JSC “Afrikantov OKBM” Activities in the Field of NPP Pump Equipment

As a result of over 50-year activities in the field of nuclear reactor plants designing for nuclear industry and nuclear power engineering JSC “Afrikantov OKBM” has accumulated a vast experience in designing, mastering fabrication technologies, production, installation, adjustment, repair, in-service maintenance, and upgrading of equipment and its main components, including pump units.

Delivery of pumps and pump spare parts to NPPs and Nuclear Power Systems (NPS)

- Main circulation pumps for stationary NPPs
- Main circulation pumps for propulsion NPS
- Electric pumps for oil and gas industry
- NPP-shared system pumps
NPP Main Circulation Pumps

High quality of main circulation pumps designed by JSC "Afrikantov OKBM" is proved by more than 30 years of operation.

- Operation period of main circulation pumps TsNN-3, 4 for BN-350 reactor exceeds 120,000 hours.
- Operation period of main circulation pumps TsNN-8, 9 for BN-600 reactor is 200,000 hours.
- Operation period of main circulation pumps TsVN-8 for NPP with RBMK reactor exceeds 100,000 hours.
- Operation period of shaft seal assemblies in RBMK MCP is 30,000 hours, and their upgrade in BN MCP has increased their lifetime up to 50,000 hours.
TsVN-8 Main Circulation Pumps for RBMK-1000 Reactor Plant

- Continuous coolant (water) circulation in the boiling channel reactor circuit
- No leaks of pumped fluid into the environment through application of the shaft hydrodynamic end seal
- Reliable operation of the hydrostatic bearing (operated in pumped medium) in startup, transient and emergency modes
- Successful operation at NPPs since 1979 with average operation period of 6,600 hours per year
- A total of 110 pumps supplied to NPPs

Main Circulation Pumps for BN-600 and BN-800 Sodium-Cooled Reactor Plants

- Continuous coolant (sodium) circulation in primary and secondary systems of fast neutron reactor plants
- Reliable sealing of internal pump cavities from the environment through application of shaft hydrodynamic end seals
- Feasibility of smooth variation of pump characteristics in various reactor plant modes
- Reliable and accident-free operation at NPPs since 1970 with annual average operation period of 8,100 hours
- A total of 24 pumps supplied to NPPs

<table>
<thead>
<tr>
<th>Pump output flow, m³/h</th>
<th>BN-600</th>
<th>BN-800</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MCP-1</td>
<td>MCP-2</td>
</tr>
<tr>
<td></td>
<td>9,700</td>
<td>8,000</td>
</tr>
<tr>
<td>Head, m</td>
<td>95</td>
<td>52</td>
</tr>
<tr>
<td>Temperature of pumped medium, °C</td>
<td>380</td>
<td>322</td>
</tr>
<tr>
<td>Electric motor power, kW</td>
<td>3,400</td>
<td>1,500</td>
</tr>
<tr>
<td>Assigned lifetime, h</td>
<td>57,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Assigned service life, year</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Weight, t</td>
<td>120</td>
<td>65</td>
</tr>
</tbody>
</table>

MCP-1 for BN-800 RP
Canned Pumps for Ship-Based Nuclear Power Systems

More than 1000 canned electric pumps were manufactured and supplied for NPS of cargo and passenger vessels.

The canned pumps designed by JSC "Afrikantov OKBM" are highly reliable that is proved by their successful operation as part of marine nuclear power systems (NPS).

Maximum operation period and service life (150,000 hours and 30 years, respectively) were achieved during operation of primary system main circulation electric pumps as part of icebreaker Arktika NPS.

Main Circulation Pumps for CEFR Reactor Plant

- Implementation of main joints designs proved by long-term operation as a part of BN-600 pumps
- Complete control of rotation speed from 15 to 100% to ensure reactor operation modes
- No ingress of the cooling water into the sodium cavity through air cooling of the top cover and the shaft

Four main circulation pumps of primary and secondary systems were manufactured and supplied for CEFR experimental reactor plant.

