VA TECH is the global leader in bulb-type generators. More than 160 designed units in operation worldwide.

Selected References:
- Ma Jin Tang (China) 3 x 20.0 MVA 75.0 rpm
- Altenwörth (Austria) 9 x 45.0 MVA 103.0 rpm
- Racine (USA) 2 x 25.0 MVA 62.0 rpm
- Pak Mun (Thailand) 4 x 36.0 MVA 100.0 rpm
- Ybbs/Persenbeug 1 x 46.0 MVA 75.0 rpm
- Freudenau (Austria) 6 x 32.0 MVA 65.2 rpm
- Fei Lai Xia (China) 4 x 39.0 MVA 83.3 rpm
- Da Yuan Du (China) 4 x 33.5 MVA 65.2 rpm

(with a bulb diameter of 9 m, the world’s largest bulb-type generators)
Bulb Generator - Design

- Access shaft
- Stator
- Lateral support
- Vertical support
- Foundation side plate (embedded in concrete)
- Foundation support (embedded in concrete)
Bulb Generator - Design

- Lifting plate
- Stator core
- Stator frame
Bulb Generator - Design

Rotor body

Poles

Slipring support

Leads

Sliprings

www.vatech-hydro.com

ANDRITZ
Bulb Generator - Design

INSTALLATIONS IN BULB

- Cooling air fan
- Air-water cooler
- Air duct
- Cooling water piping
Bulb Generator - Design

INSTALLATIONS IN BULB

- Stator terminals
- Air dehumidifier
- Neutral point transformers
- Oil head
- Bulb floor
Bulb Generator - Design

LOCATION OF AUXILIARY PLANTS

- Cooling water pipes
- Oil high tank
- Pressure vessel
- Oil hydraulic controller (turbine)
- Oil pipes
- Oil tank

- Cooling water plant, Brake plant
- DC unit distribution board, Unit control board
- Excitation
- LV unit distribution board
- Neutral grounding resistor
- HV cables
Bulb Generator - Design

WATER-WATER-COOLER INSTALLATION

Water-water-cooler
Bulb Generator - Design

Generator Combined Bearing

- Bearing body
- Bearing pads
- Bearing support
- Turbine casing
- Shaft
Bulb 2000

A NEW DESIGN FOR BULB TYPE GENERATORS
WHY A NEW DESIGN?

- Economic competition between
  - direct driven and
  - step up gear driven bulb generators
  at ratings up to 15 MVA

- Gear driven
  - "Arkansas 13"

- Conventional bulbs
  - standard "Greifenstein"
  - fin cooling "Gmunden"

- New design
  - "Bulb 2000"
Gear driven design "Arkansas 13" 10.57 MVA

- Turbine speed: 77.07 rpm
- Step up gear
- Generator speed: 900 rpm
- Runaway speed: 2,645 rpm (not standardised rotor)

Efficiency generator + gear = 96.4%

Cooling through surface coolers integrated in the stream liners
Bulb 2000

Standard design "Greifenstein"  38 MVA

Rated speed 93.75 rpm
Runaway speed 273 rpm
Efficiency 97.91 %

Cooling through double shell cooler integrated in the bulb nose or coolers in the stream liners between the access shafts
Bulb 2000

Standard

New (Bulb2000)
Bulb 2000

Cooling System (as built)

Air flow through:
Bulb nose area - opening turbine stay ring - radial Ventilator - air ducts - small openings in turbine stayring - DE endwinding - air gap and pole gap - NDE endwinding - cooling duct inside bulb nose - bulb nose area
Comparison of size: Bulb2000 - Gear driven generator Unit

"Deutschfeistritz" Comparison of length

<table>
<thead>
<tr>
<th></th>
<th>Bulb-</th>
<th>Generator</th>
<th>Turbine</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nose</td>
<td>(mm)</td>
<td>Stator</td>
<td>Sum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BULB 2000</td>
<td>2,050</td>
<td>1,850</td>
<td>3,900</td>
<td>4,440</td>
</tr>
<tr>
<td>Conventional bulb generator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with intermediate cooling water circuit and aluminium-Cooler</td>
<td>2,050</td>
<td>1,950</td>
<td>4,000</td>
<td>4,440</td>
</tr>
<tr>
<td>cooling jacket</td>
<td>2,250</td>
<td>1,950</td>
<td>4,200</td>
<td>4,440</td>
</tr>
<tr>
<td>with FIN-Cooling</td>
<td>2,610</td>
<td>1,950</td>
<td>4,560</td>
<td>4,440</td>
</tr>
<tr>
<td>Gear driven generator</td>
<td>12,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bulb 2000

