# PEUTZ

Sunbeam BV
Attn. Mr. P. Wieriks
P.C. Staalweg 60
3721 TJ
The Netherlands

Mook, January 19th, 2017

Subject:     Wind tunnel studies into wind loading on PV panel support systems Sunbeam
Ref.:        MvU/MvU/WC 15163-3E-BR

Dear Mr.Wieriks,

Herewith we send you a letter discussing your elaboration of the ballast weight needed for the application of Sunbeam Nova and Universal systems on flat roofs. We have checked the documents you sent us and checked the Sunbeam Calculator tool.

In 2015 we have conducted a series of wind tunnel tests on your behalf. We used scale models (at scale 1:15) of solar PV panels mounted on a rectangular bluff building model, by means of models of the Sunbeam Nova system. This has been done for 24 wind directions in steps of 15 °.

Down here the set up in our wind tunnel is shown.

We have determined the lift and drag forces and the ballast weight needed to keep the PV panels and supports at their place during a storm. The elaboration of the measured pressures into forces and moments has been done with the formulas from the Standard NVN 7250:2007 'Zonne-energiesystemen - Integratie in daken en gevels - Bouwkundige aspecten' (Solar energy systems – Integration in roofs and facades – Building aspects). Based upon all measurements we have carried out since 2010 for Sunbeam BV and other Clients, we know the determining component for the ballast weight is the combination of lift and drag. Therefore, this has been worked out for several systems of Sunbeam BV in 2015.

The reference wind pressure, $q_p$ [kN/m$^2$], is prescribed in the National Annexes to the European Standard EN 1991-1-4:2005. The wind tunnel measurements concern a model of a 6 m high building with reference wind speed of 27 m/s in country terrain. The resulting reference wind pressure upon application of wind areas II in The Netherlands amounts to $q_p = 0,71$ kN/m$^2$. The resulting ballast weights can be recalculated for other countries, wind areas, terrain categories and building heights upon adopting the proper value of reference wind pressure, $q_p$ [kN/m$^2$].

The Standard EN 1990:2002 prescribes the load factor, which is 1.35 for systems like PV panels, and 0.9 for favourably acting self weight and ballast.

By combination of the reference wind pressures, the load factors and the lift and drag forces we have measured, the ballast weight and the resulting total weight can be calculated for all systems of Sunbeam BV that we have modeled and measured in our wind tunnel. The approach and the results and conclusions have been laid down in our report WC 15163-1E-RA dated September 4, 2015.

Sunbeam BV at its turn, has made a document with gives an account of their calculation tool, the Sunbeam Calculator: "Justification for Sunbeam ballast values"dated January 10th, 2017 and submitted it to us for assessment. We can conform this document contains a proper interpretation of our wind tunnel measurements and the underlying basic assumptions. The Sunbeam Calculator has been checked as well by ourselves and it's output matches the wind tunnel results.

Yours sincerely,
Peutz bv

ir. G.M. van Uffelen