LandVac & VIG Technologies presents:

VACUUM INSULATING GLASS

WHERE THE WINDOW BECOMES THE WALL!
In 1893, James Dewar, a British physicist and chemist, invented the vacuum flask.

From then on, people began thinking how to use this technology on architectural glass.

In 1913, a German, Mr. Zoller, put forward the concept of vacuum glass in his patent for the first time.
OVERVIEW

• Who are the players.
• What is a VIG and what makes it work?
• Why is VIG ready today?
• A look at the performance numbers.
• A VIG factory overview.
• VIG in a high performance curtain wall (case study).
• Q&A.
WHO IS LANDVAC?

- LandVac is a division of LandGlass Technology Co. Ltd.
- LandGlass manufactures and sells glass tempering furnaces worldwide
- LandGlass developed & patented LandVac Vacuum Insulating Glass
- 100 Scientists
- 8 Years of research and development
- LandVac is exclusively represented by VIG Technologies in North America
WHO IS VIG TECHNOLOGIES, LLC?

• Headquartered in Jupiter, Florida – USA
• VIG Technologies, LLC proudly serves as the exclusive North American distributor for LandVac®.
• Shares it location with IGE Glass Technologies
ABOUT OUR VACUUM INSULATING GLASS OR VIG

VIG is an insulating glass unit with a 0.3mm vacuum gap between the glass panes instead of air or inert gas.

Structure of LandVac Vacuum Insulating Glass

- Glass #1
- Low-E Coating
- Micro Support Pillars
- Getter material
- Glass #2
- High-Vacuum Chamber
- Evacuation Port
- Edge Seal
- Edge Seal
Components of LandVac Vacuum Insulating Glass

- Super long life – 25+ years
- Proprietary – Low Temperature Sealing Technology
- High compression flexible edge seal – 4x
Components of LandVac Vacuum Insulating Glass

- Aesthetically pleasing
- 0.3mm - 0.01” diameter pillars
- 60mm – 2.4” spacing
Components of LandVac Vacuum Insulating Glass

- Windload
- Flatness
- Safety (SGCC – certified)
Components of **LandVac** Vacuum Insulating Glass

- Not all VIG’s are equal
- Highest vacuum VIG (10 -4 mTorr)
- Evacuation Port – 25+ years
ABOUT OUR VIG

Components of **LandVac** Vacuum Insulating Glass

- Improve U-value (R-value)
- Improved SHGC
- Different Low-E’s available
Components of LandVac Vacuum Insulating Glass

- A getter is a deposit of reactive material that is placed inside a vacuum system, for the purpose of completing and maintaining the vacuum.
WHY IS LANDVAC VIG READY FOR COMMERCIALIZATION TODAY?

• Fully functioning VIG factory operating since 2015
• Maximum size available today: 60x96” - 1.5x2.5m
• Minimum size: 12x12” – 0.3x0.3m
• Maximum size 78x125” - 2.0x3.2m Available 2020
• Millions of sq.ft. of capacity available today
• 182 patents on product and process (+240 patents)
• Patented convection tempering technology for super flat glass
• LandVac metallic “cool-seal, no-lead” edge seal technology
IGU / VIG PERFORMANCE DEFINITIONS

- **U-value/factor**: A measure of heat gain or heat loss through glass due to the thermal conductance. The lower the better and the reciprocal of R-value.

- **R-value**: Thermal resistance of a glazing system. The higher the better and the reciprocal of the U-value.

- **VLT**: The percentage of visible light that is transmitted through the glass.

- **SHGC**: Solar energy that enters into the building's interior. The higher the SHGC the higher the heat gain.

- **STC**: Sound Transmission Class Rating is used to categorize acoustic performance. The higher the better.
SO NOW THE NUMBERS
# CURRENT IGU PERFORMANCE VALUES

## Double Silver Low-E

<table>
<thead>
<tr>
<th>Makeup</th>
<th>Thickness</th>
<th>U-Value (R)</th>
<th>SHGC</th>
<th>VLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1” / 25.4mm</td>
<td>0.34 (3.0)*</td>
<td>0.38</td>
<td>70%</td>
</tr>
<tr>
<td>Argon</td>
<td>1” / 25.4mm</td>
<td>0.25 (4.0)*</td>
<td>0.37</td>
<td>70%</td>
</tr>
<tr>
<td>Triple, Air</td>
<td>1 3/4” / 44.5mm</td>
<td>0.22 (4.7)</td>
<td>0.34</td>
<td>63%</td>
</tr>
<tr>
<td>Triple, Argon</td>
<td>1 3/4” / 44.5mm</td>
<td>0.19 (5.2)*</td>
<td>0.34</td>
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*measured at an independent lab
**CURRENT IGU PERFORMANCE VALUES**

**Double Silver Low-E**

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</tr>
<tr>
<td><strong>VIG</strong></td>
<td><strong>5/16” / 8.3mm</strong></td>
<td><strong>0.07 (15.4)</strong>*</td>
<td><strong>0.37</strong></td>
<td><strong>70%</strong></td>
</tr>
</tbody>
</table>

*VIG pillar spacing is 60mm
*measured at an independent lab
CURRENT IGU PERFORMANCE VALUES

