



Commercial Inspection and Testing Services (CITS)

Project No.	10CA61338
Client File No.	SV18578
Report Issued By	UL India Pvt. Ltd.
Date	January 12, 2011

Client Name:	RELIANCE INDUSTRIES LTD	Testing Location:	1. UL INDIA Pvt Ltd, KALYANI PLATINA, IIIRD FLOOR, WHITEFEILD, BANGLORE 2. CENTRAL POWER RESEARCH INSTITUTE, C.V. RAMAN ROAD, SADASIVNAGAR,
Address:	BLDG 8, 1ST FL RCP, THANE - BELAPUR RD GHANSOLI.	Address:	
City, State, Zip	NAVI MUMBAI MUMBAI, MH 400701	City, State, Zip	BANGLORE -560080
Contact:	DR. VENKATESWARLU venkatesh.pamuru@ril.com	Contact:	Dr. N. VASUDEV
Phone:	+91-22-29782640	Phone:	+91-985379043

Scope of Work:

Testing of Solar Photovoltaic modules as per **IEC 61701 Standard for SALT MIST CORROSION TESTING OF PHOTOVOLTAIC (PV) MODULES**

Type:

Solar Photovoltaic Modules

Number of samples Tested:

THREE (Model Number RS1220, RS1280 having different aluminum frames and Model AS101000103 having ARC Glass as addition with aluminum frame same as of RS1280).

Details of Aluminum Frame

1) AS101000103 & MM100501200- ALOM Extrusions Ltd, Alom House, Dr. Harendra Kumar Mukarjee Sarani, Kolkatta-700701, West Bengal

2) MM100302588- J.M. Industries, GALCO group, L-195, M.I.D.C, Ahemednagar-41411, Maharashtra.



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Thickness of Aluminum Coating: ALOM Extrusions Ltd – 14 microns minimum.
J.M. Industries – 10 Microns minimum.

Coating/ plating Process: ALOM Extrusions Ltd – Sulphuric acid based
J.M. Industries – Sulphuric Acid based

Date(s) of Test(s): 2010-12-28 to 2011-01-12

Particulars of tests conducted: **Salt Mist test**
Test in accordance with Standard: In general accordance with IEC 61701, as per customer's request.

Sample tested :

Model No.	Serial No.	Description of frame manufacturer	Wattage (W) / Dimensions (mm)	Number of sample tested
RS1220	MM100302588	J.M. Industries	20W - 543x341x20	1
RS1280	MM100501200	ALOM Extrusions	80W - 1009x661x35	1
RS24300-S6	AS101000103	ALOM Extrusions with ARC glass	290W - 1980x997X43	1

Test Conditions:

A) Initial Measurements.
a) Visual inspection.
b) I-V characteristic at STC
C) Insulation test

B) Salt Mist Test (96 Hours).

C) Final measurements.
a) Visual inspection.
b) I-V characteristic at STC
C) Insulation test

Test Results: Test results to the sample tested.

Enclosure: Page No. 3 – Annexure A: Summary.
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Page 13 – Annexure C: Instrument Calibration Details.
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Annexure A Summary of test results

Test results:

Test No.	Test Name	Results
1	Visual Inspection Test (Before Salt Mist Test)	<ol style="list-style-type: none">1. No mechanical deterioration of module components observed.2. No mechanical corrosion of module components observed.
2	Maximum Power Determination (Before Salt Mist Test)	Maximum Power Attained :- <ol style="list-style-type: none">1. AS101000103 - 295.341W2. MM100501200 - 86.575 W3. MM100302588 - 24.067 W
3	Insulation Test (Before Salt Mist Test)	No Dielectric breakdown was observed.
4	Salt Mist Test (96 hours)	No mechanical deterioration or corrosion of module components was observed.
5	Visual Inspection Test (After Salt Mist Test)	<ol style="list-style-type: none">1. No mechanical deterioration of module components observed.2. No mechanical corrosion of module components observed.
6	Maximum Power Determination (After Salt Mist Test)	Maximum Power Attained :- <ol style="list-style-type: none">1. AS101000103 - 292.00W2. MM100501200 - 85.063W3. MM100302588 - 23.687W
7	Insulation Test (After Salt Mist Test)	No Dielectric breakdown was observed.

Test nos. 1, 2, 3, 5, 6 and 7 were carried out at UL India Pvt Ltd.

Test nos. 4 was carried out at Third party lab (CPRI, Bangalore), and was witnessed by UL personnel.



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Annexure B

Test Methods and Results

Visual inspection (Before Salt Mist Test)

Test samples

Two samples of the Solar modules each of 225W, 60 cells manufactured with two different frames were submitted for testing.

