**

**Photo 11 PTC Test photograph**

## 3.3 Field Exposure

### 3.3.1 Test scenario analysis

Field exposure is to place the inverter under direct sunshine, which is more accurate than a solar simulator. An ideal field is the coastal area salty, with high temperature, high humidity and strong sunshine. Hainan Wanning is a place like this. In the summer, the highest ambient temperature is up to 35℃, so the temperature of inverter cabinet could be more than 60℃. An sudden rain could lower the temperature of the cabinet by 30℃. The coastal field is a complex place full of salt, humidity, rain and large temperature variation, an idea place to verify product reliability.

### 3.3.2 Test method

The test area is 350M away from the coast. The inverter is hang on the mounting racks and connected to a simulating PV DC power source, a monitoring system and then fed-into grid. A weekly inspection will check the status of the inverter and read its parameters like yields, internal temperature, etc. Field exposure is an open source, where the test station will record

daily humidity, temperature and components of salt. The inverter, like a real scenario, powers on at 7:00am, feeds into the grid and stops power output after 7:00pm. The test duration will last more than 1 year.

**Photo 12 Off-shore Test Station**

**Photo 13 350M exposure field of inverter**

# 4 Conclusion

Huawei places great emphasis on reliability, not only focusing on a long lifespan of the product, but also making a long-term research on material features and matches of different materials, accumulating rich engineering design and test experience. Meanwhile, Huawei has a top class test lab worldwide, which has a full set of environment simulating devices and advanced test capability, including climate, mechanism, wind, rain, irradiation, icing, advanced HALT test and dust or corrosion test.

All Huawei products should pass these high-demanding quality test. That's why Huawei products can endure challenges anywhere, from the extremely cold Arctic to extremely hot Africa, from coastal salty area to deserts.

PV inverter team learns from rich experiences of our wireless products range, but also an in-depth research of special environment in the inverter industry. Inverter long-term reliability is guaranteed through product deisgn and tests. It is believed that quality is our life. Data is a true proof with our sincerity to serve our clients. These trials forge high relaiblity of our products that have been applied worldwide and enjoyed a great fame.