



CASE STUDY: SMT Scharf

SLIC Batteries using AmpCool™ AC-110

Gary Testa, President & CEO, Engineered Fluids, Inc.

5th Annual Battery Thermal Management Innovation USA – Palo Alto, CA

Engineered Fluids, Inc.

Specialized developer of Single-phase Liquid Immersion Cooling Solutions

High-Performance Biodegradable, Non-Toxic, Non-Corrosive Dielectric Coolants

BitCool®- Dielectric Immersion Coolants designed specifically for ASIC based miners

- Supports all ASIC Crypto-mining devices

ElectroCool®- Dielectric Immersion Coolants for Semiconductors and Servers

- Server / CPU / GPU / SSD / DRAM
- Lasers / LEDs / RF Amplifiers / Tubes / Processors / RADAR
- Battery / Fuel Cell cooling for Power Generation (Solar / Wind / Conventional) in stationary electrical storage applications

AmpCool®- Dielectric Immersion Coolants for Batteries, Electric Motors and Hydraulics

- Electric motors & motor controllers
- Hydraulic power transmission and actuator systems
- Battery and Fuel Cell cooling in hybrid and electric vehicles

Products for protecting and cleaning electronic equipment during and after immersion

VoltCool® Additives - Highly Concentrated Transformer Oil Protection

- Power & Distribution Transformers, Switch Gear, AC & DC feeder lines
- Anti-oxidation and Corrosive Sulfur Stop Additives for use with hydrocarbon transformer oils

Dielectric Solvents – Safe and Effective Removal of Dielectric Fluids and Mineral Oils

- Fully dielectric solvents for use with all electronics and immersion cooling systems



OFFICIAL RACE TEAM TECHNICAL PARTNER
COOLANTS AND LUBRICANTS



FEATURE DRIVER

BLAKE FULLER

3X PIKES PEAK WINNER

MULTIPLE ELECTRIC
WORLD RECORD HOLDER

VEHICLE

TESLA PLAID

POWER: 1020 HP

0-150MPH: 9 seconds

Engineered Fluids, Inc.

- **Engineered Fluids, Inc. is a private company headquartered in the USA**
 - Headquarters, system development and prototype lab in St. Petersburg, FL
 - Chemical manufacturing and distribution facility in Tyler, TX
- **Genesis:**
 - Dr. David Sundin – Founder, Chief Scientist – 40yrs experience in development, manufacture, and applications of Dielectric Thermal Transfer Fluids
 - Gary Testa – Founder, President & CEO – serial entrepreneur with 30yrs experience in global sales, marketing, product management & development in mobility, telecom, cloud and software
 - David and Gary founded Engineered Fluids in 2017 to bring to market the Dielectric Coolants that David had spent 7 years perfecting for electronics cooling applications
- **Engineered Fluids Today**
 - Production Capability: 1.5mln Liters weekly (single shift) in our new facility in Tyler, TX
 - Customers: over 9,500 customers in more than 80 countries
 - Distribution Network:
 - EU / UK Distribution from own warehouse in Amsterdam, NL
 - Global Distribution & JV Partners: Australia, China/HK, Egypt, Israel, South Africa, and Taiwan.

Battery Cooling Technologies – Pros / Cons

Air Cooling

- **Pros:** Simple, Uses conditioned cabin air, no chance of leakage
- **Cons:** Restrictive in location, low heat transfer capacity, high battery temperature gradients, requires extensive use of TIMs, Fan noise, Low temp operation requires pre-heating of cabin air (or dedicated heater)

Water/Glycol Cooling w/Cold Plates – Tab, Surface, or Combination Cooling

- **Pros:** Highest heat capacity, lower battery temperature gradient, better thermal management
- **Cons:** System complexity, battery cell specific cold plates, leakage and shortage risks with conductive coolant, higher weight, higher maintenance, low temp operation requires pre-warming, No thermal run-away quenching

