



A Customer's Journey to SLIC Cooled Li-on Batteries using AmpCool™ AC-110

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

Automotive IQ's 11th Annual Thermal Management for EV/HEV 2023 – Munich Germany

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

SubmergeDeep®- Dielectric Pressure Compensation Fluids and Coolants for Subsea Applications

- Remote Operated Vehicles, Submarine Cables, Subsea Oil and Gas Downhole rigging
- Battery, chargers, electric motor, LED lighting, and hydraulic manipulators.

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

ENGINEERED
FLUIDS

ELECTRIC+
PERFORMANCE

OFFICIAL RACE TEAM TECHNICAL PARTNER
COOLANTS AND LUBRICANTS

ENGINEERED
FLUIDS

100TH
RUNNING



JUNE 26, 2022

FEATURE DRIVER

BLAKE FULLER

3X PIKES PEAK WINNER

MULTIPLE ELECTRIC
WORLD RECORD HOLDER

VEHICLE

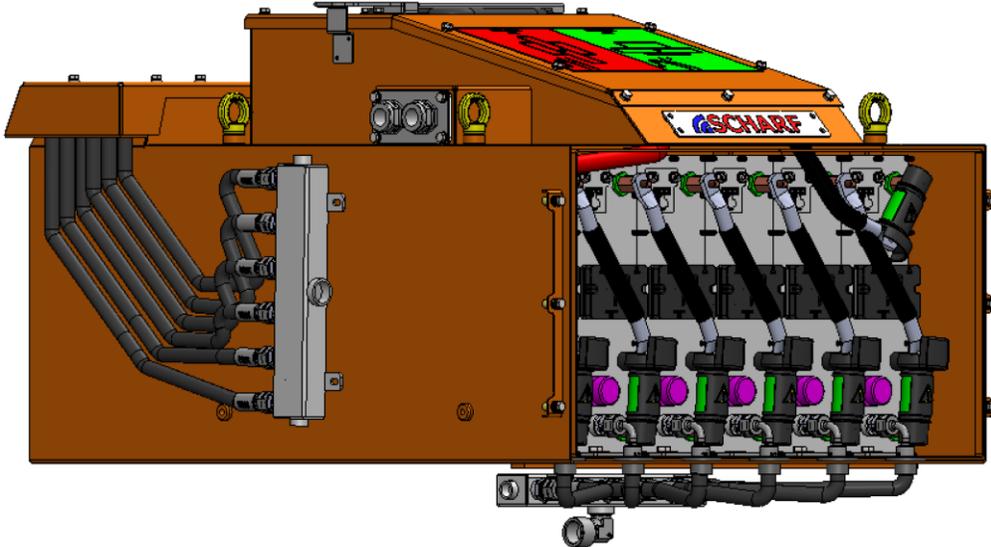
TESLA PLAID

POWER: 1020 HP

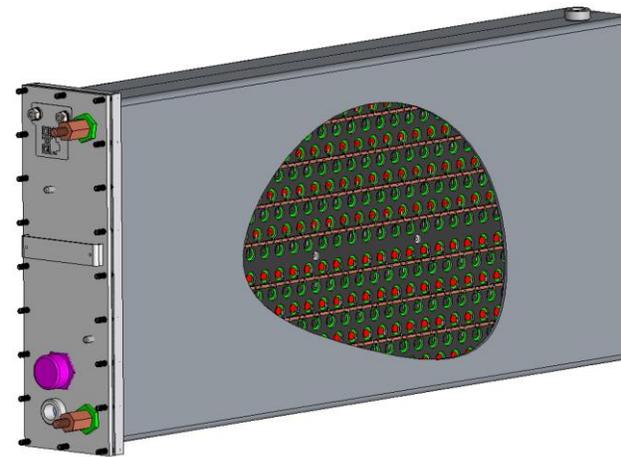
0-150MPH: 9 seconds



SCHARF SLIC Battery System with AmpCool™ AC-110



SLIC Removable Battery Pack & Charger



SLIC Battery Module

Battery Specifications
Capacity: 40.24 Kw/h
Charge Time 1C: 2 Hrs
Voltage: 600VDC
Range: 220km
Coolant: AmpCool AC-110

For more information: https://www.smtscharf.com/product/scharf_lev?lang=en

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Battery and Charger System Design Criteria

