SAMINCO international

Bonne Posma, CEO
Kenny Boles, VP-Market Development

A DRIVING FORCE IN POWER

Our History

1968

Saftronics founded in South Africa

(still in operation)

1976

Saftronics opens in Ontario

(now SAF Drives)

1986

Saftronics opens in New York

(moved to Fort Myers, Florida in 1987 - purchased by Emerson in 2005)

1992

Saminco Incorporates and opens in Florida

2001

Saminco opens in West Virginia

2009

Saminco opens China office

2011

Saminco opens South Africa office

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Our Main Facilities

Ft. Myers, FL

3,500 m^2 (37,674 ft^2)

Manufacturing, Test and Development Facility

Huntington, WV

2,700m^2 (30,000 ft^2)

Service and Training Facility

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Saminco Proving Grounds

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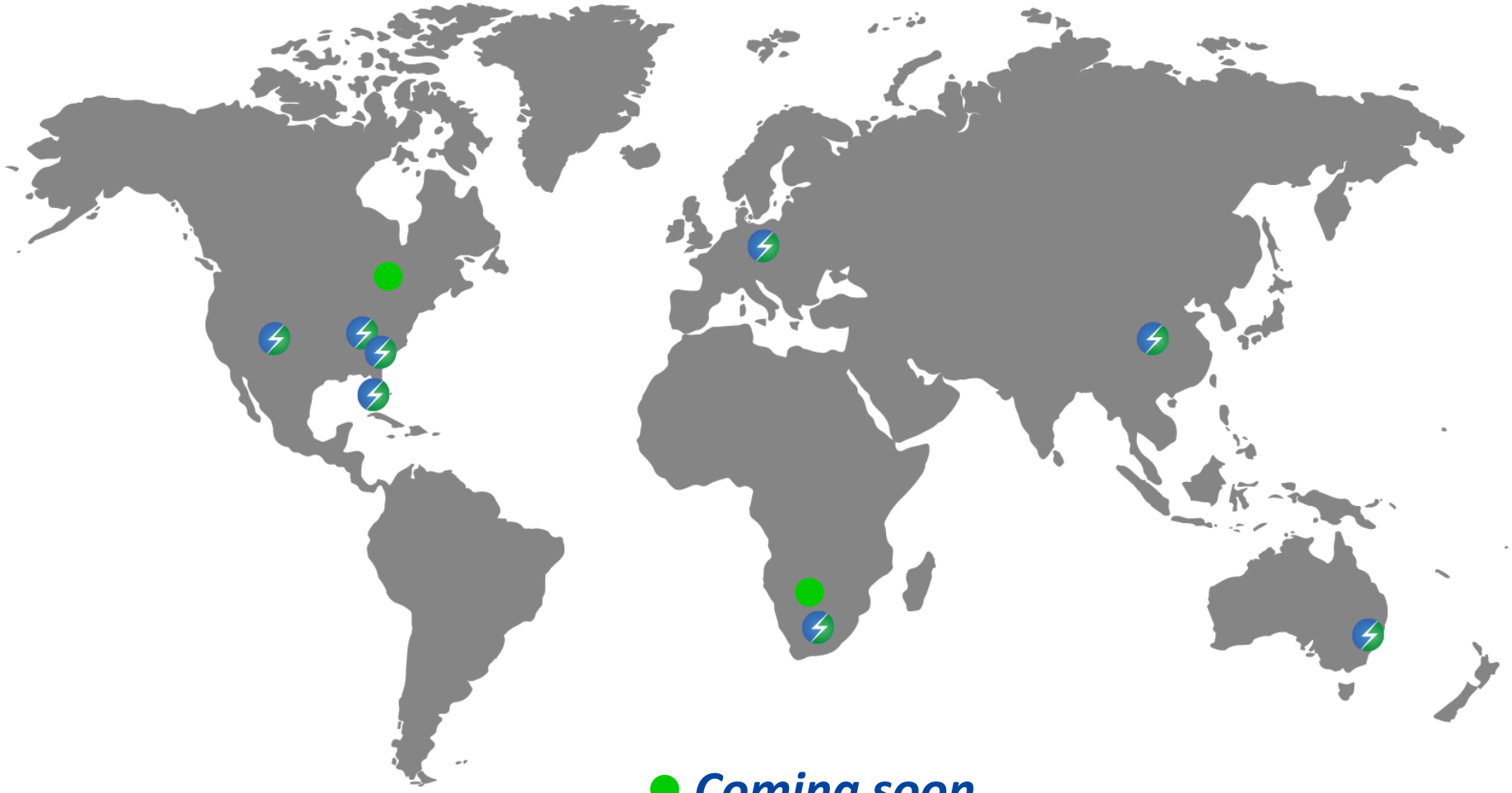
Our Locations



● *Coming soon*

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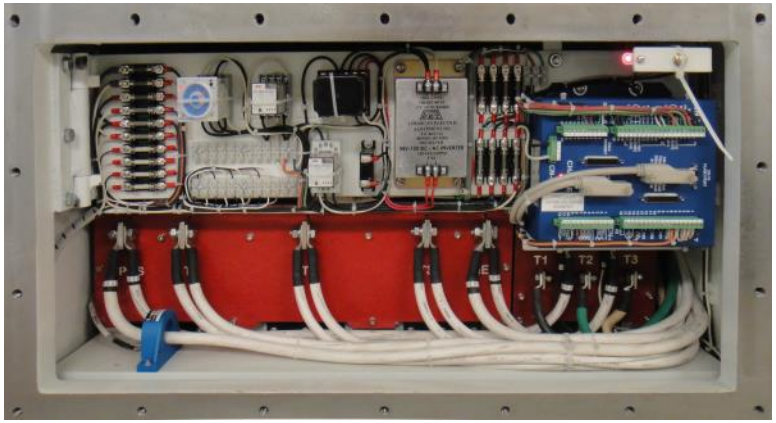
Breakthrough Drive Technology



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Worldwide Customer Base

Joy Global
Caterpillar Global
American
Caterpillar Global Europe
Brookville
Sandvik
Phillips Machine Service
GE Fairchild
Simmons Equipment
Narco
Highland Machinery
CAI
Mankin Equipment
MEI
Irwin Car
Southern Mine Service
Repair King
Auxier Welding
Alpha Natural Resources
Consol Energy
Solvay Chemicals
Alliance Resources
Blackhawk Mining
Murray Energy
Sunrise Coal
Booth Energy
Armstrong Coal
Sasol
Tiandi
Cliffs Resources
Arch Coal
Anglo
Rofomex
Peabody Coal
Prairie State Generating
Agrium
IAMGold
US Silver
and many more…

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Heading into….

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Unrivaled Drive Experience

1. Over (600) 80-360V DC/DC rail equipment traction systems for battery and trolley power
2. Over (400) 180-360V DC/DC traction systems for shuttle cars
3. Over (200) 600V DC/AC VFD systems for shuttle cars
4. Over (50) 480V-630V AC/AC VFD systems for material haulage equipment

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Unrivaled Drive Experience *continued*

5. Over (40) 1,000VAC VFD systems for crushing, conveying and augering equipment
6. Over (40) 80-320VDC VFD's for scoops, coal haulers and shield haulers
7. 2008 - Developed first battery powered LHD system for use in hard rock mining.
8. 2015 - Developed first 630V Sodium Nickel LHD system for use in hard rock mining equipment.

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Saminco Pure Electric System

Not to Scale

A. Traction Drive
B. Precharge Drive
C. Down Chopper
D. MCM
E. On-Board Display
F. Radio Remote Control
G. Handheld Programmer
H. Footswitch
I. Pump Motor
J. Traction Motor
K. Battery Charger

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Battery Electric LHD

Battery Electric Propulsion System with
Reduced Energy Consumption

By Bonne Posma, CEO, Saminco Inc.

Presented at MINExpo2016
Revised 4 October 2016

A DRIVING FORCE IN POWER

Diesel Driven Equipment Has Become a BIG Problem for Operators of Underground Mines



LHD's, Haul Trucks, Mantrips and Locomotives used in mining and tunneling



In order: Atlas Copco-LHD, Caterpillar-Haul Truck and LHD, RDH-Haul Trucks, Sandvik- LHD

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Diesel's Inherent Problems

1. Maintenance of Engine.
2. Transport and Storage of flammable fuel.
3. Inhalation of harmful DPMs (diesel particulate matter)
4. Increased Ventilation requirements.
5. Heat Produced.
6. Turbulence of exhaust stirs up harmful dust.
7. Noise Generated (typical exposure of 105dB necessitates double hearing protection-*see next page*)

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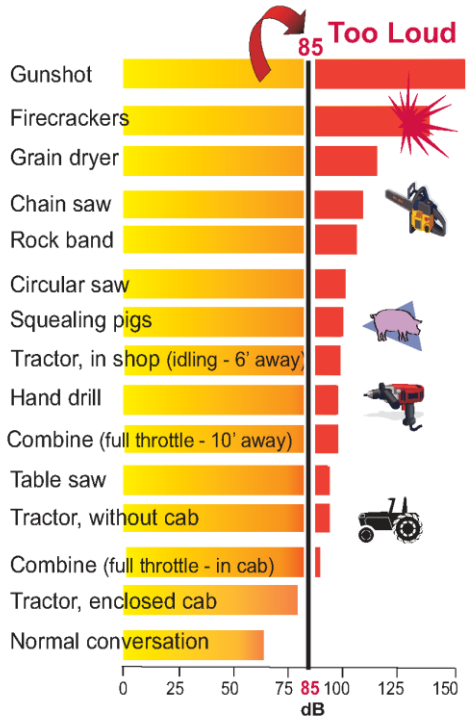
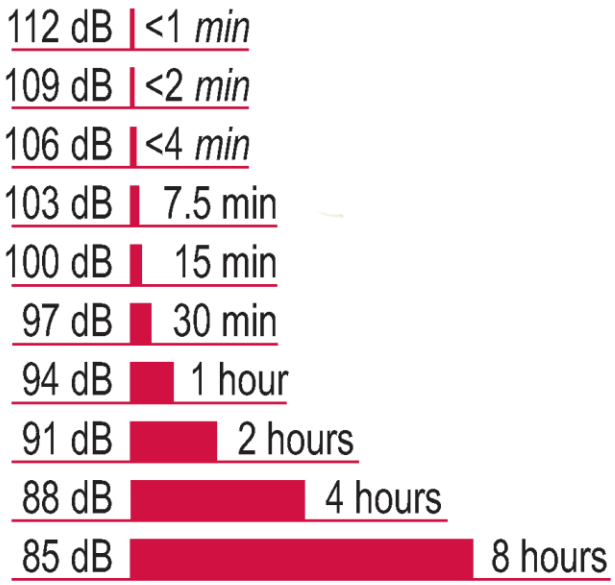
Safe vs. Unsafe Noise Levels



A "decibel" is the unit used to measure the loudness of sound. Decibel levels for each item shown in the graph may vary.