<table>
<thead>
<tr>
<th>Pump output flow, m³/h</th>
<th>MCP-1</th>
<th>MCP-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, m</td>
<td>855</td>
<td>570</td>
</tr>
<tr>
<td>Temperature of pumped medium, °C</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Electric motor power, kW</td>
<td>160</td>
<td>110</td>
</tr>
<tr>
<td>Assigned lifetime, h</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Assigned service life, year</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Weight, t</td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

MCP-2 for CEFR RP

Canned Pump for KLT-40 RP

Canned Pumps for Ship-Based Nuclear Power Systems

4

4

4

4

4
Electric Pumps for Oil and Gas Industry

The pumped medium is neutral, aggressive and harmful liquids of all hazard classes as per GOST 12.1.007. The parameters of the mains are: 380 V voltage and 50 Hz frequency. The pumps can be used for pumping of media with other parameters as agreed with the customer.

Advantages of canned pumps produced by JSC “Afrikantov OKBM”:
- High operating reliability
- National production facilities
- Field technical support during operation
- Possibility of technical examination and extension of assigned reliability indices [lifetime and service life]

The main parameters of electric pumps designed for petrochemical industry and ready to be released to production are given in the Table.

Development and manufacturing of pumps with the parameters required by the customer is feasible.

<table>
<thead>
<tr>
<th>Output flow, m³/h</th>
<th>Head, m</th>
<th>Temperature of pumped medium, °C</th>
<th>Power, kW</th>
<th>Weight, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN 50/250</td>
<td>50</td>
<td>400</td>
<td>330</td>
<td>4700</td>
</tr>
<tr>
<td>GEN 170/190-03</td>
<td>50</td>
<td>125</td>
<td>44</td>
<td>900</td>
</tr>
<tr>
<td>GEN 10/40</td>
<td>12</td>
<td>45</td>
<td>170</td>
<td>2950</td>
</tr>
</tbody>
</table>

The table and images show the specifications and visual examples of the pumps.
Pumps for production of liquefied natural gas (LNG)

JSC “Afrikantov OKBM” develops cryogenic pumps (CP) for production of liquefied natural gas (LNG). In the nearest future it is planned to develop a test facility base — cryogen test facility — to test Russian equipment of LNG production. It is necessary for tests of main process equipment, materials, and for certification which will be used at LNG production plants.

Now only three similar testing complexes are available in the world in the USA and in Japan.

JSC “Afrikantov OKBM” Pumps for NPP-Shared Systems

Since 1995, plant-shared system pumps have been delivered to NPP units based on experience gained by JSC “Afrikantov OKBM” during designing of main circulation pumps.

Within the framework of the Long-term Action Program for Rosatom State Corporation (2009-2015), JSC “Afrikantov OKBM” has developed the Program of Designing and Manufacturing of Pump Equipment for Plant-Shared Systems which covers development of new designs and mastering of manufacturing of pump equipment for operating NPPs and NPPs under construction.

Plant-Shared System Pumps Supplied to Russian NPP Power Units

BN 3800-20 Booster Pump

- Supplies feed water within PTA 3750-100 turbine unit of VVER-1000 power units
- Designed to replace PTA 3800-20 booster pumps at NPPs with VVER-1000 reactors

Since 2001, 7 pumps have been manufactured and delivered to Kalinin, Novovoronezh, Balakovo, Volgodonsk NPP power units and as reserve stock of Rosenergoatom Concern.

APEA 250-75 Emergency Feed Pump

- Ensures emergency cooling of channel reactor power units
- Designed to replace PE 250-75 pumps at NPPs with RBMK-1000 reactors

In 2003, the pilot pump was delivered to reserve stock of Rosenergoatom Concern.

