第6回 韓日燃料技術交流會

Managing Electrostatic Hazards in ULSD Handling

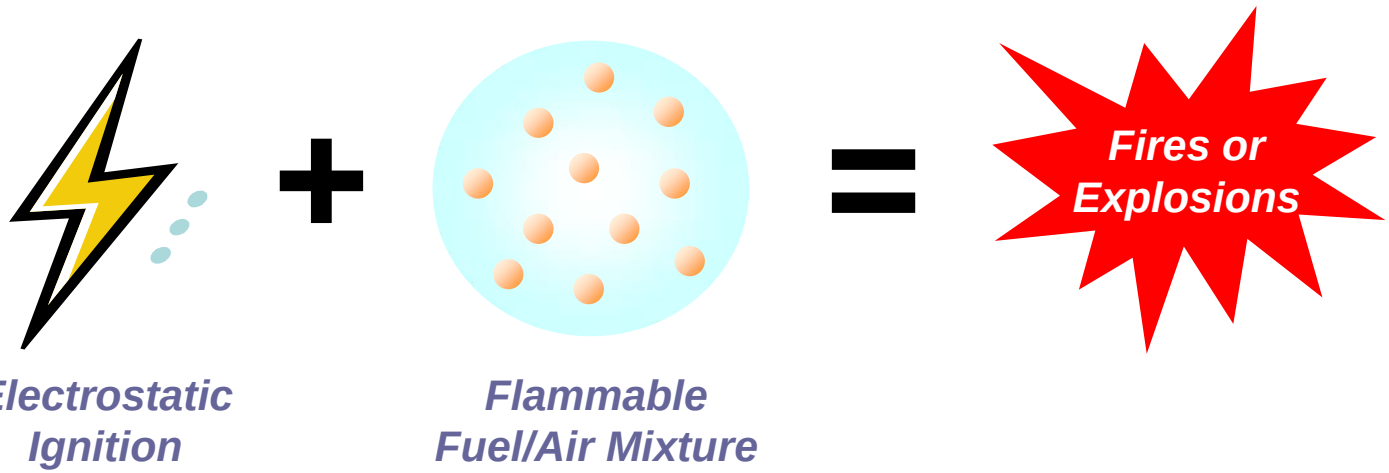
2005. 9.

SK Corporation

Contents

Electrostatic Incidents

“Every year a number of fires and explosions in petroleum product systems are attributed to spark ignition from accumulated static electricity. ”

