TEST REPORT

No. AR 14 TEST 093
14/0108

Cat. 0

CEI EN 60068-2-68: 1997
Environmental testing – Part 2: Tests – Test L: Dust and Sand

§6 Test LC: Blown Dust and Sand (Lc1 method)

Issued to:

DUSOL INDUSTRIES LLC
P O BOX 381057
United Arab Emirates

Sample description:

Tested PV module type: DS72300W

Included Extended Types
- see Annex 3 -

Test result: **Pass**

Annexes: 3

ALBARUBENS Srl
Via Gaudenzio Ferrari 21/N
21047 Saronno (VA) – Italy

Issue date:
December 10th, 2014

Head of the Laboratory
Eng. Giuseppe Terzaghi

Test Report No.	:	**AR14TEST093**
Test performed by	:	**Fabio Zapparata**
Written by	:	**Nicoletta De Luca**
Verified by	:	**Giuseppe Terzaghi**
Approved by	:	**Giuseppe Terzaghi**
Issued date [YYYY/MM/DD]	:	**2014/12/10**

Summary of testing:

Tests performed (name of test):	**Testing location:**
Test LC: Blown Dust and Sand (Desert storm)	**Albarubens srl** **via Consorziale Saronnino, 70/20-22** **21040 Origgio (VA) – Italy**

Summary of compliance with National Differences: N/A

Copy of marking plate:

Figure 1: Type label

Picture of sample:

Figure 2: Front view of test sample

Figure 3: Rear view of the test sample

Figure 4: Detail view of closed J-box

Figure 5: Detail view of cables, connections and Polarity mark on the cable

GENERAL INFORMATIONS	
Possible test case verdicts: - test case does not apply to the test object .....:	N/A
- test object does meet the requirement.....:	Pass (P)
- test object does not meet the requirement.....:	Fail (F)
Testing:	
Date of receipt of test item [YYYY/MM/DD].....:	2014/08/08
Date (s) of performance of tests [YYYY/MM/DD] .....:	Start 2014/09/18– End 2014/10/02

General remarks:

This report shall not be reproduced except in full without the written approval of the testing laboratory.

The test results presented in this report relate only to the item(s) tested.

Any additional text/description/comment, reported in “Supplementary information *”, refers to opinions and interpretations, not accredited by ACCREDIA.

"(see remark #)" refers to a remark appended to the report.

"(see Annex #)" refers to an annex appended to the report.

"(see appended table)" refers to a table in the Test Report.

“(*)” refers to not accredited by ACCREDIA.

General product information:

Product Electrical Ratings:

Module type	**DS72300W**			
Voc [V]	**45.3**			
Vmp [V]	**36.5**			
Imp [Adc]	**8.21**			
Isc [Adc]	**8.94**			
Pmp [W]	**300**			
Maximum system voltage [V]	**1000**			
Series Fuse Rating [A]	**30**			

Test item description:

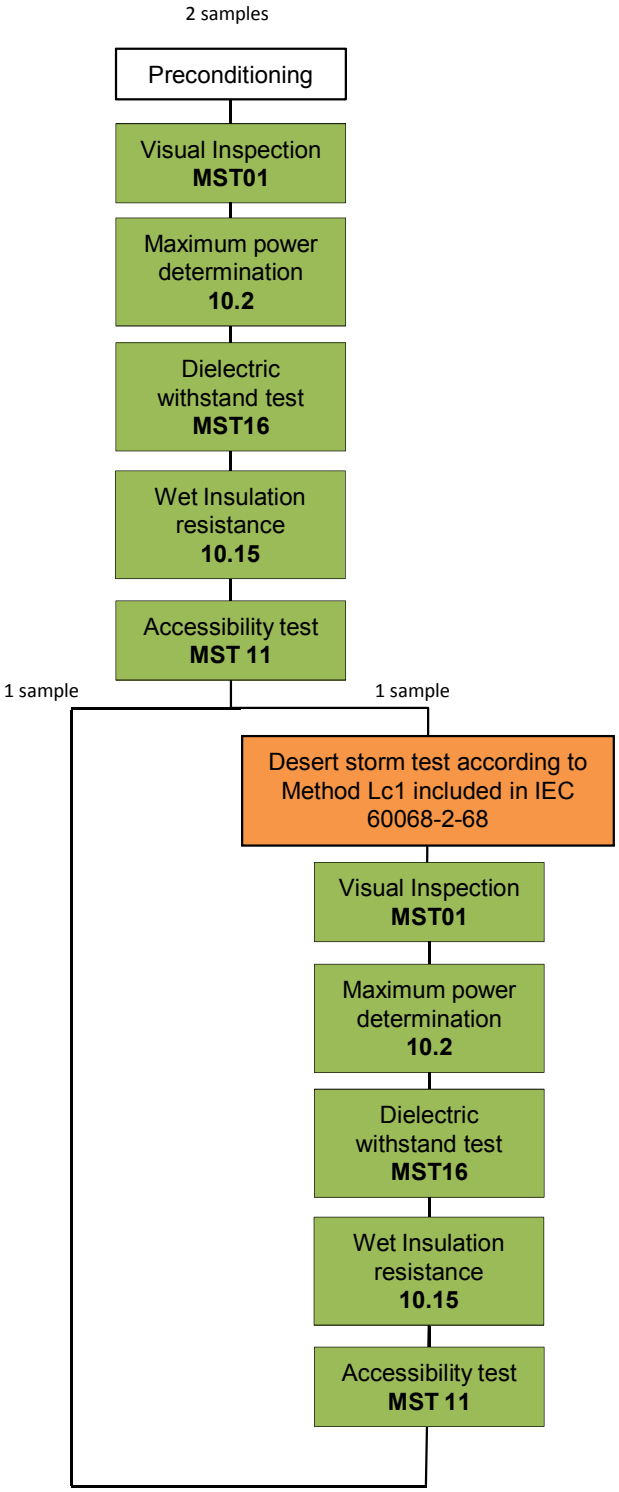
Trade Mark.....:	DUSOL
Name, monogram or symbol of manufacturer....:	DUSOL
Type or model number .....:	DS72300W
Serial number.....:	Serial number provided in a separate label embedded inside the module.
Polarity of terminals or leads .....:	Positive leads marked with “+” sign and Negative leads marked with “-” sign on a label wrapped around the lead.
Maximum system voltage.....:	1000
Maximum over-current protection rating .....:	30

Fire safety class .....:	n.d.
Safety application class .....:	A

Description of module construction: (Manufactories and part numbers, unless otherwise specified)	
Sample .....:	Random sampling from production ☒ Prototype submitted by client ☐ Sampling from field (already installed) ☐
Identification of materials	
Front cover type..... :	Glass
Front manufacturer/model/thickness :	Flat solar group
Rear cover type ..... :	Backsheet
Rear cover manufacturer/model/thickness ..... :	Isovoltaic AAA3554/0.35mm
Encapsulant type ..... :	EVA
Encapsulant manufacturer/model..... :	STR/Photocap15585HLT
Frame type and material ..... :	Aluminium
Frame manufacturer..... :	Akcome Metals Technology
Adhesive for frame ..... :	Silicone Sealant
Adhesive manufacturer/model ..... :	Tonsan 1527
Adhesive for junction box ..... :	Silicon Sealant
Adhesive manufacturer/model ..... :	Tonsan 1527
Potting material..... :	n.d.
Internal wiring dimension between cells ..... :	2mm,+/-0.5mm
Internal wiring dimension between strings ..... :	3mm,+/- 0.5mm
Soldering material..... :	Interconnect Ribbon
Soldering material manufacturer/model..... :	Gebauer&Griller
Cell	
Cell type technology ..... :	3BB Multi
Cell manufacturer/model ..... :	MOTECH
Cell manufacturing location ..... :	Taiwan
Cell dimensions L x W (mm) ..... :	156x156
Cell thickness (µm)..... :	200
Cell area (cm²)..... :	243.36
Components	
Junction box manufacturer/model ... :	156B 4t-6d/Ningbo GZX
Cable manufacturer/model ..... :	GZX4mm2 100cmx2
Connector manufacturer/model..... :	MC4
Bypass diode manufacturer/model.. :	12SQO45S

Module design	
Module dimensions L x W x H (mm) :	1955X990X42
Minimum distances Between cells ... :	2mm, +/-0.5mm
Minimum distances Between cell and edge of laminate ..... :	20mm, +/-1mm
Minimum distances Between any current carrying part and edge of laminate ..... :	10mm, +/-1mm
Total number of cells ..... :	72Cells
Serial-parallel connection of cells..... :	72Series
Cells per bypass diode ..... :	12Cells
No. of bypass diodes..... :	6
Components information	
Diode	
Bypass diode rating [A] ..... :	12A
Bypass diode maximum junction temperature [°C] ..... :	85°C
Bypass diode Thermal resistance from junction to leads (RTHJL) [°C/W] ..... :	n.d.
Bypass diode Thermal resistance from junction to case (RTHJC) [°C/W] ..... :	n.d.
Other ..... :	n.d.