<table>
<thead>
<tr>
<th></th>
<th>CP 268/205</th>
<th>CP 40/400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumped medium</td>
<td>LNG</td>
<td>ethane</td>
</tr>
<tr>
<td>Medium temperature at pump inlet, °C</td>
<td>-154</td>
<td>-40...+26</td>
</tr>
<tr>
<td>Volumetric capacity, not less than, m³/h</td>
<td>268</td>
<td>40</td>
</tr>
<tr>
<td>Head, not less than, m</td>
<td>205</td>
<td>400</td>
</tr>
<tr>
<td>Power, not less than, kW</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>Aggregate mass, t</td>
<td>4.9</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Output flow, m³/h

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, m</td>
<td>3,800</td>
</tr>
<tr>
<td>210</td>
<td></td>
</tr>
</tbody>
</table>

Output flow, m³/h

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, m</td>
<td>250</td>
</tr>
<tr>
<td>780</td>
<td></td>
</tr>
</tbody>
</table>
**Artesian (TsVA) and Semi-submersible (PPN) Pumps for NPPs with VVER-100 RPs**

The pumps of safety classes 3 and 4 of seismic resistant design are intended to pump sea and fresh water in NPP equipment cooling systems, process water supply systems and drainage systems.

JSC “Afrikantov OKBM” supplied 86 units of artesian type pumps and 46 units of semi-submerged type pumps for Leningrad NPP-2, Baltic NPP and Belarusian NPP.

<table>
<thead>
<tr>
<th>TsVA 1700-67</th>
<th>TsVA 1200-45</th>
<th>TsVA 2700-20</th>
<th>TsVA 360-35</th>
<th>TsVA 130-20</th>
<th>PPN 160-29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output flow, m³/h</td>
<td>1,700</td>
<td>1,200</td>
<td>2,700</td>
<td>360</td>
<td>130</td>
</tr>
<tr>
<td>Head, m</td>
<td>67</td>
<td>45</td>
<td>19.5</td>
<td>34.5</td>
<td>22</td>
</tr>
<tr>
<td>Power, kW</td>
<td>500</td>
<td>250</td>
<td>250</td>
<td>75</td>
<td>18.5</td>
</tr>
<tr>
<td>Height from the support flange, mm</td>
<td>5,980</td>
<td>6,080</td>
<td>5,138</td>
<td>9,215</td>
<td>(13,350)</td>
</tr>
<tr>
<td>Discharge nozzle diameter, mm</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>Assigned lifetime until overhaul, h</td>
<td>105,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service life, year</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Submersible and Semi-submersible Pumps for NPPs**

- Pumping of highly contaminated liquids, aggressive and corrosive media
- Designing of shaft sealing assemblies and cable to ensure reliable motor sealing
- Main parts contacting the pumped medium made of austenitic corrosion-resistant steel

<table>
<thead>
<tr>
<th>Submersible</th>
<th>Semi-submersible</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPN 2/25</td>
<td>TsPN 2/25</td>
</tr>
<tr>
<td>TsPN 2/50</td>
<td>TsPN 100/25</td>
</tr>
<tr>
<td>GEN 16/30</td>
<td></td>
</tr>
</tbody>
</table>

| Output flow, m³/h | 2 | 2 | 2 | 100 | 25 | 25 |
| Head, m | 25 | 25 | 50 | 25 | 20 | 30 |
| Depth of immersion, m | 0.64 | 3 | 3 | 3 | 20 | 20 |
| Electric motor power, kW | 2.2 | 2.1 | 2.9 | 20 | 4 | 5 |
| Electric motor weight, kg, not more than | 150 | 78 | 88 | 300 | 120 | 260 |
| Service life, year | 50 | 50 | 50 | 50 | 50 | 50 |

Since 2002, JSC “Afrikantov OKBM” has manufactured and delivered over 150 semi-submersible and submersible pumps to NPPs.
AtsNSB 150-110 Emergency Boron Injection Pump

The pump is designed to inject boric acid solution from the emergency storage tank into the primary system of VVER-1000 NPPs in emergency modes associated with primary system cooldown. The safety class is 2.