How long it takes for a particular sound level to become dangerous to the human ear.



http://nasdonline.org/static_content/documents/1938/d001885.pdf

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The Diesel Engine's Problems

* http://www.msha.gov/01-995/2006docs/control%20tech.ppt

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The Diesel Engine's Problems

Regulations and Requirements to transport and store flammable fuel in confined spaces underground.

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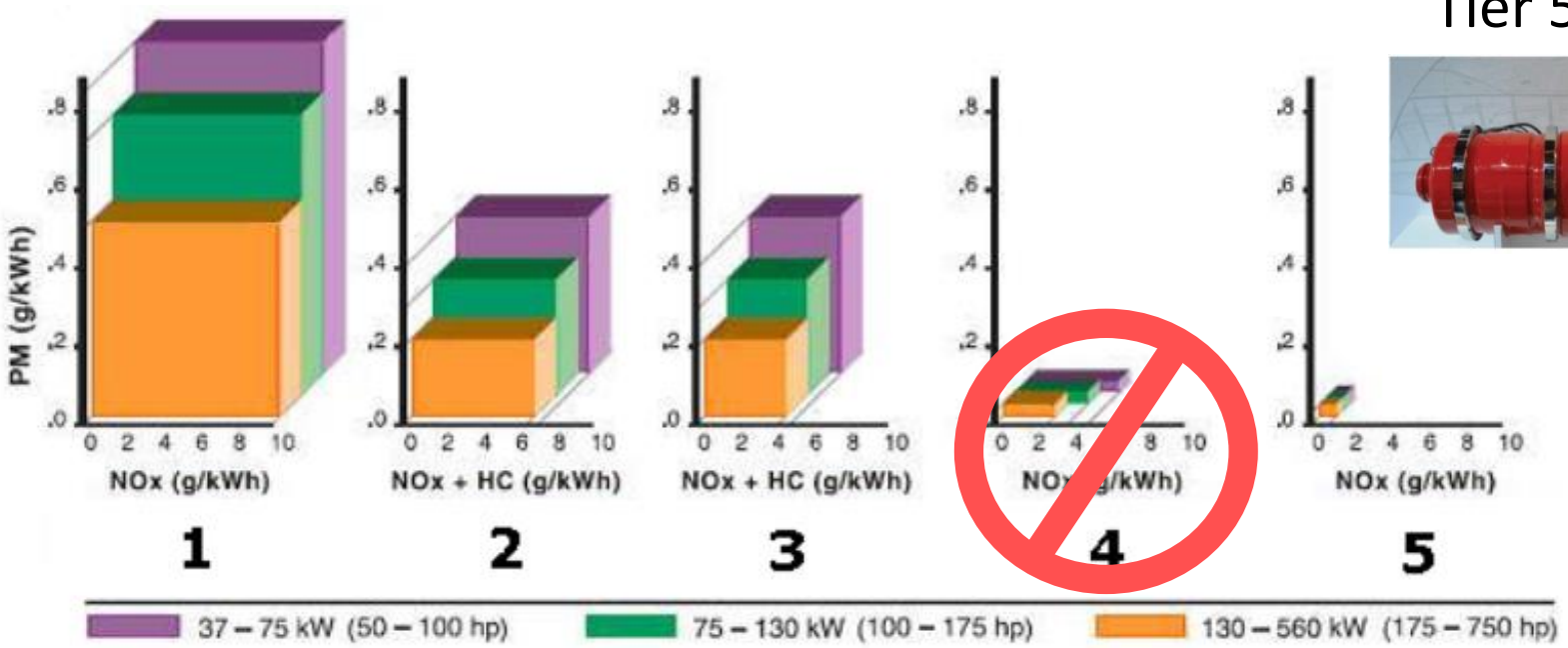
The Diesel Engine Emissions of DPM
Are you prepared to meet Tier 5 filtering?

Tier 5 filter



EPA/EU emissions regulations 37-560 kW, 50-750 hp

Diagram key
y-axis = Particulate matter (grams per kilowatt-hour)

Preparing for future emissions reductions

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The Diesel Engine's Problems

VENTILATION

- Widely used method for DPM control
- DPM reduction proportional to air flow
  - Double air flow = 50% DPM reduction
- Ventilation can be costly

Major upgrades: 16' dia shaft = $1000/ft

Electricity: 250K cfm @ 1" WG = 40 HP

40 HP x 100 hrs/wk @ 10¢/kw-hr = $15K/yr

2x airflow = 8x HP = 8x electricity cost

Q: How much air is enough?

A: Depends on DPM control strategy

* http://www.msha.gov/01-995/2006docs/control%20tech.ppt

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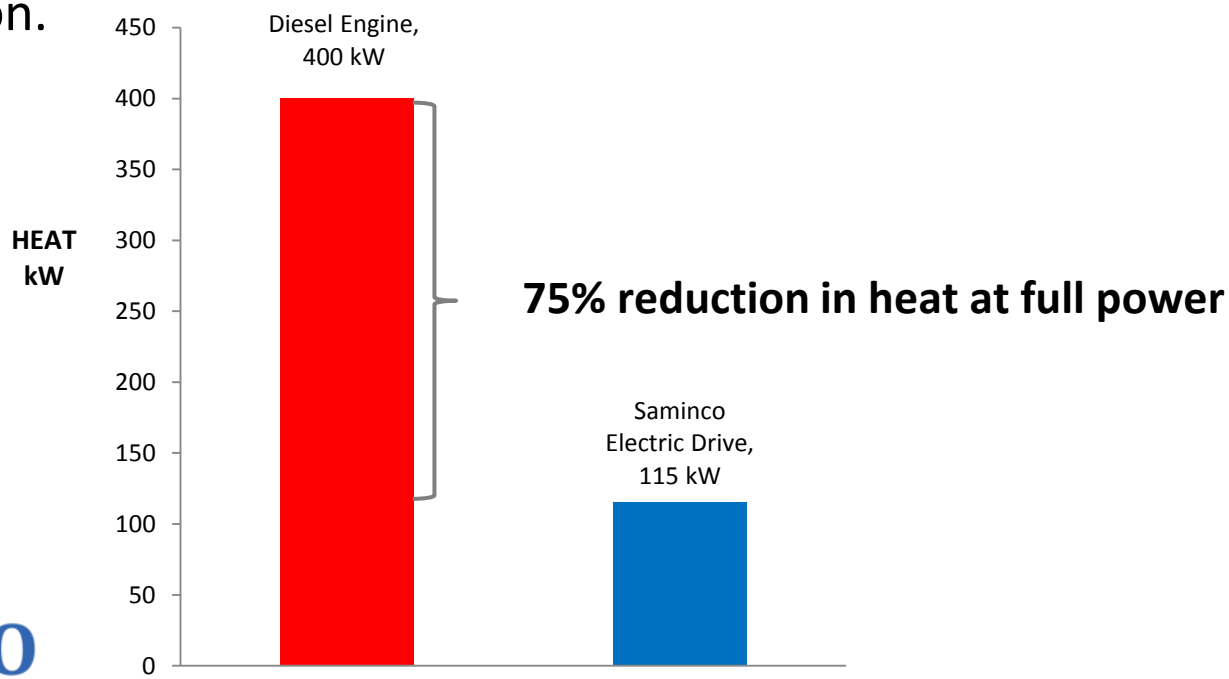
The Diesel Engine's Problems

Heat Generation

- Example LHD used a 98kW diesel engine
  - At full power, this engine will produce 400kW of heat (assuming 25% efficiency).
- The Saminco propulsion system is 90% efficient and at 100kW mechanical output, will produce about 115kW of heat, approximately a 75% reduction.



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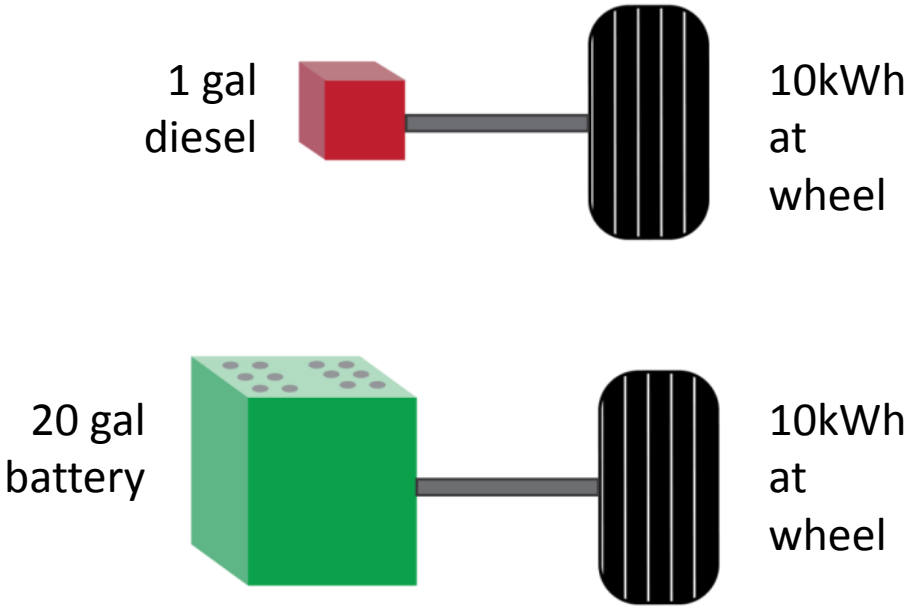
The On-board Energy Challenge

Diesel fuel has 20X the energy density of an advanced Lithium or Molten Salt (SoNick) battery



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Industry Challenges

- Providing sufficient on-board battery energy
- Minimizing energy consumption
- Operating in hot environments (In a typical full muck operation using a diesel powered 6 yd^3 LHD to move 20 loads and perform cleaning during for 45 minutes, the stope temperature increased by 9°C (16°F).