Testing procedure



Module assignment:

Lab Serial Number	Sample S/N	Remark
2014297	140600583	none
2014309	140600609	none

Test LC: Blown Dust and Sand (Desert storm)		
Requirement + Test	Result - Remark	**Result**

Initial examination	All modules	—
Preconditioning ..... :	5 kWh/m²	
Visual inspection – MST 01 ..... :	See table MST 01 Int	P
Maximum power determination ..... :	See table 10.2 Int	P
Dielectric withstand test – MST16..... :	See table MST 16 Int	P
Wet leakage current test ..... :	See table 10.15 Int	P
Accessibility test – MST11 ..... :	See table MST 11	P

Sand test	1 Module		**Result**
	Test LC: Blown Dust and Sand (Desert storm)..... :	2 Hours	—
	Final measurements MST 01, 10.2, MST16, 10.15, MST 11 ..... :	See table Desert storm	P

MST 01 Int	**MST 01 – visual inspection (initial)**	—
Test Date [YYYY/MM/DD] .....:	2014/08/19 – 2014/08/27	—

Sample #	**Nature and position of initial findings – comments or attach photos**	**Result**
2014297	No visual defects	P
2014309	No visual defects	P

Supplementary information *: none

10.2 Initial	**TABLE: Maximum power determination (initial).**	—
Test Date [YYYY/MM/DD] .....:	2014/08/19 – 2014/08/27	—
Module temperature [°C] .....:	Corrected to 25	—
Irradiance [W/m^2] .....:	[1]	—

Sample #	**First Ratio[2]**	**Pmp * k_1' (W)**	**Vmp * k1'' (V)**	**Imp * k_1''' (A)**	**Voc * k_1'' (V)**	**Isc * k_1''' (A)**	**FF (%) init**	**Result**
2014297	--	280.7	37.4	7.5	44.1	8.5	75	N/A
2014309	1.000	280.8	36.6	7.7	44.3	8.6	74	N/A

Supplementary information *:

[1] Relative measurements with irradiance levels different from 1000 W/m^2 (between 700 W/m^2 and 1100 W/m^2) were performed. This test uses 2014297 (Pmp = 280.7 W) as control module.

The test 10.2 of EN61215 is performed making a comparison between the “control module” and any other measured module.

[2] First Ratio between control module and measured

$$\text{RATIO} = \frac{Pmp_s * \sout{k_t}'}{Pmp_c * \sout{k_t}'}$$

Before Ageing
k_1 = calibration coefficient at he time of Ps_1 e Ps_2 measurements. Depending on temperature, irradiance, spectrum, etc ; but same for both control and samples

Ps_1

$$R1 = \frac{Ps_1 * \cancel{k_1}}{Pc_1 * \cancel{k_1}}$$

Pc_1

MST 16 Int	**TABLE: MST 16 – Dielectric withstand test (Initial)**				—
Test Date [MM/DD/YYYY] .....:			2014/08/19 – 2014/08/27		—
Test Voltage applied [V] .....:			☒ 6000 for class A ☐ 3000 for class B		—
Sample #	**Measured**	**Required**	**Dielectric breakdown**		**Result**
	MΩ	MΩ	Yes (description)	No	
2014297	2750	21		X	P
2014309	4040	21		X	P
Remarks: Minimum requirement according to the standard is 40 MΩ*m^2. Size of module [m²] = 1.93					
Supplementary information *: Minimum Insulation Resistance Required [MΩ] = 21				2nd Check: ☒ RL	

10.15 Initial	**TABLE: Wet leakage current test (Initial)**			—
Test Date [MM/DD/YYYY] ..... :		2014/08/19 -2014/08/27		—
Test Voltage applied [V] ..... :		1000		—
Solution resistivity [Ω cm] .....:		< 3,500 at (22 ± 3)°C		
Solution temperature [°C] ..... :		23		
Sample #	**Measured [MΩ]**	**Limit [MΩ]**		**Result**
2014297	2070	21		P
2014309	1170	21		P
Remarks: Minimum requirement according to the standard is 40 MΩ*m^2. Size of module [m²] = 1.93				
Supplementary information *: Minimum Insulation Resistance Required [MΩ] = 21			2nd Check: ☒ RL	

