# Polysiloxane gel lamination technology

Technical data & application examples

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Historically, the early and widespread technology was use of an encapsulant of silicone elastomers based on low molecular weight siloxane rubber (cold cure).

Along with the indisputable advantages, such as high optical transparency and resistance to the light aging, such encapsulants have some disadvantages, like duration of the curing process and, consequently, low productivty, lack of adhesion and the need for special surface treatment of solar cells and protective coatings, and toxicity of used catalysts curing.

Nowdays vast majority (more than 90 %) of PV panels is laminated in EVA films with low temperature resistance 80oC and low chemical inertness.

EVA laminated PV panels in V-trough concentrator in Carrisa Plains just after installation

EVA laminated PV panels in V-trough concentrator in Carrisa Plains after 6 months

# Types of EVA laminated PV panel failures

| Type of failures | % of total failures |
|---|---|
| **Corrosion** | **45.3** |
| **Cells or interconnect break** | **40.7** |
| Output lead problem | 3.9 |
| J-box problem | 3.6 |
| Delamination | 3.4 |
| Overheated wires or diodes | 1.5 |
| Mechanical damage | 1.4 |
| Defective bypass diodes | 0.2 |

Since 90’s there is  positive experience of testing and operation of semiconductor devices, using so-called sealed polysiloxane gels.

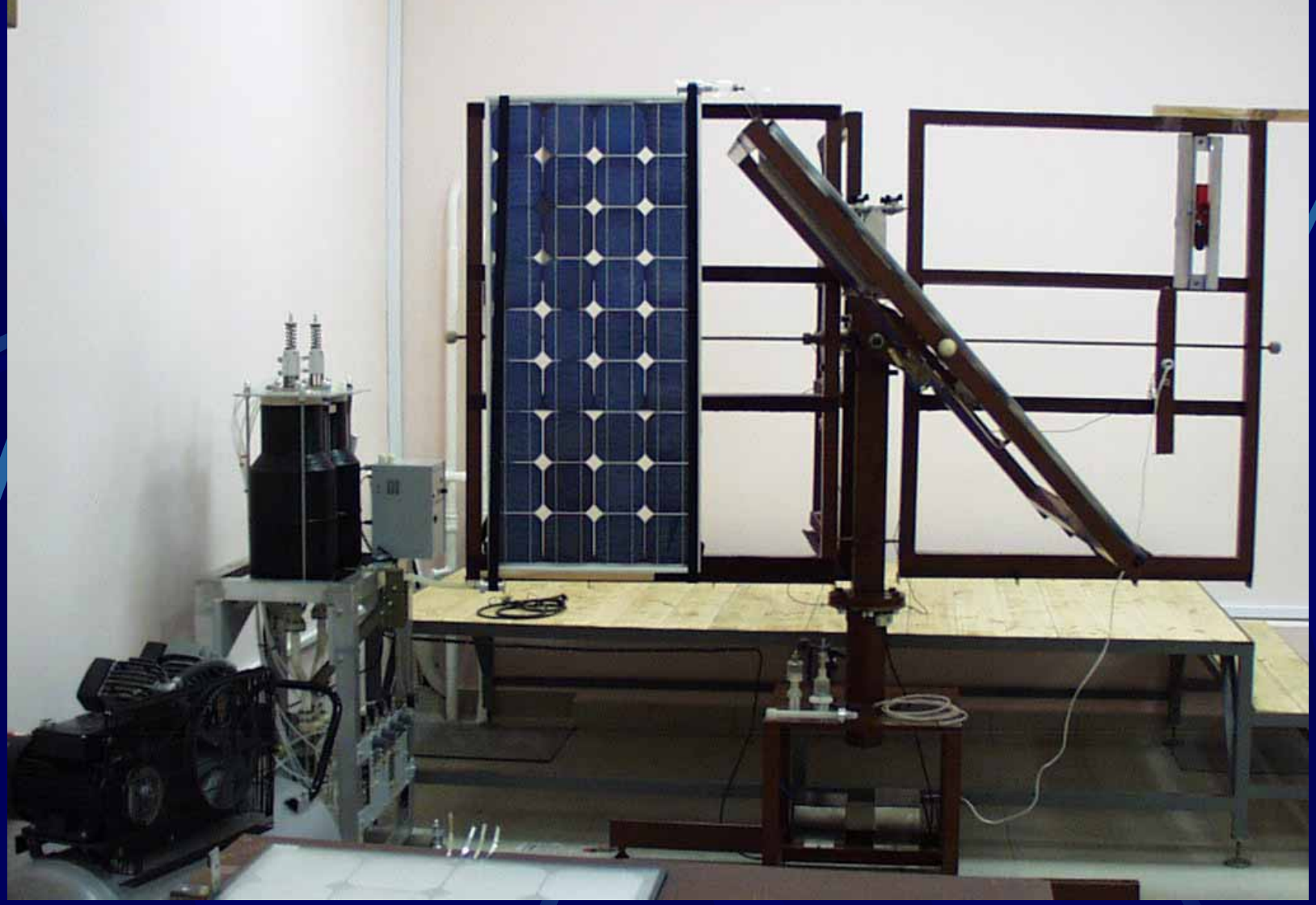
Structural features of the resulting vulcanized, namely, comparable to the length of the linear portions of the polymer chains and cross-bridges cause a number of unique properties acquired through a combination of the properties of a viscous liquid and solid.

