Smart Solar Glass
For
Smart Solar Cities

GUJARAT BOROSIL LTD
FEB 24, 2017

BOROSIL’s 302.4 kWp Roof top R & D installation at Bharuch, Gujarat (India)
India imports nearly; 80% of its crude oil consumption, 15% of its coal consumption and 35% of its natural gas consumption and also 75% of Greenhouse gas emissions are produced in Cities & Communities.

IT’S A CHALLENGE and Immediate Solution - Dovetail Renewable Energy with Conventional Energy for Smart Cities

The Government of India has a vision of developing 100 SMART CITIES as satellite towns of larger cities by modernizing the existing mid-sized cities.

In 2015, Smart Cities Awas Yojna Mission - A total of ₹980 billion (US$15 billion) was approved for development of 100 smart cities and rejuvenation of 500 others.
Solar and other forms of renewable energy has been emerged as an essential in changing the face of modern India in the coming years. The Smart City guidelines insists 10% of the Smart City’s energy requirement to come from solar.

Hon’ble Prime Minister’s vision of making 100 Smart Cities with emphasis on -

- Solar power generation in City & offsite
- Solar Water Heaters for hot water
- Solar PV Rooftop systems for electricity
- Solar street lightings
- Solar pumps for water lifting
- Solar concentrators for steam based cooking
- Solar traffic signals, solar road studs/blinkers
Let’s brief on Fundamental of Soda Lime Silica Glass and its significance in Solar Energy Segment
SODA LIME SILICA Glass

- Soda-Lime-Silica glass is the most prevalent glass, used in Civil Construction and glass containers (bottles and jars) for beverages, food, and other commodities.

- This is relatively inexpensive, chemically stable, reasonably hard, extremely workable and accounts for more than 90% of manufactured glass.

- This is environment friendly as it uses common, easy to extract materials, without generating much waste in the production process. Again the recycling ratios of glass are one of the highest of all materials.

- Typically Soda lime glass is made from a recipe of raw materials such as sand, dolomite, limestone, feldspar and refining agents such as sodium sulphate and carbon.

- Pre weighed batches of the raw materials is fed into a melting furnace to convert the raw materials into melt at aprx. 1550°C. The melt then converted into sheets of various thickness from 2 to 25 mm by various FORMING Method – Rolled Process, Float, PPG etc.

- The formed sheets are termed as Float Glass, Sheet Glass And Textured Glass based on process and some properties of the product.
What is Solar Radiation?

- **Solar radiation** is radiant energy emitted by the sun from a nuclear fusion reaction that creates electromagnetic energy.

- The spectrum of **solar radiation** is close to that of a black body with a temperature of about 5800 K.

- The electromagnetic spectrum explains the different types of light waves that are emitted from the sun. About half of the **radiation** is in the visible short-wave part of the electromagnetic spectrum.

The visible range for Human being start from 380 nanometers Violet Ray and end with 720 nanometers Red Ray. The pneumonic for the visible spectrum is **VIBGYOR** that correspond the all 7 rays within Visible Spectrum.

Upper and Lower boundary of Visible Spectrum are known as **UV (Ultra Violet)** and **IR (Infra Red)**.
What is Solar glass?

- Solar glass is a type of Construction Material, that designed to block radiant heat transfer, which is basically the amount of heat from the sun that passes through the glass and into whatever space is on the other side.

- The basic function of solar glass is to transmit as much solar energy as possible while protecting the solar cell and the entire grid which produces and channelizes electricity. Solar energy panels offer alternative solutions to a range of energy requirements, from small scale domestic applications to large scale solar power stations, from cloudy northern rooftops to hot sunny deserts.

- Solar glass is an integral and important element of these solar panels.

- Solar glass is used in applications such as Photovoltaic modules, solar thermal water heaters and Green houses.

- The Solar Spectrum used for each of these applications is different.