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Development of Existing Traction System For Battery-Electric LHD's

Present designs are based on the common diesel engine/torque converter/3 speed transmission/ drive shaft/Dana axle unit power trains. The engine also powers the hydraulic pump.

Existing battery-powered LHD's simply replaced the diesel engine with a battery-powered inverter driving a large electric motor coupled to the existing mechanical power transmission train. The electric motor also powers the hydraulic pump.

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Development Of Existing Traction System For Battery-Electric LHD's *continued*

This configuration wastes precious battery energy during idling since the electric motor must operate like a diesel engine at a minimum speed to keep the hydraulic system ready.

Moreover, the diesel engine must be revved up to provide sufficient hydraulic power during bucket operation, and the same applies to this electric motor drive system.

Other losses:

- Lights, controls and warning devices
- Cooling systems for motors, drives and batteries

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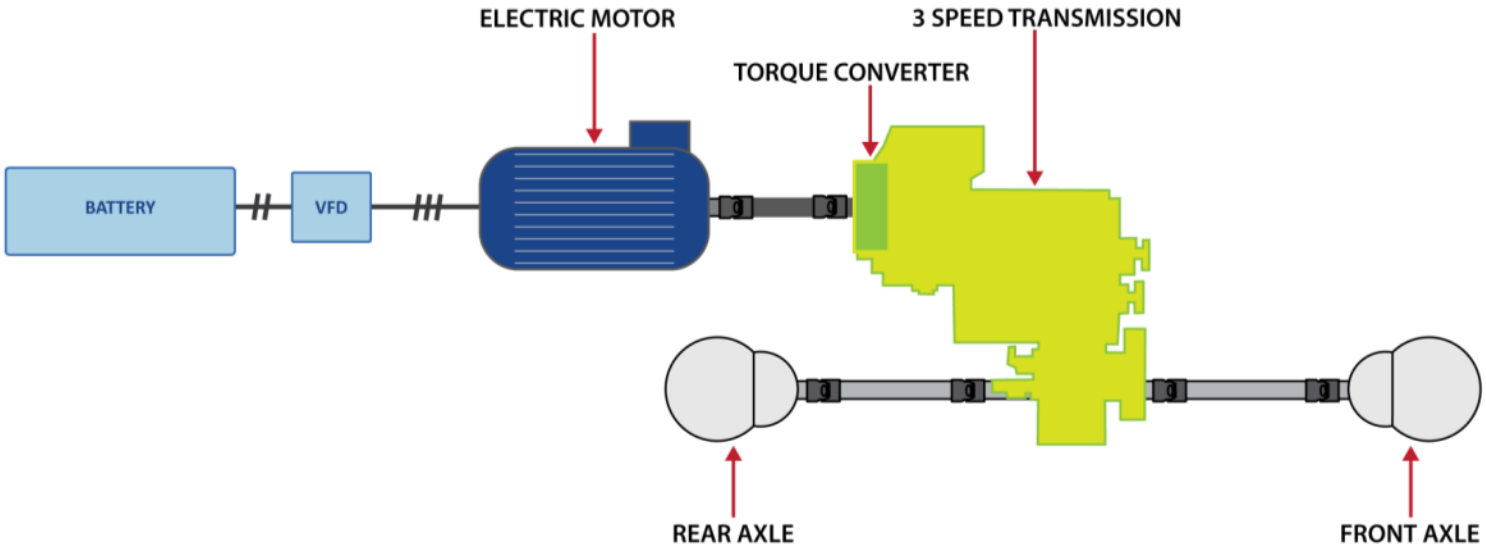
Present Battery LHD Systems By Some Competitors



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The Saminco Challenge

Unlike LHDs powered by a diesel engine or tethered/trolley powered electric LHDs or haul trucks where plenty of energy is available**, battery powered vehicles must be optimized to consume energy frugally.**

The Solution

The **Saminco Pure Electric System** has been designed with overcoming this challenge as the overriding design goal.

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Advantages of Saminco's Pure Electric System

- Separates tramming and hydraulic pump functions
- Reduces idling energy consumption rate to less than 2 kW
- Produces less heat than competitor's single motor drives
- Allows for optimum hydraulic pressure under demanding mucking conditions without affecting tramming motor operation
- Hydraulic pump RPM is reduced during idling and tramming under light hydraulic duty to reduce energy consumption.

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Advantages of Saminco's Pure Electric System *continued*

- Rugged copper-barred rotor induction motor for tramming is capable of providing 3X rated torque to provide adequate torque at all speeds without requiring a torque converter or gearbox.
- Unlike permanent magnet rotor motors, internal temperature rise up to 150°C (302 °F) will not cause any damage
- "Whisper pump" feature reduces machine noise levels to below 85 dB and reduces hydraulic fluid temperature to prolong hydraulic hose life.

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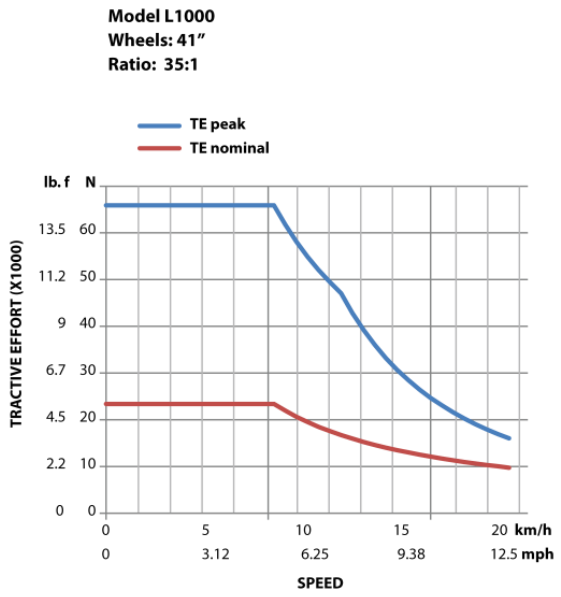
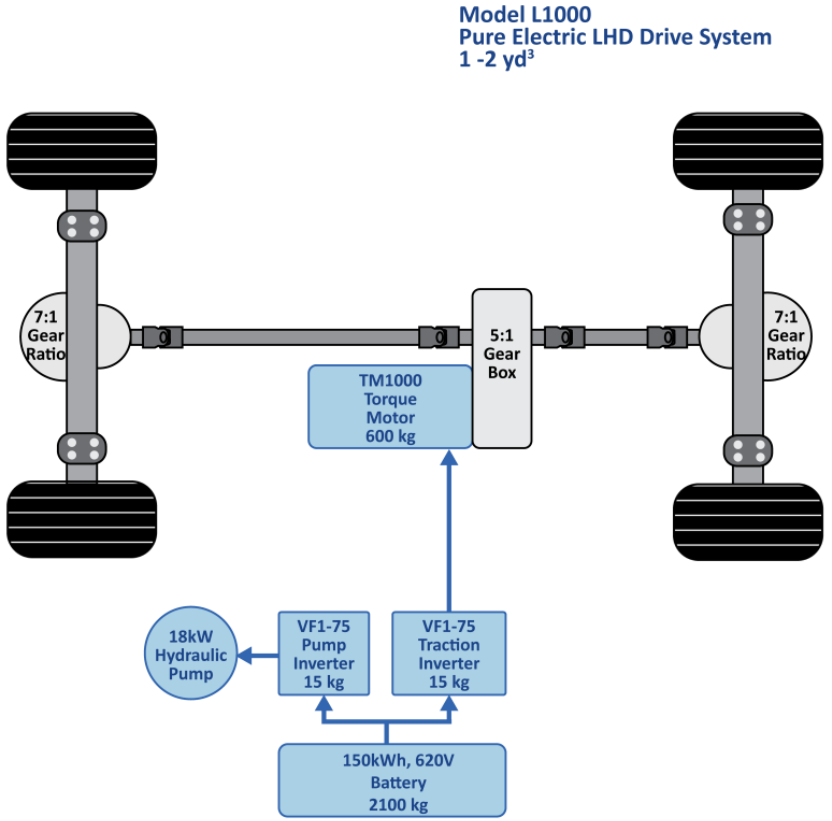
Saminco's Pure Electric System for LHD's 1 to 2 yd³