<table>
<thead>
<tr>
<th>Nominal output flow, m³/h</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal head, m</td>
<td>980</td>
</tr>
<tr>
<td>Working temperature at the pump inlet, °C</td>
<td>10-95</td>
</tr>
<tr>
<td>Power in the nominal mode (at pumped medium density of 1,020 kg/m³), kW, not more than</td>
<td></td>
</tr>
<tr>
<td>— pump power</td>
<td>685</td>
</tr>
<tr>
<td>— unit power</td>
<td>715</td>
</tr>
</tbody>
</table>

TsNR 800-230Т Emergency Cooling Down Pump

The pump is designed to inject boric acid solution into the primary system of VVER-1000 NPPs to remove heat from the core under normal/abnormal operation conditions and in emergency modes. The safety class is 2.

<table>
<thead>
<tr>
<th>Nominal output flow, m³/h</th>
<th>800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal head, m</td>
<td>230</td>
</tr>
<tr>
<td>Working temperature at the pump inlet, °C</td>
<td>10-150</td>
</tr>
<tr>
<td>Power in the nominal mode (at pumped medium density of 1,005 kg/m³), kW, not more than</td>
<td></td>
</tr>
<tr>
<td>— pump power</td>
<td>635</td>
</tr>
<tr>
<td>— unit power</td>
<td>665</td>
</tr>
</tbody>
</table>
Artesian Pumps for Tyanwan NPP

- Sea or fresh water supply to cooling systems of critical and non-critical utilities (diesel-generators intermediate cooling loop, flushing system for rotary meshes, drainage systems)
- Radial bearings operated in pumped medium to ensure stable pump operation with suspended (including solid) matter in the pumped medium up to 1.6 kg/m²
- Hydraulic section and outlet casing materials with a special galvanic protection system to facilitate prolongation of casing parts service life up to 40 years
- Main parts contacting the pumped medium made of austenitic corrosion-resistant steel with maximum corrosion resistance in sea water

Artesian and Semi-submersible Pumps for Kudankulam NPP

- Pumping of sea or fresh water
- Shaft drive designed to ensure up to 20,000 pump startups per year (each 20 min.) and electric motor service life over 12 years
- Main parts contacting the pumped medium made of austenitic corrosion-resistant steel with maximum corrosion resistance in sea water

Since 2002, JSC “Afrikantov OKBM” has manufactured and delivered 57 artesian pumps to two power units of Tyanwan NPP.

In 2004–2005, 32 artesian pump equipment units and 5 semi-submersible pumps were designed, manufactured and delivered to Kudankulam NPP.
Shaft End Seals for NPP Pump Equipment

Within the framework of NPP system pump equipment upgrade, design documentation for end seals and servicing systems was developed, and the following pilot samples were manufactured and delivered to NPPs:

- PTA 3750-75 feed pump of VVER-1000 power units (groove seal replacement)
- PEA 850-65 feed pump of VVER-440 power units (gland seal replacement)
- PEA 1650-75 feed pump of RBMK-1000 power units (groove seal replacement)
- PEA 250-75 emergency feed pump of RBMK-1000 power units (gland seal replacement)

Artesian pumps

<table>
<thead>
<tr>
<th>Output flow, m³/h</th>
<th>TsVA 20-30</th>
<th>TsVA 20-30/1</th>
<th>PPN 2/25-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, m</td>
<td>30</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Height from the support flange, mm</td>
<td>3,900</td>
<td>5,650</td>
<td>450</td>
</tr>
<tr>
<td>Electric motor power, kW</td>
<td>7.5</td>
<td>7.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Assigned lifetime, h</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>Service life, year</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>465</td>
<td>510</td>
<td>92</td>
</tr>
</tbody>
</table>

Semi-submersible pumps

<table>
<thead>
<tr>
<th>Output flow, m³/h</th>
<th>TsVA 20-30</th>
<th>TsVA 20-30/1</th>
<th>PPN 2/25-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, m</td>
<td>30</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Height from the support flange, mm</td>
<td>3,900</td>
<td>5,650</td>
<td>450</td>
</tr>
<tr>
<td>Electric motor power, kW</td>
<td>7.5</td>
<td>7.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Assigned lifetime, h</td>
<td>30,000</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>Service life, year</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>465</td>
<td>510</td>
<td>92</td>
</tr>
</tbody>
</table>

Upgrade of Pump Equipment of NPP-shared Systems

JSC “Afrikantov OKBM” is upgrading safety system pumps to enhance reliability of bearing assemblies and end seals. In 2005, TsNR-800-230R pump was manufactured, tested and accepted by the interdepartmental commission. Three pump units with the upgraded pumps of this type passed acceptance tests and were delivered to Volgodonsk (Rostov) NPP Unit 2, and one pump was delivered to Balakovo NPP Unit 1.

