

# **Variable Torque Motors (VTM)**

## **Series 3000 Hybrid Electric System**

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## **Emergency Response Guide**

**Note – This system is installed in Class 3 – 7 Heavy Duty Buses and Trucks as either a Hybrid Retrofit or in New Production Vehicles. Unlike production car hybrids, this system is not limited to a specific model or manufacturer.**



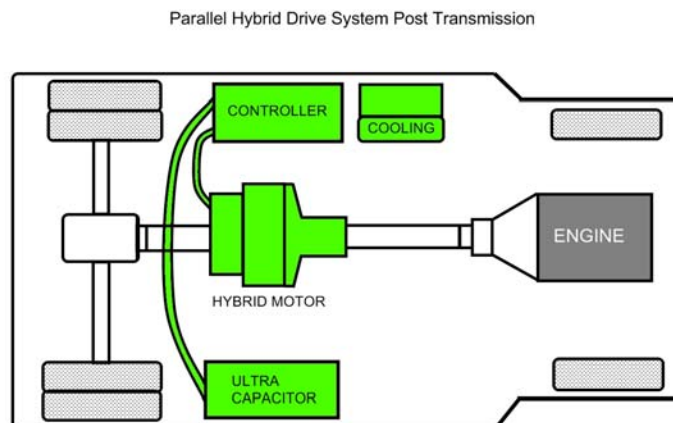
**Typical Hybrid Vehicle Applications**

## About This Guide:

This First Responder Guide for the Variable Torque Motors (VTM) Hybrid Drive System is intended to enhance safety by:

- Assisting VTM hybrid identification
- Outlining VTM Hybrid Safety Features
- Illustrating typical component locations
- Explaining the ultracapacitor energy storage
- Outlining recommended emergency response tactics for various scenarios
- Providing additional MSDS and phone assistance information
- For additional technical assistance, please contact us at [info@variabletorquemotors.com](mailto:info@variabletorquemotors.com) or at (260)-747-3633 - Eastern time zone

Thank you for taking time to study this guide and enhance your preparedness with the new trend in hybrid electric vehicles!



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## VTM hybrid characteristics, Identification

1. Why is a hybrid electric system different?
  - a. Storage of braking energy as electricity
  - b. Electric motor used to boost acceleration using this energy to save fuel and emissions
  - c. Provides a secondary drive system to the vehicle engine
2. How do you tell if the VTM hybrid system is installed - Identification?
  - a. Vehicles have “Hybrid Electric Vehicle” signs on the sides and rear
  - b. The hybrid motor / generator is always installed in the driveline (as part of the driveshaft) of a truck or bus – this is a bright safety green color
  - c. The motor controller and energy storage are installed under the vehicle in a bright safety green color steel case
  - d. ALL high voltage cables are in a bright orange wire loom
  - e. Green / yellow hybrid driver panel installed on dash
3. Differences between the VTM Series 3000 and other hybrids:
  - a. Most other hybrids store and operate on 200 – 500 Volts – This system uses 60 – 96 Volts for enhanced safety
  - b. Most other electric hybrids store the electricity in high energy batteries – This system uses ultra capacitors that have limited energy storage and a rugged sealed case for increased safety
  - c. The VTM system is installed on commercial vehicles such as school buses, transit buses and delivery trucks



