Metallurgy & Process Design
Develop Ideas; Test; Create Your Product

Concept & Design Development
Bench-Scale Optimization
Pilot Plant Demonstration
Product/Technology Commercialization
New Custom Designed Facility
Conveniently Located in Richmond, BC
Research Facility – 20,000 ft²

- >24 full-time scientists and engineers
Manufacturing Facility – 30,000 ft\(^2\)

- 30 engineers, designers and technicians
> 350 Clients Worldwide

In Mining, Clean Tech, Water Treatment & Environment
One-Stop Shop for your Process Development

**Bench-Scale Studies**
- Product design
- System design
- Proof of Concept
- Flowsheet development
- Scale-up strategies
- Process optimization
- **In-house analytical testing**

**Pilot Plant Demonstrations**
- General design & layout
- Structural & electrical specifications
- Custom modified parts
- Fabrication to specs
- Electrical engineering
- Commissioning
- HAZOP & safety inductions
- Continuous or batch operations
- Responsible waste management
- **In-house analytical testing**
Metallurgy & Process Design

- Scoping Studies
- Flowsheet development
- Unit operation testing
- Pilot Plants
- Bulk sample processing
- Market sample creation
- Integrated in-house analytical support
- Operational support
Mineral Processing

- Crushing, grinding
- Liberation studies
- Particle size distribution
Mineral Processing

- Gravity concentration
- Magnetic separation
Mineral Processing

- Flotation schemes, including locked cycle testing
- Column flotation
- Pilot Plant flotation
Solid Liquid Separation

- Settling
- Vacuum Filtration
- Pressure Filtration

Pilot-Scale Filter Press
Pyrometallurgy

- Smelting
- Roasting
- Reductive roast
Hydrometallurgy

- Leach studies
- Pressure oxidation
- Precipitation & dissolution
Hydrometallurgy

- Solvent extraction batch tests
- Solvent extraction small- & large-scale piloting
- Ion exchange bench-scale & pilot plant demonstrations
- Electrowinning small- & large-scale piloting
Biohydrometallurgy & Environmental

- Bioleaching
- Innovative sulfur-reducing and bacterial reactor designs
- NF and RO pilot plant studies
Gold and Silver Extraction
Cyanide Destruction
Our **Gold & Silver Expertise**: Customized Studies

- Mineral Processing
- Diagnostic Leaching & Preg-robbing
- Cyanide Leaching
- Cyanide Detox
- Non-Cyanide Leachates
- Smelting & Pure Au Recovery
- Electrowinning Circuits
- Carbon Characterization
- Carbon Loading & Stripping
- Carbon Regeneration
- Cyanide Recovery

**Flowsheet Development, Bench-Scale Simulations, Optimization, Scale-Up Studies, Pilot Plant Demonstrations & more**
Carbon Optimization in Gold Circuits

- Carbon Characterization
- Carbon Loading & Stripping
- Carbon Regeneration
Diagnostic Leaching of Au & Ag Ores
Cyanide Leaching of Au & Ag

Cyanide Heap Leaching

Electrowin & Collect Au & Ag

Smelt Au & Ag Doré

Post-Leach Cyanide Detoxification
Cyanide Detox

- Cyanide detox technology for gold producers:
  - $\text{SO}_2$ air/$\text{H}_2\text{O}_2$/ Caro’s Acid processes for cyanide destruction
  - Test work conducted for several major gold producers, leading to plant design
  - Developing technology for use of lower cost catalyst
Bench-Scale Cyanide Detox Optimization
SO₂ Cyanide Detox System Technology: Gas Handling Building

- PCL Oxygen Generators
- Dessicant Drier System
- Kaeser Air Compressors
SO₂ Cyanide Detox System Technology: Liquid SO₂ Control Building
SO$_2$ Cyanide Detox System Technology: Liquid SO$_2$ Storage Tank
Example Projects
From Mine to Product: Lithium Ion Manganese Batteries

Electrolytic Processing for EMD

Mn Mine

MnCO₃

Low Grade Ore

MnO₂

Button Cell Batteries

LiB Cathode

Chemical Oxidation for CMD
### Specialized Flotation Projects

- Pyrite-arsenopyrite separation
- Copper-nickel-cobalt & PGM flotation from ultramafic deposits
- Impact of process solution on lead zinc silver flotation
- Copper and gold flotation from vein deposits
Specialized Flotation Projects

- Carbonaceous matter flotation
- Vanadium shale flotation
- Carbon flotation from e-waste pyrolysis products
- Graphite flotation for battery recycling
- Boric acid flotation from brines
- Sodium carbonate flotation from brines
- Copper and gold flotation from incinerator ash
Kemetco Technology: Bio-Metals
High Rate Biological Sulfide Generator

Two Principle Applications:

- Acid Mine Drainage Treatment
- Cu heap leaching of low grade/end-of-life heaps (replacement for SX-EW)

- 7-12x faster sulfide
- Smaller plant size → lower capital costs
- Use low-cost nutrients → low operating cost

Two images: one of an acid mine drainage and one of a copper heap leaching site.
Biological Methods for Leaching & Mine Drainage Treatment
Process Optimization: H$_2$S recovery
Example Projects

- Numerous projects in Ag, Zn, Cu, Co, Ni & Pb recovery
- Recovery of Ag from refractory ores
- Recovery of Zn from oxide tailings
Example Projects:
Optimizing Co-Ni Separation by SX Bench-Scale Study

Bench-scale loading kinetic testing

- 2 min contact
- 3 min contact
- 4 min contact
Example Projects: Cu-Co-Ni Separation by SX Bench-Scale Study

