PHOSPHATE PROCESSING TECHNOLOGIES
Unlock Potential, Create Value
Tenova TAKRAF is an integrated solutions provider to the global mining, bulk material handling, minerals processing and beneficiation industries, offering innovative technological solutions as well as process and commodity knowledge along the industry value chains. With the integration of the well-known DELKOR and, more recently, the Tenova Advanced Technologies (formerly Bateman Advanced Technologies) brand of products into TAKRAF, our portfolio for the mineral processing and beneficiation sectors has been considerably enhanced.

Tenova Advanced Technologies offers differentiated, project-specific process technologies based on decades of research, equipment design and project execution. Solutions offered include expertise in mineral beneficiation, solvent extraction for hydrometallurgical processing, electro-winning, in-house R&D facilities, and complementary processes.

At its core, Tenova Advanced Technologies offers phosphate beneficiation process development and proprietary technologies for the purified phosphoric acid industry, both complemented by in house laboratory and pilot plant facilities.

**VALUE CHAIN: PHOSPHATE**
PHOSPHATE BENEFICIATION

Tenova Advanced Technologies provides the full suite of technologies for the beneficiation of phosphate rock. Project services ranging from process development through feasibility studies to turnkey projects are available for:

- Sedimentary and igneous ore types
- Carbonaceous and/or siliceous gangue
- Terrestrial and marine deposits
- Low grade phosphates
- High impurity phosphates
- Reclamation of phosphate from tailings

Tenova Advanced Technologies specializes in crushing, grinding, size, magnetic and gravity separations, flotation as well as thermal and chemical beneficiation, thickening and filtration.

Our team of specialists also offers beneficiation process development for a range of minerals such as base metals, industrial and heavy minerals.

RESEARCH AND DEVELOPMENT

Tenova Advanced Technologies has an in-house laboratory and pilot plant facilities for solvent extraction, purified phosphoric acid and mineral beneficiation test work. The R&D facility is well equipped to handle a wide range of phosphate ore types with its wet and dry beneficiation laboratories and modern analytical technology.
Tenova Advanced Technologies provides the full suite of technologies required for the production of phosphoric acid from phosphate rock and wet process phosphoric acid, including the solvent extraction stages, acid purification and concentration, and to produce high quality food or technical grade phosphoric acid. The data acquisition during the process development stage is continuously monitored and improved to ensure reliable plant design information.

- Pre-treatment – impurity removal such as sulphates, cadmium, fluorides and arsenic
- Purification – using proprietary solvent extraction processes and selection of the optimal solvent for the purification stage
- Post-treatment – bringing the product to its final specification through concentration, solvent recovery and the reduction of total organic carbon

Recently, Tenova Advanced Technologies has developed processes for producing food and technical grade purified phosphoric acids from Low Grade Phosphates (<22% P₂O₅ and 2.5% Fe₂O₃) and Sewage Sludge Incinerator Ash (15 to 20% P₂O₅ and 10 to 15% Fe₂O₃). The latter process is designed to reclaim phosphate value from urban wastes.

Over the years, Tenova Advanced Technologies has cultivated a comprehensive step-by-step approach to project development, ensuring fulfillment of the project requirements client specifications and successful delivery of the project.

<table>
<thead>
<tr>
<th>PROJECT/ENGINEERING STAGES</th>
<th>DEVELOPMENT STAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scoping Study &amp; Pre-Feasibility</td>
<td>Need</td>
</tr>
<tr>
<td>Feasibility</td>
<td>Laboratory</td>
</tr>
<tr>
<td>Definitive Feasibility</td>
<td>Pilot</td>
</tr>
<tr>
<td></td>
<td>Demonstration</td>
</tr>
<tr>
<td></td>
<td>Design, Supply &amp; Construction</td>
</tr>
<tr>
<td></td>
<td>Commissioning &amp; Start-up</td>
</tr>
</tbody>
</table>

PROCESS GUARANTEE & MECHANICAL WARRANTY
SELECTED PROJECTS

PHOSPHATE BENEFICIATION

- **MOSAIC FERTILIZER LLC**
  Ona Phosphate, Florida
  Process development high MgO ore

- **AFRIG SA**
  Phosphate Project, Senegal
  1Mtpa concentrator, Process development

- **COMINCO RESOURCES**, Hinda Phosphate Project, Republic of Congo
  4.0M tpa concentrator
  Process development (lab & pilot)
  Ore variability study, Pre-feasibility study

- **MA’ADEN PHOSPHATE COMPANY**, Al Jalamid and Umm Wu’al Projects, Kingdom of Saudi Arabia
  4.5M tpa and 5.0M tpa concentrators
  Process development (lab & pilot)
  Basic engineering & FEED

- **NAMIBIAN MARINE PHOSPHATE**, Sandpiper Project, Namibia
  3.0M tpa concentrator
  Process development (lab & pilot)
  Pre-feasibility study
  Basic engineering, Definitive feasibility study

- **ARAFURA RESOURCES**, Nolans Bore Project, Australia
  0.5M tpa concentrator
  Process development (lab & pilot)
  Basic engineering

- **VINACHEM**, Lao Cai Apatite Project, Vietnam
  1.7M tpa concentrator Process review
  Development Basic Engineering Package

- **BOFAL**, Mauritania
  1.0M tpa concentrator
  Process development (lab & pilot), Basic engineering
  Bankable feasibility study

PURIFIED PHOSPHORIC ACID, PHOSPHATE PROCESSING

- **NIRMA LTD**, India
  Food grade PPA 21,000tpa (P₂O₅) from rock/HCl
  Process development (lab & pilot)
  feed stock selection
  Basic engineering & FEED SX, design & supply

- **GUJARAT Alkalies and Chemicals LTD**, India
  Food grade PPA 21,000tpa (P₂O₅) from rock/HCl
  Process development (lab & pilot)
  feed stock selection
  Basic engineering & FEED, SX design & supply

- **MA’ADEN, Wa’ad Al Shamal**, Kingdom of Saudi Arabia
  Food grade PPA 50,000 tpa (P₂O₅) from WPA
  Process development (lab & pilot)
  Basic engineering & FEED, SX design & supply

- **WENGFU PHOSPHATES**, China
  Food grade PPA 100,000 tpa (P₂O₅) from WPA
  Process development (lab & pilot)
  Basic engineering & FEED, SX design & supply

- **EUROCHEM KARATAU**, Kazakhstan
  Phosphate chemical complex process selection study