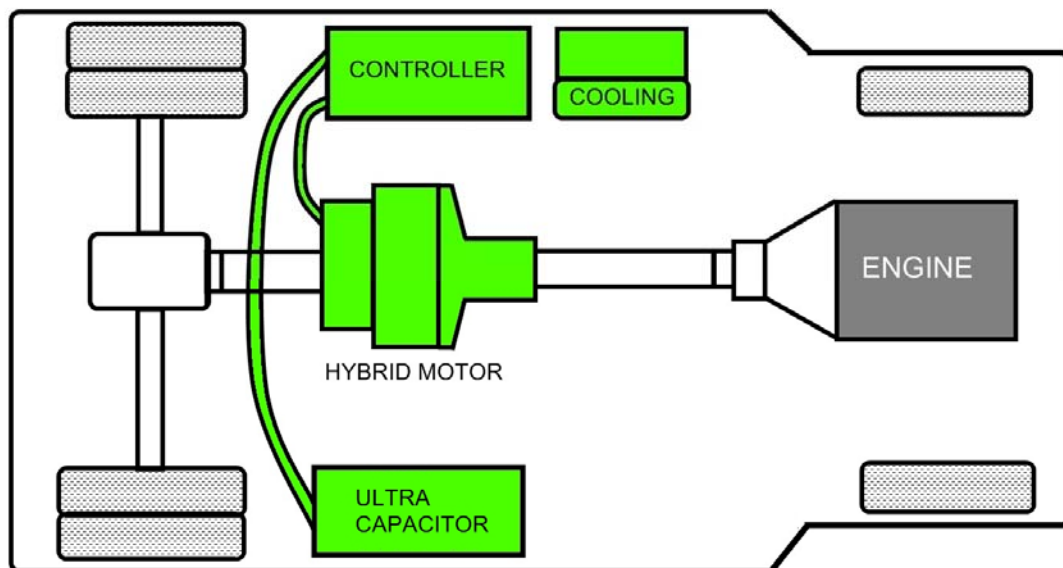
## **VTM Safety Features:**

- When the vehicle ignition is OFF, the hybrid system is always OFF and SAFE – Energy isolated inside the ultracapacitor housing
- The vehicle must be moving at ½ mph or higher speed for the hybrid to engage – the hybrid drive cannot move the rear wheels when the vehicle is stopped
- A Ground Fault Interrupter (GFI) is active whenever the ignition is ON. IF any high voltage leakage to the vehicle frame is detected, ALL contactors open to isolate and protect the system's stored energy
- In a crash or rollover, an inertia switch automatically disconnects the hybrid energy source
- The high voltage (+) supply cable contains a fuse that will open in the event of a high current short circuit
- The VTM hybrid system uses a lower voltage (60 – 96 Volts) than other hybrids (200 – 500 Volts) for increased safety
- Instead of batteries, the VTM hybrid system uses ultra capacitors with limited energy storage that are contained in a rugged sealed aluminum inner housing and a steel outer housing.
- This hybrid system is powered solely by conserving vehicle braking energy – it is never plugged into a charger or high voltage receptacle
- If the ignition cannot be turned OFF, pushing IN a red palm button located on the ultra capacitor housing front panel will disconnect and isolate the high voltage energy source
- ALL cables and wiring that can contain high voltage are covered with a safety orange covering and protected with an internal copper shielding braid covering
- The VTM hybrid system was approved by the Indiana Dept. of Education and Indiana State Police for retrofit into school buses on Jan. 25, 2008

## Typical hybrid component locations:

- **Motor / Generator** – Cylindrical safety green housing in the drive shaft between the transmission and the rear axle
- **Ultra capacitor energy storage** – in a safety green rectangular housing under the vehicle floor – usually between the frame rail and skirt
- **Hybrid controller** – in a safety green rectangular housing under the vehicle floor – usually between the frame rail and skirt
- **DC Cables** – In safety orange wire loom, between the energy storage and hybrid controller (60-96 V. DC when ignition is ON)
- **Motor cables** - In safety orange wire loom, between the motor / generator and hybrid controller (60-96 V. AC only when the wheels or driveshaft is turning)
- **Cooling module** – Shoe box sized housing providing dedicated hybrid cooling with standard automotive water/ glycol antifreeze – usually located next to hybrid controller under the vehicle floor

Parallel Hybrid Drive System Post Transmission



## What is inside an ultra capacitor?



Maxwell Ultra Capacitor module (2 or 4 per hybrid)