Thorough upgrade of this pump is performed using units similar to that previously designed by JSC “Afrikantov OKBM” and successfully tested both during on-site operation and operation at JSC “Afrikantov OKBM” test facilities.
JSC “Afrikantov OKBM”
Test Facility Complex

The test facility complex is aimed at solving the strategic task on provision of a test base for production of pump equipment, such as: NPP-shared system pumps and main circulation pumps of BN-800 primary and secondary systems.

Universal Pump Test Facility (UPTF)

The universal pump test facility (UPTF) has been constructed by JSC “Afrikantov OKBM” to carry out full-scale tests of pump equipment for over 60 dimension types (including import-substituting and upgraded equipment) in support of upgrading the operating NPP power units and commissioning of new NPP power units.

The universal pump test facility includes:

- Facility for testing feed and condensate pumps with flow rates from 500 to 4,500 m³/h
- Facility for testing condensate, main-line and feed pumps with flow rates from 200 to 1,200 m³/h
- Facility for testing condensate, feed and safety system pumps with flow rates from 20 to 250 m³/h
- Facility for testing artesian pumps of hydraulic facilities with flow rates from 120 to 3,500 m³/h
To date, 23 pump dimension types have been designed and are being manufactured.

### UPTF Main Technical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>ST-1873</th>
<th>ST-1874</th>
<th>ST-1875</th>
<th>ST-1867</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test facility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow rate range, m³/h</td>
<td>500÷4,500</td>
<td>200÷1,200</td>
<td>20÷250</td>
<td>120÷3,500</td>
</tr>
<tr>
<td>Design pressure, MPa</td>
<td>4</td>
<td>6</td>
<td>20</td>
<td>0.5</td>
</tr>
<tr>
<td>Maximum temperature</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>of working medium, °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage, V</td>
<td>6,000</td>
<td>6,000/380</td>
<td>6,000/380</td>
<td>6,000/380</td>
</tr>
<tr>
<td>Electric motors</td>
<td>400÷2,000</td>
<td>250÷80/110÷200</td>
<td>500÷800/19÷200</td>
<td>250/18.5÷132</td>
</tr>
<tr>
<td>consumed power, kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total electric power</td>
<td>2,100</td>
<td>850</td>
<td>850</td>
<td>260</td>
</tr>
<tr>
<td>Circuit volume, m³</td>
<td>60</td>
<td>45</td>
<td>42</td>
<td>100</td>
</tr>
<tr>
<td>Test facility weight</td>
<td>130,000</td>
<td>36,000</td>
<td>18,000</td>
<td>100,000</td>
</tr>
<tr>
<td>kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working medium</td>
<td>Domestic or distilled water</td>
<td>Domestic water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test facility height</td>
<td>8÷10</td>
<td>20÷22</td>
<td>20÷22</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test facility area, m²</td>
<td>1,200</td>
<td></td>
<td></td>
<td>600</td>
</tr>
</tbody>
</table>

### UPTF Test Facilities for Pumps of NPP-Shared Systems

**Artesian Pumps Test Facility**

Pump testing at ST-1874 test facility

General view of ST-1867 test facility

General view of ST-1867 test facility with TWA type pump
Test Facility for BN-800 Reactor Plant Pumps

ST-1477 test facility was constructed to perform integrated full-scale water tests of MCPs of BN-800 primary and secondary systems.

- Test representativeness achieved through water testing that excludes the need for expensive and fire-hazardous test facilities to perform sodium tests of BN-800 pumps
- Integrated testing of MCP electric drives under actual loading conditions in various operation modes