

Sustainable Industrial Processing Summit & Exhibition

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SIPS



STARKEY INTERNATIONAL SYMPOSIUM

<http://www.flogen.org/sips2016/starkey.php>

SUMMARY:

Consulting – Served mining industry as a Consulting Engineer since 1989.
Operations – Held senior positions in operating mines/mills. Kidd Creek, Inco.
Milling – Designed new and expanded process plants for Kilborn and Kvaerner.
Mining – Designed and assessed mining methods and costs for new ore zones.
Studies – Managed/worked on gold, base metal, and industrial mineral projects.
Testwork Supervision - Flowsheet development for all types of ores/processes.
Fieldwork – Argentina, Bolivia, Brazil, Canada, Chile, Greece, Ireland, Russia, Kazakhstan, Liberia, Mauritania, Mexico, Namibia, Tasmania, Turkey, USA
Grinding – Well known as inventor of the SPI, and the Standard Autogenous Grinding Design (SAGDesign), and SAG Variability (SVT) Tests.

EXPERIENCE:

July 2000 to Present

President and Principal Consulting Engineer, Starkey & Associates Inc.

Grinding Design & Process Engineering. Startup services. Due diligence. Clients: Acadian Mining, Agnico, Aker Solutions, Amec, Ammtec, Apogee, ArcelorMittal, Aurora Energy, Avalon, Avion, Barrick, Bluenote Mining, Claude Resources, Dawson Met Lab, Detour Gold, Fluor, Freeport, Hatch, Hecla, High River Gold, Hudbay, INCO, Irgiredmet, Kinross, Metso, Minorex, New Millenium Resources, Norilsk, Oromin, Outotec, Phelps Dodge, Placerdome, Plenge, Polymetal, Polyus Gold, Probe, SNC-Lavalin, SRK, TOMS, Troy Mine, Vale, Xstrata Cu, XPS.

Developed the SAGDesign Test for commercial use and formed the SAGDesign Consulting Group (Starkey, Dawson, Outotec) in 2002. Starkey directs the work and designs the mills, 11 labs do the testwork, patented by Outotec (2004).

Projects completed: Over 150 grinding mill design projects from 2004 to 2015.

- Design mills - Lakeshore Gold, Probe, Lalor, Alexandrovskoe, Beleya Gora.
- Design process for iron concentrator (Hasancelibi) in Turkey for Hatch, 2011.
- Design t/h & mills for Frieda River, Papua New Guinea. SAGDesign method.
- Design mills for Bozshakol. Compared results with others to settle dispute.
- Design mills for Fedorova (Barrick). Hard ore could not be designed by others.
- Due diligence review of three plants for Polyus Gold 2008-9. Olympiada.
- Design grinding mills for Fortune Minerals NICO Project in the NWT 2008.
- Design grinding mills for Norilsk projects, Bistrinskoe, 2008.
- Review SPI grinding data and mill design for 4 Xstrata projects, 2008.
- Assess expansion of Acadian Mines Pb Zn plant from 1500 to 2500 t/d.
- Lead mill engineer for AK's BHPB Olympic Dam Expansion Project team.
- Design Berezitovy lead & zinc flotation circuit for Au tails. Capex and opex.
- Designed new grinding mills for Phelps Dodge Climax Moly Project, 2007.
- Check capacity of Bluenote Cariboo mills. Design new SAG mill, 2007.
- Design/move/build Berezitovy Au mill for Amur (High River) Gold, 2006.

- Designed mills for 160,000 t/d New Millennium Resources, LabMag Project.
- Designed grinding circuit for expansion of Mineral Park Project, 40,000 t/d.
- SRK due diligence team, reviewing Noranda Canadian Ni assets for Chinese.
- Reviewed operation of AG mills at IOC for Hatch expansion project.
- Re-start of renovated copper mill for Troy Mine in Montana.
- SAGDesign testing/design: Gurupi, and St Andrew, greenfield projects.
- Designed SAG/ball grinding circuit for PJV (Placerdome) project, Timmins. Layed out drill holes, selected core, supervised test work, designed mills.
- Studied the effect of pebble crushing on the Clarabelle SAG Mill, INCO.
- SNC Lavalin; select equipment for Voisey's Bay; Rosia Montana study.
- Process design review for expansion of a copper mine and mill in Tasmania.
- SRK Projects: Cachinal, Magma, Raglan South (BMO), Cerattepe, ECU, Minto, Red Mountain, Rogue, Troy, review metallurgy & NSR for Estrades.