- Organic materials hermetically sealed in a rugged aluminum case
- 65% Activated carbon (Ground coconut shells) and aluminum conductors
- 35% electrolyte – consisting of acetonitrile solvent and a salt – this solvent is a class 3 flammable material similar to acetone – nail polish remover – DOT Material UN 1684 – See MSDS pgs. 13-17
- Only 3% of the electrolyte is free material – the rest is absorbed into the activated carbon
- Because 97% of the electrolyte is absorbed in the carbon matrix, fluid spill is not normally a concern unless the modules are crushed
- **Note that if the ultracapacitor is crushed or leaks the electrolyte, avoid contact or breathing of this liquid, since this contains cyanide – see the emergency response section and MSDS for more information**
- Over voltage or over heating of the ultra capacitor usually causes an open circuit, dissipating the stored voltage
- As with many organic materials and plastics, burning of the carbon and electrolyte with insufficient oxygen can produce CO (carbon monoxide) and HCN (Hydrogen Cyanide) gasses that are poisonous
- In case of fire, use water spray (fog), foam, dry chemicals, or CO 2.
- Ultra capacitor modules are on rubber vibration mounts and sealed inside a steel case



## EMERGENCY RESPONSE

- On arrival, emergency responders should follow their standard operating procedures for vehicle incidents
- For the safety of all personnel, always treat the hybrid system as if it is ON – until this is proven to be SAFE
- During emergency situations, remember that the VTM hybrid system is OFF and SAFE whenever the vehicle ignition is OFF.
- IF the vehicle has an impact, the impact sensor opens and the hybrid may be OFF and SAFE, but this should be verified
- If the Ground Fault Interrupter (GFI) senses electrical leakage to the vehicle frame, it will automatically open protective contactors and the hybrid will be OFF and SAFE.
- If the ignition cannot be turned OFF, press IN the red palm button on the ultracapacitor front panel and this will make the hybrid OFF and SAFE

### EMERGENCY RESPONSE – Collision – Extrication

- When approaching the vehicle, look for any signs of leakage or damage. The hybrid coolant is standard auto antifreeze. If the green ultracapacitor case is crushed (with red palm button on panel), look for any leakage of a clear solvent like electrolyte. **CAUTION- if capacitor electrolyte leakage is found, avoid contact or breathing. This solvent (DOT Material UN 1684 – Acetonitrile) is both FLAMABLE AND TOXIC – contains cyanide**
- Use of Self Contained Breathing Apparatus (SCBA) is strongly advised
- Immobilize the vehicle -
  - Chock the drive wheels & set the parking brake
  - Shift transmission into park or neutral
- Disable the vehicle - Turn OFF the vehicle ignition or press IN the red palm button to disable the hybrid system and make it OFF and SAFE
- If extrication is needed, avoid crushing the safety green ultracapacitor housing – identified by the **RED Palm Button** on its front panel and the single orange covered cable
- DO NOT cut into any **ORANGE** covered cables – they may contain high voltage
- If necessary, locate and disconnect the 12 V battery in the vehicle. Loss of 12V DC power makes the hybrid system OFF and SAFE.