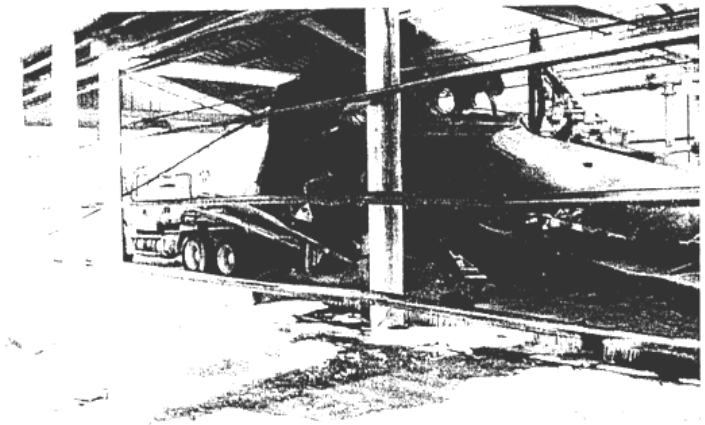


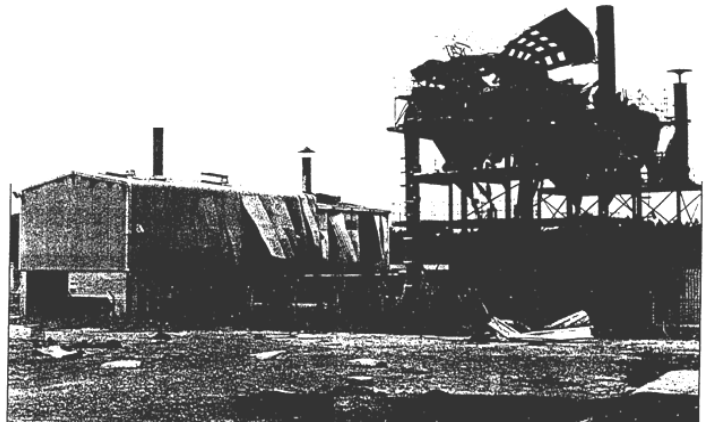
Electrostatic Ignition

Flammable Fuel/Air Mixture

ASTM D 4865, “Standard Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems”

Electrostatic Incidents





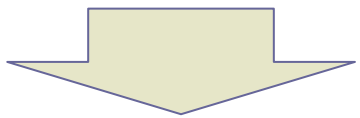
Shell, Static Electricity in Petrol Stations
The Safety & Health Practitioner, March 1996
Octel, Risk Management of Ultra Low Sulfur Ground Fuel

Electrostatic Incidents

- **2 incidents in Sweden, April 1997**
- **1 incident in France involving a fatality, 1997**
- **6 incidents in Canada after ASA[1)] injection failed, 1996-97**
- **1 incident in Germany, 1997**

[1)]ASA: Anti-static Agent

Octel, Ultra Low Sulfur Fuels: Conductivity



“The risk of electrostatic incidents with low sulfur (<50 ppm) was an order of magnitude higher.

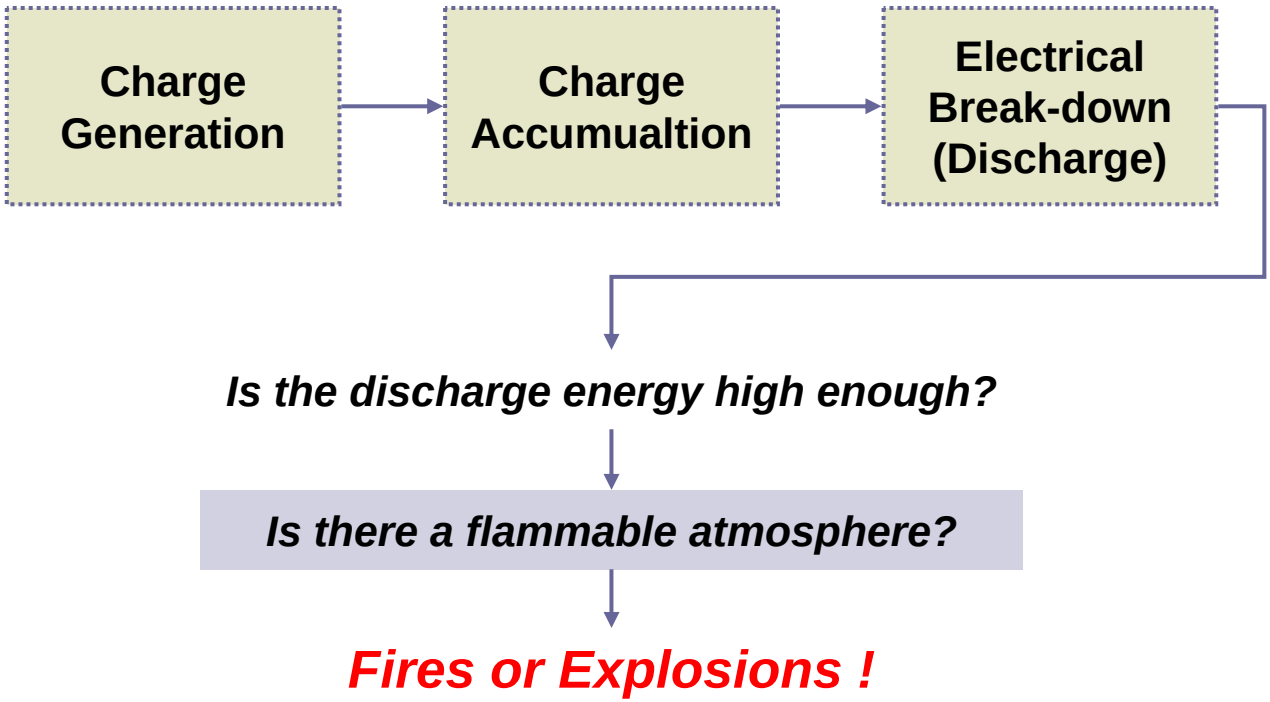
The risk can be about 30 times higher.”