<table>
<thead>
<tr>
<th>Application</th>
<th>Solar Spectrum (nm)</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green houses</td>
<td>300 - 780</td>
<td>Aid in photosynthesis and Better growth of Plant</td>
</tr>
<tr>
<td>Photovoltaic modules</td>
<td>380 -1100</td>
<td>Photocells respond to solar radiation within this range.</td>
</tr>
<tr>
<td>Solar water heaters</td>
<td>up to 2500</td>
<td>Use thermal energy from the sun</td>
</tr>
</tbody>
</table>
Now, let’s see the experience in Solar Initiative Inside and outside our country.
Germany, USA and Japan are leaders in adopting grid-connected SPV rooftop systems. Germany has highest PV installed capacity of over 38 GW of which 71% is in rooftop segment (as on 31.08.2015). Italy has 12.7 GW PV installation with over 60% rooftop systems. In Europe of total 50.6 GW PV installation, over 50% in in rooftop segment. FIT is norm in Europe while net-metering is popular in USA.
The solar rooftop is most economical and popular solar energy option. In India market potential for rooftop SPV is 124 GW.

- No additional land – Need rooftop of residential, commercial, institutional & industrial buildings.
- 10 SQM area is KWp capacity. And Initial Cost would be Rs.75,000 per KWp.
- Cost of electricity generation Rs.7.00 per KWh and with 30% subsidy of MNRE is about Rs.5.50 per KWh.
- Low gestation time
- Electricity generated, is opted to be fed into the grid at regulated feed in tariffs or used for self consumption with net-metering. Eventually a Reduction of power bill with surplus supply of electricity to local EB.
- Initiative will definitely support in Local employment generation.
Rooftop presents its own unique challenges

- The roof area is always a constraint and one needs to have high efficiency modules made with high output solar cells and high transmission solar glass to generate maximum power output in a given limited roof area.

- GBL is on expansion of its tempering capacity that will enable it to make 2mm fully tempered Solar glass – as a pioneering effort in India as well as very few around the Solar Glass World.

- This low thickness high transmission glass and high efficiency modules coupled with low weight would be ideal for roof top installations.

L&T in Punjab having Largest Roof Top Plant in the World - 7.52MW with more than 30,000 PV panels and Power from the plant being fed to the local grid through a PPA signed with the state distribution company.
Gautham Greens, A 20000 sq ft warehouse in New York the first commercial scale greenhouse attached to a supermarket. Equivalent to 6 acre traditional soil farming.

- This uses high transmission Solar glass and electronic systems and also outfitted with irrigation system using 20 times less water.
- The Project eliminates long distance travel for food thereby eliminating emissions and at the same time maintaining nutrient quality for customers.

And there are many more such rooftop Green houses built by smart Engineers.
Applications of Solar glass in Smart cities – Solar Thermal Hot water and heating systems

- Solar thermal water heating systems with robust copper tubes use Solar glass cover.

- Glass protects the system against weather and permits the heat from Solar radiation.

- They are economical, Robust and with higher transmission.

- The System can be also used for room heating, HVAC, swimming pool heating etc.

- This is more efficient in heating applications as it does not require to convert radiation into electrical energy and then back to thermal energy.
Applications of Solar glass in Smart cities – Solar Thermal Hot water and heating systems

For Cities starved of land space, deploying the solar modules in waterbodies is a new possibility and Japan has pioneered this concept.

Japan has installed floating modules in various ponds, lakes etc. as it lacks land space. A 10 GW of Solar power has been commissioned in 2015.

This can be adopted for Cities like Mumbai lacking land space.
BIPV - Building Integrated Photovoltaics.

- Photovoltaic materials replace Conventional Glass Façade in areas like Skylights and facades.
- This enhance elegance of a building at the same time being used as energy resource.
- 2 mm fully tempered solar glass can be the ideal solution for BIPV modules. They are economical in form of higher transmission, Cost and less construction load.

