

Evaluation of hail grain production methods

results of a Round Robin in Switzerland and Austria

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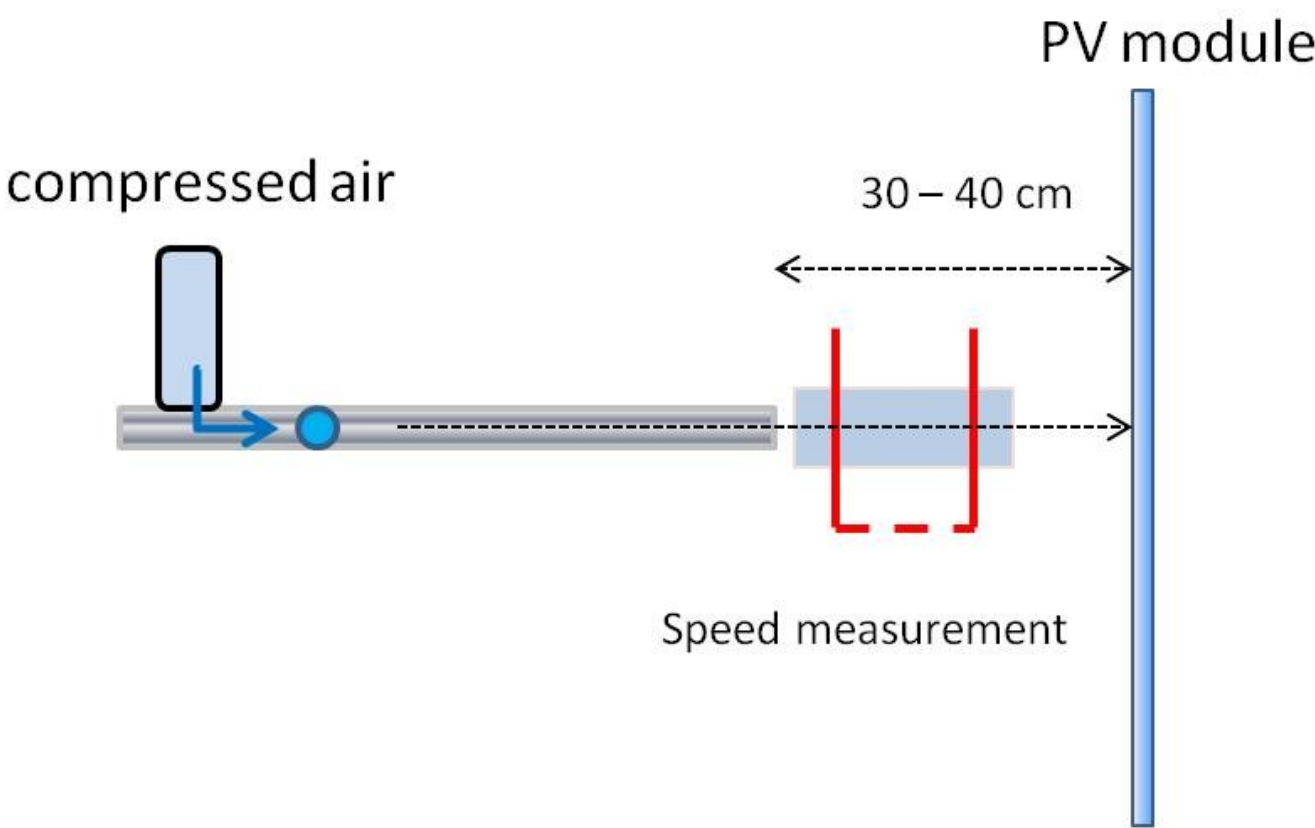
INTRODUCTION

For the qualification of PV modules in accordance to the IEC 61215 and IEC 61646 standards the hail resistance test is mandatory. Chapter 10.17 of the standard describes the launching equipment and the measurement instrumentation, but has some lacks in the definition of the hail grain quality. In fact laboratories in Switzerland and Austria found different results in testing hail impact resistance in particular for building materials. Supposition is, that the differences were mainly due to the ice quality of the hail grain. In this work a round robin was performed between three institutes in Switzerland and one in Austria, which test building materials, thermal collectors and PV modules, to determine the quality of the hail grains.

LAUNCHING SYSTEM

The launching system for the hail grain is composed of a launching tube and a device to measured the speed of the hail grain. For IEC standard the ice temperature should be $-4^{\circ}\text{C} \pm 2\%$, for Switzerland -20°C .

Speed 23 m/sec $\pm 5\%$
Weight 7,53 g $\pm 2\%$
Diameter 25 mm $\pm 2\%$



PRODUCTION METHODS

Hailstones are produced with three different methods with diameters 25, 30, 35, 40 and 50 mm

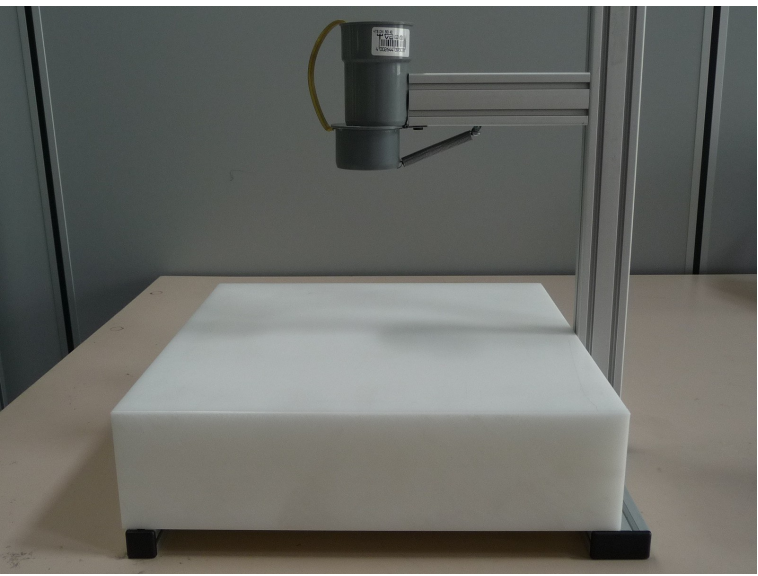
- in silicon rubber molds
- In aluminum molds
- Melting out from a



