



# OUTOTEC® BIOX® PROCESS

Outotec® BIOX® is a robust, easy to operate and sustainable technology for the treatment of refractory gold concentrates. The process is especially suitable for remote locations. The BIOX® process can operate over a wide range of feedstock characteristics and can be customised to suit the specific requirements of each project. The BIOX® process has a proven track record with over 30 years of commercial operating experience.

BIOX® plant design utilizes robust, energy efficient equipment to ensure consistent process performance. The simplicity of the process and the design ensures low capital cost, ease of operation and high operator safety.

Value-adding features are the HiTeCC and ASTER™ enabling technologies and full range of service offering and knowledge transfer.

## BENEFITS

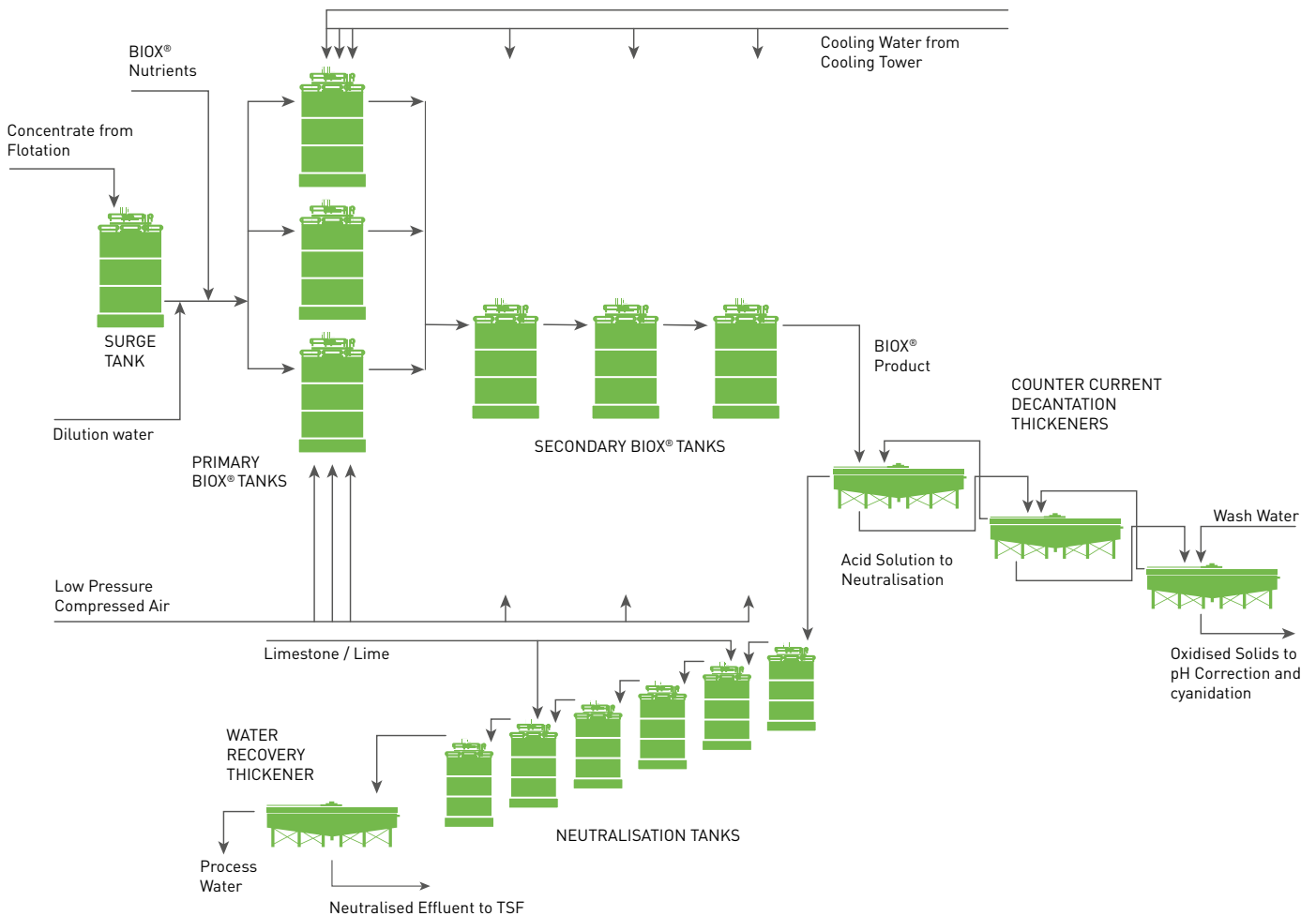
- Improved rates of gold recovery
- Reduced capital cost
- Long track record of commercial operation and ongoing process improvement
- Robust technology that is suited to remote locations
- Environmentally friendly