1) Design Cost and Simplicity

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

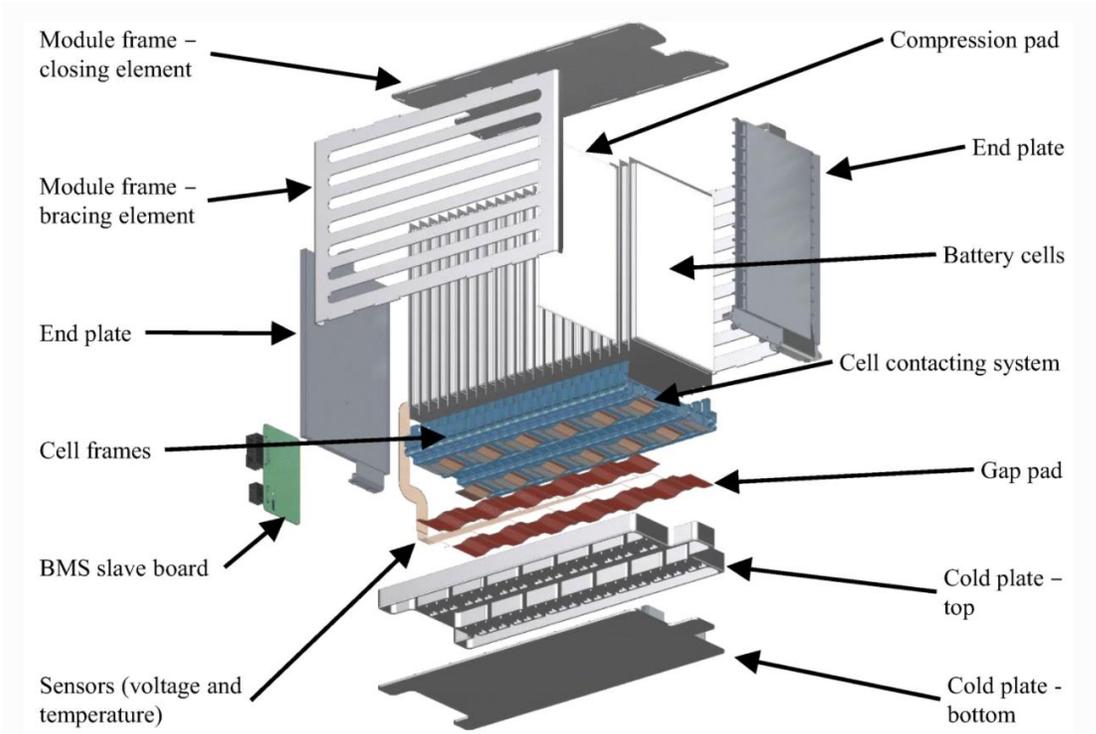
2) Safety – Flammability and Fumes

- I. Mining & Marine applications

3) Environmental and Personal Safety

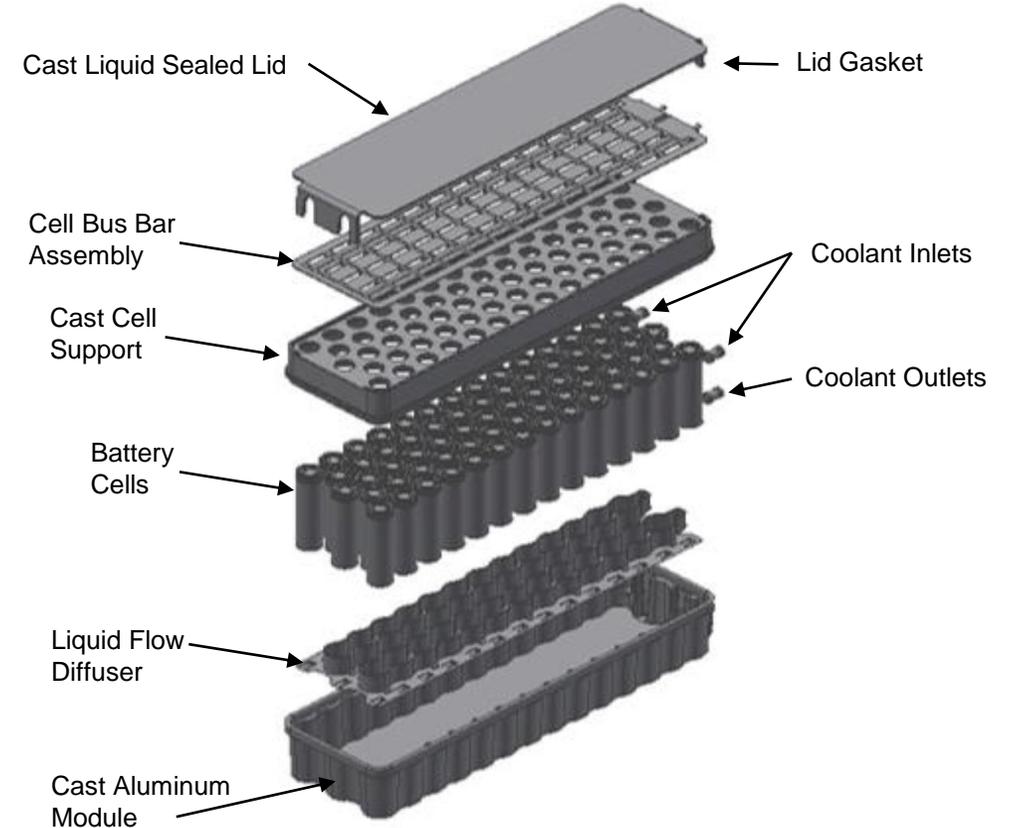
- I. Biodegradation
- II. Toxicity
- III. Closed Loop Recycling

SLIC: Increased Performance with Reduced Cost & Complexity



Water/Glycol Cold-plate Cooled Battery Module

- Heat plate adds significant complexity and cost
- TIM placement is critical to ensure efficiency
- Cell-bus bar cooling is particularly challenging
- Leaks/crash damage creates dangerous short risk Complex / costly materials protection required between cells to prevent adjacent cell thermal runaway



SLIC Cooled Battery Module

- Use of molded components reduces cost & weight
- Elimination of cell specific cold-plates increase flexibility between cell suppliers and cell technology
- AmpCool replaces all TIM and eliminates need for precision fitment of cells, TIM, and cold-plates
- Direct liquid cooling of cells and bus bars without risk

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Compatibility with Common EV / Automotive Materials

- Material compatibility is a critical factor when considering full immersion of electronics and battery systems
- Engineered Fluids has invested 1,000's of man-hours in testing and certifying the widest range of materials and components to ensure faster and secure solution development for our customers
- We produce new materials compatibility test reports regularly for specific materials provided for testing by manufacturers, suppliers, and customers
- We are the **ONLY** Dielectric Coolant manufacturer that freely publishes our material compatibility guide and provides continuous updates
- We are the **ONLY** Dielectric Coolant manufacturer that provides 5 and 10 year specification warranties for its products.
- You can find our continuously updated Material Compatibility Guide here:
 - <https://www.engineeredfluids.com/material-compatibility>

