INTRODUCTION

Solar photovoltaics has undergone massive research and development leading to steep price reductions and efficiency improvements throughout the supply chain. This combined with subsidy inputs from the government has fueled a massive growth of this industry. As per latest MNRE report, module manufacturing currently stands at just over 2500 MW and is poised to further increase to meet the growing demand. Having said that, solar investments are still long term with paybacks of 8 years or more and hence it is important to maintain durability, reliability and at the same time ensure cost effectiveness of this investment.

With the accumulated expertise of more than 20 years in the EVA processing field, Brij has been supporting this industry by manufacturing high quality solar cell encapsulants.

PV MODULE BASICS

A Crystalline module though looks simple, is a combination of highly engineered materials working together in tandem to harness energy. Thus each and every component used affects its quality, durability and is as important as any other. One such component is the Ethylene Vinyl Acetate (EVA) encapsulant. This transparent layer of plastomer forms a protective layer over and under the solar cells preventing water, dirt and other external impurities from contaminating the cells and at the same time ensures optical transmissivity and electrical isolation.

A PV module is not only judged by its electrical performance but also by its annual degradation, and product life time. Hence a cheaper module might seem to be an attractive option today but might be packed with low quality components leading to a short life span and hence low return on investments. What happens when a solar panel is protected with a poor quality encapsulant?

A variety of defects can be experienced like degradation of electrical parameters, yellowing of module surface, water ingress and delamination.

QUALITY ASSURANCE AND TEST STANDARDS

Product testing is a form of quality assurance in relation to product research and development. Although this process is considered as the most tedious and expensive stage of research and development; it is still imperative. The standard tests for determination of quality of various module components and especially EVA are vastly varied and sometimes ambiguous. However the following tests are generally used to define quality of the EVA encapsulant films.

1. Encapsulant tests.

Some or all of these tests can be performed on the shop floor on regular basis to ensure consistancy.

1.1 Peel strength (Adhesion test)

Adhesion of EVA to substrate is key to the longevity of a module throughout its operational lifetime. Low adhesion is a good indication of expired EVA or exposure to moisture during transit/storage or even improper laminating conditions. EN 1895 & ASTM D-1876 test standards can be followed to determine the peel strength accurately. Spring balance test is...
often used in the industry as quick test to validate the incoming material. Values between 75 N/cm and 125 N/cm can be used as a reference for quality control.

### 3.1.2 Gel Content Test (Crosslinking ratio).
Gel content of EVA is a measure of degree of crosslinking of the polymer. Lower gel content indicates lower degree of crosslinking, which severely jeopardises the long term mechanical integrity of the module. ASTM D-2765 test standard can be followed to determine the gel content accurately. Variations of the same are often used to approximate the gel content values at shop floor level.

![Figure 2: Soxlets extraction apparatus](image)

If encapsulant is not expired, lower gel content is generally due to lower crosslinking and hence inappropriate laminating conditions. Gel content levels of 70% and higher are recommended for longer lifetimes.

### 3.1.3 Thermal shrinkage.
EVA films have an inherent tendency to shrink when heated at lamination temperatures, which if not controlled might lead to breakage of solar cells, misalignment of strings, amongst other stability issues. Shrinkage is generally caused due to process induced stresses during the manufacturing of EVA films however the rule ‘lower the shrinkage and better the encapsulant’ is not generally true due to a variety of other trade-offs. Globally, shrinkage levels of 2% or less are acceptable and are known to cause no laminating problems.

At Brij, many other tests such as optical transmittance, tensile strength, water absorption, volume resistivity etc. are performed regularly for internal quality assurance purposes. These may or may not be conducted by a module manufacturer.

### 3.2 Module Tests.
EVA is an important ingredient of a solar module and hence it is important to test its impact on module lifetime. The following tests though performed at the module level may be impacted by the quality of encapsulant film.

#### 3.2.1 Accelerated aging.
To simulate external environment and also accelerate the slow natural ageing process, IEC and other testing bodies have devised several laboratory tests in order to predict module output and condition at end of life. Following tests are of importance with respect to EVA encapsulant:

- **3.2.1.1 Damp heat test.**
  Determination of the ability of the module to withstand the effects of long-term exposure to humidity and heat is an important aspect of this test. The test has a standardized procedure according to IEC 61215 wherein the module is subjected to 85°C, 85% relative humidity for 1000 hrs. The damp heat test is used to determine module durability and provides a measure of the overall integrity of the module. However, this test method may be misleading to allow a statement on the overall quality of the laminating. Peel tests are essential to determine the overall quality of the laminating. It is a good test for Indian conditions comprising high humidity and temperature.

#### 3.2.1.2 UV Testing.
Most plastomers including EVA are sensitive to UV radiation and undergo degradation on its constant exposure. Hence it is important validate if this degradation rate is well under the prescribed limits to ensure long term stability. In this test, the module is exposed to 15 kwh/m² UV light within 280nm to 320nm and atleast 5kwh/m² in 320 to 385nm spectrum at temperature of 60°C.

Cerium oxide in glass is partially responsible for absorbing the UV component of spectrum and hence reducing the degradation. But use of cerium free glass for lamination may have an adverse effect on degradation rates.

#### 3.2.1.3 Thermal Cycling.
In real scenario, solar modules specially in cold climates withstand changes in temperature and sometimes from subzero to 30-40 degrees in a single day. This causes thermal fatigue due to continuous expansion and contraction of components. IEC61215 tests this by...
exposing the modules to 200 cycles between -40°C to 85°C, with the cycle time not exceeding 6hrs.

Generally, this is a good test to determine durability and reliability of solar cells.

3.2.1.4 Humidity Freeze.
The purpose of this test is to determine the ability of module to withstand changes in temperature in humid conditions. It checks the ingress of moisture through various layers of solar panel. Under IEC 61215, 10 cycles of exposure to 85°C at 85% RH for first 20 hrs and -40°C without RH control for next 4 hrs are performed. It is one of the best interface tests and checks the quality of adhesion.

3.2.2 PID Testing.
In recent years, MW scale installations have pushed the voltage limits beyond 800V causing high potential gradient between the solar cells and the module frame. In some cases, this gradient is highly negative, causing the flow of leakage current from module frame to the cell. This may lead to migration of impurities (Na+) from the top glass surface through EVA into the solar cell. This potential induced degradation (PID), creates local recombination sites hence decreasing the cell efficiency and module performance. For this test, the module is subjected to a temperature of 60°C with 85% humidity under 1000v load for 96 hours.

4 SUMMARY
A durable encapsulant requires stringent quality control, uniform compositions, and use of the best available raw materials. Even a slight deterioration of any of the properties of the encapsulant over time will impair the electrical output of the module, which is of critical importance to providing a 25 to 30 year working life of a solar module.

A good EVA film should possess high peel strength, sufficient gel content, low shrinkage, and should be able to withstand the module tests and harsh environment conditions with ease.

Figure 3: Solar EVA encapsulant films

Brij is the first Indian company to manufacture EVA Encapsulation Films and is the country leader in manufacturing IEC 61215 qualified films. Through constant research and development, in-house testing laboratory and stringent quality checks, we at Brij make sure that each square meter of EVA manufactured encapsulates the modules not for 25 yrs, but for a lifetime.

Brij welcomes feedback on whitepapers and its other resources available. Please contact us by email at support@brijfootcare.in or by telephone on +91-98688-83388.

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