Window and Façade systems offer many possibilities of combining generation of solar energy and at the same time maintaining the architectural style in a smart way. Individual crystalline modules can be combined with ventilated/non-ventilated facades/windows/ solar shades and canopies.
BIPV modules to replace Laminated safety glass

World Wide Experience

Glass to Glass BIPV modules have been approved by DIBt Deutsches Institut fur Bautechnik for use as Laminated safety glass in buildings.

Many architects start using glass to glass as infill units without the need for special additional strengthening of supports.

The mechanical strength of glass to glass modules are tested and this found to be as good as the laminated safety glass and Solar Energy Generation is in addition to.

The 2 mm fully tempered solar glass can find an ideal economy for smart solar cities
Bi facial Glass to Glass PV modules use sunlight reflected from ground

Bifacial modules is another solution where space is constraint.

They convert the direct, radiant and scattered sunlight to generate energy on both the front and back side of the modules.

They use IR resistant encapsulate instead of conventional EVA.

This increase life and enable in maximizing generation time per day by using indirect sunlight also.

The lamination method with no multilayer back sheet reduces fire hazard and risk of mechanical damage over lifetime.
Bifacial modules

World Wide Experience

A typical module has about 60 monocrystalline solar cells with 20.5% efficiency on each side to generate more than 350 watt peak.

- These replace single / multi axis solar tracking system with economical bifacial modules to achieve the same efficiency. While the tracking system costs 1 $ as against bifacial modules cost only 0.5$ to get additional 30% energy.
- Bifacial modules have a life span of 50 years as compared to 25 years for conventional modules.
- 2 mm glass for both sides will be ideal for best economy.
What Makes the Solar glass Smart

The Solar Glass is smart when it performs better in desired solar application than normal Solar Glass e.g. cheap import from China, Malaysia and Taiwan. Solar Glass is the prime aid in New and Renewable energy resources with green environment.

- Soda Lime Silica Glass is an universally accepted ecofriendly product, but it threatens the environment while enriched with toxic elements like Antimony. USEPA defined the safe limit of Antimony in edible water is 6 parts per billion.
- Developing ANTIMONY FREE SOLAR GLASS was one of its main goals as Solar energy is touted to be a green energy but the public in general are not aware of the dangers of millions of tones of Antimony laced glass that will be dumped in their landfills in twenty years. In past Mumbai High court, banned use of PET bottles in medicines as those contain antimony.
- The 2mm fully tempered solar glass will enable the module manufacturers to cater new generation of PV modules for use in Smart cities.
Low Antimony Smart Solar Glass

A GBL’s niche initiative

• The basic function of solar glass is to maximize transmission of solar energy and secure the solar cell and entire grid that produces and channelizes electricity.

• Iron in glass absorbs solar energy passing through the glass and reduces the solar radiation for solar cells to produce power. Mostly the Ferrous state of iron in glass absorbs a little energy in 600 to 900 nm range that is response region of normal solar cells. Despite best efforts, some residual iron will be always remain in raw materials.

• Addition of Antimony makes an oxidizing batch, and that ensure iron in Ferric state that absorbs solar energy in the range 380 to 435 nm which is lower than the threshold limit of response of normal solar cells. Thus it does not affect output of Solar module.

• Hence Module manufacturers prefer glass with antimony.
Low Antimony Smart Solar Glass  
A GBL’s niche initiative

The problem posed by solar glass containing Antimony is a threat - Antimony is a toxic substance.

0.6 Mil-Tons of solar panels will be disposed off till 2034 in Germany alone & the figure rises to 0.6 Mil Tons per year since 2035.

In addition Japan, China and India have announced extensive solar programs. India announced its 100 GW of solar power program by 2022. This will need 0.6 Mil-Tons of panels!

Antimony in glass is leachable by water. Rain water collected from Solar modules were found to contain Antimony.

The usual method of disposal of solar panels is to crush and use as land fill. Eventually such land fill, inundated by rain will contaminate ground, corn field and our drinking water with severe toxicity several thousand times more than 6 ppb the prescribed limit of EPA in USA for drinking water.

