

# VERIFICATION STATEMENT

## GLOBE Performance Solutions

Verifies the performance of

### Cyanide-Free Gold Extraction Process

Developed by Dundee Sustainable Technologies Inc.  
Theftord Mines, QC, Canada

Registration: **GPS-ETV\_VR2019-06-30**

In accordance with

**ISO 14034:2016**

**Environmental Management —  
Environmental Technology Verification (ETV)**



John D. Wiebe, PhD  
Executive Chairman  
GLOBE Performance Solutions

June 30, 2019  
Vancouver, BC, Canada



Verification Body  
GLOBE Performance Solutions  
404 – 999 Canada Place | Vancouver, B.C | Canada | V6C 3E2

## Performance claim(s)

- i. Sulfide removal of at least 99.5% from a refractory gold bearing pyrite concentrate;
- ii. Extraction of gold contents from a refractory gold bearing pyrite concentrate through Dundee Sustainable Technologies' proprietary chlorination process and recovery by deposition on silica, with an average yield of at least 80.6%, while the average yield using the cyanide extraction methodology was at least 71.2%.

ETV verification of test results conclude that the chlorine method produces a gold extraction greater than 76.5%, which is statistically greater than the yield of 71.2% generated by the cyanide method. The mean extraction observed was 80.6% with 95% confidence limits that ranged between 77.2% and 84.0%.

## Technology description and application

Dundee Sustainable Technologies Cyanide-Free Gold Extraction Process is a proprietary technology to extract gold from ores, concentrates, or tailings without using cyanide and without leaving acid generating solid residues. This technology pre-treats gold bearing pyrite ores or concentrates in a fluidized bed roaster to oxidize sulfur to eliminate the production of acid generating rock waste. Gold is extracted from the pre-treated ore or concentrate using a proprietary chlorination method followed by gold recovery via deposition on silica. This technology is based on established scientific and technical principles in the field of chemistry and metallurgy.

The technology incorporates two processes. The first process which is related to Performance Claim #1 involves exposure of the gold bearing pyrite ore to a high temperature to oxidize the sulfide content of the ore to sulfur dioxide gas that can then be captured by a scrubber. This process removes sulfur, the primary agent responsible for acid generation of the extracted ore, rendering the sulfur content of the residue to less than 0.3 % p/p which allows the solids to be classified as non-acid generating residue.

The second process uses the oxidized sample prepared under Performance Claim #1 and exposes this material to chloride brine containing a low percentage of bromine that acts as a catalyst to the extraction procedure (halogenated brine solution). The gold dissolves from the oxidized ore into the chloride brine solution. The chloride brine solution with dissolved gold (pregnant mother liquor) is then mixed with silica sand and the oxidation/reduction potential of the liquor is lowered causing the dissolved gold to precipitate onto the silica sand. Once dried, the silica sand is heated and the molten gold is collected.

An important component of Performance Claim #2 is the comparison of the mean percent gold extracted and recovered using the Cyanide-Free Gold Extraction Process technology to the mean percent gold extracted and recovered using the industry standard cyanide extraction process. It should be noted that both processes (e.g., Chlorine and Cyanide) utilized a "split-sample", meaning that identical samples were compared using the two processes. This allowed a direct comparison of the gold extraction and recovery to be made between the Cyanide-Free method and the standard Cyanide method.

## Performance conditions

Performance test sampling for this verification was conducted at a 12 tpd (tonne per day) demonstration plant in Thetford Mines, Quebec, Canada and was supervised by Mr. Patrick Héroux, EIT, of STS Canada Inc. Sample collection was carried out in accordance with the test protocol developed by STS Canada. Samples were submitted for analysis to SGS Canada – Mineral Services – Lakefield, an accredited laboratory which conforms with requirements of CAN-P-1579, CAN-P-4E (ISO/IEC 17025:2005).

During this gold extraction pilot project, in order to maintain a high level of extraction efficiency, the chlorination requires content of < 0.5% sulphur. As some of the raw materials that feed into the Dundee extraction technology may contain levels of sulphur content up to 30-40% or greater, pre-treatment is required.

In this case, at the Demonstration plant, pre-treatment of raw materials employs a standard process of oxidation of sulphides using a fluidized bed called a "roaster". In the high temperature fluidized bed (~ 800°C), the ore concentrate is calcined which will feed the chlorination process. The resulting gases generated by this oxidation reaction (primarily SO<sub>2</sub>) will be treated or recovered before being emitted into the atmosphere.

## Verification

This verification was first completed in 2016 by the Verification Expert, *Centre for Alternative Wastewater Treatment (CAWT)* at The Sir Sandford Fleming College of Applied Arts and Technology in Lindsay, Ontario, contracted by GLOBE Performance Solutions. The original verification was completed using the Canadian ETV Program's General Verification Protocol (June 2012) and taking into account ISO/FDIS 14034:2015(E). This ETV renewal is considered to meet the equivalency of an ETV verification completed using the International Standard *ISO 14034:2016 Environmental Management – Environmental Technology Verification (ETV)*.

The data and information provided by Dundee Sustainable Technologies Inc. to support the performance claims included the following:

- 1) Sampling Campaign Report prepared by STS Canada
- 2) Sampling Procedures for chlorination process input and output
- 3) Compilation of oxidation results (MS Excel format)
- 4) Compilation of Leach Fusion Results (MS Excel format)

## What is ISO 14034:2016 Environmental management – Environmental technology verification (ETV)?

ISO 14034:2016 specifies principles, procedures and requirements for environmental technology verification (ETV) and was developed and published by the *International Organization for Standardization (ISO)*. The objective of ETV is to provide credible, reliable and independent verification of the performance of environmental technologies. An environmental technology is a technology that either results in an environmental added value or measures parameters that indicate an environmental impact. Such technologies have an increasingly important role in addressing environmental challenges and achieving sustainable development.

### For more information on the Cyanide-Free Gold Extraction Process please contact:

Dundee Sustainable Technologies Inc.  
3700, rue du Lac-Noir  
Thetford Mines, QC  
G6H 1S9 Canada  
Tel: 418.423.7247 / Fax: 581.679.0711  
info@dundeetechnologies.com  
www.dundeetechnologies.com

### For more information on ISO 14034:2016 / ETV please contact:

GLOBE Performance Solutions  
404 – 999 Canada Place  
Vancouver, BC  
V6C 3E2 Canada  
Tel: 604-695-5018 / Toll Free: 1-855-695-5018  
etv@globepperformance.com  
www.globepperformance.com

### Limitation of verification - Registration: GPS-ETV\_VR2019-06-30

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