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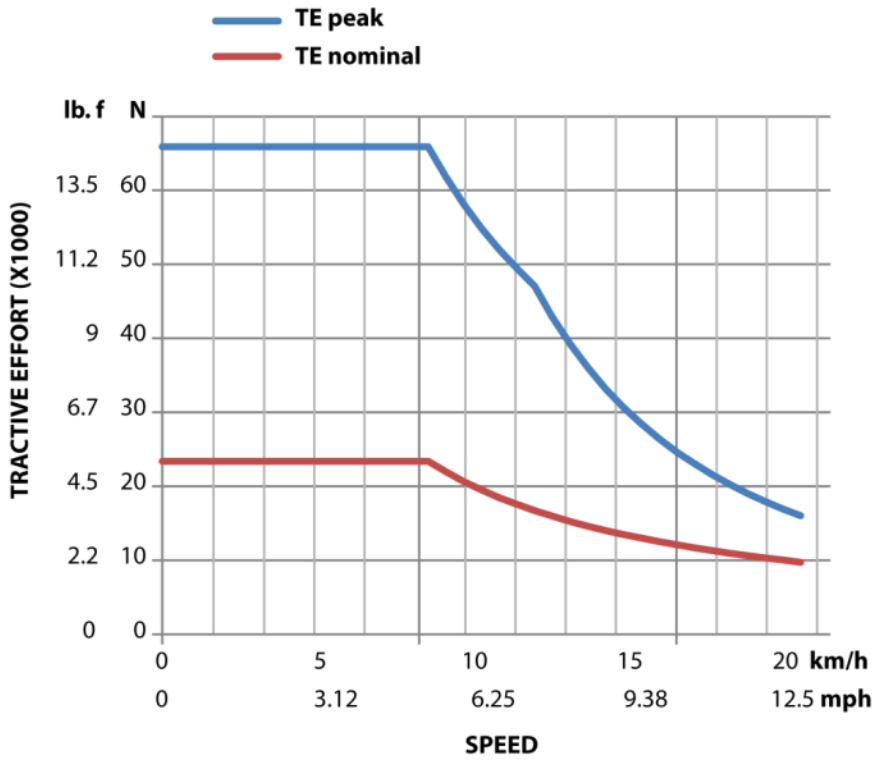
Saminco's Pure Electric System for LHD's 1 to 2 yd^3 *continued*

Model L1000
Wheels: 41"
Ratio: 35:1



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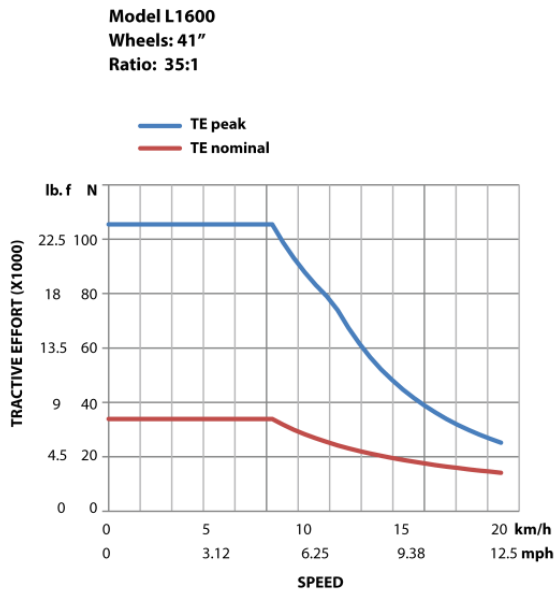
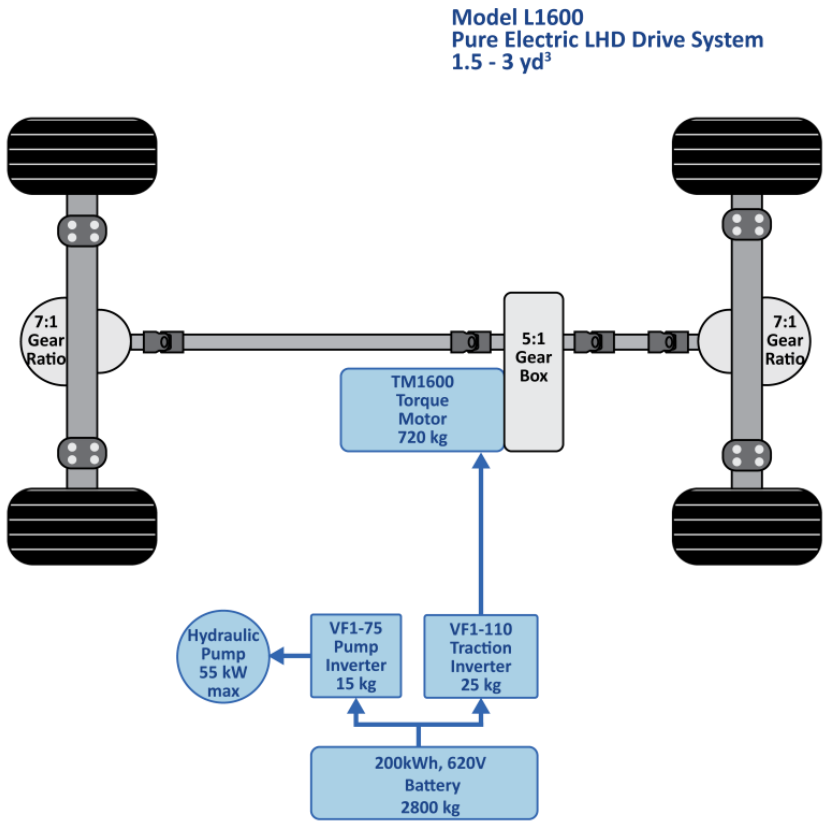
Saminco's Pure Electric System for LHD's 1.5 to 3 yd³





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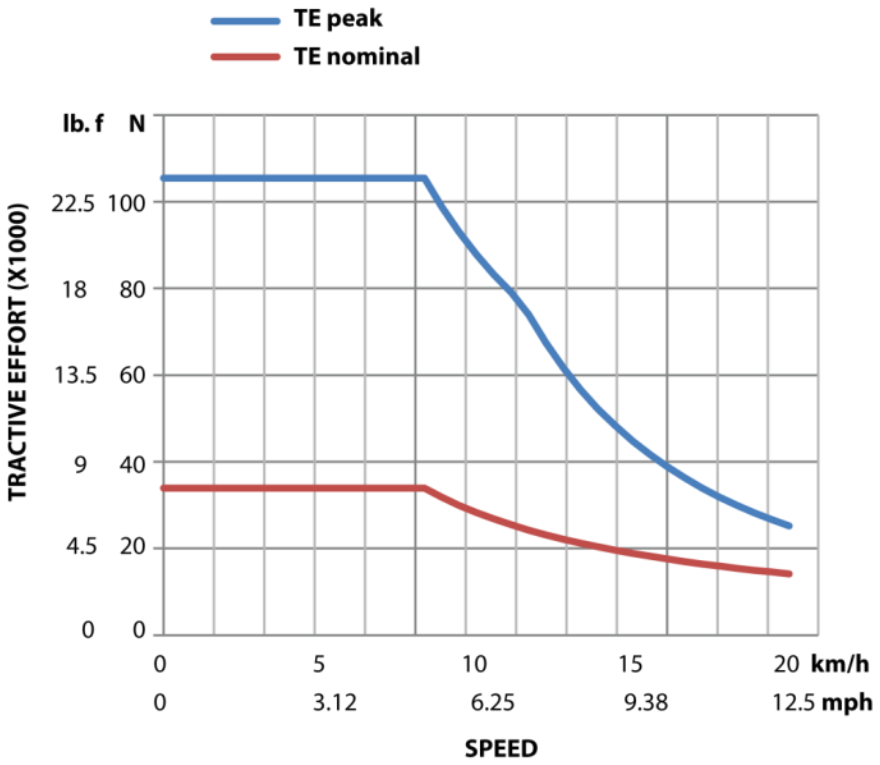
Saminco's Pure Electric System for LHD's 1.5 to 3 yd^3 *continued*

Model L1600
Wheels: 41"
Ratio: 35:1



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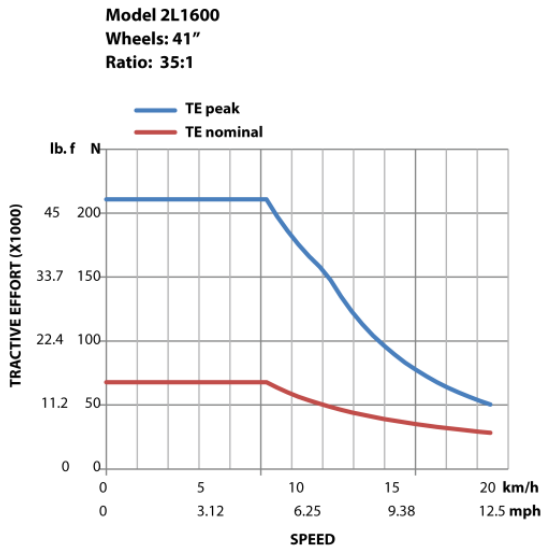
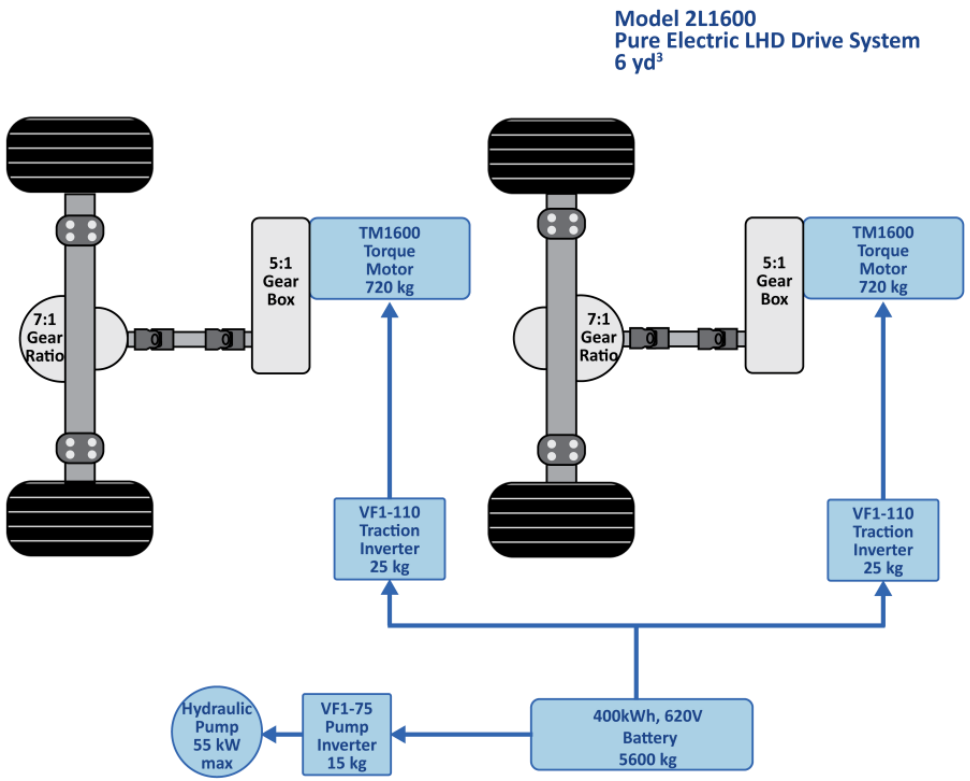
Saminco's Pure Electric System for LHD's 6 yd³