AmpCool - Material Compatibility - Batteries

Batteries & Materials	Application	AmpCool®	DS-100®	Testing & Notes
Lithium Manganese Dioxide "Li-Mn" (IEC Code: CR)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: CR927, CR1025, CR1130, CR1216, CR1220, CR1225, CR1616, CR1620, CR1632, CR2012, CR2016, CR2020, CR2025, CR2032, CR2040, CR2050, CR2320, CR2325, CR2330, CR14240
Zinc Manganese Dioxide "Alkaline" (IEC Code: LR)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: LR03, LR1, LR6, LR12, LR14, LR20, LR23, LR25, LR8D425, LR932, 4LR44, 4LR932, 8LR732
Aluminum Laminate Film	Pouch Casings	Certified	Long Term	-
Aluminum-clad Copper (Al-Cu)	Tabs	Certified	Long Term	-
Carbon Zinc (IEC Code: R)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: R03, R1, R12, R14, R20, R23, R25, R62R10
Copper	Tabs	Certified	Long Term	-
Iron Disulfide Propylene Carbonate "Lithium-iron", "Li/Fe" (IEC Code: FR)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: FR03, FR6
Lead	Terminals	Certified	Long Term	-
Lead Acid Battery - Absorbed Glass Mat, Sealed Vent	Battery Cell	Certified	Short Term	HDPE Battery Casing with sealed vent
Lead Acid Battery - Gel, Sealed Vent	Battery Cell	Certified	Short Term	HDPE Battery Casing with sealed vent
Lead Acid Battery Cell, Open Vent	Battery Cell	Certified - See Notes	Long Term	HDPE Battery Casing. Vent must be sealed against Coolant intrusion, vent tube must be routed to vent outside of coolant to prevent the cell from venting into the Coolant. H2SO4 will not interact with any of our Dielectric Coolants and does not impact the Dielectric Strength, however as will any contamination it will void all warranties.
Lead Acid Battery, Sealed Vent	Battery Cell	Certified	Long Term	HDPE Battery Casing with sealed vent
Lithium		Certified	Long Term	-
Lithium Poly Carbon Monofluoride (IEC Code: BR)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: BR1220, BR1632, BR2016, BR2032, BR2330, BR2335, BR3032, BR-2032
Lithium-Ion Cell (Pouch)	Battery Cell	Certified	Long Term	Aluminum Laminated Foil pouch with sealed vent
Lithium-Ion Cell (Prismatic)	Battery Cell	Certified	Long Term	HDPE Battery Casing with sealed vent
Nickel	Tabs	Certified	Long Term	-
Nickel Cadmium "NiCd" (IEC Code: KR)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: KR03, KR1, KR6, KR14, KR20, KR22C429
Nickel Metal Hydride "NiMH" (IEC Code: HR)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: HR03, HR1, HR6, HR14, HR20, HR22C429
Nickel Metal Hydride (IEC Code: ZR)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: ZR03, ZR1, ZR6, ZR14, ZR20, ZR22C429
Nickel-Zinc Battery, Sealed Vent	Battery Cell	Certified	Long Term	HDPE Battery Casing with sealed vent
Polypropylene, High Density (HDPE)	Battery Casings	Recommended	Short Term	Watch melting point at ~160C
Thionyl Chloride Lithium (IEC Code: E)	Battery Cell	Certified	Long Term	Sizes include but are not limited to: E14250

AmpCool - Material Compatibility - Hoses

Hose & Tubing	Application	AmpCool®	DS-100®	Testing & Notes
Continental Petroleum Transfer Hoses	Hose	Recommended	Short Term	http://catalog.contitech.us/category/category-1106
Fluorinated, ethylene propylene (FEP, Versilon™, Norell®)	Tubing	Certified	Long Term	Versilon™ C-210-A Excellent high temperature characteristics https://www.processsystems.saint-gobain.com/products/versilon-c-210-chemical-transfer-tubing
Fluorocarbon / Fluoroelastomer (FKM, FFKM, FEPM, Viton®)	Hose & Tubing	Certified	Long Term	https://www.coleparmer.com/b/viton?PubID=ZX&persist=True&ip=no&gclid=EAlaIqobChMI3snCu7rO4glVhuNkCh1yAySEAAAYASAAEgKkpPD_BwE
Fluorosilicone (FVMQ, FSI)	Hose & Tubing	Certified	Long Term	-
Nitrile (NBR)	Tubing	Recommended *See Note	Short Term	- May exhibit some shrinkage of less than 0.75%
Oil Vac, Kuriyama of America (Heavy Duty Oil Resistant Polyurethane Suction Hose) Sizes: 1.0", 1.25", 1.5", 2.0"	Hose	Certified	Short Term	This hose comes in larger diameters and is an excellent hose for large tanks and systems. Heavy duty construction and excellent compatibility. https://products.kuriyama.com/item/kuriyama-of-america/-oil-resistant-polyurethane-suction-hose-1/ov200x100
Parker Hannifin Corporation - Push-Lok Plus 801 Hose (All colors) (0.25", 0.375" 0.50", 0.75", 0.625", 1.0")	Hose	Certified	Short Term	http://ph.parker.com/us/15551/en/push-lok-plus-multipurpose-hose-801
PLICORD® FLEXWING® Petroleum Transfer Hose, Continental	Hose	Certified	Short Term	http://catalog.contitech.us/viewitems/category-1106/plicord-flexwing-petroleum-transfer-hose ID: 25.4mm (1") - 152.4mm (6") Temperature Rating: -37 °C to 93 °C
Polytetrafluoroethylene (PTFE, Teflon®)	Hose & Tubing	Certified	Long Term	-
Tygon® (Saint-Gobain)	Tubing	Certified	Short Term	2375 Ultra Chemical Resistant Tubing F-4040-A Fuel & Lubricant Tubing LP1100 Low Permeation Fuel Tubing https://www.processsystems.saint-gobain.com/product-selector-panel/fluid-transfer?field_brand=name=Versilon%E2%84%A2
Versilon® C-210 A Tubing (Saint-Gobain)	Tubing	Certified	Short Term	-