Test can be carried out as prescribed by GBL

A sample was crushed to a powder of 300 - 500 microns and was put inside a container with 50 times its volume of distilled water. This container was raised to a temperature of 121°C and kept in an autoclave at 1 bar for just 2 hours. This water was tested and was found with 4.5 PPM Antimony which is 750 times higher than prescribed limit of EPA in USA for drinking water.
The proposal to ban of Antimony trioxide through amendment 87 was adapted by the committee of European Parliament set up to work on revision of the EU directive 2002/95/EC on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS recast) on 2.6.2010

At that time, dispensation was granted to optical glass and solar glass because the industry represented then that it wasn’t possible to make these products without Antimony.

Since then, the world’s top glass companies have been hard at work, trying to develop glass without Antimony.

While Glass leaders Schott and Corning have developed Antimony Free glass for applications such as Cooktop Glass, OLED packaging, Solar glass and BOROSIL took the cudgels to develop the same in Solar Glass and succeeded in their efforts and at the same time meeting SPF's stringent testing to obtain P1 grade for Solar glass. It has also obtained TuV certification for Antimony Free Glass.
Low Antimony Smart Solar Glass

A GBL’s niche initiative

Common methodology of selecting Solar Glass in India by Flash Tester.

- Conventional Solar glass with Antimony retains a slight edge over solar glass without or low Antimony.
- A non conventional Solar Glass with low or 0 antimony would show CTM loss in flash tester of about 2 watt in a 250 W module a, which is less than 1%. The tendency amongst the module manufacturer is not to accept a single watt of output loss even compromising by endangering the mankind with usage of toxic glass.

Although Developing ANTIMONY FREE SOLAR GLASS should be one of prime moto of Solar energy, touted to be a green energy. But lacking awareness in general create dangers - millions of tones of Antimony laced glass that will be dumped in their landfills in twenty years.

From Green aspect of Smart Cities initiative, the regulatory bodies need to decide banning Antimony for solar glass.

- The PV Solar business and regulatory bodies must turn its attention to disposal of these solar panels when they become defunct.
  - How will these be disposed?
  - What will be the method and cost of disposal?
  - Who will bear the cost of disposal? The users? If so, should they be warned that disposal of panels having glass with Antimony could become exorbitant?
  - Can the 1% higher output justify any additional disposal cost?

E.g. Lead used to be added to petrol for better performance. A temporary dip in performance with unleaded petrol was soon overcome with better engine design. New engines significantly outperform the old engines which used petrol with lead.
GBL Antimony Free Glass

Test certificates from SPF, Rapperswil Switzerland prove antimony-free solar glass to be the highest performer in the world today.

The process of making antimony-free glass led to the complete re-engineering of the glass composition. In addition to making the glass toxin free, Borosil SolarBurst glass has many additional attributes that lead to better performance:

- **High Chemical Durability**
  Chemical durability of our antimony-free glass is 6.7 ml vs. an average of 8.6ml for other solar glasses, as measured in tests laid down by USP.

- **Lowest Iron Content**
  With an iron content of less than 80 ppm, antimony-free glass is the lowest iron content solar glass in the world.

- **High resistance to PID**
  A high degree of resistance to Potential Induced Degradation (PID) is built into the glass. Tests conducted by the Photovoltaic Institute in Berlin have demonstrated that glass from Borosil is the most resistant to PID as compared to the product from other leading manufacturers.
Solar Burst smart Glass that holds Sunlight

Borosil SolarBurst glass is already the world's best. Every single day is a journey to make it even better. Each milestone has proven to be a leap for the solar industry.