Single-Phase Liquid Dielectric Coolant – Full Immersion Cooling (SLIC)

- **Pros:** High heat capacity, lowest battery temperature gradient, excellent thermal management, tab & surface cooling, low pressure, low system complexity, reduced weight, lower cost components & coolants, environmentally friendly coolants, simple leak detection, Low temp operation can utilize heat storage in coolant for short term shut down, good thermal run-away quenching
- **Cons:** Long term low temp storage requires pre-heating

News Flash - 2-Phase Immersion Coolants Discontinued

3M 2-phase coolants being phased out of production and use

- Due to well documented health and environmental impacts of Perfluorooctanoic acids (PFOAs) and pressure by key investors 3M announced its discontinuance of its Novec™ and Fluorinert™ and more than 370 other products that use these chemistries. 3M is facing more than \$590mln in cleaning up their Belgium Zwijndrecht production site and is already

Cost, Responsibility and Risk due to PFOA use and storage

- Insurance companies and users are PFOAs are bracing for the massive costs of litigation and risk assessment due to the use and storage of PFOAS and in particular those uses that create airborne and water contamination.
- In one lawsuit alone a \$4bln USD settlement was reached, and hundreds of such suits are in motion in Europe and the United States.

Interesting reading:

3M to Exit PFAS Manufacturing by the End of 2025

- <https://news.3m.com/2022-12-20-3M-to-Exit-PFAS-Manufacturing-by-the-End-of-2025>

3M Belgium Production Facility Compelled to Shut Down After Alarming Levels of PFAS Found in Citizens

- <https://www.motleyrice.com/news/3m-belgium-pfas-facility-shut-down>

The PFAS & PFOA Insurance Coverage and Litigation Battleground

- <https://www.propertycasualty360.com/2022/04/18/pfas-and-pfoa-litigation-and-regulation-an-emerging-insurance-coverage-battleground-414-220627/?slreturn=20230115043325>

DuPont, Chemours and Corteva Reach \$4 Billion Settlement on 'Forever Chemicals' Lawsuits

- <https://www.ewg.org/news-insights/news-release/dupont-chemours-and-corteva-reach-4-billion-settlement-forever-chemicals>



SMT Scharf's journey to SLIC enabled Batteries using AmpCool AC-110™

"Safety, reliability, and performance were the driving factors in our choice of AmpCool AC-110 for our battery cooling solution. When you are operating at more than 2,000 meters below the surface of the earth, equipment failures are never an option and fire is simply unthinkable."

Jan-Hendrik Hollenbach, Lead Design Engineer / SMT Scharf Africa Ltd.



Battery and Charger System Design Criteria

1) Design Cost and Simplicity

- I. Weight
- II. Material Compatibility
- III. Manufacturability
- IV. Time to Market

2) Mine Safety & Operation

- I. Mining & Marine applications
- II. Battery resiliency to cell failure
- III. Ability to continue operation to next schedule maintenance after failure
- IV. Ability to replace individual cells after failure rather than entire battery module

3) Environmental and Personal Safety

- I. Biodegradation
- II. Toxicity
- III. Closed Loop Recycling

EV Batteries for Underground Mining Operations

The Ultimate EV Vehicle Challenge

- Manned load, haul and dump vehicles operating up to 13,125ft (4km) below the surface.
- Air temperatures up 60C
- LHD vehicles with gross loaded weights up to 60 tons operating in 6hr shifts with 2hr changeovers
- Extremely limited ventilation and emergency egress routes
- High concentrations of airborne particulate matter
- Three operating shifts per 24 hours



LHD Vehicle Battery Module Requirements

Safety First!