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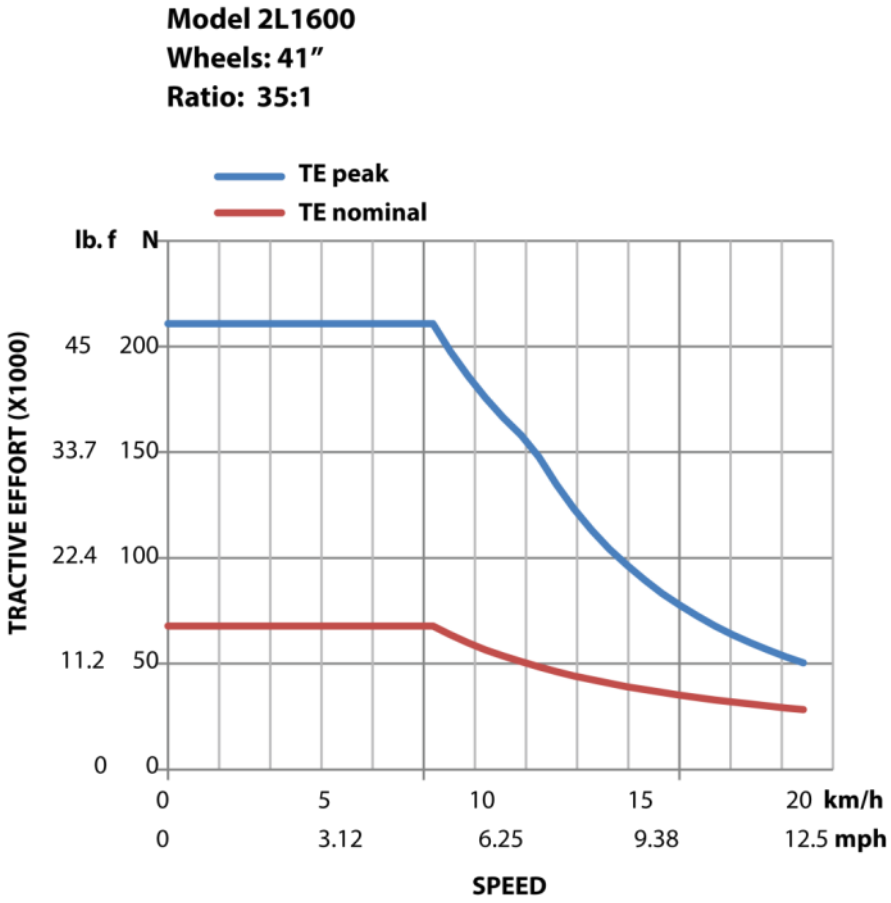
Saminco's Pure Electric System for LHD's 6 yd^3 *continued*



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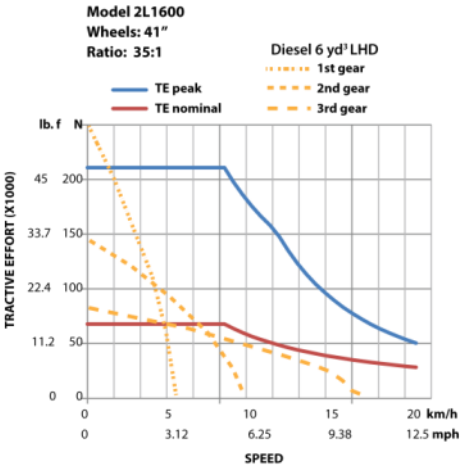
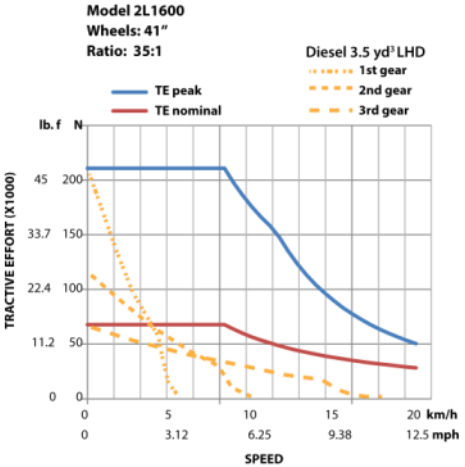
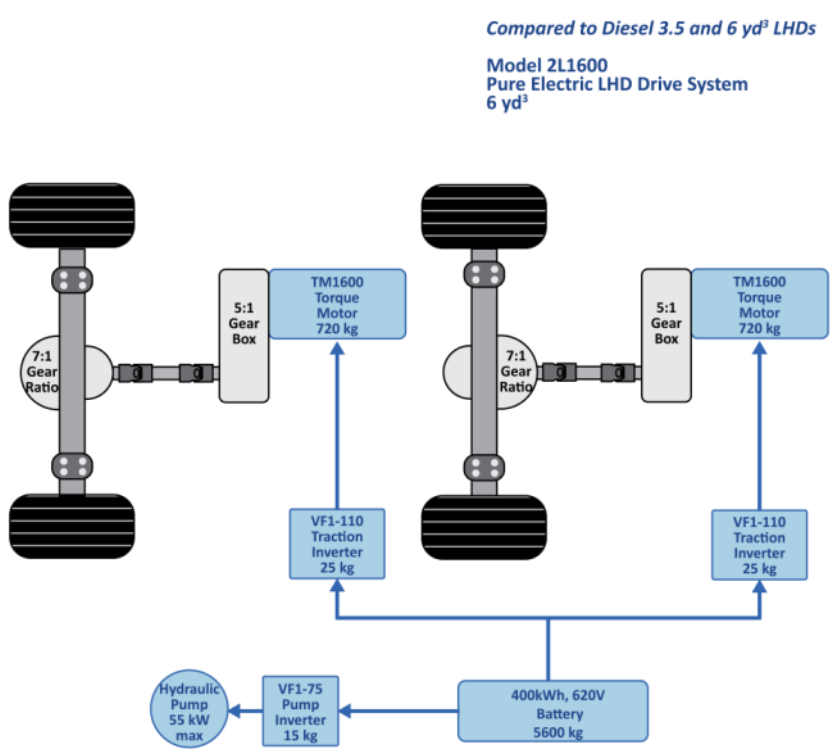
Saminco's Pure Electric Compared To Existing Diesel 3.5 and 6 yd³ LHD's







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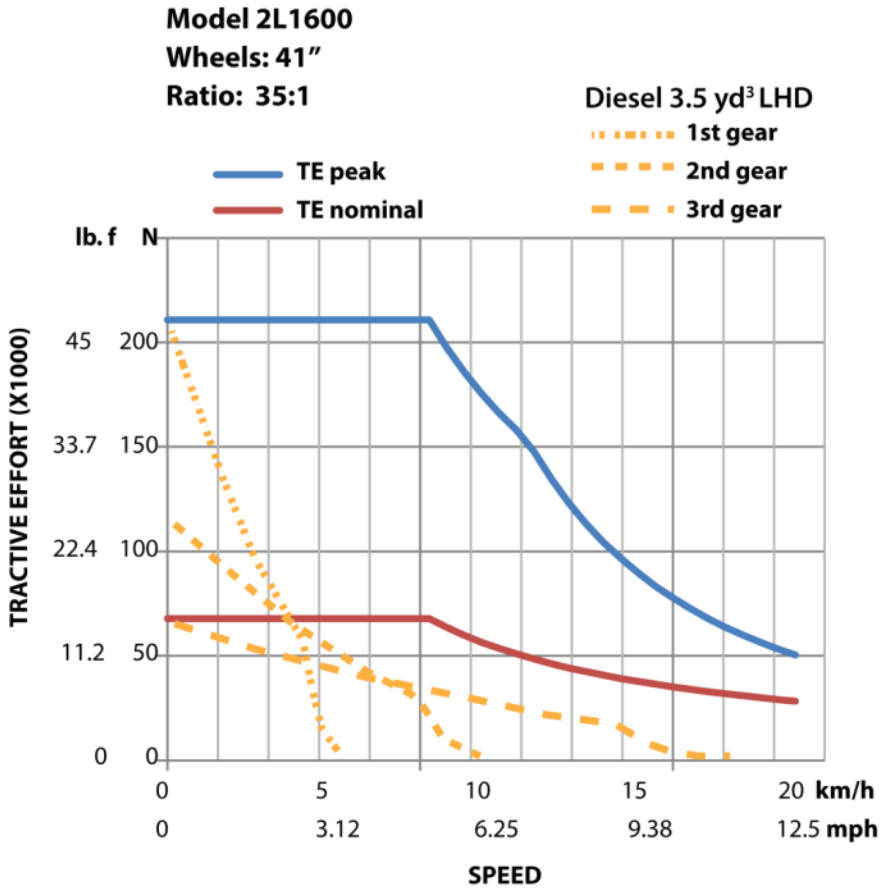
Saminco's Pure Electric Compared To Existing Diesel 3.5 yd³ LHD *continued*