## EMERGENCY RESPONSE – Fire

- Use of Self Contained Breathing Apparatus (SCBA) should be used for fighting any vehicle fire because of the toxic smoke that can be produced
- Ultracapacitors store a limited amount of energy when compared to batteries and VTM ultracaps are contained in a much more robust steel and aluminum protective housing
- The VTM hybrid voltage of 55-96 VDC WILL NOT follow water back up a fire hose and cause a shock to a fire fighter
- Ultracapacitors contain 35% electrolyte consisting of acetonitrile solvent and a salt. This solvent is a class 3 Flammable liquid and is toxic. It is similar to acetone- DOT material UN 1648 – ACETONITRILE – see MSDS pgs. 12-16
- When approaching the vehicle, look for any signs of leakage or damage. The hybrid coolant is standard auto antifreeze. If the green ultracapacitor case is crushed (with red palm button on panel), look for any leakage of a clear solvent like electrolyte. **CAUTION- if capacitor electrolyte leakage is found, avoid contact or breathing. This solvent (DOT Material UN 1684 – Acetonitrile) is both FLAMMABLE AND TOXIC – contains cyanide**
- See the enclosed MSDS for fire fighting guidelines and CHEMTREC toll free phone # 1- 800-424 -9300
- Disable the vehicle - Turn OFF the vehicle ignition or press IN the red palm button to disable the hybrid system and make it OFF and SAFE. Within five seconds, the voltage in the **orange cables** has been dissipated
- If extrication is needed, avoid crushing the safety green ultracapacitor housing – identified by the **RED Palm Button** on its front panel
- DO NOT cut into any **ORANGE** covered cables – they may contain high voltage
- If necessary, locate and disconnect the 12 V battery in the vehicle. Loss of 12V DC power makes the hybrid system OFF and SAFE.
- The ultracapacitor cells are contained inside a thick wall aluminum gasketed housing as a module. The modules are rubber vibration mounted and contained inside a galvanized steel housing
- Testing by Maxwell Technologies (ultracapacitor mfg.) has shown that in a fuel fed fire ultracapacitor modules resist the fire twice as long as batteries and then dissipate their electrical energy internally

## EMERGENCY RESPONSE – Spills – First Aid

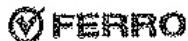
- When approaching the vehicle, look for any signs of leakage or damage. The hybrid coolant is standard auto antifreeze. If the green ultracapacitor case is crushed (with red palm button on panel), look for any leakage of a clear solvent like electrolyte. **CAUTION- if capacitor electrolyte leakage is found, avoid contact or breathing. This solvent (DOT Material UN 1684 – Acetonitrile) is both FLAMMABLE AND TOXIC – contains cyanide.**
- Use of Self Contained Breathing Apparatus (SCBA) is required
- Remove people in contact with electrolyte through skin contact or breathing to fresh air, follow MSDS guidelines – pgs. 12-16
- See the enclosed MSDS for spill and first aid guidelines - CHEMTREC toll free phone # 1- 800-424 -9300
- If the electrolyte is present outside the housing, note the low flash point of 46 F. Avoid ignition sources and static sparks
- The electrolyte can be absorbed into the skin, lungs and eyes and can produce cyanide compounds in the body – similar to urethane paint and foam components – wear full protective gear to avoid contact

## EMERGENCY RESPONSE – Submersion

- The double sealed steel housing and gasketed aluminum shell of the ultracapacitor modules provides multiple protection in a submersion / immersion situation
- The Ground Fault Interrupter (GFI) is active whenever the ignition is ON. If any high voltage leakage to the frame is detected, ALL contactors will open to isolate and protect the systems stored energy.
- In a crash or rollover, an inertia switch opens to automatically disconnect the hybrid energy source
- The VTN hybrid uses a lower voltage (55 – 96 Volts) than other hybrids (300 – 500 volts) for increased safety
- When the vehicle ignition is OFF, the hybrid system is always OFF and SAFE – energy is isolated inside the ultracapacitor housing

## **Roadside Assistance and Towing –**

- **If the hybrid is acting erratically or is displaying a continuous RED light on the driver panel, turn the control switch to OFF. This will disable the hybrid and decouple the hybrid magnets inside the motor to eliminate drag. The trip can then be continued using the vehicle engine until hybrid service can be obtained. This fail safe feature insures continued passenger service.**
- **Vehicles with the VTM hybrid system should not be towed at highway speeds with the rear wheels on the ground and the drive shaft rotating.**
- **Highway towing with the rear wheels raised is OK**
- **Use of tow dollies to support the rear wheels is OK**
- **If the vehicle must be towed at highway speeds with the rear wheels on the ground, the rear drive shaft (between the hybrid motor and rear axle) MUST be removed**
- **WARNING – towing with the rear wheels down and the hybrid rotating voids the warranty and can generate excessive heat and voltages inside the hybrid motor.**