- Battery module must withstand up to 7% cell failure without impacting vehicle operations
- 650 – 1,000VDC operating Voltages
- 1 Hour full SOC / 20 min Rest
- 200-300kWH total battery system size
- Failed cells must be repairable during standard maintenance operations
- Must support Fast Onboard Charging
- Gas management and dissipation during thermal events
- Hazardous Certification
 - South Africa: SANS 10086-2:2013



Lithium-Ion Battery Module Failures

Battery Failures represent a significant safety threat in underground mines

- Air-cooled battery module design unable to meet requirements due to ambient temperatures in mine.
- Water-cooled battery modules unable to achieve hazardous certification due to battery fire hazards due to leaking and seal failures
- Immersion testing of other coolants failed to meet hazard requirements
 - Organic Esters and Mineral Oils failed in testing due to ignition threat and material compatibility issues with plastics and seals in system.
- **Engineered Fluids' AmpCool™ AC-110 mitigated all threats**
 - Cell to cell thermal runaway propagation **eliminated**
 - **Maintained surrounding cell operations and voltages** during thermal runaway of adjacent cell
 - **Enabled failed cell replacement** within module without special tools
 - Enabled cell and module **thermal management to achieve fast charging**
 - **Extended cell charging cycles** and increased cell SOC

Electric Mining Vehicle

Immersion cooled Battery Module for Hazardous Environments



In production use in South Africa's largest gold and platinum mines.

Immersion Cooled Battery Module

Certified for Hazardous Environment Use in South Africa





AmpCool[®] Dielectric Coolants & Lubricants ***Simple, Effective and Safe***

Biodegradable, non-toxic, food-grade dielectric coolants for full immersion cooling



AmpCool® Dielectric Coolants & Lubricants

High Performance Coolants specifically designed for EV Applications

- Proven application performance
- 1600x more thermally efficient than air.
- Purpose designed as heat transfer fluids
- Biodegradable, non-allergenic, non-toxic, food-grade certified
 - No respiratory or skin irritations or allergic reactions.
- Foam inhibiting for use in electrical motors, gear box, and high flow applications
- Zero Global Warming Potential
- No Special Handling or storage requirements
 - -50 to +200C operating temperatures
 - 10-year shelf life / 10-year operating life
 - Shippable by air / -80C Storage temps
- Increases reliability and the service life of device and electronic components

AmpCool® Dielectric Coolants

AmpCool Dielectric Coolants are the highest performance biodegradable, non-toxic dielectric thermal management fluids available.

AmpCool Coolants feature the broadest material compatibility, highest safety, and widest useful temperature range.

Download Information on AmpCool:

- [Technical Data Sheets](#)
- [Safety Data Sheets](#)

CHARACTERISTICS OF AMPCOOL DIELECTRIC COOLANTS

Product ID	AC-110	AC-120	AC-130	AC-140
Typical Application	General purpose battery and charger cooling	High performance low viscosity, battery, and charger cable cooling	Cooling of high temperature invertors, chargers, and generators	High fire resistance battery and charger cooling
Appearance	Clear			
Fluid Behavior	Non-Compressible, Isotropic, Newtonian			
Dielectric Strength	>60kV			
Resistivity (ohm-cm)	>1x10 ¹⁴			
Dielectric Constant	2.080	2.091	2.200	2.220
Refractive Index n _D ²⁰	1.441	1.442	1.453	1.462
Pour Point (°C)	-57	-66	-62	-52
Flash Point (°C)	193	157	228	280
ISO 4406 Particle Count	17/15/12	17/15/12	17/15/12	17/15/12
Total Sulfur (ppm)	0	0	0	0
Density, g/cc @ 15.6°C	0.82	0.80	0.82	0.84
Coefficient of Thermal Expansion, volume/°C	0.00067	.00067	0.00065	0.00063
Kinematic Viscosity (cSt)	0°C: 43.10 40°C: 8.11 100°C: 2.22	0°C: 18.99 40°C: 5.02 100°C: 1.70	0°C: 144.00 40°C: 19.00 100°C: 4.10	0°C: 794.61 40°C: 67.00 100°C: 9.53
Thermal Conductivity (W/m²K)	0°C: 0.1382 40°C: 0.1359 100°C: 0.1325	0°C: 0.1382 40°C: 0.1359 100°C: 0.1325	0°C: 0.1478 40°C: 0.1459 100°C: 0.1430	0°C: 0.1600 40°C: 0.1584 100°C: 0.1561
Specific Heat (kJ/kg°C)	0°C: 2.0608 40°C: 2.2121 100°C: 2.4390	0°C: 2.0608 40°C: 2.2121 100°C: 2.4390	0°C: 2.0575 40°C: 2.2060 100°C: 2.4288	0°C: 2.0460 40°C: 2.1912 100°C: 2.4090
Global Warming Potential	0	0	0	0
Biodegradability	>93%	>93%	>70%	>50%
Materials Compatibility Warranty	Yes	Yes	Yes	Yes
Product Operational Warranties (Yrs) ¹	0, 5, 10	0, 5, 10	0, 5, 10	0, 5, 10
Shelf Life (Yrs) ²	25	25	25	25