Test conditions

Carefully inspect each sample under an illumination of not less than 1000 lux for the following conditions:

1. No mechanical deterioration of module components is observed.
2. No mechanical corrosion of module components is observed.

Compliance Criteria – The Visual inspection before Salt mist test shall not exhibit any mechanical deterioration or corrosion on solar was observed.

Result –

The Visual inspection before Salt mist test did not exhibit any mechanical deterioration or corrosion on solar modules.

Maximum power determination (Before Salt Mist Test)

Test samples

Same samples after Visual Inspection were subjected to Maximum Power determinations (Before Salt Mist Test).

Test configuration

The following equipment was used to perform I-V characteristic measurements in simulated sunlight (solar simulator):

- a) Class A solar simulator in accordance with IEC 60904-9. The designated test area was greater than the area that is spanned by the test specimen.
- b) A PV reference solar module in accordance with IEC 60904-2 was used to calibrate the sun simulator
- c) The means for monitoring the temperature of the test specimen and the reference device to an accuracy of ± 1 °C and repeatability of ± 0.5 °C.



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- d) An irradiance sensor that tracks the instantaneous irradiance was placed in the test plane. This irradiance sensor was linear in the range of irradiances over which the measurements were taken.
- e) The temperature of the reference device and the specimen was measured using instrumentation with accuracy of ± 1 °C with repeatability of ± 0.5 °C.
- f) Equipment for measuring the current of the test specimen and reference device to an accuracy of ± 0.2 % of the reading.
- g) Equipment for measuring the voltage of the test specimen and reference device to an accuracy of ± 0.2 % of the reading.

Compliance Criteria –

The Solar modules underwent the Maximum power determination test before Salt Mist Test, in order to record the Electrical data (Maximum Power) which was compared and analyzed for Percentage degradation after performing Salt Mist Test.

Result –

10.2	TABLE: Maximum Power Determination (initial)					
	Cell temperature (°C)	25			—
Irradiance (W/m ²)	1000			—	
Initial examination						
Sample No.	Voc (V)	Vmp (V)	Isc (Amps)	Imp (Amps)	Pmp (W)	
MM100302588	21.791	18.097	1.421	1.330	24.067	
MM100501200	21.817	17.286	5.365	5.008	86.575	
AS101000103	44.668	36.561	8.609	8.078	295.341	



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Insulation Test (Before Salt Mist Test)

Sample Requirements

Same two Solar modules from Maximum power determination test were submitted for this test.

Test configuration

- a) Connect the shorted output terminals of the module to the positive terminal of a d.c. insulation tester with a current limitation.
- b) Connect the exposed metal parts of the module to the negative terminal of the tester
- c) Increase the voltage applied by the tester at a rate not exceeding 500 V./sec. to a maximum equal to 1000 V plus twice the maximum system voltage (i.e. the maximum system voltage marked on the module by the manufacturer). If the maximum system voltage does not exceed 50 V, the applied voltage shall be 500 V. Maintain the voltage at this level for 1 min.
- d) Reduce the applied voltage to zero and short-circuit the terminals of the test equipment to discharge the voltage build-up in the module.
- e) Remove the short circuit.
- f) Increase the voltage applied by the test equipment at a rate not to exceed 500 V/sec. to 500 V or the maximum system voltage for the module, whichever is greater. Maintain the voltage at this level for 2 min. Then determine the insulation resistance.
- g) Reduce the applied voltage to zero and short-circuit the terminals of the test equipment to discharge the voltage build-up in the module.
- h) Remove the short circuit and disconnect the test equipment from the module.



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Results –

Sample #	Length m	Width m	Area (L x W) m ²	Minimum Resistance 40 Mohm*m ² /Area	Measured Insulation resistance (MΩ)	Di-electric Breakdown
MM100302588	0.54	0.34	0.1836	217Mohm	424MΩ	No
MM100501200	1.01	0.66	0.6666	60Mohm	272MΩ	No
AS101000103	1.98	1.00	1.98	20.20Mohm	224MΩ	No

Salt Mist Test (96 Hours)

Test samples

Same two samples were used for evaluating the Salt Mist test.

Test configuration

The chamber for this test was constructed of such materials that would not influence the corrosive effects of the salt mist. The detailed construction of the chamber, including the method of producing the mist are as follows :

- The conditions in the chamber were within the limits specified;
- A sufficiently large volume with constant, homogeneous conditions (not affected by turbulence) is available
- No direct spray impinges upon the specimens under test;



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- d) Drops of liquid accumulating on the ceiling, the walls or other parts did not drip on the specimens;
- e) The chamber was properly vented to prevent pressure build-up and allow uniform distribution of salt fog. The discharge end of the vent was protected from squalls which can cause strong air currents in the chamber.