# TREATMENT SOLUTION FOR A WIDE RANGE OF REFRACTORY SULPHIDES

The Outotec BIOX® process, for the treatment of refractory gold concentrates, has been in commercial operation for over 30 years with 13 successful BIOX® plants commissioned worldwide. To date, over 25 million ounces of gold have been produced through BIOX®.

BIOX® process is especially suitable for remote locations by virtue of the simplicity of operation and scalability of the technology using the modular design. Commercial BIOX® plants operate at treatment capacity within the range of 20 to 2137 tons per day of flotation concentrate, in various climate zones.



Bespoke BIOX process design is developed for each project and can be configured to treat a wide range of sulphur concentrate grades.

### Wide range of concentrate feed material

- Refractory and high arsenic sulphides (pyrite, arsenopyrite, pyrrhotite)
- Preg-robbing sulphides (in package with HiTeCC process)
- Gold-copper sulphides
- Uranium containing sulphide concentrates

### Ongoing R&D and process improvement

The BIOX<sup>®</sup> design has evolved over the years with incorporation of the knowledge and experience from every project into the design of the latest BIOX<sup>®</sup> plant. Generation III BIOX<sup>®</sup> design philosophy launched during 2013 focussed on delivering an improved process robustness and ease of operation.

The Generation IV BIOX design include the use of the latest state of the art agitation and aeration systems to effect a step-change lower in the capital and operating cost structure of the process. The new MesoTherm process utilises a combination of mesophile (40 degC) bacteria for the primary oxidation stage followed by thermophile (65 degC) bacteria for the secondary oxidation stage, to lower the cyanide consumption following biooxidation.



### Sustainability

BIOX<sup>®</sup> process meets the standards set by current environment protection legislation. Approval for application of BIOX<sup>®</sup> process has been obtained from environment protection agencies of a number of countries including the USA, Ghana, Brazil, New Zealand and Australia known as the countries with utmost strict environment protection legislation.

## SUMMARY OF COMMERCIAL BIOX<sup>®</sup> OPERATIONS

MINE	COUNTRY	CONCENTRATE TREATMENT CAPACITY [TPD]	REACTOR SIZE [m <sup>3</sup> ]	DATE OF COMMISSIONING	CURRENT STATUS
Fairview	South Africa	62	340 <sup>a</sup>	1986	Operating
Saõ Bento	Brazil	150	550	1990	Decom <sup>c</sup>
Harbour Lights	Australia	40	160	1991	Decom <sup>c</sup>
Wiluna	Australia	158	480	1993	C&M <sup>b</sup>
Obuasi	Ghana	960	900	1994	C&M <sup>b</sup>
Coricancha	Peru	60	262	1998 (2010)	C&M <sup>b</sup>
Fosterville	Australia	211	900	2005	Operating
Suzdal <sup>e</sup>	Kazakhstan	520	650	2005 / 2010	Operating
Bogoso	Ghana	820	1500	2007	C&M <sup>b</sup>
Jinfeng	China	790	1000	2007	Operating
Kokpatas <sup>f</sup>	Uzbekistan	2138	900	2009 / 2011	Operating
Agnes <sup>g</sup>	South Africa	20	60	2010	C&M <sup>b</sup>
Runruno	Philippines	404	1300	2016	Operating

<sup>a</sup> The volume of the two primary reactors at Fairview.

<sup>b</sup> Care and maintenance

<sup>c</sup> Decommissioned

<sup>e</sup> Plant Capacity expanded from 196 to 520 tpd in 2010.