H.D.Kattenwinkel, 2nd CEN/TC Symposium Automotive Fuels, 2003

Contents

Electrostatic Ignitions

- **Electrostatic discharges are caused by a three stage process.**

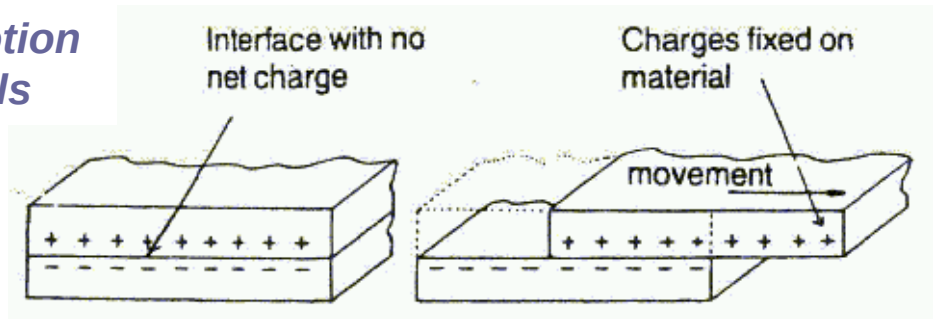


Charge Generation

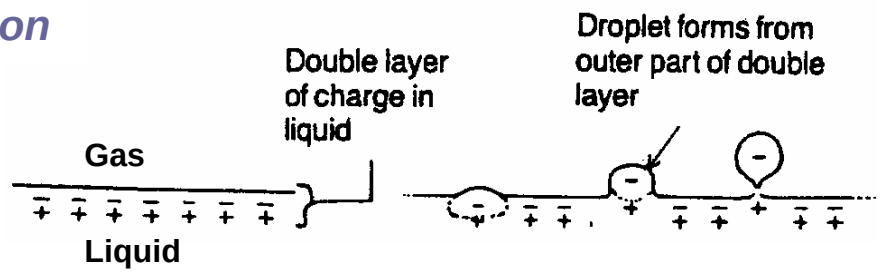
Generation → Accumualtion → Discharge

- **Whenever a hydrocarbon liquid flows with respect to another surface, a charge is generated in the liquid and an equal but opposite charge is imposed on that surface.**
- **This charge is attributed to ionic impurities present in ppm or ppb.**

Charging by bulk motion of insulating materials

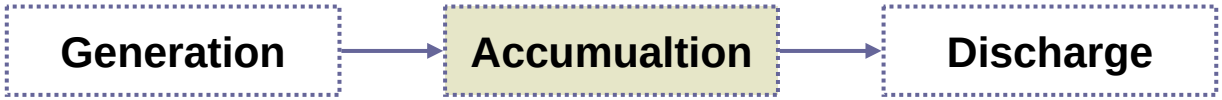


Charging by atomisation



H. Walmsley, Journal of Electrostatics, 27 (1992) 13-29

Charge Accumulation



- **Indicated by its charge relaxation time, which means the time for a charge to dissipate to e^{-1} (approximately 37%).**

※ **Complete dissipation time**
at 1 pS/m = 54 seconds
at 100 pS/m = 0.54 seconds