AmpCool - Material Compatibility - Plastics

Plastics	Application	AmpCool®	DS-100®	Testing & Notes
Acrylonitrile-Butadiene-Styrene (ABS)		Not Recommended	Not Recommended	-
Ethyl Tetra-Fluoro Ethylene (ETFE) (Tefzel®, Fluon®, Neoflon®, Teflon®)		Certified	Long Term	-
Fluorocarbon Polyamide (Nylon®)		Recommended	Short Term	-
Liquid Crystal Polymer (LCP)		Recommended	Short Term	-
Nylon® (polyamide 11)		Certified	Long Term	-
Nylon® (polyamide 66)		Certified	Long Term	-
Nylon® (polyamide 510)		Certified	Long Term	-
Phenolic (selected types)		Recommended	Short Term	-
Polyacetal (Denim®, Ceicon®)		Recommended	Short Term	-
Polyakylene Terphthalate- Includes Polyethylene (PET) and Polybutylene (PBT) Terphthalates		Recommended	Short Term	-
Polyamide (Nylon®)		Recommended	Short Term	-
Polybutylene		Not Recommended	Not Recommended	-
Polycarbonate (Lexan®, Makrolon®, Monogal®, Palsun®, Zelux®)		Recommended	Short Term	Operating temperature range: -40C to 140C / -40F to 284F
Polyethylene, High Density (HDPE)		Recommended	Short Term	Selected grades are recommended. Materials compatibility testing is highly recommended, especially for applications > 50C
Polyethylene, Low Density (LDPE)	Tanks / Containers	Not Recommended	Short Term	-
Polyketone Thermoplastics (Includes PEK, PAEK, and PEEK)		Recommended	Short Term	-
Polymethacrylate (Acrylic, Plexiglas®, Acrylite®, Lucite®, Polycast®, Optix®, Chemcast®)		Limited Applications	Limited Applications	Note operating temperature range: -34°C to 70°C / -30°F to 158°F
Polyoxymethylene (POM)		Recommended	Short Term	-
Polyphenylene Sulfide (PPS, Durafide®, Ryton®)		Certified	Long Term	-
Polypropylene	Tanks, Racks, Structural elements	Not Recommended	Not Recommended	Polypropylene is generally less resistant to chemical attack than polypropylene
Polystyrene		Not Recommended	Not Recommended	Will dissolve rapidly in coolant.
Polytetrafluoroethylene (PTFE, Teflon®)		Recommended	Short Term	-
Polyvinyl Chloride (PVC, CPVC)	Wire Insulation	Recommended	Short Term	Some wire types experience a stiffening of insulation, but no loss of insulating capacity.
Polyvinyl Chloride (PVC, CPVC)	Structural Elements	Not Recommended	Short Term	This material can be come brittle with age and heat and is not recommend for any structural elements that are under stress.
TPE - Thermoplastic Elastomer - Ethylene Propylene Diene type (Santoprene®)	Wire Insulation	Not Recommended	Short Term	-
TPE - Thermoplastic Elastomer - Nitrile type	Wire Insulation	Recommended	Short Term	-
TPE - Thermoplastic Elastomer - Copolyester type (Hytrel®)	Wire Insulation	Recommended	Short Term	-
TPU - Thermoplastic Urethane	Wire Insulation	Recommended	Short Term	-
Polyvinyl Chloride (PVC, CPVC)	Structural Elements	Not Recommended	Short Term	This material can be come brittle with age and heat and is not recommend for any structural elements that are under stress.

AmpCool - Material Compatibility - Seals/Gaskets

Seals - Gaskets - O Rings	Application	AmpCool®	DS-100®	Testing & Notes
Acrylonitrile-Butadiene *(H-NBE, L-NBR)	Seal / Gasket / O-Ring	Recommended	Short Term	-
AFLAS® (Asahi Glass Ltd)	Seal / Gasket / O-Ring	Certified	Long Term	Excellent high temperature characteristics (-5C to 205C)
Epichlorohydrin, Closed Cell (ECH)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Chlorinated Ethylene Copolymer (Alcryn®)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Cross Linked Polyethylene (XLPE)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Ethyl Tetra-Fluoro Ethylene (ETFE) (Tefzel®, Fluon®, Neoflon®, Teflon®)	Seal / Gasket / O-Ring	Certified	Long Term	Excellent high temperature characteristics
Ethylene Propylene (EPM)	Seal / Gasket / O-Ring	Recommended	Short Term	EPM seals used in electrolytic capacitors have not been shown to be a problem.
Ethylene- Acrylate (Vamac®)	Seal / Gasket / O-Ring	Recommended	Short Term	Low temperature use only
Fluorinated Ethylene Propylene (FEP, T/FEP, Norell®, AFLAS®)	Seal / Gasket / O-Ring	Certified	Long Term	Excellent high temperature characteristics
Fluorocarbon / Fluoroelastomer (FKM, FFKM, FFPM, FEPM, Chemrez®, Kalrez®, Viton®)	Seal / Gasket / O-Ring	Certified	Long Term	- Engineered Fluids recommends this material as its first choice for all seals, O-rings, and gaskets used with its Directric Coolants.
Fluorosilicone (FVMQ, FSI)	Seal / Gasket / O-Ring	Certified	Long Term	-
Neoprene-impregnated cork	Seal / Gasket / O-Ring	Recommended	Short Term	May discolor fluid under full immersion, however in use as a gasket the material exposed directly to the Coolant is minimal with no adverse impact.
Nitrile Butadiene (NBR)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Nitrile-impregnated cork	Seal / Gasket / O-Ring	Recommended	Short Term	May discolor fluid under full immersion, however in use as a gasket the material exposed directly to the Coolant is minimal with no adverse impact.
Polyacrylate (ACM)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Polychloroprene (CR, Neoprene®)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Polyester (selected types)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Polyurethane	Seal / Gasket / O-Ring	Certified	Long Term	-
Polysulfide (Thiokol, T, PPS)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Polytetrafluoroethylene (PTFE, Teflon®)	Seal / Gasket / O-Ring	Certified	Long Term	-
Polyurethane (AU, EU, selected types)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Silicone (MQ, VMQ, PMQ, SI)	Seal / Gasket / O-Ring	Recommended	Short Term	Use only clear, dyed silicone materials may bleed. Some brands are not pure silicone and contain additives that breakdown. Recommend testing. Observe all temperature limits of products.
Ultra High Molecular Weight Polyethylene (UHMWPE)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Urethane Rubber Polyester (AU)	Seal / Gasket / O-Ring	Recommended	Short Term	-
Urethane Rubber Polyeter (EU)	Seal / Gasket / O-Ring	Recommended	Short Term	-