Loading as a function of pH

pH 1.07  pH 2.08  pH 3.02

CoSO$_4$ and CuSO$_4$ final products
Example Solvent Extraction Projects

- Co, Ni and Ag recovery by SX from spent catalyst
- U-V recovery and separation from ash by SX
- Mo-Fe-Al separation by SX
Example Projects

- Direct LiOH generation from brine by electrodialysis
- Optimization of electrowinning circuits
- Cyanide recovery
- Development of non-cyanide leachants for gold recovery

Bench-scale electrodialysis set-up
Example Projects

- W upgrading technique by desliming and agglomeration
- Reductive roasting of barite and pyrolusite
- Chromite upgrading by gravity separation
- Carbon testing
- Lime testing including slaking rate, ALI and neutralization potential
Clean Technology
Production of Battery-grade \( \text{Li}_2\text{CO}_3 \) & \( \text{LiOH} \)

- Spodumene \( \rightarrow \) Flotation/roasting followed by \( \text{H}_2\text{SO}_4 \) leach

- Brines \( \rightarrow \) purification followed by \( \text{Li}_2\text{CO}_3 \) precipitation

- Brines \( \rightarrow \) purification followed by electrochemical generation of \( \text{LiOH} \)

- \( \text{Li}_2\text{CO}_3 \) conversion to \( \text{LiOH} \)
Battery-Grade LiOH•xH₂O from Brine

Brine concentration by evaporation

Li₂CO₃ from brine

Electrodialysis

LiOH crystallization

Battery-grade LiOH•xH₂O
Vanadium Redox Battery (VRB)

- Redox flow battery
- Bipolar graphite plates for superior electrical conductivity and chemical resistance
- Power Conversion System (PCS) that converts raw DC current into usable AC current while charging and discharging the battery

Single VRB cell
VRB Energy Storage System

VRB pilot: 60 KW

VRP Pilot – electrical & controls panel
Rechargeable Zn-Air Batteries

- Higher capacity through innovative configuration
- Improved cycle life via magnetic enhanced field
- System protection to prevent water loss
Zinc Alkaline Rechargeable Battery

◆ Developed from Dr. Karl Kordesch’s Patent Portfolio with 35 worldwide patents
◆ Smaller Size and Lighter Weight In Comparison to Conventional Lead Acid Battery
◆ Superior charge retention of 7 years (low self discharge)
◆ No memory effect
◆ Environmental superiority
Zinc-Air Battery Prototypes – 50 kWh
Mg – Air Fuel Cell
Lightweight Lead Acid Battery

- 4.5 times higher surface area
- fit into existing battery manufacturing process;
- adapts into the existing lead acid battery recycling system.

Conventional Lead Acid Battery  Battery with EVTP Collector

- 30% less weight (Lead)
- 70% faster in recharge
- 60% more cranking power
- 25% smaller footprint
- Lower cost

Identical Output Comparison - 12 V, 75 Ah Batteries
CO₂ Capture Technology

- Flue gas is captured using a rotary adsorption machine
- CO₂ is selectively adsorbed on proprietary structured carbon adsorbent
CO\textsubscript{2} Electrochemical Reduction Technology

Bench-scale electrochemical cell

Pilot-scale: 100 kg/day CO\textsubscript{2} to formate/formic acid
Kemetco Technology: Neutral Salt
Electrochemical Metal Cleaning Systems

No fumes or spent acid
Kemetco Metal Cleaning Innovations: Over 50 systems in use worldwide

KOREA - SPRING WIRE MANUFACTURE

BAHRAIN - HIGH VOLTAGE POWER CABLE MANUFACTURE

USA - VALVE SPRING WIRE MANUFACTURE

ITALY - FIBRE OPTIC CABLE MANUFACTURE

CANADA - STAINLESS STEEL SCREEN MANUFACTURE

HITACHI - MACHINING WIRE MANUFACTURE
Water Treatment & Environment
Electrochemical Waste Water Treatment
Ultrafiltration, Nanofiltration & Reverse Osmosis Pilot & Commercial Systems

RO bench scale unit

UF and RO commercial system
Bench-Scale Cyanide Detox Optimization
SO₂ Cyanide Detox Commercial System

Liquid SO₂ Building

Liquid SO₂ Storage Tank & Tank Housing
Ammonia Removal from Mining Effluents

IX Column

Automated IX Pilot Trailer Fitted with 6 IX Columns

Control Panel
Biological Mine Drainage Treatment
Kemetco Technology: e-Waste Recovery

Electronic Waste Metals Recovery Technology

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<th>METAL</th>
<th>Fine Powder</th>
<th>Weight %</th>
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<tr>
<td>Zn</td>
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*Gold content: <212 µm*
Scale-up & Pilot Plants
From Flowsheet Design to Pilot Plant

Recovery of Mn from Low Grade Ores
Recovery of Mn from Low-Grade Ores

Pilot Thickener

MnCO$_3$ Precipitation from PLS

Pilot Filtration
Arsenic Removal & Stabilization from Copper Concentrates (Bench-Scale Study)

- Extensive experience with Cu concentrate upgrading & As removal, leading to pilot plant demonstration
Pilot-Scale Demonstration of Arsenic Removal from Copper Concentrate
Bench-Scale Electrochemical Chlorate Generation

Bench-scale sodium chlorate cells

Bench-scale lithium chlorate cell
Pilot-Scale Chlorate Electrochemical Cell
15,000 A System
Calcium Chloride Pilot Plant
Lithium-Ion Battery Recycling Pilot

High Purity NMC and NCA
Products from Recycled Lithium-Ion Batteries
Lithium Carbonate – Boric Acid Pilot Plant
Vat Leaching Circuit
Crystallization
Evaporation Train
Pilot-Scale Flotation
Neutralization Circuit
Lithium Recovery Circuit (partial)