1) See product specific warranty statement for terms and conditions.

2) Shelf Life duration is stated for a sealed original steel container, Shelf life period is included in the warranty period.

AmpCool® Dielectric Coolant & Lubricants

AmpCool Dielectric Lubricants are the highest performance biodegradable, non-toxic dielectric lubricating thermal management fluids available.

AmpCool Dielectric Lubricants are designed for electric system cooling applications involving bearing contact and hydraulic power transfer.

Download Information on AmpCool:

- [Technical Data Sheets](#)
- [Safety Data Sheets](#)

CHARACTERISTICS OF AMPCOOL DIELECTRIC LUBRICANTS

Product ID	AC-210	AC-220	AC-230	AC-240
Typical Application	General purpose Dielectric Cooling Lubricant	High performance low viscosity, high stability, with excellent lubricity	Cooling of high temperature electronic and power transfer	Extreme temp lubrication and cooling for motors and actuators
Appearance	Clear			
Fluid Behavior	Non-Compressible, Isotropic, Newtonian			
Dielectric Strength	>60kV			
Resistivity (ohm-cm)	>1x10 ¹⁴			
Dielectric Constant	2.080	2.091	2.100	2.190
Refractive Index n _D ²⁰	1.441	1.453	1.450	1.490
Pour Point (°C)	-51	-64	-44	-47
Flash Point (°C)	194	235	270	282
ISO 4406 Particle Cnt.	17/15/12	17/15/12	17/15/12	17/15/12
Total Sulfur (ppm)	0	0	0	0
Density, g/cc @ 15.6°C	0.82	0.82	0.83	0.84
Coefficient of Thermal Expansion, volume/°C	0.00069	.00066	0.00066	0.00064
Kinematic Viscosity (cSt)	0°C	43.47	117.00	305.00
	40°C	8.61	17.70	39.00
	100°C	2.40	4.00	7.24
Thermal Conductivity (W/m*K)	0°C	0.1455	0.1478	0.1518
	40°C	0.1403	0.1459	0.11508
	100°C	0.1325	0.1430	0.1495
Specific Heat (kJ/kg°C)	0°C	2.0450	2.0575	2.0502
	40°C	2.2094	2.2060	2.2030
	100°C	2.4261	2.4288	2.4180
Global Warming Potential	0	0	0	0
Biodegradability	>92%	>70%	>70%	>50%
Materials Compatibility Warranty	Yes	Yes	Yes	Yes
Product Operational Warranties (Yrs) ¹	0, 5, 10	0, 5, 10	0, 5, 10	0, 5, 10
Shelf Life (Yrs) ²	25	25	25	25

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For more information...

Engineered Fluids, Inc.

4917 Profit Drive, Tyler Texas 75707 USA

+1.725.218.1955

sales@engineeredfluids.com

support@engineeredfluids.com

www.engineeredfluids.com

Buy online: <https://shop.engineeredfluids.com/>