Third Party Verification of Safety and Thermal Runaway Containment

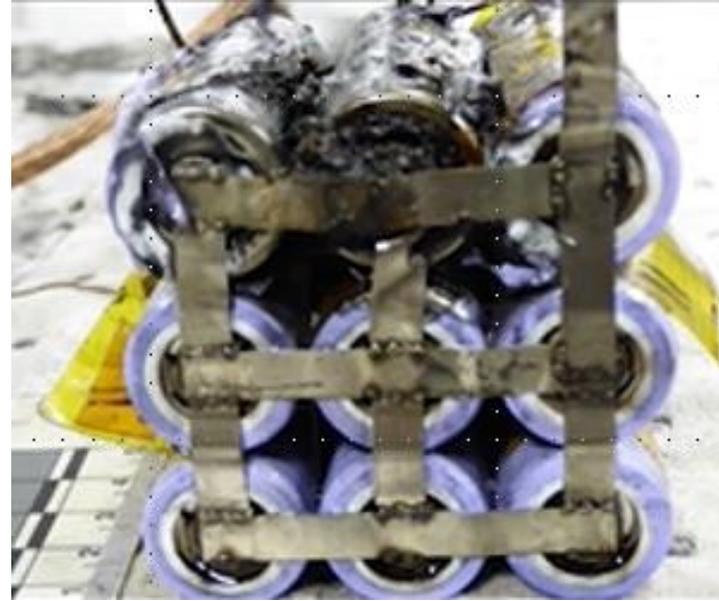
Simulation of Thermal Runaway in a multi-cell battery immersivity cooled with AmpCool™ Dielectric Coolant



Thermal Runaway Protection & Safety



Air / Cold-plate Cooled



SLIC Cooled

- SLIC provides highly effective cell cooling to prevent thermal runaway
- If thermal runaway occurs the goal is to prevent it spreading to other cells
 - Dramatically increase flow of coolant to remove heat and hot gases from cells
 - Thermal breakdown of AmpCool increases heat removal
 - AmpCool does not flash to gas at contact, however expansion does occur, and gases need to be vented from system
- During crash scenarios AmpCool does not enable shorting which is a leading cause of runaway

AmpCool - Third-party Testing and Verification

Insights into Fire Propagation in NMC 21700 Cell Modules with and without Immersive Cooling

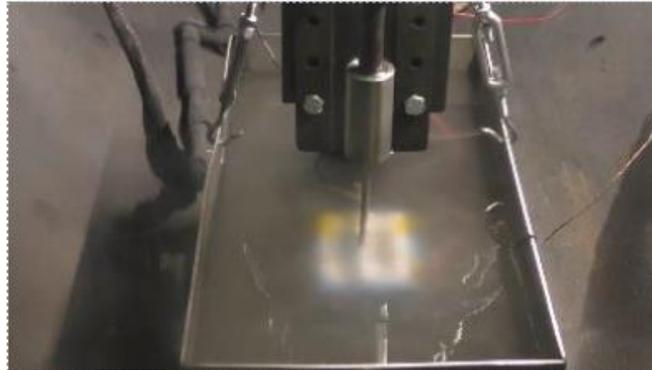
SOUTHWEST RESEARCH INSTITUTE®

Bapi Surampudi PhD, Mickey Argo, Parker Smith
Presented at the International Battery Seminar
07302020

SwRI Test Setup

Item	Specification
3.1 Standard discharge capacity	Min. 4,000mAh - Charge: 0.5C(2A), 4.20V, 0.05C(200mA) cut-off @ RT - Discharge: 0.2C(800mA), 2.5V cut-off @ RT
3.2 Rated discharge capacity	Min. 3,900 mAh - Charge: 1.5C(6A), 4.20V, 0.025C(100mA) cut-off @ RT - Discharge: 10A, 2.5V cut-off @ RT
3.3 Nominal voltage	3.6V
3.4 Standard charge	CCCV, 2A, 4.20 V, 200mA cut-off
3.5 Rated charge	CCCV, 6A, 4.20 V, 100mA cut-off
3.6 Charging time	Standard charge : 180min / 200mA cut-off (@ RT) Rated charge: 70min / 100mA cut-off (@ RT)
3.7 Max. continuous discharge (Surface temperature)	35A(Without temperature cut) 45A(With 80 °C temperature cut)
3.8 Discharge cut-off voltage	2.5V (End of discharge)
3.9 Cycle life	Capacity \geq 2,400mAh @ after 250cycles (60% of the standard capacity @ RT) - Charge : 6A, 4.20V, CCCV 100mA cut-off @ RT - Discharge: 35A, 2.5V cut-off @ RT
3.10 Retention characteristics	Capacity recovery(after the storage) \geq 3,510 mAh (90% of the rated capacity @ RT) - Charge : 6A, 4.20V, CCCV 100mA cut-off @ RT - Storage : 30 days (@ 60 °C) - Discharge : 10A, 2.5V cut-off @ RT
3.11 Cell weight	70.0g max
3.12 Cell dimension	Height : Max 70.30mm Diameter : Max 21.22mm
3.13 Operating temperature (Ambient)	Charge : 0 to 45 °C Discharge: -20 to 60 °C
3.14 Operating temperature(°) (Surface)	Charge : 0 to 50 °C (recommended recharge release < 45 °C) Discharge: -20 to 80 °C (must re-discharge release < 60 °C)
3.15 Storage temperature(°) (Recovery 90% after storage)	1 year 0~25 °C 3 months 0~45 °C 1 month 0~60 °C