In VIESH research institute was developed the original manufacturing technology of vacuum glazing with a thermoplastic spacers around the perimeter, characterized in that the evacuated cavity is filled with an optically transparent medium in the form of liquid polysiloxane compound, laminable at room temperature on the mechanism of hydrolysis in the low-modulus gel.

Recently VIESH in cooperation with TRAXLE Solar Company developed industrial scale technology suitable for multi MW PV panel production plants. The TRAXLE Solar Company is the only owner of the worldwide license of this technology

| | EVA | Silicone gel |
|---|---|---|
| Long term operating temperature | -40 +80oC | -60 +250oC |
| UV radiation resistance | low | High |
| Operating lifetime | ~25 years | ~40-50 years |
| Laminator energy consumption | 49 kWh | 4.5 kWh |
| Refractive index | 1,482 | 1.406 |
| Transparency for solar radiation | 8% (360nm) | 90% (360nm) |
| Transparency for solar radiation | 62% (400nm) | 92% (400nm) |
| Transparency for solar radiation | 91% (600-1000nm) | 93% (600-1000nm) |
| Corrosive agents - lamination | Acetic acid | no |
| Corrosive agents - ageing | Acetic acid | no |
| Modulus of elasticity | 10.0 $N/mm^2$ | 0.006 $N/mm^2$ |
| Linear coeff. of thermal expansion | 4.0 x $10^{-4}$ $K^{-1}$ | 2.5 x $10^{-4}$ $K^{-1}$ |

Comparison of EVA & silicone gel encapsulant properties



Silicone gel panel lamination unit – 1st generation (MK I)

Panel size: 160x80cm (~190W) & 165x100cm (~250W)

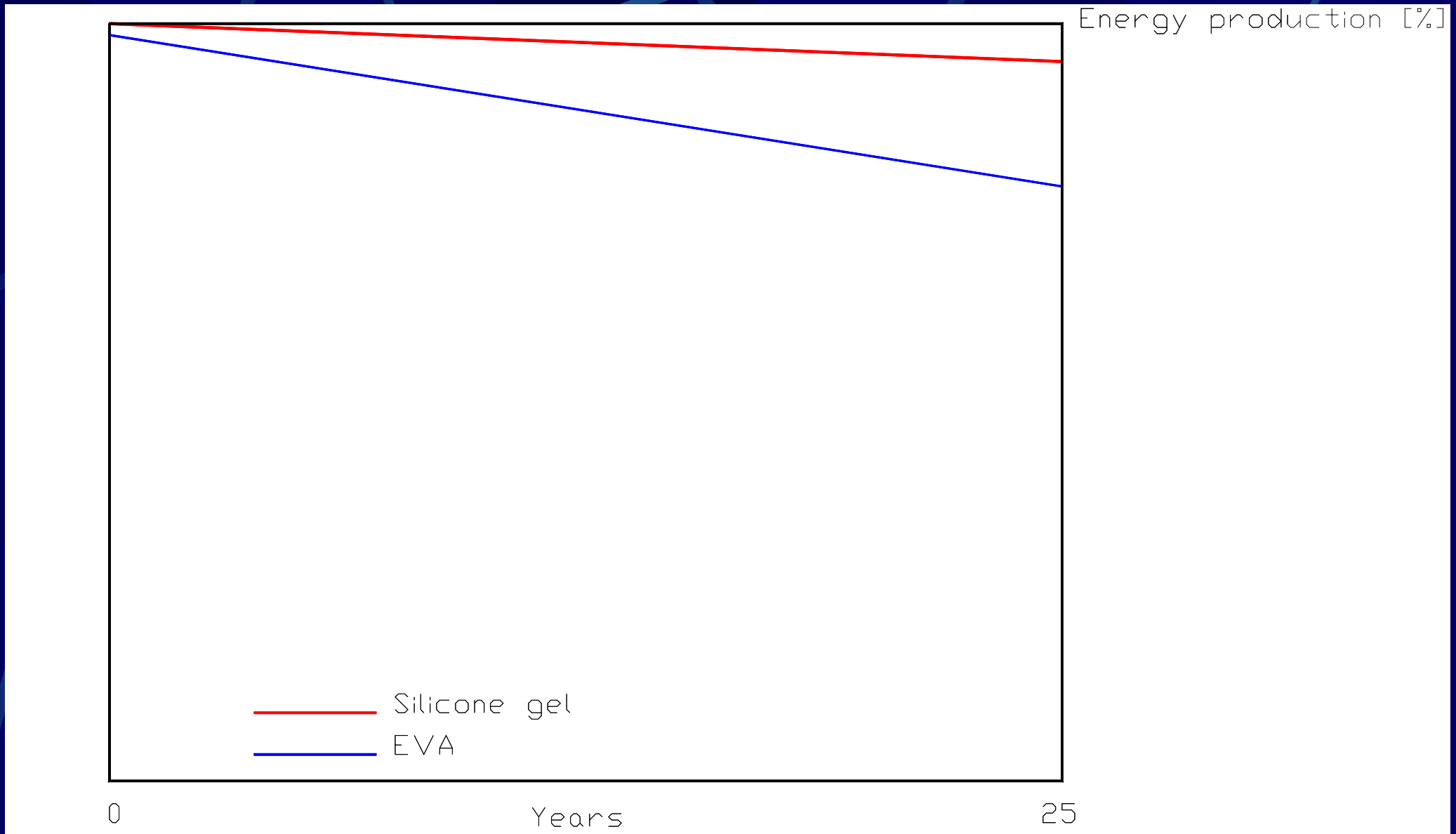
Production rate: 28 panels a day, 6667 panels a year (1.6 MW)