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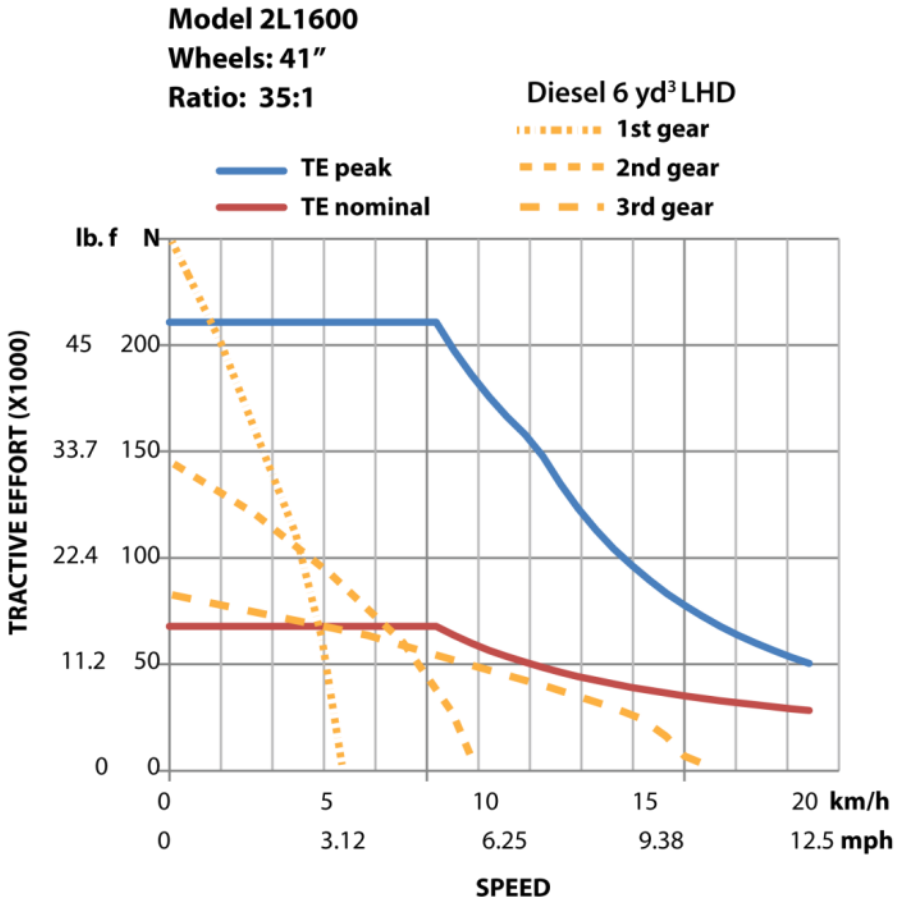
Saminco's Pure Electric Compared To Existing Diesel 6 yd³ LHD *continued*



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Batteries for Saminco's Pure Electric Drive System

1. SoNick Battery

Saminco has had excellent results with the FIAMM **SoNick** molten salt battery, which can reliably operate over a temperature range of -40°C to +60°C (-40°F to +140°F) without extra cooling. Its internal temperature can safely rise to 270°C (518°F), and battery overheating is unlikely to be a problem, even in areas where the virgin rock temperature is high in deep mines.

Another important advantage compared to aqueous batteries is the absence of gassing during charging or discharging.

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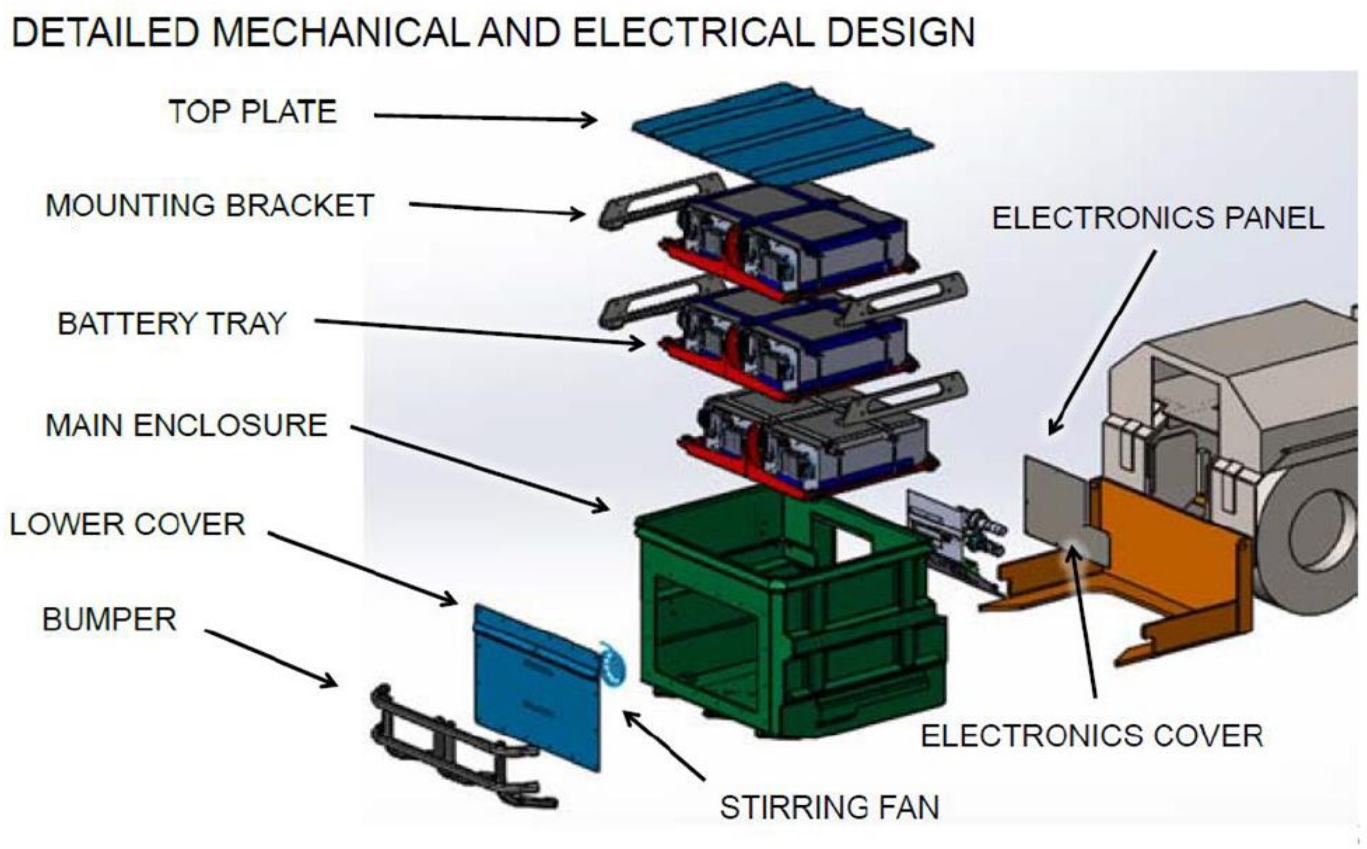
SoNick Battery



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SoNick Battery on the LHD

- 141 kWh battery
- weight: 1200 kg (2,640 lbs)
- 6 x 620V / 38Ah

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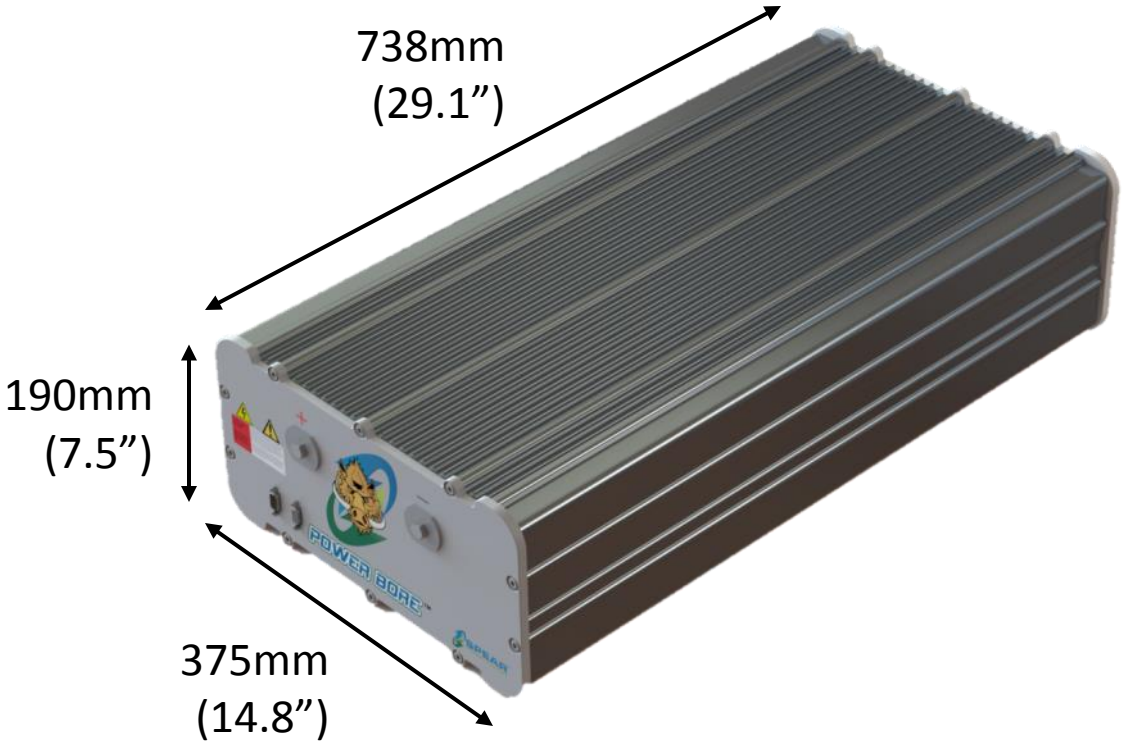
Batteries for Saminco's Pure Electric Drive System

2. Spear® Power Bore™ Lithium Battery



Power Bore-8N Lithium Battery

- 88.8V
- 8.5kWh
- Capacity: 52.5L/14.6 gal
- Operating Temperature: -30°C to 55°C (-22°F to 131°F)
- Weight: 68 kg (150 lbs)

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Spear® Power Bore-8N Lithium Battery

The Spear® Lithium battery is capable of accepting rapid charging (limited by sufficient power being available from the mine's electrical system).