Specification of the Samsung 40T 21700 Cell



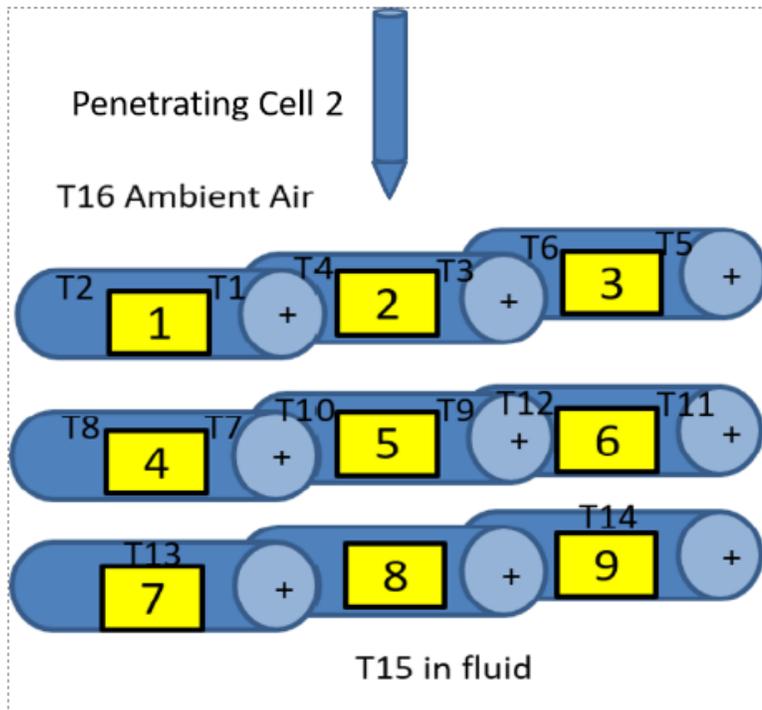
Coolant Container and Pneumatic Nail Penetration Rig



9PS1 Module with 0.5 mm Cell Spacing



Module Configuration



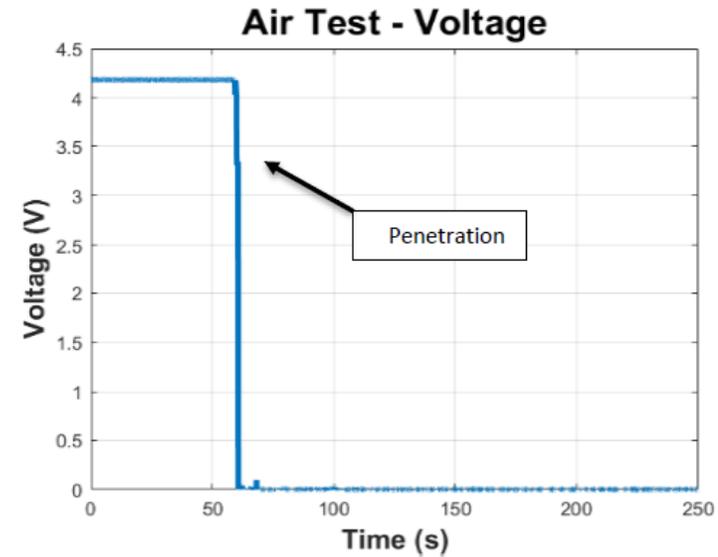
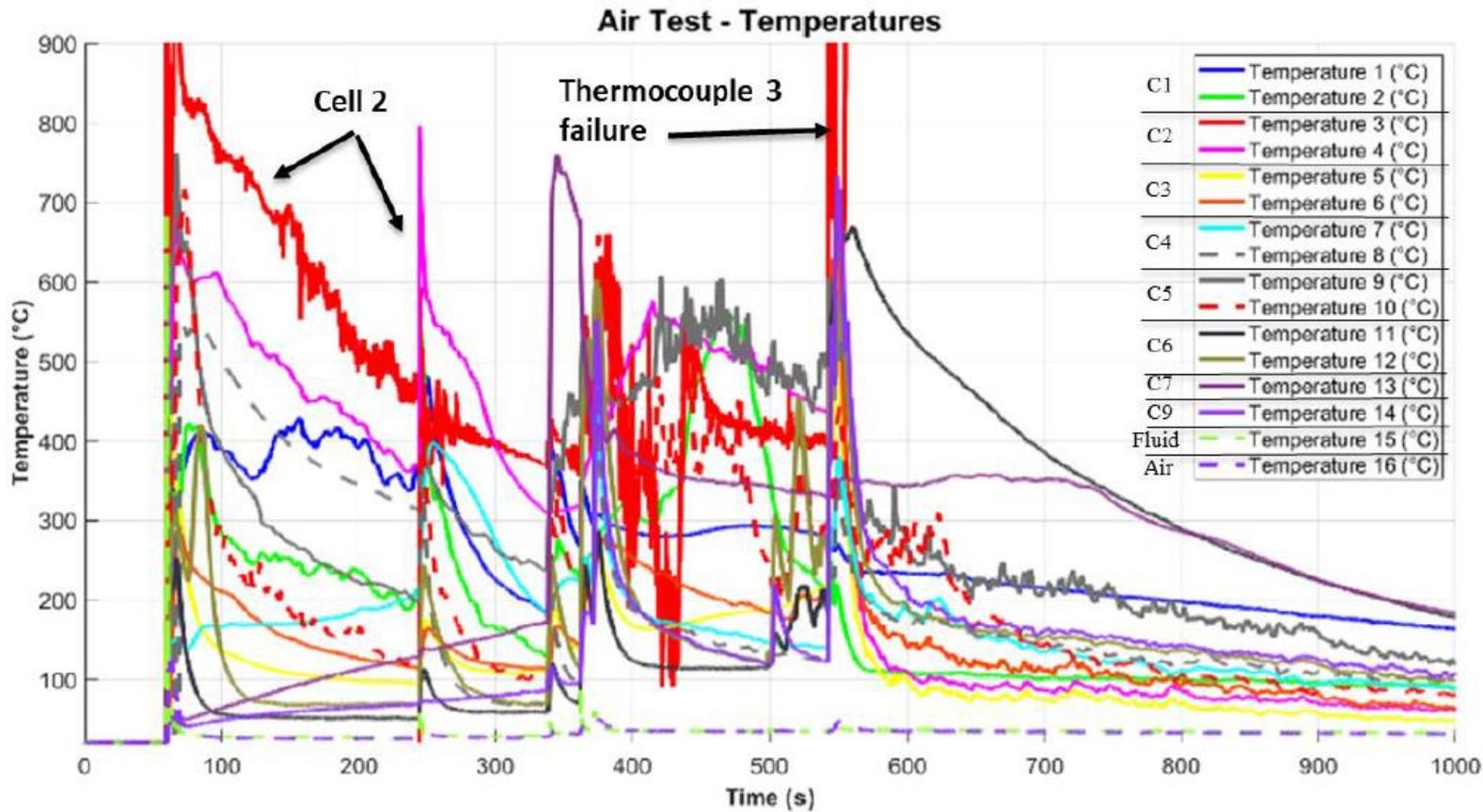
 = Cell #