1994 to 2000

Consultant / Manager, Minnovex Technologies Inc., Toronto, Ontario

Directed fieldwork to calibrate SPI Test by measuring ore hardness as a function of SAG power in 5 plants. (See paper #5). Assisted in the commercialization of the SPI test. Provided operating logistics and engineering calculations for mill size Vs power draw for CEET software. Site visits for grinding studies and flotation column start-ups. Selected drill core for SPI tests.

- **Raglan.** Picked 192 samples for ore body hardness profile and BM test.
- **TVX Skouries, Greece.** Drill core samples, SAG/ball grinding design.
- **Agnico Eagle Laronde Project.** Designed SAG mill. See paper #8.
- **Endako Mines, BC.** Study of rod ball grinding circuit performance.
- **Lisheen Project, Ireland.** Start-up of 6 flotation columns (Pb, Zn).
- **BHP Escondida, Chile.** SAG benchmark grinding studies.
- **Phelps Dodge Candelaria, Chile.** SAG benchmark grinding studies.
- **Anglogold Navachab Mine, Namibia.** Samples & SAG benchmark study.

1994 to 1998

Consultant / Supervising Process Engineer, Kvaerner Metals, Toronto, ON

Concurrently with Minnovex, worked on feasibility studies, training junior engineers on the team, supervision and start-up projects as noted below.

- **Baley Gold Project** in Siberia for Armada Gold. Prefeasibility study.
- **Galmoy Lead Zinc Mill, Ireland.** Assisted in the start-up of SAG plant.
- **Kubaka Project, Omolon Gold.** SAG circuit design. See publication #7.
- **Mantua Project** in Cuba. Cu heap leach pilot plant. Gossan Au heap leach.

1992 to 1994

Consulting Engineer, Oakville, ON

Assignments prior to joining Kvaerner included:

- **Holt-McDermott** - Aug. '94. Studied effect of adding a screen to the SAG mill discharge. Costs/benefits were calculated. Report was submitted before leaving site. Screen was added and t/h increased by 50%.
- **Iron Ore Company of Canada** - Feb./July '94. Labrador City. Completed material balance for the Carol Mill. Drew as-built flowsheets. Ways to increase recovery and reduce costs were found. See publication #3.
- **Minnovex** - Dec. '93. Operated column flotation pilot plant at Cobre, NM to clean copper. The work resulted in the sale of a column.
- **Campbell Mine** - Aug. '93. Studied Red Lake crushing plant. Report was submitted on site. Tonnage was increased by 25% within two months.
- **Iron Ore Project** - May '92 to Aug. '93. Spent 1 year overseas for Davy Canada setting up labs, training staff and developing an iron ore quality prediction system. Used new SAG Test. *This ore hardness profile data became the basis for a Joint Venture with Minnovex re: the SPI test.*

1989 to 1992

President, Applied Ore Testing Inc., Oakville, ON

Completed feasibility study and arranged financing for the laboratory and pilot plant. During startup, the 2 kg Starkey SAG test (now SPI) was invented by JS.

- **Taseko Mines Ltd.** - Laboratory study of Cu/Au flotation of Fish Lake ore. Gold recovery was improved by 23 percentage points and copper by 3%.
- **Kilborn Limited** - Pilot plant testing of backfill preparation for Ashanti Goldfields. Lab flotation, cyanide leaching, grinding tests were also done.
- **INCO Limited** - Pilot plant dry grinding of 5 tonnes of smelter product.
- **Cyanamid Canada** - Development of standard laboratory flotation procedures on Kidd Creek ore to evaluate alternate reagents.
- **Royal Oak Mines** - Pilot SAG milling of Pamour ore. Done as a SAG mill startup and to test the recycle water from unique tailings system.

1977 to 1989

Senior Metallurgist, Kilborn Limited, Toronto, ON

Top level of technical staff. Responsible for process design, flowsheets, equipment sizing and specification, bid analysis; layout review, slurry and water piping systems and P&ID's, for workability. Prepared reports. Also involved in start-ups and consulting work. Plants worked well and started up on time (often under budget). These goals were achieved by avoiding errors during design.