It uses a proprietary internal cooling system to address heating problems when operated in high temperature environments, and while subjected to rapid recharging.

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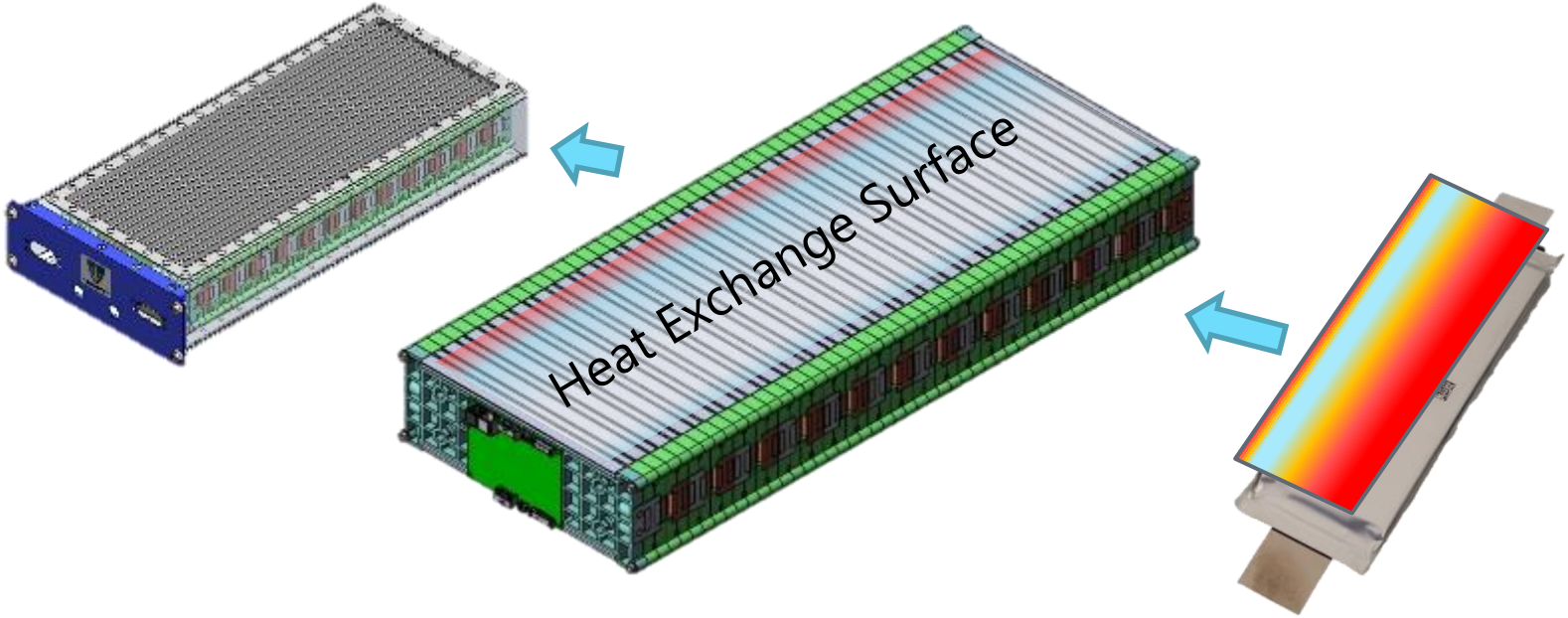
Thermal Management of Spear® Lithium Battery

Spear's proprietary thermal management system transfers heat from cell face to the heat exchangers mounted to the top and bottom of each 8N module.



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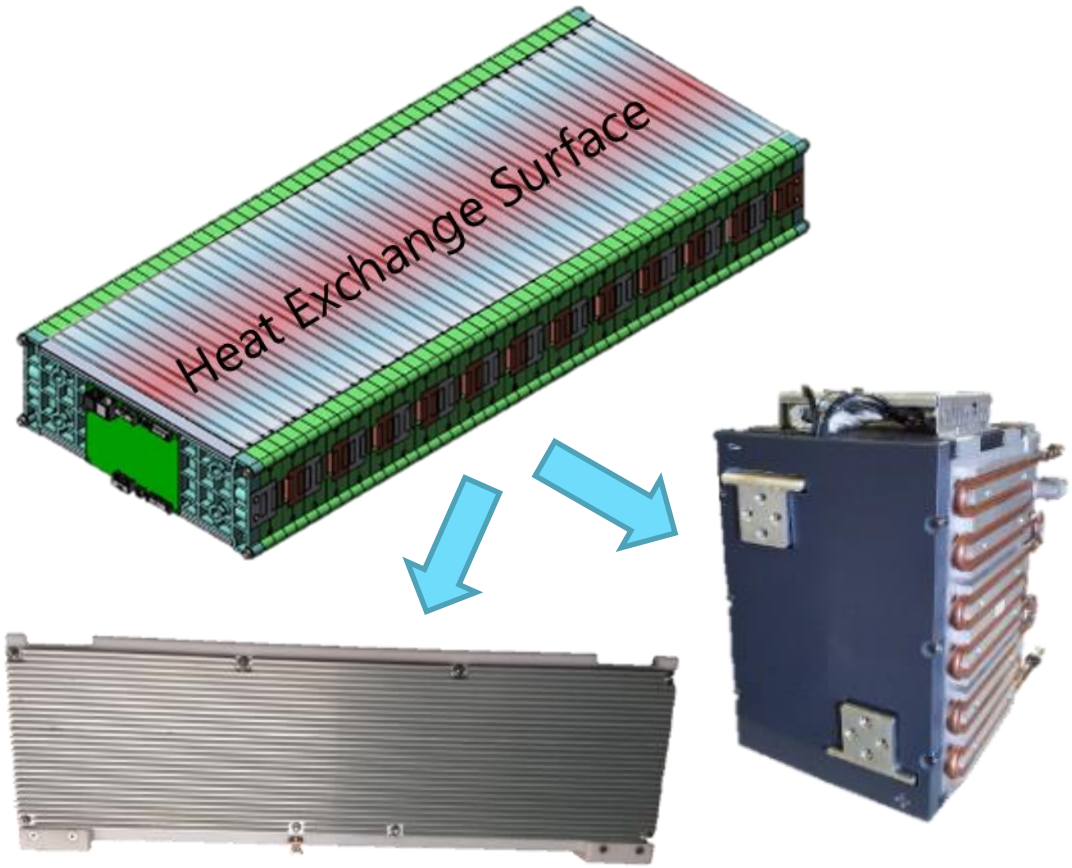
Thermal Management of Spear® Lithium Battery *continued*



Spear's SMOD heat transfer surfaces allow for the addition of optional air or liquid heat exchangers to run above 40°C (104°F) ambient and still maintain optimum cell life.

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Features of Saminco Pure Electric Energy – Saving Features

- Independent tramming – avoids energy losses in existing torque converters
- No gear shifting required – reduces weight and avoids gearbox losses
- Independent “on demand” hydraulic pump system allows maximum hydraulic pressure - reverts to “whisper mode” during idling to conserve energy.

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Features of Saminco Pure Electric Energy – Saving Features *continued*

- Energy recovery during downhill operation (with overriding surge absorber to prevent battery overcharging).
- Total energy consumption during idling is typically less than 2kW, partly the result of the hydraulic pump operating in low-energy consumption ‘whisper mode’.
- Noise Reduction: A typical 6 yd^3 machine generates 105dB noise, resulting in operators having to wear double hearing protection. The Saminco Pure Electric System generates 89dB under normal operation and less than 85dB in ‘whisper mode’.