- Cell form factor is 2 | 700
- Cell cathode is an NMC
- Module is in 9PSI configuration
- 16 K-type thermocouples on cells as shown
- Module was conditioned to 100% SOC at 25 °C

Air Base Line Testing

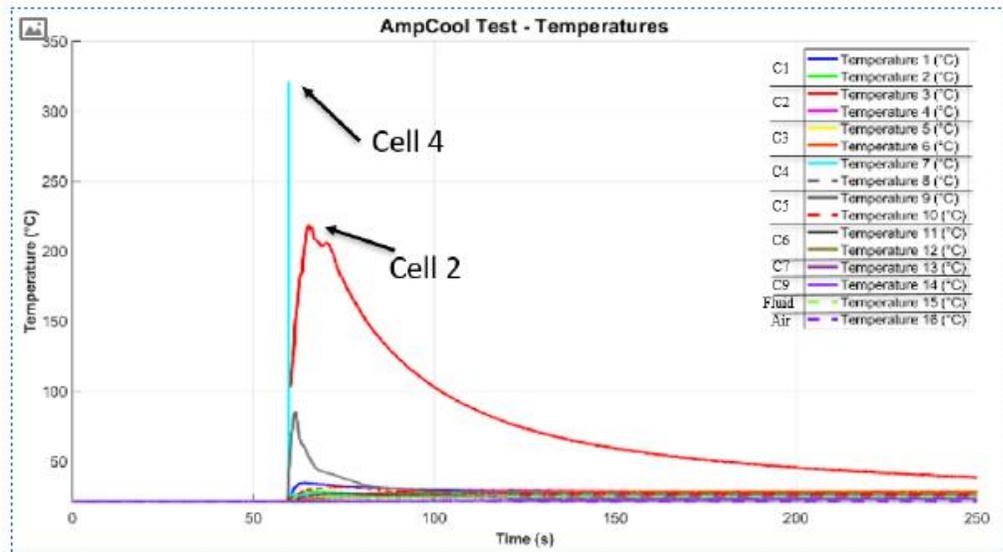


b) Posttest Module



a) Module Voltage Over Time

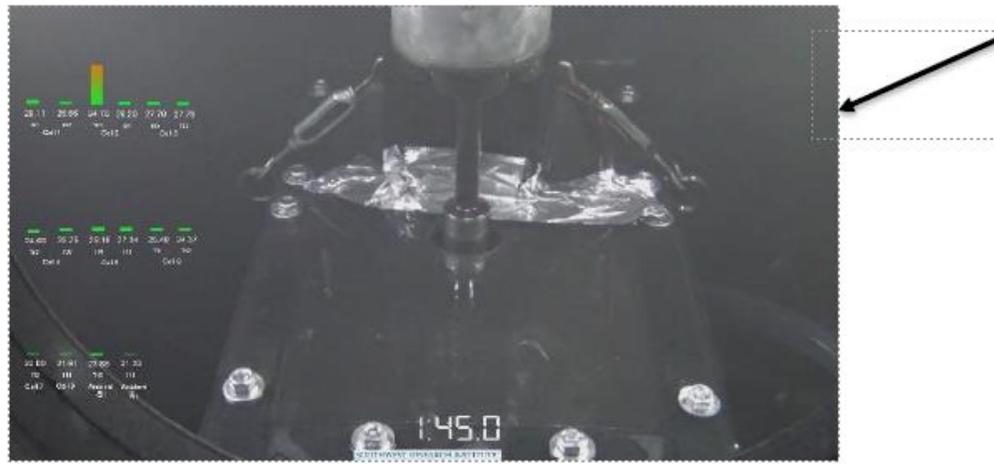
Penetration with Immersive Coolant



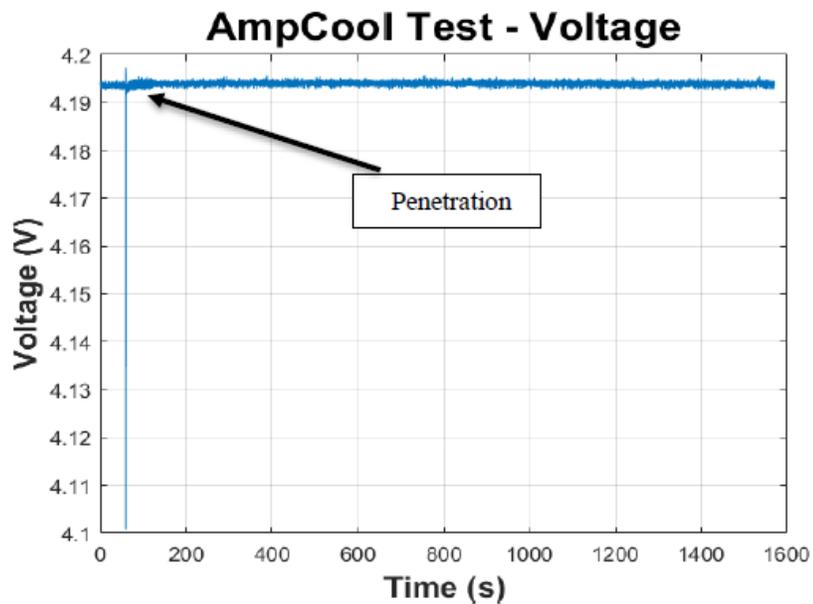
■ Immediate smoke cloud upon penetration

■ No visible fire

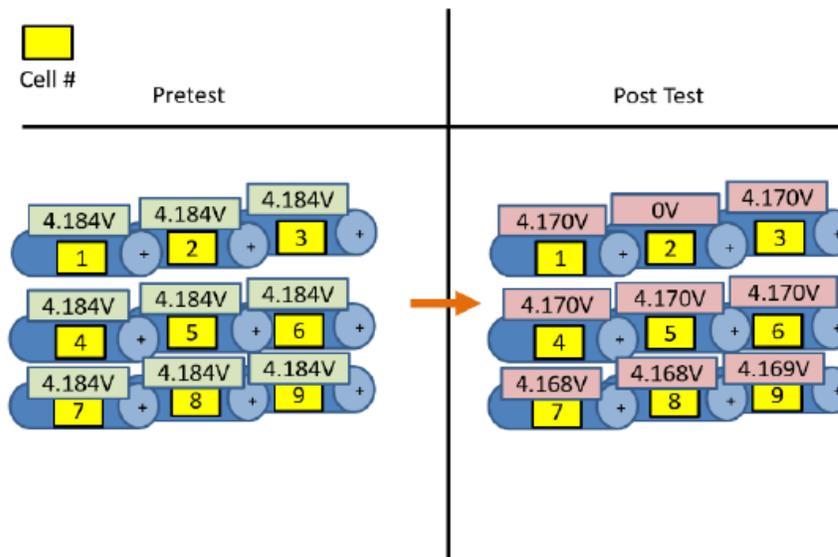
■ Smoke remained trapped in container but dispersed over time.



State of the Module After Immersion Test ...



a) Module Voltage Over Time



b) Posttest Cell Voltages

Conclusion

- The immersive coolant AmpCool™, was successful in preventing fire propagation to neighboring cells. By carrying heat away from target cells, a clear increase in failure thresholds, localization and mitigation of fire propagation is demonstrated with the immersed module in comparison to the baseline test
- Extrapolating from safety to performance, with effective removal of heat from cells, battery packs can deliver high power, can be charged quickly, and passive cell balancing activity can be minimized due to lower temperature differentials across the pack. Indirectly, these traits also enhance life and reduce warranty costs

Battery and Charger System Design Criteria

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2) Safety – Flammability and Fumes

- I. Mining & Marine applications