CHARACTERIZATION AND MEASUREMENT METHODS

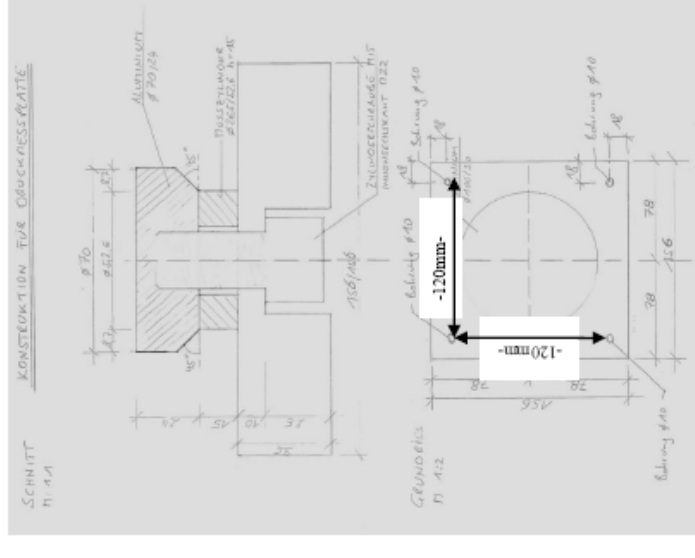
DROP TEST

To evaluate the quality of the hailstone a drop test was developed. The hailstone was dropped on a POM-C block of 12.5 kg. The fracture probability in dependence of the height should give an indication on the quality of the hail grain.



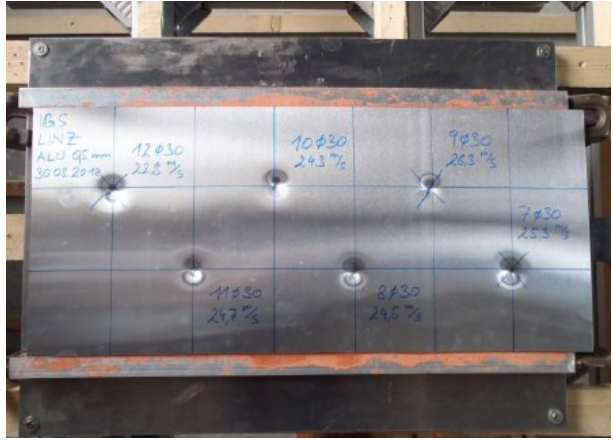
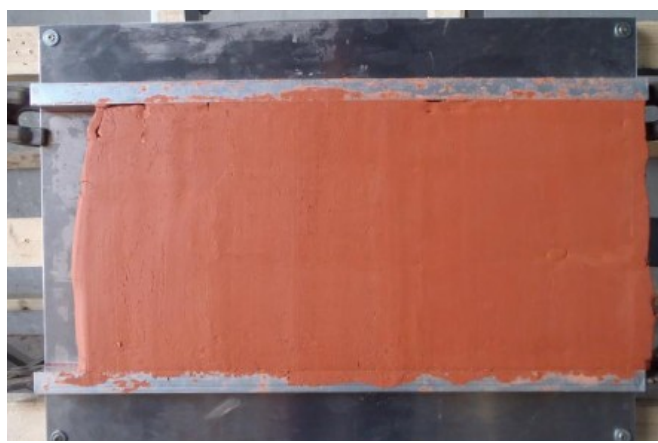
LOAD CELL

The impact energy of the hailstone on the PV module was measured with a load cell.



PLASTICINE METHOD

To evaluate the impart energy of the hailstone a plasticine support with a Al plate (0.5 and 0.8 mm thickness) was prepared. The depth of the impression give the impact energy



RESULTS

IMPACT ENERGY MEASURED WITH LOAD CELL AND PLASTICINE METHOD

1. The measurement of the impact energy with the load cell and the plasticine method are comparable and both are suitable.
2. The best results in terms of reproducibility are achieved with the hail grains obtained with the melting method due to the clear appearance which allows the detection of defects as cracks, bubbles etc. The reproducibility of the impact energy was for all diameters better then 4%. The impact energy of the hail grains produced with the silicon and Al molds varied about 13 %.

INFLUENCE OF THE ICE TEMPERATURE ON THE IMPACT ENERGY

The impact energy of hail grains at -4°C and -20°C (30—40 and 50 mm diameter) was measured with the load cell. The impact energy of the hail grains stored at -2°C to -4°C is lower then the hail grains stored at -20°C (36% for the 30 mm, 31% for 40 mm and 34 % for the 50 mm diameter)

DROP TEST

This test is not suitable for the evaluation of the quality of the hail grain due to slow impact energy and no correlation between impact energy and drop height.

CONCLUSIONS

- The production method of and quality the hail grains is as important as the launching device and the measurement instruments
- The impact energy depends on ice temperature, it is lower for hail grains stored at higher temperature
- Ice balls obtained with the melting method give results with the smallest spread of impact energy due to the better evaluation of the quality of the ice
- Measurement results obtained with the load cell and the plasticine are comparable

ROUND ROBIN PARTNERS:

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