**Anti-reflective coating**
- Light transmission and performance durability certified by TUV Rheinland, Netherlands
- Light transmission > 93.5 ~ 94% for single side AR coated glass
- Cost effective model that achieves a balance between optimal light transmission gain and coating durability
- Smooth and uniform surface morphology ensures a seamless contact surface and hydrophobic characteristics

**AR Coating Optimization**
- Module Power Gain
- Coating Durability

**ARC Structural Design**

Integration of material & process enables optimal coating performance

Tighter porosity control = higher transmittance & durability
Solar Burst smart Glass that holds Sunlight
Solar Burst smart Glass that holds Sunlight

Lowest Iron Content

With an iron content of less than 80 ppm, Borosil SolarBurst Glass is the lowest iron content glass in the world.

Certificate of Analysis

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>% Fe2O3</th>
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<tbody>
<tr>
<td>Glass sample</td>
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Issued by: [Signature]

[Date]

[Stamp]

GTS

[Address]

TÜV Rheinland

[Address]
The glass is smart enough to take care of movement of Sun in the sky and give high transmission even when the sun is at a steep angle.

- This is called Incident angle modifier and SPF has measured the same and has found that GBL glass has higher transmission.
# QUALITY CONFORMITY

## Light transmission and IAM of Tempered Glass
### WUR Test Report

### General

<table>
<thead>
<tr>
<th>Client</th>
<th>Borosil</th>
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<tbody>
<tr>
<td>Date</td>
<td>26 February 2014</td>
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<tr>
<td>Researcher</td>
<td>Vida Mohammadihaki</td>
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</table>

### Results

<table>
<thead>
<tr>
<th>Mean Values</th>
<th>T normal</th>
<th>T hemispherical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method (appendix)</td>
<td>WUR-TNO</td>
<td>WUR-TNO</td>
</tr>
<tr>
<td>Mean (appendix)</td>
<td>NEN 2675</td>
<td>NEN 2675</td>
</tr>
<tr>
<td>Tempered glass</td>
<td>92.2 ± 0.5 %</td>
<td>77.3 ± 0.5 %</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample</th>
<th>Angle of Incidence</th>
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<tbody>
<tr>
<td></td>
<td>10</td>
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<tr>
<td>Tempered glass</td>
<td>92.4</td>
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## Light transmission and IAM of ARC Glass
### WUR Test Report

### General

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<tbody>
<tr>
<td>Date</td>
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<tr>
<td>Researcher</td>
<td>Vida Mohammadihaki</td>
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### Results

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</tr>
<tr>
<td>Mean (appendix)</td>
<td>NEN 2675</td>
<td>NEN 2675</td>
</tr>
<tr>
<td>Tempered ARC glass; ARC liquid Honeywell</td>
<td>94.7 ± 0.5 %</td>
<td>79.2 ± 0.5 %</td>
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</tbody>
</table>

<table>
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<tr>
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<th>Angle of Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Tempered ARC glass; ARC liquid Honeywell</td>
<td>94.9</td>
</tr>
</tbody>
</table>
What Makes the Solar glass Smart

The smart solar glass takes care of Potential Induced Degradation caused by migration of Sodium ions from the glass into the cell when the module made of Solar glass is installed in a solar farm where the voltages are 1000 V and above, causing damage of the modules or reduction in power output.

- GBL has achieved this by suitably tweaking its Solar glass chemical composition.
- Further this is also the reason for high chemical durability of this Solar glass.
Field Tests
The phenomenal leaps Borosil took in the research labs needed to be proven on the field, so field tests were conducted on modules made from Borosil SolarBurst Glass against modules made with glass from a leading European producer. The results speak for themselves.

Over a period of 12 months, clusters of 96 modules placed side by side in our rooftop R&D installation, have yielded the results shown below. All modules were made by EMMVEE Photovoltaic Power Pvt. Ltd. at the same time, using identical components, except for the glass. The results are automatically posted continuously online and are in the public domain.