<sup>f</sup> Plant Capacity expanded from 1069 to 2138 tpd in 2011.

<sup>g</sup> Demonstration scale plant.



BIOX® process solubilises and oxidizes the arsenic in the BIOX® reactors. BIOX® process effectively stabilizes arsenic into ferric arsenate - the chemical precipitate recognized by the US EPA as the best available technology for this application.

### Robust Technology

The BIOX® process can operate under a wide range of climatic conditions; from the tropics to the Arctic, from dry arid regions to rain forests, from sea level to high altitudes. The Corricancha BIOX® plant is located 3000m above sea level in the Andes Mountains in Peru.

The plant design can be modified to suit any climatic conditions with extreme cold and hot temperatures. The BIOX® process generates exothermic heat, which makes it possible to operate at temperatures below -47 °C without external heating. This has been confirmed by the operation of the Suzdal BIOX® plant in Kazakhstan where temperatures below -40 degC is encountered for extended periods during winter.

The BIOX® bacterial culture has been adapted to high arsenic concentrations. The Corricancha BIOX® plant in Peru treated a concentrate with an arsenic grade of 26 %.

### BIOX® Users Group

Every licensed user of the BIOX® technology becomes a member of the BIOX® Users Group. The objective of the Users Group is to promote communication and interaction between the different BIOX® plants as well as interaction with the BIOX® team. All the members meet every second year, usually at the most recent BIOX® plant, to give feedback on the progress and major achievements at each operation. The areas for future development and research are also identified and discussed.

## BIOX® PROJECT DEVELOPMENT FRAMEWORK

PHASE	REQUIREMENTS	DURATION	RESULTS
BIOX® BATCH AMENABILITY TESTING	7 - 12 kg concentrate	3 - 4 months	Detailed report with: <ul style="list-style-type: none"> <li>• Rate of oxidation</li> <li>• Gold recovery vs oxidation</li> <li>• Order-of-magnitude reagent consumptions</li> </ul>
ORDER OF MAGNITUDE AND PRE-FEASIBILITY STUDY	Treatment rate Concentrate grade Unit cost data	2 months	<ul style="list-style-type: none"> <li>• Conceptual flow diagram</li> <li>• Preliminary equipment list</li> <li>• Order-of-magnitude capital and operating cost estimates</li> </ul>
BIOX® PILOT PLANT RUN	Testwork agreement 150 kg / 650 kg concentrate	6 months	Detailed report with: <ul style="list-style-type: none"> <li>• Design parameters</li> <li>• Reagent consumptions</li> <li>• Operating strategy</li> </ul>
PROCESS DESIGN DEVELOPMENT	Process design development	2 months	Process design package containing: <ul style="list-style-type: none"> <li>• Process design specifications</li> <li>• Mass and heat balance</li> <li>• Flow diagrams</li> <li>• Valve and instrument diagrams</li> <li>• Equipment list</li> <li>• Detailed equipment specifications</li> </ul>
ENGINEERING DESIGN, CONSTRUCTION AND COMMISSIONING	Engineering design, construction and commissioning		<ul style="list-style-type: none"> <li>• Approval of mass balance, process flow diagrams and valve and instrument diagrams</li> <li>• Bacterial inoculum</li> <li>• Operating manual</li> <li>• Operator training</li> <li>• Plant commissioning</li> </ul>
POST-COMMISSIONING OPTIMIZATION AND AUDITS			<ul style="list-style-type: none"> <li>• Ongoing technical support</li> <li>• Structured process of plan optimization</li> <li>• Regular scheduled technical audits aimed at process improvement</li> </ul>

**For further information on BIOX® please get in touch at [BIOX@outotec.com](mailto:BIOX@outotec.com)**

Outotec develops leading technologies and services for the sustainable use of Earth's natural resources. Our 4,000 top experts are driven by each customer's unique challenges across the world. Outotec's comprehensive offering creates the best value for our customers in the mining, metal, energy, and chemical industries. Outotec had sales of approximately EUR 1.3 billion in 2018, and its shares are listed on NASDAQ Helsinki.  
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