*Double silver Low-E IGU with Argon*

In vertical position
R-Value = 4.0

In horizontal position
R-Value = 2.7
LANDVAC VIG PERFORMANCE VALUES

**VIG unit**

In vertical position
R-Value = 15.4

In horizontal position
R-Value = 15.4
## CURRENT IGU PERFORMANCE VALUES

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</tr>
</thead>
<tbody>
<tr>
<td>Standalone VIG</td>
<td>5/16” / 8.3mm</td>
<td>0.07 (15.4)*</td>
<td>0.37</td>
<td>70%</td>
</tr>
<tr>
<td>Hybrid, DS</td>
<td>1 1/8” / 28.5mm</td>
<td>0.06 (18.0)*</td>
<td>0.27</td>
<td>56%</td>
</tr>
<tr>
<td>Hybrid, TS</td>
<td>1 1/8” / 28.5mm</td>
<td>0.05 (18.3)</td>
<td>0.22</td>
<td>50%</td>
</tr>
</tbody>
</table>

*DS = Double silver Low-E coating  
*TS = Triple silver Low-E coating
“Double VIG” = two VIG units with an airspace between.
“Double VIG Hybrid” = Low-E-coated outboard with two VIG units inboard.

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<tbody>
<tr>
<td>Double VIG</td>
<td>Argon</td>
<td>1 3/16” / 30mm</td>
<td>0.03 (28.8)</td>
<td>0.27</td>
</tr>
<tr>
<td>Double VIG</td>
<td>Argon, #4 Low-E</td>
<td>1 3/16” / 30mm</td>
<td>0.03 (30.0)</td>
<td>0.27</td>
</tr>
<tr>
<td>Double VIG</td>
<td>Krypton, #4 Low-E</td>
<td>1” / 25.4mm</td>
<td>0.03 (30.2)</td>
<td>0.27</td>
</tr>
<tr>
<td>Double VIG Hybrid</td>
<td>Argon</td>
<td>2” / 50.8mm</td>
<td>0.03 (32.8)</td>
<td>0.20</td>
</tr>
<tr>
<td>Double VIG Hybrid</td>
<td>Argon, #4 Low-E</td>
<td>2” / 50.8mm</td>
<td>0.03 (34.2)</td>
<td>0.20</td>
</tr>
<tr>
<td>Double VIG Hybrid</td>
<td>Krypton, #4 Low-E</td>
<td>1 5/8” / 41.3mm</td>
<td>0.03 (35.1)</td>
<td>0.21</td>
</tr>
</tbody>
</table>
THE R-10 CURTAIN WALL

Better

• UCW3500 Unitized Curtain Wall
• Assembly U factor = .28 BTU/hr-sqft°F /1.59 W/m²K
• System R-value = 3.57
**THE R-10 CURTAIN WALL**

**Today's best**

- COG U factor = .12 BTU/hr-sqft°F / .681 W/m²K
- Assembly U factor = .17 BTU/hr-sqft°F / .965 W/m²K
- System R-value = 5.88
WHERE THE WINDOW BECOMES THE WALL!

- H-VIG -COG U factor (imperial) = .052 BTU/hr-sqft°F (metric) = .295 W/m²K
- Assembly U factor (imperial) = .108 BTU/hr-sqft°F (metric) = .612 W/m²K
- System R-value = 9.26 → 10.0
- 100°C - 180 °F Delta T

Exterior Temperature 0°F / -17.6°C
Interior Temperature 70°F / 21.1°C
TESTING PERFORMED

- ASTM E1233, ASTM E330
  - Pressure cycling and sustained loads performed with no breakage

- Modified ASTM E2188

- Acoustics:
  - STC Rating: 33
  - ASTM E90 / ASTM E413
  - OITC Rating: 32
    - ASTM E1332
  - Weighted Sound Reduction $R_w = 36-39$ dB

- ANSI Z97.1: Fully tempered
VIG MANUFACTURING FACILITY IN NORTH AMERICA USING LANDVAC INTELLIGENT AUTOMATION TECHNOLOGY
VIG FACTORY FACTS

• **Space required:** 150,000 sq.ft. / 15,000 m² per line
• **Annual output per line:** 2.5-4.0 million sq.ft. (250k-400k m²)
• **Power:** 5.0 Mega Watts per line
• **Max. Glass Size:** 78” x 125” (2.0m x 3.2m)
• **Fully automated factory**
• **Investment required**
• **ROI** less then 3 years
• **VIG fabrication only – sell to everyone**
MARKETS

- Residential
- Commercial
- Institutional
- Refrigeration
- Others
- Stand alone VIG, Hybrid VIG & more
- Net-zero energy buildings
- Passive house projects

Architecture and Construction
Building Integrated Photovoltaics
Agriculture
Automotive & Transportation
Thermal Comfort

- **Trends:** Occupants most often misinterpret down-drafting as air infiltration
- **Sources:** Downdraft currents resulting from high temperature variations at center of glass
VIG Performance: Acoustic Comfort

- Results assume basic aluminum, thermally broken window System
THE FUTURE IS NOW

Thank you!

Questions?