3) Environmental and Personal Safety

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

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



For more information...

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www.engineeredfluids.com

Buy online: www.engineeredfluids.store



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

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



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 ElectroCool:

- [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	18.99	144.00
	40°C	8.11	5.02	19.00
	100°C	2.22	1.70	4.10
Thermal Conductivity (W/m*K)	0°C	0.1382	0.1382	0.1478
	40°C	0.1359	0.1359	0.1459
	100°C	0.1325	0.1325	0.1430
Specific Heat (kJ/kg°C)	0°C	2.0608	2.0608	2.0575
	40°C	2.2121	2.2121	2.2060
	100°C	2.4390	2.4390	2.4288
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 Lubricants

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

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

Download Information on ElectroCool:

- [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 40°C: 8.61 100°C: 2.40	117.00 17.70 4.00	305.00 39.00 7.24	595.00 69.87 10.19
Thermal Conductivity (W/m²K)	0°C: 0.1455 40°C: 0.1403 100°C: 0.1325	0.1478 0.1459 0.1430	0.1518 0.11508 0.1495	0.1597 0.1585 0.1566
Specific Heat (kJ/kg°C)	0°C: 2.0450 40°C: 2.2094 100°C: 2.4261	2.0575 2.2060 2.4288	2.0502 2.2030 2.4180	2.0733 2.220 2.440
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

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.