## MATERIAL SAFETY DATA SHEET

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Ferro Corporation, Fine Chemicals Division  
Baton Rouge Operation  
111 West Irene Road  
Zachary, LA 70791 USA

Emergency telephone number:  
CHEMTREC: 1-800-424-9300

Plant Number: 1-225-654-8801

## 1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: Purolyte® 4510 100 L PV  
Chemical Family: Electrolyte Solution  
CAS-No.: Mixture  
Product code: 1311953

Date of Preparation: 05/27/2004

## 2. COMPOSITION/INFORMATION ON INGREDIENTS

Exposure Limits	CAS-No.	Weight %	OSHA	ACGIH
Components				
Acetonitrile	75-05-8	70 - 80%	40 ppm TWA 70 mg/m <sup>3</sup> TWA	20 ppm TWA skin - potential for cutaneous absorption
Tetraethyl ammonium tetrafluoroborate	429-06-1	20 - 30%	Not established	Not established

## 3. HAZARDS IDENTIFICATION

## Emergency Overview

Danger

NFPA 704

Color: Colorless  
Physical state: Liquid  
Odor: Sweet aromatic

Health: 2  
Fire: 3  
Instability: 1

DANGER FLAMMABLE! Vapors may travel to a source and flash back. Probable reproductive hazard. Overexposure may cause CNS depression. May cause eye/skin irritation. May cause irritation of respiratory tract. May cause gastrointestinal irritation.

## Potential Health Effects

Principal routes of exposure: Eye contact. Skin contact. Inhalation.

Eye contact: Contact with eyes may cause irritation or burning.

Skin contact: May cause moderate to severe irritation, burning, and dryness of the skin.

Inhalation: Liver and kidney injuries may occur. Breathing of mists, vapors, or fumes may irritate the nose, throat and lungs. Symptoms may include headache, excitation, euphoria, dizziness, incoordination, difficulty breathing, drowsiness, light-headedness, blurred vision, fatigue, stomach pain, nausea or vomiting, tremors, convulsions, loss of consciousness, cyanosis, central nervous system depression, coma, respiratory arrest and death, depending on the concentration and duration of exposure.

Ingestion: May cause irritation of the mouth, throat and gastrointestinal tract. Inhalation of high vapor concentrations can cause CNS-depression and narcosis. Liver and kidney injuries may occur. May cause cardiac disturbances and/or muscle tremors and impaired motor function. Symptoms may be delayed.

Chronic toxicity: Prolonged or repeated exposure may cause liver or kidney damage. This product may cause teratogenic or mutagenic effects. Tetraethylammonium tetrafluoroborate can form highly corrosive hydrofluoric acid.

## Other information on acute toxicity:

Acetonitrile is metabolized in the liver to water, formic acid, and hydrogen cyanide. The cyanide is further metabolized to thiocyanate. The onset of symptoms is generally delayed pending conversion to cyanide.

Product name: Purolyte® 4510 100 L PV

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**HMS:**  
**Health:** 2  
**Fire:** 3  
**Physical hazard:** 1  
**PPE:** H

#### 4. FIRST AID MEASURES

**Eye contact:** Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Call a physician immediately.

**Skin contact:** Wash off immediately with soap and plenty of water removing all contaminated clothes and shoes. Get medical attention if irritation develops.

**Inhalation:** Move to fresh air. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. Call a physician immediately.

**Ingestion:** Rinse mouth. Drink plenty of water. Never give anything by mouth to an unconscious person. Do not induce vomiting without medical advice. Call a physician immediately.

**Notes to physician:** Treat symptomatically. Exposure should be treated as cyanide poisoning. Effects may be delayed. May be partially metabolized to cyanide in the body. Have a cyanide kit available. If ingested, irrigate the stomach. In the case of ingestion, the stomach should be emptied by gastric lavage under qualified medical supervision.