Atomizer (s)

The atomizer(s) used were of such a design and construction as to produce a finely divided, wet, dense mist. The atomizer(s) was made of material that is non-reactive to the salt solution.

Salt solution Concentration

The salt used for the test was high quality sodium chloride (NaCl) containing, when dry. The salt solution concentration shall be 5 ± 1 by weight.

pH value

The pH value of the solution was 7.09, at a temperature of 35 ± 2 degree C.

Salt Mist test

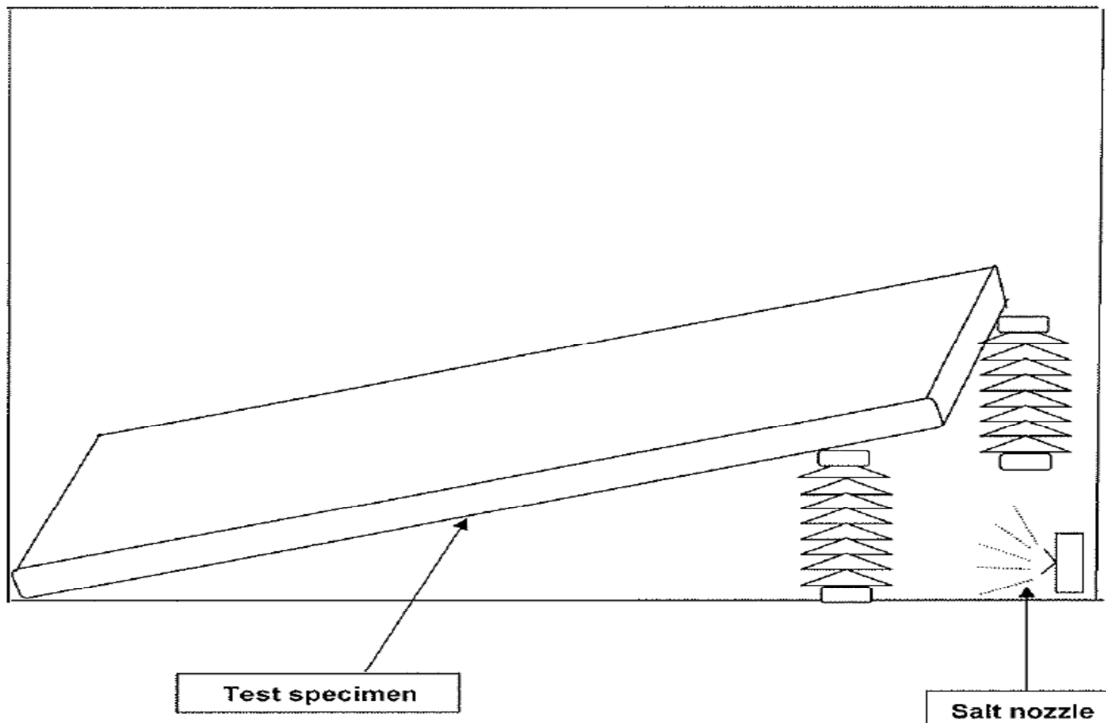


Fig.1– Schematic diagram of the test set-up / test lay-out



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Compliance Criteria –

- a) No mechanical deterioration or corrosion of module components which would significantly impair their function during their intended life.
- b) The electrical performance (maximum power) shall not decrease by more than 5 % of the initial value.
- c) The requirements of the insulation test shall meet.

Result –

No mechanical deterioration or corrosion of module components was observed.

Visual inspection (After Salt Mist Test)

Test samples

The module which underwent the salt mist test were put under Visual Inspection test to determine any degradation in the module.

Test conditions

Carefully inspect each sample for the following conditions:

- 1. No mechanical deterioration of module components is observed.
- 2. No mechanical corrosion of module components is observed.

Compliance Criteria – The Visual inspection after Salt mist test Should not exhibit any mechanical deterioration or corrosion on solar modules was observed.

Result –

The Visual inspection after Salt mist test did not exhibit any mechanical deterioration or corrosion on solar modules.

Maximum power determination (After Salt Mist Test)

Test samples

The two solar modules samples which undergone the visual inspection test were selected for maximum power determination

Test configuration

The following equipment were used to perform I-V characteristic measurements in simulated sunlight (solar simulator):



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- a) Class A solar simulator in accordance with IEC 60904-9. The designated test area was equal greater than the area that is spanned by the test specimen.
- b) A PV reference solar module in accordance with IEC 60904-2 was used to calibrate the sun simulator
- c) The means for monitoring the temperature of the test specimen and the reference device to an accuracy of ± 1 °C and repeatability of ± 0.5 °C.
- d) An irradiance sensor that tracks the instantaneous irradiance in the test plane. This irradiance sensor was linear in the range of irradiances over which the measurements are taken.
- e) The temperature of the reference device and the specimen was measured using instrumentation with an accuracy of ± 1 °C with repeatability of ± 0.5 °C.
- f) Equipment for measuring the current of the test specimen and reference device to an accuracy of ± 0.2 % of the reading.
- g) Equipment for measuring the voltage of the test specimen and reference device to an accuracy of ± 0.2 % of the reading.