The tests re-affirmed the fact that BOROSIL SolarBurst Glass has superior performance even in field conditions.
Conformity of EN 12150-1 (4mm) Fragmentation and Mechanical Strength

Test report

Test report relating to a glass product according to European standard EN 12150-1, fragmentation and mechanical strength, concerning the product with trade mark: Tempered Prismatic Solar Glass, type: 4 mm, manufacturer: Gujarat Borosil Limited.

Certificate

Certificate Reg. No: 01 100 106716
Certificate Holder: GUJARAT BOROSIL LIMITED
Address: Ankiteshwar Rajpura Road,
Village: Goward, Tal: Jamnagar,
Dist. Bharuch – 392 001, Gujarat, India.

Scope: Manufacturing and supply of sheet glass including annealed, tempered and AR coated solar glass, figured/patterned glass.

Validity: The certificate is valid from 2014-08-25 until 2016-11-25.

TUVRheinland Precisely Right
Conformity of Performance ARC Glass
Performance Durability

Test report

Test report relating to a glass product according to - amongst others - standard ASTM D3508, and DIN 58001, concerning the product marked as: Tempered glass with AR coating PV modules, manufactured by: Gujarat Borosil Ltd.

Client: Gujarat Borosil Ltd., Village Ghodkad, Taluka Rajodi, District Bhavnagar-364301, State Gujarat, India

Project number: 002D4756
Project name: 12.4L13 rev.4 tests on tempered glass, PV modules
Number of pages: 31

Conformity of Performance EN 12600 (3.2mm)
Drop Pendulum test

Test report

Test report relating to a glass product according to European standard EN 12600, Pendulum test for flat glass, concerning the product marked as: Borosil 5.2 mm clear patterned, manufactured by: Gujarat Borosil Limited

Client: Gujarat Borosil Limited, Village Ghodkad, Taluka Rajodi District Bhavnagar-364301, State Gujarat, India

Project number: EN13320A
Project name: Borosil 5.2 mm clear patterned
Number of pages: 3
Certificate of constancy of performance
(CE Mark)

Certificate of constancy of performance
0336 – CPR – 89208623 A

In compliance with Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 (the Construction Products Regulation or CPR), this certificate applies to the construction product(s).

Thermally toughened soda lime silicate safety glass
specific by the commercial name(s)
Low iron high transmission solar textured glass

placed on the market under the name or trade mark
Gujarat Borosil Limited

Ambawadi, Rajpipla Road, Village Sowali
Tul - Jagatiben Dal - Bharuch
Gujarat State, India 392001

and produced in the manufacturing plant(s)
Gujarat Borosil Limited

See address above.

This certificate attests that all provisions concerning the assessment and verification of constancy of performance described in Annex ZA of the standard(s)

EN 12150-2:2004

under system 3 (voluntary certification) for the performance set out in this certificate are applied and that the factory production control conducted by the manufacturer is assessed to ensure the constancy of performance of the construction product.

This certificate was first issued on 23 February 2016 and will remain valid as long as neither the harmonized standard, the construction product, the AVCP methods, nor the manufacturing conditions in the plant are modified significantly, unless suspended or withdrawn by the notified product certification body.

TÜV Rheinland Nederlands BV
Westerveld 73
NL – 8237 AV Arnhem
The Netherlands

Amherst, 11 April 2016

C.C.M. van Houten, Manager operations

Conformity of ITT Report
(3.2mm and 5mm)

CONFORMANCE OF ITT REPORT
1750 – 33296/33627


EN 12150 & EN 12600 on patterned low iron glass

Commercial name(s)
3.2 & 5.0 mm solar glass

placed on the market by
Gujarat Borosil Limited

and produced in the factory
Gujarat Borosil Limited

Village Borosil Tower Jhagdisa District Bharuch 392001 State Gujarat India

is submitted by the manufacturer to ITT testing at
TÜV Rheinland Nederland B.V.
acting as Notified Body 1750 under EU GC-9 tasks.