MST 11 Int	MST 11 – Accessibility test (Initial)		
Test Date [MM/DD/YYYY]..... :			—
Sample #	**Position in test sequence:**	**Nature and position of findings – comments or attach photos**	**Result**
2014309	Initial examination	☐ The probe does not contact any live electrical part ☒ Some live electrical parts are accessible: negative lead is accessible, with the warning: do not disconnect under load	P
Remark: At no time during the test shall there be less than 1 MΩ resistance between the test fixture and the module electric circuit			
Supplementary information *: none			

Test LC	**TABLE: Desert storm**		—
Test Date [YYYY/MM/DD/] start/end .....:		2014/09/18 – 2014/10/02	—
Sample #.....:		2014309	
Particle size distribution .....:		• bigger than 850µm : 4.67% in weight • smaller than 850µm : 95.29 % in weight • smaller than 600µm : 78.46 % in weight • smaller than 425µm : 45.13 % in weight • smaller than 300µm : 21.63 % in weight • smaller than 212µm : 10.3 % in weight • smaller than 150µm : 4 % in weight	—
Test procedure			—
Sand injection	Hours ..... :	2	—
	Air velocity ..... :	20 m/s	
	Chamber rel. Humidity..... :	< 25%	

Sample #	**Open circuits (yes/no)**	**Result**
2014309	Yes	P

Supplementary information *: none

(MST 01 Visual inspection after Test LC)		—
Test Date [MM/DD/YYYY]:	2014/10/02	—

Sample #	**Nature and position of initial findings – comments or attach photos**	**Result**
2014309	- Nothing to report	P

Supplementary information *:

Fig.6: Sample after desert storm test

Fig.7: Sample after desert storm test

10.2	TABLE: Maximum power determination after desert storm	—
Test Date [YYYY/MM/DD] .....:	2014/10/02	—
Module temperature [°C] .....:	Corrected to 25	—
Irradiance [W/m^2] .....:	[1]	—

Sample #	Ratio[2] after the test	Pmp * k_2' (W)	Vmp * k_2'' (V)	Imp * k_2''' (A)	Voc * k_2'' (V)	Isc * k_2''' (A)	FF (%) init	Result
2014297	--	280.7	37.4	7.5	44.1	8.5	75	N/A
2014309	0.978	272.0	36.6	7.4	43.9	8.5	73	N/A
Pmp degradation after this test [%] ≤ 5%								P

Supplementary information *:

[1] Relative measurements with irradiance levels different from 1000 W/m^2 (between 700 W/m^2 and 1100 W/m^2) were performed. This test uses 2014297 (Pmp = 280.7 W) as control module.

The test 10.2 of EN61215 is performed making a comparison between the “control module” and any other measured module.

Before Ageing

k_1 = calibration coefficient at he time of Ps_1 e Ps_2 measurements. Depending on temperature, irradiance, spectrum, etc ; but same for both control and samples

Ps_1

$$R1 = \frac{Ps_1 * \cancel{k_1}}{Pc_1 * \cancel{k_1}}$$

Pc_1

After Ageing

k_2 = calibration coefficient at the time of Ps_1 e Ps_2 measurements. Depending on temperature, irradiance, spectrum, etc ; but same for both control and samples

Ps_2

$$R2 = \frac{Ps_2 * \cancel{k_2}}{Pc_2 * \cancel{k_2}}$$

Pc_2

Typically $k_1 \neq k_2$ but

$$\frac{R_2}{R_1} = \frac{\frac{Ps_2 * k_2'}{Pc_2 * k_2'}}{\frac{Ps_1 * k_1'}{Pc_1 * k_1'}} = \frac{Ps_2}{\cancel{Pc_2}} * \frac{\cancel{Pc_1}}{Ps_1} = \frac{Ps_2}{Ps_1} \geq 0.95$$

(MST 16 – Dielectric withstand test after Test LC)					
Test Date [MM/DD/YYYY].....:			2014/10/02		—
Test Voltage applied [V] .....:			☒ 6000 for class A ☐ 3000 for class B		—
Sample #	**Measured**	**Required**	**Dielectric breakdown**		**Result**
	MΩ	MΩ	Yes (description)	No	
2014309	4000	21		X	P
Supplementary information *: The test was performed with a Test voltage of 5kV for application class A					

(10.15 Wet leakage current test after Test LC)			
Test Date [MM/DD/YYYY] .....:	2014/10/02		—
Test Voltage applied [V] .....:	1000		—
Solution resistivity [Ω cm] .....:	< 3,500 at (22 ± 3)°C		—
Solution temperature [°C] .....:	23		—
Sample #	**Measured [MΩ]**	**Limit [MΩ]**	**Result**
2014309	530	21	P
Supplementary information *: none			

(MST 11 – Accessibility test after Test LC)			
Test Date [MM/DD/YYYY]	2014/10/02		—
Sample #	**Position in test sequence:**	**Nature and position of findings – comments or attach photos**	**Result**
2014309	Final examination	Nothing to report	P
Supplementary information *: At no time during the test shall there be less than 1MΩ resistance between the test fixture and the module electric circuit.			