Major Kilborn clients and their projects are listed below:

- **Stewart Lake Resources '89** - Kirkham Graphite Project for mining and milling on a cottage lake. Project Manager for feasibility study.
- **Lac Minerals '88** - Williams Mine. Started up SAG/Ball circuit.
- **INCO Metals '88** - Shebandowan Project. Studied feasibility of converting nickel mill for gold flotation and cyanide leach processing.
- **NovaGold Resources '87** - Feasibility of vat cyanide leaching of gossan ore.
- **Campbell Red Lake Mines '81 & '86** - Expanded to 1100 then 1250 TPD by adding a new grinding/gravity circuit. CIP circuit on tails also added.
- **Carlson Mines '85** - James Bay Kaolin Project. Feasibility study for mining, processing, transport and sale of Kaolin and Silica products.
- **Rio Algom Limited '84** - East Kemptville Tin Project. Prefeasibility and final engineering. Sized grinding mills and defended choice before a panel.
- **Denison Quintette Coal Project '83/84.** Supervised all process plant design. Spent 60 days on site as part of the start up team.
- **Imperial Oil '77** - Gays River Project. New grass roots lead/zinc plant. Prepared equipment spec's, chose equipment and did layout/piping design.

1974 to 1977

Lecturer, Laurentian University, Sudbury, ON

Set up and taught evening courses in Mineral Processing / Mining Engineering.

1974 to 1977

Mine Engineer, INCO Limited, Copper Cliff, ON

At Levack, staff of 40, layout, surveying, incentive bonus, production planning.

1971 to 1974

Section Leader, INCO Limited, Copper Cliff, ON

Responsible for production metallurgy with a staff of 6 engineers and technicians.

1965 to 1971

Chief Metallurgist, Kidd Creek Concentrator

Responsible for production improvements, supervision of tin recovery pilot plant.

1964 to 1965

Research Engineer, Ontario Research Foundation, Rexdale, ON

Process engineer for AG and SAG pilot plant projects for A. MacPherson (client)

1961 to 1964

Plant Metallurgist, Kam Kotia Porcupine Mines Ltd.

Responsible for plant metallurgy and development of a new Zn recovery circuit.

EDUCATION: BAsc., 1961, Mining Engineering, University of Toronto

PROFESSIONAL: Harbour Award, U of T, for volunteer teaching, and Gull Lake Survey Camp restoration committee 2010-11.
Canadian Mineral Processors Board of Directors, Member 2007 to present.
Past Chair and member of CMP Board of Directors, 2006.
Chair, Canadian Mineral Processors, 2005. Division of CIM.
1st Vice-Chair Canadian Mineral Processors, 2004. (Technical program).
Art MacPherson Award, 2004 “for significant contributions to comminution”
Chair, CMP Toronto Branch, 2002-3. Current member of Toronto CMP Board.
Certificate of Authorization, Professional Engineers Ontario, 1989 (present).
Designated as a Consulting Engineer by PEO, 1989.
Member Canadian Institute of Mining and Metallurgy.