#### 5. FIRE-FIGHTING MEASURES

**Flash point:** 8 °C ( 46°F) Method: closed cup

**Suitable extinguishing media:** Carbon dioxide (CO<sub>2</sub>). Dry chemical. Foam. Water may be ineffective. In the event of fire, cool tanks with water spray.

**Hazardous decomposition products:** Carbon oxides. Hydrocarbons. Nitrogen oxides (NO<sub>x</sub>). Hydrogen fluoride. Oxides of boron. Hydrogen cyanide (hydrocyanic acid).

**Special protective equipment for firefighters:** As in any fire, wear self-contained breathing apparatus pressure-demand, NIOSH (approved or equivalent) and full protective gear.

**Unusual hazards:** Risk of explosion if heated under confinement. Vapors are heavier than air and may spread along floors. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion.

#### 6. ACCIDENTAL RELEASE MEASURES

**Personal precautions:** Evacuate area of all unnecessary personnel. Keep people away from and upwind of spill/leak. Remove all sources of ignition.

**Environmental precautions:** Do not allow material to contaminate ground water system. Do not flush into surface water or sanitary sewer system. Prevent further leakage or spillage. Local authorities should be advised if significant spillages cannot be contained.

**Methods for cleaning up:** Absorb spill with inert material (e.g. dry sand or earth), then place in a chemical waste container. In the case of respirable dust and/or fumes, use self-contained breathing apparatus and dust impervious protective suit. Dispose of promptly. Clean contaminated surface thoroughly.

#### 7. HANDLING AND STORAGE

**Handling:** Handle in accordance with good industrial hygiene and safety practice. Do not breathe vapours or spray mist. Avoid contact with skin, eyes and clothing. Wash hands thoroughly before eating, drinking or smoking. To avoid ignition of vapors by static electricity discharge, all metal parts of the equipment must be grounded. Empty containers may contain toxic, corrosive, flammable/combustible or explosive residue or vapors. Do not reuse without adequate precautions.

**Storage:** Keep containers tightly closed in a dry, cool and well-ventilated place. Keep product and empty container away from heat and sources of ignition. This compound is hygroscopic.

#### 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

**Engineering measures:** Use only in area provided with appropriate exhaust ventilation. Ensure that eyewash stations and safety showers are proximal to the work-station location.

**Respiratory protection:** When workers are facing concentrations above the exposure limit they must use appropriate certified respirators. In the case of hazardous fumes, wear self contained breathing apparatus.

**Hand protection:** Chemical-resistant gloves and impermeable body covering to minimize skin contact. Use butyl or neoprene rubber gloves.

**Skin and body protection:** Wear chemically protective gloves, lab coat or apron to prevent prolonged or repeated skin contact. If conditions warrant, use butyl rubber apron and boots.

**Eye protection:** Tightly fitting safety goggles. If splashes are likely to occur, wear: Face shield.

**Exposure limits:** Fluoride compounds have limits of 2.5 mg/m<sup>3</sup> (TWA ACGIH).

## 9. PHYSICAL AND CHEMICAL PROPERTIES

<b>Color:</b>	Colorless	<b>Physical state:</b>	Liquid
<b>Odor:</b>	Sweet aromatic	<b>Molecular weight:</b>	No data available
<b>Boiling point/range (°C):</b>	No data available	<b>pH:</b>	No data available
<b>Specific gravity (Water =1):</b>	< 1	<b>Vapor pressure (mmHg):</b>	No data available
<b>Evaporation rate (Water =1):</b>	< 1	<b>Water solubility (mg/l):</b>	No data available
<b>VOG content (%)</b>	No data available		

## 10. STABILITY AND REACTIVITY

**Stability:** Stable under recommended storage conditions.

**Polymerization:** Will not occur.

**Hazardous decomposition products:** Carbon oxides, hydrogen cyanide (hydrocyanic acid), Hydrogen fluoride. May generate hydrofluoric acid and/or borontrifluoride when exposed to high temperature when exposed to high temperatures or acids.