New design BULB 2000

- No gear
- Very high efficiency
- Smaller power house dimensions
- Simple cooling design
- One access shaft only (turbine side)
- Unusual high cooling air temperature, but normal winding and core temperature
- Cheaper

References
- Deutschfeistritz / STEWEAG
- Lambach / ENERGIE AG
DIFFERENCES TO CONVENTIONAL BULB GENERATOR DESIGN

- Sliprings and motor driven fans on driving side
- Oil head near turbine bearing - radial oil supply
- Generator with high efficiency
  (appr. 98.5 %, for comparison Gmunden: 96.4 %)
- Heat dissipation only through casing and bulb nose (without fins)
- All supply lines (oil, water, power, control) arranged in turbine side access shaft
- Cold air appr. 60°C
- Warm air appr. 85°C
- Temperatures below admissible values according IEC class B
ACHIEVEMENT OF COST REDUCTION

- No generator access shaft
- No air/water heat exchanger
- No intermediate cooling circuit (or bulb nose with fins)
  - No conical part of bulb
- No vertical support
- No auxiliary installations and dividing wall in bulb
- No cooling water pumps
- Stator core with abutting frame
- Simple rotor design
## Bulb Generator References

### Generators with Large Bulb Diameter

<table>
<thead>
<tr>
<th>Year</th>
<th>Plant</th>
<th>Nos</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>Racine / USA</td>
<td>2</td>
<td>8,640</td>
</tr>
<tr>
<td>1981</td>
<td>Greifenstein / Austria</td>
<td>9</td>
<td>8,100</td>
</tr>
<tr>
<td>1992</td>
<td>Ybbs (unit 7) / Austria</td>
<td>1</td>
<td>8,750</td>
</tr>
<tr>
<td>1993</td>
<td>Freudenau / Austria</td>
<td>6</td>
<td>8,750</td>
</tr>
<tr>
<td>1993</td>
<td>Belleville / USA</td>
<td>2</td>
<td>8,750</td>
</tr>
<tr>
<td>1996</td>
<td>Dayuandu / China</td>
<td>4</td>
<td>9,000</td>
</tr>
<tr>
<td>1997</td>
<td>Feilaixia / China</td>
<td>4</td>
<td>8,600</td>
</tr>
</tbody>
</table>

**Total**  28 units  966 MVA
### Bulb Generator References

Generators with Big Core Length

<table>
<thead>
<tr>
<th>Year</th>
<th>Plant</th>
<th>Nos</th>
<th>Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>Altenwörth / Austria</td>
<td>9</td>
<td>2,550</td>
</tr>
<tr>
<td>1975</td>
<td>Asele / Schweden</td>
<td>1</td>
<td>1,550</td>
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<tr>
<td>1977</td>
<td>Racine / USA</td>
<td>2</td>
<td>1,500</td>
</tr>
<tr>
<td>1981</td>
<td>Vajukoski / Finland</td>
<td>1</td>
<td>1,500</td>
</tr>
<tr>
<td>1987</td>
<td>Kokkosniva / Finland</td>
<td>1</td>
<td>1,580</td>
</tr>
<tr>
<td>1990</td>
<td>Kurkiaska / Finland</td>
<td>1</td>
<td>1,580</td>
</tr>
<tr>
<td>1991</td>
<td>Pak Mun / Thailand</td>
<td>4</td>
<td>1,600</td>
</tr>
<tr>
<td>1992</td>
<td>Ybbs (unit 7)</td>
<td>1</td>
<td>1,500</td>
</tr>
<tr>
<td>1992</td>
<td>Jing Nan / China</td>
<td>2</td>
<td>1,500</td>
</tr>
</tbody>
</table>

