the future of curved glass is now
Introduction

BiRadial Glass b.v. is a company specializing in the production of freely curved glass for architectural applications. Our production method is based on the application of an adjustable mould which is industrially developed by the extensive research and experience of over 20 years.

Whereas conventional manufacturing of freely curved glass requires producing a unique mould for each glass panel, implying a labour-intensive and critically complex process, BiRadial Glass saves time and costs by using the adjustable mould.

BiRadial Glass b.v. offers designers, engineers and constructors an innovative glass bending technique to create single and double curved glass facade panels directly from CAD data. Biradial Glass b.v. manufactures with minimum tolerances of very high dimensional accuracy. This results from a thorough, high level understanding of the digital modeling and component engineering.

Freely curved Glass

The use of curved shapes in architecture grows enormously. This requires curved panels. Some base materials can easily be transformed under pressure, by using advanced molding equipment. However, the possibilities to transform glass panels are limited.

Complicating factor is the minimal required temperature variation during shaping of the glass, to prevent surface distortion. Variations cause irregular and unwanted reflections. With the process BiRadial Glass b.v. developed, many limitations in transforming glass have been overcome. The opportunity now exists to accurately produce almost any desired curved shape.

Key Characteristics
- Single and double curvatures possible without material waste for the mould
- Our production highly reduces mould costs (mould production, transport, installation, production time)
- Computer-driven file-to-factory production process
- Very exact measurements
- Minimal breakage during bending
- Improved quality by the industrial processing
Material Selection
Laminated glass
Chemically toughened / Tempered glass
Insulating glass with optional gas filling

Industrial Glass types
Clear glass
Reflective glass
Tinted glass
Low iron glass
Anti-Reflective glass
Low-E glass

Your requirement:
BiRadial glass b.v. is constantly researching and developing on the glass shaping. Therefore, we encourage you to contact us with your project specific requirement.

Glass Specifications
The BiRadial Glass b.v.’s adjustable mould now offers the possibility to manufacture double and single curved panels up to 3.4 meters in length.

<table>
<thead>
<tr>
<th>net panel size - mm</th>
<th>1800 x 2400</th>
<th>3400 x 2400</th>
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</thead>
<tbody>
<tr>
<td>largest panel size</td>
<td></td>
<td></td>
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<tr>
<td>radius x - mm</td>
<td>1350</td>
<td>4000</td>
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<tr>
<td>smallest radius in x</td>
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<tr>
<td>radius y - mm</td>
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<td>smallest radius in y</td>
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<td>depth z - mm</td>
<td>400</td>
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<td>greatest dim in z</td>
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The Production process

BiRadial Glass b.v.’s production process is enabled by the integration of Parametric design CAD software with automated software used to drive robotics. The CAD software interfaces with industrial file formats dwg, dxf, iges, solid works, etc, to work with designers, architects & engineers during design stage, and to produce the production and management data and finally provides tracking and installation data.

1 Architects Design
   3D Model created in Autocad, 3DStudio, Catia, Rhino, Maya, Microstation, Solidworks etc.

2 Surface formatting
   The original CAD files are converted to parametrically controlled format for analysis of geometry. The surface is then visually optimized to get high quality precision in contours and reflections before creating individual panels.

3 Create panel definition for surfaces
   Panelization or subdivision of original envelope with user defined rule set governing panel shape and size, orientation, split lines, minimum radius control, material selection, type of glazing, thickness of glass, fixing and substructure. This phase marks the freezing of the design stage. Biradial glass upto this phase will support the design activity with panelization and constructability feedback.

4 Panel extraction and set out
   Individual panels are extracted from the finalized envelop with their corresponding geometry. Assigning panels with individual codes and real world coordinates. Grouping and ranking of similar geometry (size and radius) of panels and preparing them for the digital production sequence.

5 Digital Production Data
   Parametric positioning of individual panels on the digital mould, digital balancing of panels, Analysis for material loss, element stress and quality control. Determine bending co-ordinates and heights of the actuators for the adjustable mould. Prepare numerical data for CNC panel cutting and adjusting the mould in the glass bending furnace.