Energy consumption: 5kW

## **Silicone gel lamination technology - Advantages**:

a) Inert material – Unlike EVA encapsulant which can decompose, because of high temperature (80oC) or ultraviolet radiation, to acetic acid (causing degradation of solar cells), the silicone gel is inert in wide ranges of temperatures up to 250oC.
***It results in very reduced (50%) failure rate of PV panels.***

b) Highly transparent material – The silicone gel is more transparent for solar radiation, compared to EVA. It results in about 1.5% higher energy gain of new (BOL) PV panels laminated in Silicone gel compared to EVA. ***The End Of Life (25 years) energy gain is about 15% (no yellowing/browning).***




Energy production estimate. Lattitude 35 deg. 500m above sea level

# Graphical comparison of energy (i.e. gross profit) production between EVA and gel laminated PV panels


FV panel energy production.  Lattitude 35 deg. 500m above sea level.

c) Gel instead of solid state encapsulant – The silicone gel, unlike solid state EVA, enables mechanical stress relaxation during PV panel thermal cycling between day and night.

The points a-c result in extended PV panel lifetime well over 50 years.

d) Recycling – at the end of panel life its recycling (including solar cells extraction) is easy by silicone gel laminated panels compared to EVA laminated panels.

e) Shape flexibility – Unlike EVA solid film the silicone gel enables lamination of complex shapes (cylindrical...)。

f) Low energy consumption – The energy need for silicone gel module lamination is reduced ~10 times compared to EVA film lamination.

g) Price – there is negligible price difference between silicone gel and EVA technology.

h) Environmentally friendly technology (no poisons)

# Markets for silicone gel laminated PV panels

a) Best glass/glass panels: Lifetime~50 years in moderate climate (EVA laminated panel lifetime 25 years), enhanced energy gain up to 15%

b) Panels for extreme environments: (e.g. Tibet) with strong UV radiation (~4500m above sea level) and/or very hot north Africa, Arabia

c) Panels for concentrators. Silicone gel laminated panels are suitable for V-trough concentrators and other PV concentrators with lifetime ~20 years. (EVA laminated panel lifetime 1-3 years)

d) Customized PV panels with complex shapes

# Examples of silicone encapsulants applications

a) PV panels with high enhanced lifetime (up to 50 years) and enhanced energy gain (+15%)

b) PV panels for high operation temperatures up to 110oC (Africa, Arabia….)

c) Combined (hybrid) PV-thermal panels

dCombined (hybrid) PV-thermal panels) Solar PV concentrators. V-trough concentrators, 5X – 9X con

The Traxle Solar Company is recently using silicone gel laminated PV panels in V-trough concentrators (geometrical concentration 2.2X) and in Super TRAXLE 5X concentrators (geometrical concentration 4.5X).


Tracking Ridge concentrator. Energy gain +60%

V-trough concentrator 3kW,+105% energy gain. Silicone gel laminated panels should be used

TRAXLE 5X concentrator 2kW with silicone gel laminated bifacial panels energy gain+185%

# IP & Know-How

- Patents (worldwide PCT)
- Production Know-How
- Follow-on research and development

Thank you for attention !