**Materials to avoid:** Incompatible with strong acids, strong alkalis and oxidizers.

**Conditions to avoid:** Heat, flames and sparks.

## 11. TOXICOLOGICAL INFORMATION

### Acute toxicity

No data is available on the product itself.

**Target Organ Effects:** Liver, Kidney, Lungs, Nerves.

**Teratogenicity:** Animal experiments showed mutagenic and teratogenic effects.

**Other information on acute toxicity:** Acetonitrile is metabolized in the liver to water, formic acid, and hydrogen cyanide. The cyanide is further metabolized to thiocyanate. The onset of symptoms is generally delayed pending conversion to cyanide.

### Component information

Component information, if any, is listed below

#### Acetonitrile

**NIOSH - LD50s and LC50s:** = 1250 µl/kg Dermal LD50 Rabbit  
 = 2460 mg/kg Oral LD50 Rat  
 = 269 mg/kg Oral LD50 Mouse  
 = 2693 mg/kg Inhalation LC50 Mouse 1 h  
 = 7561 mg/kg Inhalation LC50 Rat 8 h  
**ACGIH - Carcinogens:** A4 - Not Classifiable as a Human Carcinogen

## 12. ECOLOGICAL INFORMATION

Aquatic toxicity: Acetonitrile; = 1840 mg/L LC50 fathead minnow 96 h flow-through.

Persistence and degradability: Acetonitrile; BOD: 17%, 5 days.

### 13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: Dispose of according to all federal, state and local applicable regulations. Where possible recycling is preferred to disposal or incineration.

### 14. TRANSPORT INFORMATION

#### DOT:

UNID No: UN1648  
Proper shipping name: Acetonitrile mixture  
U.S. DOT - Hazard Class: 3  
Packing group: II

#### TDG (Canada):

Proper shipping name: Acetonitrile mixture  
Hazard class: 3  
Packing group: II

### 15. REGULATORY INFORMATION

#### U.S. Regulations:

#### Acetonitrile (70 - 80%)

SARA 313: 1.0 percent de minimis concentration  
1.0 percent de minimis concentration (Chemical Category N108)  
TSCA 12(b): Listed

#### State Regulations

This product or its ingredients have been evaluated for New Jersey, Pennsylvania, and California Prop 65 supplier notification requirements. Substances that are subject to notification requirements, if any, are listed below.

#### Acetonitrile (70 - 80%)

NJRTK: en 0008  
PARTK: Listed

#### Canadian WHMIS

WHMIS hazard class: B2 Flammable liquid, D1A Very toxic materials, D2B Toxic materials.

#### Components

Acetonitrile (70 - 80%)

#### WHMIS Ingredient Disclosure:

0.1% (English Item 12, French Item 43)

#### International Inventories

TSCA 8(b): All the ingredients are on the TSCA list.  
Canadian DSL: One or more ingredient(s) are not on the DSL list.  
EINECS: All the ingredients are on the EINECS list.  
Philippines (PICCS): Listed.  
Japan (ENCS): Not listed.  
Korea (KECL): Not listed.  
China (IECS): Listed.  
Australia (AICS): Listed.

### 16. OTHER INFORMATION

Product name: Purolyte® 4510 100 L PV

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**For Industrial Use Only**

Prepared by: Ferro Technical Center

The information and recommendations contained in this Material Safety Data Sheet have been compiled from sources believed to be reliable and to represent the most reasonable current opinion on the subject when the MSDS was prepared. No warranty, guaranty or representation is made as to the correctness or sufficiency of the information. The user of this product must decide what safety measures are necessary to safely use this product, either alone or in combination with other products, and determine its environmental regulatory compliance obligations under any applicable federal or state laws.

**End of Safety Data Sheet**

Product name: Purolite® 4510 100 L PV

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