6 Panel bending
   Automated adjusting of the adjustable mould. Positioning of glass panels and bending them in the furnace.

7 Panel finishing
   Check for accuracy and quality control. Material treatment sessions include chemical toughening, laminating, insulating etc. Embedding of tracking codes for onsite installation etc.
Possible Glazing types

Frameless Glazing
BiRadial Glass panels can be clamped onto or be supported by backing supports like aluminum mullions, stainless steel posts or structural glass fins. For spider construction applications the BiRadial Glass panels, with optional holes, can in house be chemically toughened.

Structural glazing
The glass panels can be fit in a curtain wall when for example combined with the AA 100 Q Twist - aluminum facade system for freely arched facades. Such system allow for various textures in the finishing. This product innovation resulted from the collaboration between Dr. Karel J. Vollers, Van Campen Industries and Alcoa Architectuursystemen.
Tendering for glass facades

BiRadial Glass b.v. tenders for glass facade constructions, based on architectural drawings and technical performance specifications. The cost of engineering and production largely depends on the complexity of the curvature and panel dimensions.

Panel shape optimization performed in collaboration with the BiRadial Glass engineers will significantly reduce costs.

Collaborative Engineering

BiRadial Glass b.v. provides related glass and facade engineering services. We may be involved in any step of the design and production process to work with clients, architects, engineers, manufacturers, and contractors. We assist architects and engineers to realize their designs.

Our team of specialized Architectural engineers operate with the latest in digital technology to provide unmatched services in:

- 3D development and rationalization of facades
- design of backing construction and framing systems
- panelization of glass facades
- finite element analysis
- thermal performance analysis and other engineering tasks
**BiRadial Glass b.v. team**  
Dr.ir. Karel J. Vollers (Director)  
Ir. Daan Rietbergen (Data Engineer)  
Ir. Sagar R. Thorat (Commercial Director)  
Tetterode Glas Voorthuizen (Production Facility)

**Research and Development**  
BiRadial Glass b.v. puts much emphasis on technological self-development through research and innovation. We are open to research subjects on freely curved glass facades, to work in collaboration with Architects, Engineers, Contractors and Manufacturers for technical development in the building industry.  
Ongoing research projects include Adjustable mould for glass, non-standard framing systems, adjustable mould for curved concrete panels, and adjustable mould for curved GRP composite panels.  
The development of the computer adjusted glass bending mould is supported with a STW-Valorisation Grant. The STW program makes new scientific research possible at the interface of science and society. The program is supervised by the Dutch Ministry of Economic Affairs.

**Production and Procurement**  
Our partners are invited in concertation with clients. With our Valued Partners we, by combined capacities, cover all stages of design materializing. To meet specific demands, we in consult with client, select appropriate partners.  
Our valued Partner Tetterode Glas Voorthuizen was founded in 1968 by glass artist Floris van Tetterode. Through the years, the firm developed into a medium sized industrial glass bending company with a high professional competence and big innovative strength. Having produced for both the top segment of architecture, and for modest housing and art projects, they have a great reputation. An enthusiastic group of Tetterode Glas Voorthuizen employees together with Karel Vollers and Daan Rietbergen form an innovative team. In collaboration they develop many new technologies. The Biradial Glass b.v.’s bending technology is an example of the innovative approach to building.  
In recent years, cooperation between the Delft University of Technology and Tetterode Glas Voorthuizen developed a large number of prototype moulds by which freely double curved glass panels can be manufactured. The latest production process includes digitally converting drawings to adjustment data of the adjustable mould. So to realize the drawn planes in glass, these adjustment data can also be taken from an existing framing or in situ rebate into which the new pane is to be placed. Modern measuring equipment enables Tetterode Glas Voorthuizen to very accurately determine the positions of points on the existing shapes, and then to combine the data into freely curved surfaces.

**Transportation and Logistics**  
All glass and curtain wall components are packaged with inhouse designed steel frames, designed for transportation by road and sea. They can be delivered to site, be stored, ready for installation onto a building anywhere in the world. Our fabrication facility has quick time accessibility to world class ports.

**Contact personnel**  
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