Compliance Criteria –

The Solar modules undergone the Maximum power determination test after Salt Mist Test, in order to record the Electrical data (Rated Maximum Power) which will be compared and analyzed for Percentage degradation after performing Salt Mist Test.

Result –

TABLE: Maximum Power Determination						
10.2						
Cell temperature (°C) :	25			—	
Irradiance (W/m ²) :	1000			—	
Initial examination						
Sample No.	Voc (V)	Vmp (V)	Isc (Amps)	Imp (Amps)	Pmp (W)	
MM100302588	21.778V	18.057V	1.397A	1.312A	23.687W	
MM100501200	21.806V	17.229V	5.266A	4.937A	85.063W	
AS101000103	44.624V	36.487V	8.511A	8.003A	292.00W	

Degradation Observed :

Sample No	Pmax – Pre salt mist	Pmax test – Pro salt mist	Degradation (% Pmax)
MM100302588	24.067	23.687W	1.5
MM100501200	86.575	85.063W	1.7
AS101000103	295.341	292.00W	1.1



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Insulation Test (After Salt Mist Test)

Sample Requirements

Same two solar modules were submitted for this test.

Test configuration

- a) Connect the shorted output terminals of the module to the positive terminal of a D.C. insulation tester with a current limitation.
- b) Connect the exposed metal parts of the module to the negative terminal of the tester
- c) Increase the voltage applied by the tester at a rate not exceeding 500 V./sec. to a maximum equal to 1000 V plus twice the maximum system voltage (i.e. the maximum system voltage marked on the module by the manufacturer). If the maximum system voltage does not exceed 50 V, the applied voltage shall be 500 V. Maintain the voltage at this level for 1 min.
- d) Reduce the applied voltage to zero and short-circuit the terminals of the test equipment to discharge the voltage build-up in the module.
- e) Remove the short circuit.
- f) Increase the voltage applied by the test equipment at a rate not to exceed 500 V/sec. to 500 V or the maximum system voltage for the module, whichever is greater. Maintain the voltage at this level for 2 min. Then determine the insulation resistance.
- g) Reduce the applied voltage to zero and short-circuit the terminals of the test equipment to discharge the voltage build-up in the module.
- h) Remove the short circuit and disconnect the test equipment from the module



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Results –

Sample #	Length m	Width m	Area (L x W) m ²	Minimum Resistance 40 Mohm*m ² /Area	Measured Insulation resistance (MΩ)	Di-electric Breakdown
MM100302588	0.54	0.34	0.1836	217Mohm	1301MΩ	No
MM100501200	1.01	0.66	0.6666	60Mohm	465MΩ	No
AS101000103	1.98	1.00	1.98	20.20Mohm	375MΩ	No

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Annexure C
Instrument Calibration Details

Inst. ID No.	Instrument Type	Make	Function / Range	Last Cal. Date	Next Cal. Date
00306093 (CPRI)	Thermometer	APPA 55	0 ⁰ to 50 ⁰ c	01-07-2010	30-06-2011
12640-416 (CPRI)	Ph meter	DECIBLE	0-14 Siemens/mV	12-07-2010	11-07-2011
0602015002 (CPRI)	Conductivity meter	DOT TECHNOLOGY	0-200 milli semens/cm	23-04-2010	30-04-2011
IN-01 (UL)	Inclinometer	JHONSON MAGNETIC ANGLE LOCATOR	360 ⁰	07-04-2010	07-04-2011
S70-D0112 (UL)	Electronic Load Board / Sun Simulator	SPIRE	1000W/m2	24-05-2010	24-05-2011
RT02 (UL)	Insulation Tester	KIKUSUY	5000 MΩ / 1000 V DC	16-06-2010	16-06-2011
DI01 (UL)	Dielectric tester	KIKUSUY	0-10KV (AC/DC)	13-01-2010	13-01-2011
TM05 (UL)	Thermometer	FLUKE	-100 to 200°C	27-11-2010	27-11-2011
TP-02 (UL)	Measuring Tape	3M	3 meter	13-03-2010	13-03-2011
H-11 (UL)	Temperature and humidity data logger	OMEGA	15-40°C, 30- 90 % RH	11-05-2010	11-05-2011