Total 22 units 838 MVA
## Bulb Generator References

Generators with Heavy Rotor Weight

<table>
<thead>
<tr>
<th>Year</th>
<th>Plant</th>
<th>Nos</th>
<th>Weight (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>Altenwörth / Austria</td>
<td>9</td>
<td>151</td>
</tr>
<tr>
<td>1977</td>
<td>Racine / USA</td>
<td>2</td>
<td>158</td>
</tr>
<tr>
<td>1981</td>
<td>Greifenstein / Austria</td>
<td>9</td>
<td>143</td>
</tr>
<tr>
<td>1987</td>
<td>Kokkosniva / Finland</td>
<td>1</td>
<td>130</td>
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<tr>
<td>1988</td>
<td>Oberaudorf / Germany</td>
<td>2</td>
<td>129</td>
</tr>
<tr>
<td>1990</td>
<td>Kurkiaska / Finland</td>
<td>1</td>
<td>141</td>
</tr>
<tr>
<td>1991</td>
<td>Pak Mun / Thailand</td>
<td>4</td>
<td>137</td>
</tr>
<tr>
<td>1993</td>
<td>Freudenau / Austria</td>
<td>6</td>
<td>146</td>
</tr>
</tbody>
</table>

Total 34 units 1,268 MVA
Bulb Reference

KARKAMIS / Turkey

Installed capacity: 209 MVA, Contract: 1996

Scope of Performance:

- LEADER OF CONSORTIUM
- OVERALL RESPONSIBILITY for
  - Project Financing
  - Civil Works & Hydraulic Steel Structure
  - Electrical Equipment
  - Mechanical Equipment

Supplies:

- BULB TYPE GENERATORS
- STEP UP TRANSFORMERS
- HV SWITCHYARD
- EXCITATION-, PROTECTION- & CONTROL SYSTEM
- BALANCE OF PLANT EQUIPMENT
- Installation, Commissioning and Commissioning Coordination
KARKAMIS / Turkey
The power plant is located on the Euphrates River in the southeastern part of Turkey, approximately 80 km from Gaziantep, the district capital, near the Syrian border.

A consortium under the lead of VA TECH HYDRO got the contract to built this project on a Turnkey basis under the guidelines of the bilateral protocol between Turkey and Austria. The power plant commenced operation in December 1999 after 43 months of construction work, more than 1 month ahead of schedule. The project consists of a powerhouse, a spillway system with gates and two earthfill dams.

The scope of supply of VA TECH HYDRO included six Bulb generators, three Main Transformers, Protection-Excitation and Control Systems, Generator Switchgear, 154 kV Switchyard as well as other balance of plant equipment.

Technical data:
- Output: 34.8 MVA
- Voltage: 9.0 kV
- Speed: 88.2 rpm
- Stator diameter: 7,500 mm
YBBS / Austria

Ybbs Persenbeug in Lower Austria was built from 1954 to 1959 and was the first hydroelectric station on the river Danube in Austria. The two powerhouses (north and south) were equipped with three vertical shaft Kaplan-turbines each having a weir system in the middle and a double ship lock beside. In the 1990’s one additional unit was included while the power station was fully operable. The seventh unit is the largest Bulb-turbine installation in Europe with a maximum output of 55 MW and it has all advantages of a state of the art low head installation.

VA TECH HYDRO supplied major parts of the turbine and the generator of this large unit. Today this is a classic example of increasing the efficiency of already existing power plants.

Technical data:
- Output: 48.5 MW / 55 MVA
- Voltage: 8 kV
- Head: 12.1 m
- Speed: 75 rpm
- Runner diameter: 7,500 mm
- Stator diameter: 8,750 mm
LAMBACH / Austria

This power station is located on the river Traun near Linz in Upper Austria and features the latest development of VA TECH HYDRO’s low head equipment including two Bulbturbine /Generator units of the BULB 2000 design.

The BULB 2000 is a very efficient solution for low head power stations developed for medium-size power plants with further simplification and reduction of auxiliary equipment including generator cooling system.

For this reason the overall efficiency of the units is very high and the investment cost could be reduced drastically thus offering a very feasible solution for run-off river power stations.

VA TECH HYDRO supplied the entire electro-mechanical equipment including hydraulic steel structures for this plant.

Technical data:
Output: 8 MW / 10 MVA
Voltage: 6.3 kV
Head: 8 m
Speed: 150 rpm
Runner diameter: 3,600 mm
Stator diameter: 4,500 mm
WEINZOEDL / Austria

Straflogenerator
Experience
Weinzoedl / Austria

Location: Styria

\[ D_G = 6,660 \text{ mm} \]
\[ n = 150 \text{ rpm} \]
\[ S = 9.5 \text{ MVA} \]
2 units

Contract Year: 1980

ONE OF THE LARGEST STRAFLOGENERATORS WORLDWIDE!