---------- End of Test Report No. AR 14 TEST 093----------

List of Annexes

Annex 1: List of measurement equipment
Annex 2: Statement of the estimated uncertainty of the test results
Annex 3: Model to be included in the test report

Annex 1: List of measurement equipment

Description	Identification #	Application
Weather station	4.33	Preconditioning
Rubber support	6.66	Preconditioning
Digital caliper	3.40	MST01
Tape Measure	4.16	MST01
Luxmeter, LP471PHOT, DeltaOhm	3.16	MST01
Camera	6.68	MST01
Examination table	6.28	MST01
Consolle	4.14	10.2
Mobile consolle	4.44	10.2
Solar simulator AAA class	4.86	10.2
Double support (I and II)	6.5	10.2
PC DataLogger (I…XI)	6.40	10.2
Software Solarlab	6.54	10.2
Portable thermo-hygrometer	5.4	MST 16
Insulation tester (I and II)	4.137	MST16
Insulation tester (I and II)	4.137	10.15
Conductivimeter	5.1	10.15
Inox tank	4.117	10.15
Portable timers	4.118	10.15
Ammonia- Damp heat chamber 2	4.73	10.15
Damp heat chamber 4	4.80	10.15
Damp heat chamber 5	4.98	10.15
Damp heat chamber 6 BIG	4.110	10.15
Test finger	4.7	MST11
HT Multimeter (I and II)	4.120	MST11
Ammonia- Damp heat chamber 2	4.73	MST11
Damp heat chamber 4	4.80	MST11
Damp heat chamber 5	4.98	MST11
Damp heat chamber 6 BIG	4.110	MST11
Sand test fixture	4.111	Test LC (Desert storm)
Portable thermohygrometer	5.4	Test LC (Desert storm)

Annex 2: Statement of the estimated uncertainty of the test results

The measurement uncertainties stated in this document have been determined according to EA-4/02. they were estimated as expanded uncertainty obtained multiplying the standard uncertainty by the coverage factor k corresponding to a confidence level about 95%. Normally, this factor k is 2.

10.2 Maximum power determination: Ratio = 0.5%, Pmp = 1.7%
MST16 Dielectric withstand test / 10.15 Wet leakage current test: Resistance = 14.1%
Sand Test: Sand concentration = 12.4%
Air/sand velocity = 8.3%
Time = 0.58%

Annex 3: The photovoltaic modules with the models

Tested type	Cell number	Cell size [mm]	Module size [mm]	Cell technology	Rated power [W]
DS72300W	72	(156X156)mm	(1955x990)mm	3BB Multi	300Wp

*** Extended PV module type without need of re-testing (according to IECEE "Retest Guidelines"):**

Type *	Cell number	Cell size [mm]	Module size [mm]	Cell technology	Rated power [W]
[DS60250W]	60	(156X156)mm	(1655X990)mm	3BB Multi	250Wp
[DS60260W]	60	(156 X156)mm	(1655x990)mm	3BB Multi	260Wp
[DS60270W]	60	(156x156)mm	(1655x990)mm	3BB Multi	270Wp
[DS72310W]	72	(156X156)mm	(1955x990)mm	3BB Multi	310Wp
[DS72320W]	72	(156X156)mm	(1955x990)mm	3BB Multi	320Wp
[DS72225W]	72	(117X156)mm	(1480X990)mm	3BB Multi	225Wp
[DS72200W]	72	(104X156)mm	(1480X990)mm	3BB Multi	200Wp
[DS72175W]	72	(92X156)mm	(1205X990)mm	3BB Multi	175Wp
[DS36150W]	36	(156X156)mm	(1480X670)mm	3BB Multi	150Wp
[DS36125W]	36	(130x156)mm	(1480x670)mm	3BB Multi	125Wp
[DS36100W]	36	(104x156)mm	(1035x670)mm	3BB Multi	100Wp
[DS3675W]	36	(78x156)mm	(785x670)mm	3BB Multi	75Wp
[DS3660W]	36	(64x156)mm	(635x670)mm	3BB Multi	60Wp
[DS3650W]	36	(52x156)mm	(535x670)mm	3BB Multi	50Wp
[DS3640W]	36	(39x156)mm	(535x670)mm	3BB Multi	40Wp