PUBLICATIONS: * Denotes principal author with other co-authors

31. *An Investor’s Perspective on Best Practices in SAG Mill Sizing.* By Spencer Reeves, John Starkey, and Keith Abergel. Presented PROCEMIN 2015 in Santiago, Chile, October 2015.
30. *Tenth Anniversary of SAGDesign Testing: Production Successes and Development.* * By John Starkey, Jenna Hedderson, Spencer Reeves and Michel Brissette. Presented at SAG Conference 2015 in Vancouver, Canada, September 2015.
29. *Achieving Design Production at Start-up Using Best Practices – Fact or Fiction?* Keynote presentation at ICCO 2015 in San Luis Potosi, Mexico, August 2015.
28. *New Project in Russia With Semiautogenous Mill; Selected According to the Results of SAGDesign Testing.* By Arkady Y. Senchenko, Yury V. Kulikov and John Starkey. Presented at IMPC 2014 in Santiago, Chile, October 2014.
27. *Geometallurgy: New Accurate Testwork to Meet Required Accuracies of Mining Project Development* by M. Brissette, V. Mihajlovic and S. Sanuri. Proceedings of the IMPC 2014 in Santiago, Chile, October 2014. Paper prep. supervised by John Starkey.
26. *Comminution Circuit Design: What Test Work is Required for a Bankable Feasibility Study?* MEI Comminution Conference 2014, Cape Town, S.A. April, 2014.
25. *Design SAG Mill Production When You Need It Most: In Day 1 and Year 1.* * PROCEMIN, Santiago, Chile, October 20, 2013.
24. *SAGDesign – Using Open Technology for Mill Design and Performance Assessments,* PROCEMIN, Santiago, Chile, Nov. 21, 2012.*
23. *Recent International Concentrator Start-ups* – Do’s and don’ts for Effective Grinding Mill Design.* MEI Comminution Conference, Cape Town, S.A. Apr. 2012.
22. *Seeking Consensus – How Many and What tests are Required for a Low Risk SAG mill Design.* SAG Conference, Vancouver B.C. September 2011.
21. *SAG Mill Grinding Design Vs Geometallurgy – Getting it Right For Competent Ores.* * Proceedings of the IMPC XXIV Conference in Brisbane, September 2010.
20. *SAG kWh/t Measured Using a Standard Test – 53 Projects in 6 Years.* MEI Comminution 2010 Conference, Cape Town, S.A. April 2010.
19. *Successful Design of the NICO Grinding Circuit for Unusually Hard Ore.* * Proceedings of the CMP Conference, Ottawa, January 2010.
18. *Impact on Grinding Mill Design of Recent New Discoveries.* * SME Mill Design Workshop, Tucson, AZ September 2009
17. *Impact on Mill Design and Flotation Control of New Discoveries in the Relationship Between Macro and Micro Grindability.* METSOC, Sudbury, Aug. 09.
16. *New Discoveries in the Relationship Between Macro and Micro Grindability.* CIM Conference, Toronto, May 2009
15. *SAGDesign Testing Review - Case Studies.* * See Proceedings of the IMPC XXIV Conference in Beijing, September 2008.

14. *Comparison of Ore Hardness Measurements for Grinding Design for the Tenke Project.** Proceedings of the CMP Conference, Ottawa, January 2007.
13. *SAG Design Testing – What It Is and Why It Works.* SAG Conference, Vancouver, B.C. October 2006
12. *Accurate, Economical Grinding Design Using SPI and Bond.* Proceedings of the IMPC XXII Conference in Capetown, October 2003.
11. *Choosing a SAG Mill to Achieve Design Performance.** Proceedings of the CMP Conference, Ottawa, January 2003.
10. *Grinding of Agrium Phosphate Ore in a 3' Diameter Pilot SAG Mill.** Proceedings of the CMP Conference, Ottawa, January 2002.

9. *Design of the Agnico-Eagle Laronde Division SAG Mill.** SAG Conference, Vancouver, B.C. October 2001.
8. *A Critical Review of SAG Design Procedures.* Presentation given at Comminution 01, Brisbane, Australia, March 2001. (Extended abstract only).
7. *Grinding Circuit Design at Kubaka Using SPI and Bond.** Proceedings of the CMP Conference, Ottawa, January 2001.
6. *Getting More From Drill Core - Preliminary SAG Design.* Randol Gold Forum, Monterey, CA, May 1997.
5. *Getting More Out of Your Drill Core.* Annual Meeting of the CIM, Vancouver, BC, April 1997. (CD ROM Format).
4. *Application of the Minnovex SAG Power Index Test at Five Canadian Plants.** SAG Conference, Vancouver, BC, October 1996.
3. *Water Usage in the Carol Concentrator.* Proceedings of the Canadian Mineral Processors Conference, Ottawa, January 1995.
2. *A New Tool For SAG Hardness Testing.** Proceedings of the Canadian Mineral Processors Conference, Ottawa, January 1994.
1. *Modernization of the Campbell Red Lake Mill in 1986.** Transactions of the CIM Gold Conference, Winnipeg, August 1987.

PRESENTATIONS: ** Denotes unpublished grinding design lecture or seminar, 2000 to 2015

1. *Seminars** SAG and Ball Mill Grinding Design – Current Practice.* ** Professional development course given at Sheridan Park, June 7, 2001
2. *Short Course** Empowering Engineers to Create Comminution Circuits Using Open Patented Technology,* given at CMP in Ottawa, January 20, 2013.
3. *Class Lectures*** At 8 universities; Queen's U; Laurentian U; UBC; Cape Town U; Irkutsk TU; HUT; CSM; Toronto U; Laval U; McGill U.