This certificate attests that all provisions concerning the ITT testing and the performances per

EN 12150 & EN 12600 on patterned low iron glass

were applied and are reported in full detail in reports for the purpose of CE marking under the condition that the manufacturer has installed the FPC and issued the declaration of conformity as included in Annex ZA of the above mentioned product or test standard.

The intended use characteristics and, where applicable, tests on the basis of application, are described in detail in the projects with reference to EN 12150 & EN 2607 about the initial type testing (ITT) that can only be made evaluable in full version.

The CE marking may only be used if all relevant and effective clauses of the product standards are applied.

This Certificate is based on an evaluation of a sample of the above mentioned product. The ITT report and documentation are at the Certificate Holder’s disposal. This Certificate does not imply assessment of the entire production of the product and does not permit the use of a TÜV Rheinland mark of conformity. The holder of the Certificate is authorized to use this Certificate in connection with the EC declaration of conformity according to Annex ZA of the product standard as an aspect of the comprehensive ITT report.

Apeldoorn, 17th of February
TÜV Rheinland Nederland BV
Bioschoutplein 11A
5245 AS Apeldoorn
The Netherlands

Manager Industrial Services, Sector Glass
QUALITY CONFORMITY

Conformity of TUV
Zero Antimony

LETTER OF COMPLIANCE

Ref: 1803026250

Holder: Gujarat Borosil Limited
Village Govavi, Tehsil Jhagadia District,
Bharuch-392001, State Gujarat, India.

Product: Glass

This letter of compliance is based on the testing of samples of the above mentioned product and to certify that the sample tested according to the SEM - EDS Analysis of glass and fulfills the requirements of Zero Antimony content.

Note: Our report under this investigation will not imply that TÜV Rheinland tested, verified, or recognized the product. Our only involvement is that of listing or Verification Notifies or other类似 services to TÜV Rheinland or in conjunction with the product.

Bangalore: 16.03.2014

Conformity of Performance
Hail Stone Impact Resistance (3.2mm) IEC 61215

WESTPAK, INC.

GUJARAT BOROSIL LIMITED
HAIL TESTING
of the Glass Sheets
Report No. 119-15-1235A, Rev. 2
Proposal No. 38670, Rev. B

Customer Information

Gujarat Borosil Limited
44 Khorma Construct House
RG/Theodore Marg
Mumbai, India 400018

Laboratory Information

Test Engineer: Jessica Sohn, Tyler Garlock, and Peter Novick, WestpakTM
Test date: July 16, 2015
Westpak laboratory: San Jose, California

WESTPAK, Inc. is accredited to ISO 17025 General Competence for Testing and Calibration Laboratories. WESTPAK, Inc. is also registered to ISO 9001 Quality Management and ISO 14001 Environmental Management Systems (#10001175 and #10004296). For accredited test methodologies, please visit www.westpak.com for the Scope of Accreditation of Westpak, Inc.

Purpose of Testing

The purpose of testing was to verify that the glass sheets were capable of withstanding the impact of hailstones. Three glass sheets were subjected to the following test input:

Acceptance criteria are specified by Clause 10.17 of IEC 61215, Edition 2.0.

Results and Observations

Test Input: Hail Test
Observations: No major visual defects, as specified by Clause 10.17 of IEC 61215, Edition 2.0. Small cracks were observed on the glass sheets as a result of this test input.

Conclusion:

With this information, the glass sheets are determined to meet the requirements of IEC 61215, Edition 2.0.
GBL’S Solar Burst Smart Glass

- Lowest Iron (<100 ppm) Textured Glass
  - Prismatic Matt & Matt Texture
  - Anti-Reflective coated textured solar glass
  - Lowest even 0 Antimony among all textured solar glass.
- Light Transmission in visible range: ≥91.5% in Uncoated and ≥93.5% in AR Coated Glass
- 7.5% more power output.
  - Major Area of Application
  - Photovoltaic modules
  - Flat thermal collectors
  - Greenhouse applications
- Our Smart Vision -
Working Towards Preserving The Earth Every Way We Can.

Thank You