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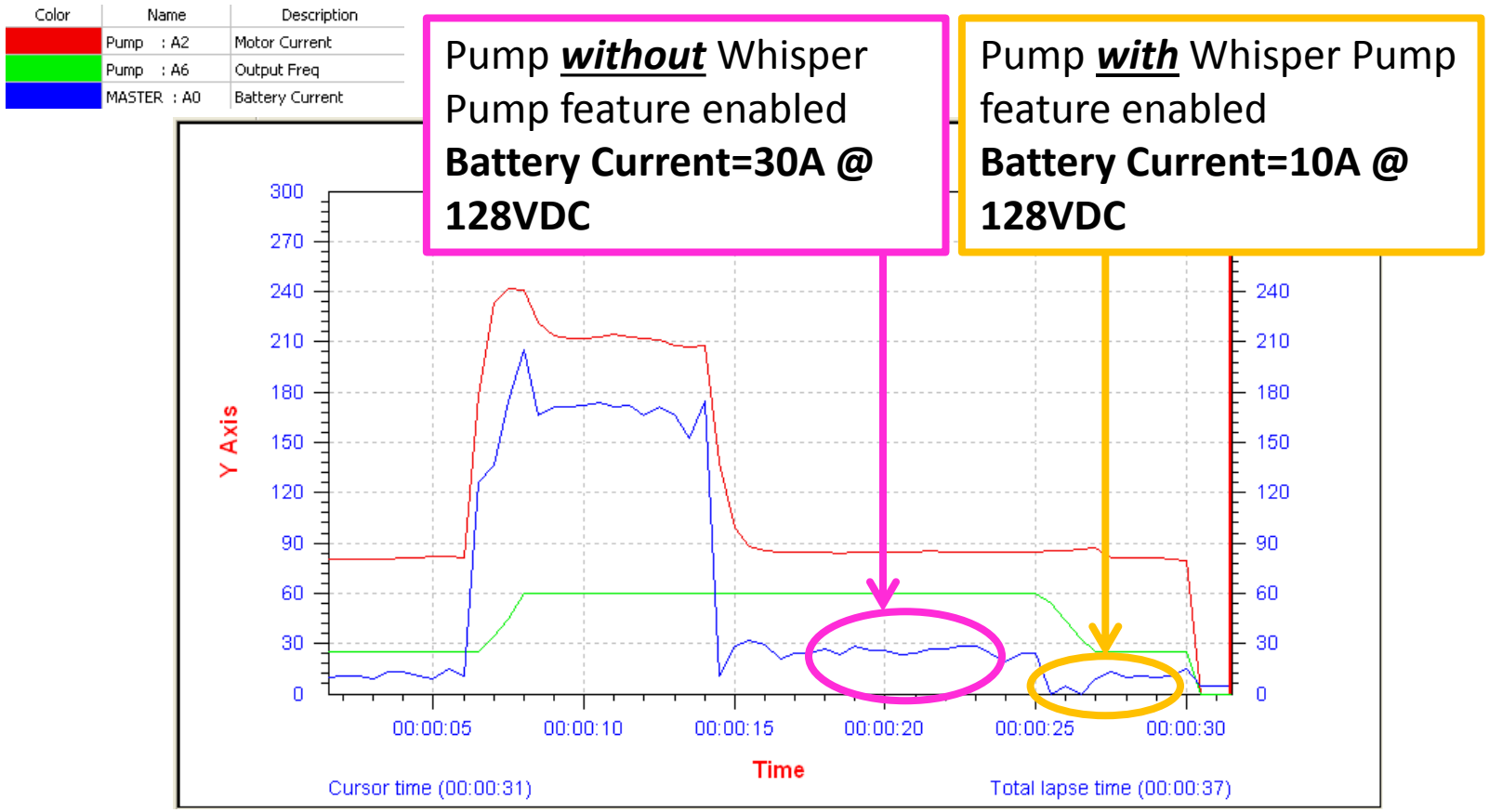
Whisper Mode Operation



During idling, typical hydraulic pump power is reduced from 3.8 kW to 1.3 kW.

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Operating Results

Over the past 18 months, successful operation in a hard rock mine with a Highland Machine 1.5 yd^3 LHD powered by a 620V / 140kWh SoNick molten salt battery, Saminco Battery Charger, and a Saminco model L1000 Pure Electric traction system confirmed 8 hour shift endurance with battery energy to spare at the end of each shift.

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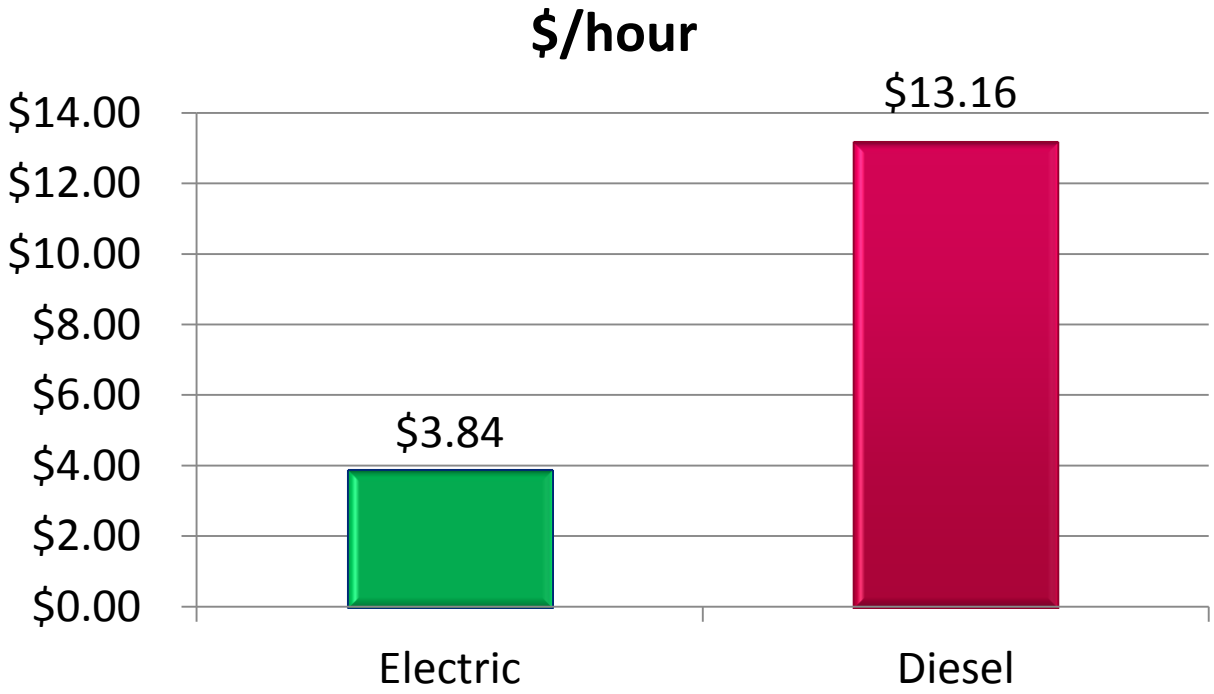
Operating Results –
Energy Consumption

It was noted that electrical energy consumption was $3.84/hour (based on 9¢/kWh electrical energy cost) compared to $13.16/hour for an equivalent diesel LHD (based on $3.29/gallon).

Energy Cost Comparison



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Operating Results –
Temperature, Noise and DPM

With the equivalent 1.5 yd^3 diesel-powered LHD at this mine, the stope temperature increased by 4°C (7°F), but there was no measurable temperature increase with the Pure Electric LHD.

Operators also reported a significant reduction in noise, and that the Pure Electric machine was so quiet that they could have a normal conversation next to the LHD when in standby idling mode.

We have no report on the potential reduction of DPM's (Diesel Particulate Matter) and ventilation requirements, but they will be very significant.

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Benefits of Saminco's Pure Electric System compared to Diesel LHD's

- Elimination of DPM's
- No measurable temperature rise in stopes
- Significant reduction in ventilation
- Which results in huge reduction in electrical energy consumption
- Enormous reduction in operating costs
- Significant reduction in noise

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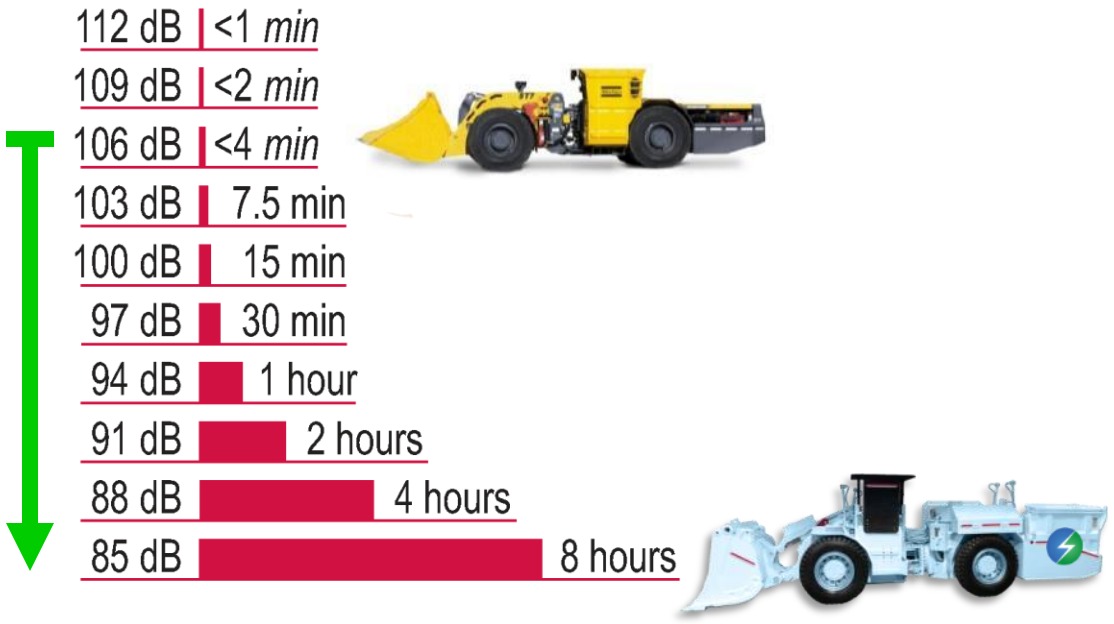
Noise Reduction with Saminco Pure Electric System

Noise reduction when using the Saminco Pure Electric System



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Benefits of Saminco's Pure Electric System compared to Diesel LHD's *continued*

- Sufficient zero speed torque to provide powerful smooth mucking, eliminating "run up" into muck pile required with Diesel LHD's
- Greatly improved operator comfort (less noise, no fumes, smooth operation)
- Regenerative braking energy recharges battery when descending

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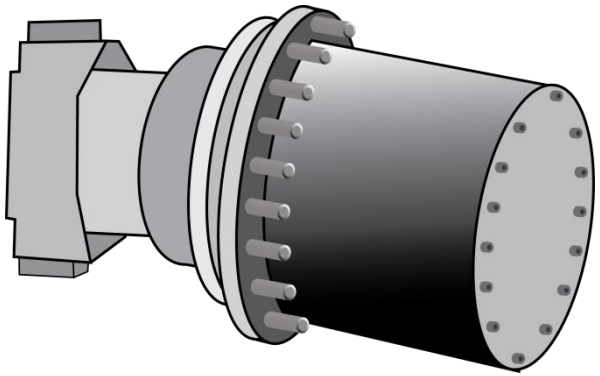
Under Development

- wheel-unit propulsion, eliminating drive shafts



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For a demonstration, visit us in Booth 4623, Central Hall

This presentation will be available on the Saminco website at www.samincoinc.com

A DRIVING FORCE IN POWER