- **For most low conductivity liquids,**

$$\tau = \frac{18}{\sigma}$$

τ : relaxation time, seconds
σ : conductivity, pS/m

Conductivities and Relaxation Times of Fuels

Liquid	Conductivity, pS/m	Relaxation Time, s
Gasoline	0.01 ~ 0.1	0.2 ~ 200
Kerosene	0.1 ~ 50	0.4 ~ 200
Diesel	1 ~ 100	0.2 ~ 20
Lube Oils	0.01 ~ 1,000	0.02 ~ 2,000

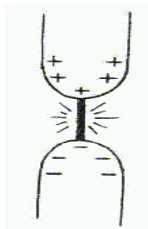
API Recommended Practice, 2003

Electrostatic Discharges

Generation → Accumualtion → Discharge

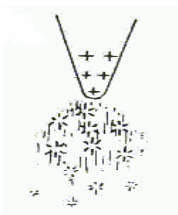
- Generated in insulating media by high electric fields. The insulation breaks down and charge is transferred to eliminate the electric field.
- Stored electrical energy is converted to heat in the discharge medium and this heat may cause ignition.

Sparks



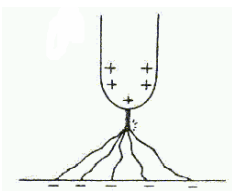
- Occur in gaps between conductors.
- Plasma channel over the entire gap.

Glow Coronas



- Occur when a sharp conductor is raised to a high potential.
- Very diffuse, no plasma channel.

Brush Discharges



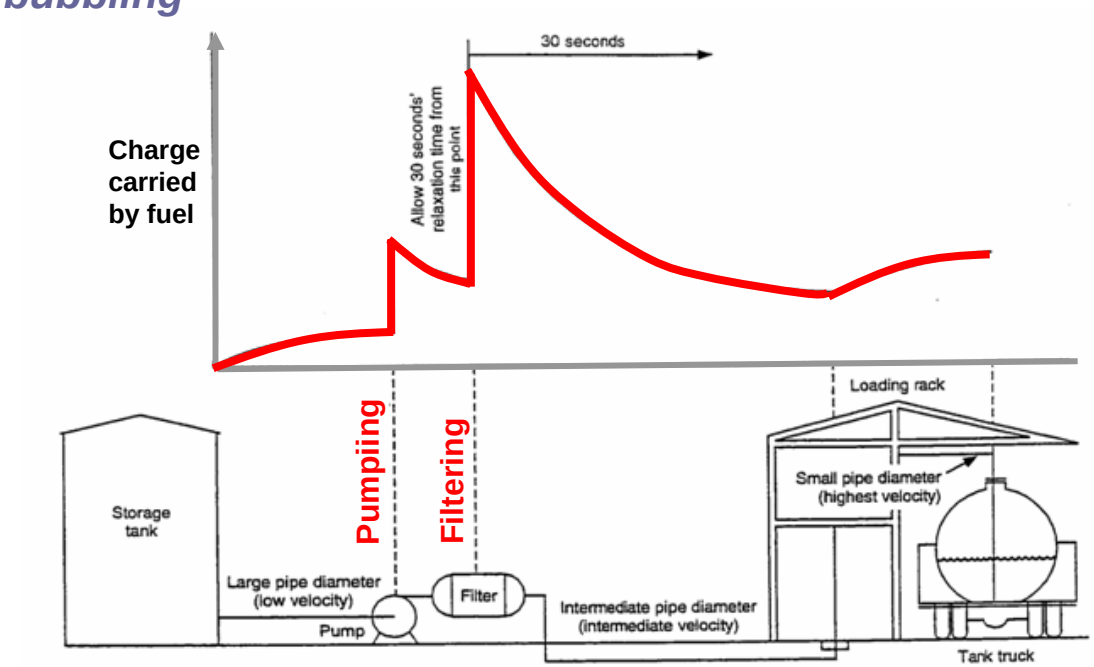
- Occur between blunt conducting electrodes and insulating materials.
- Plasma channel at one end, diffuse at other end.

H. Walmsley, Journal of Electrostatics, 27 (1992) 13-29

Contents

Potentially Hazardous Operations

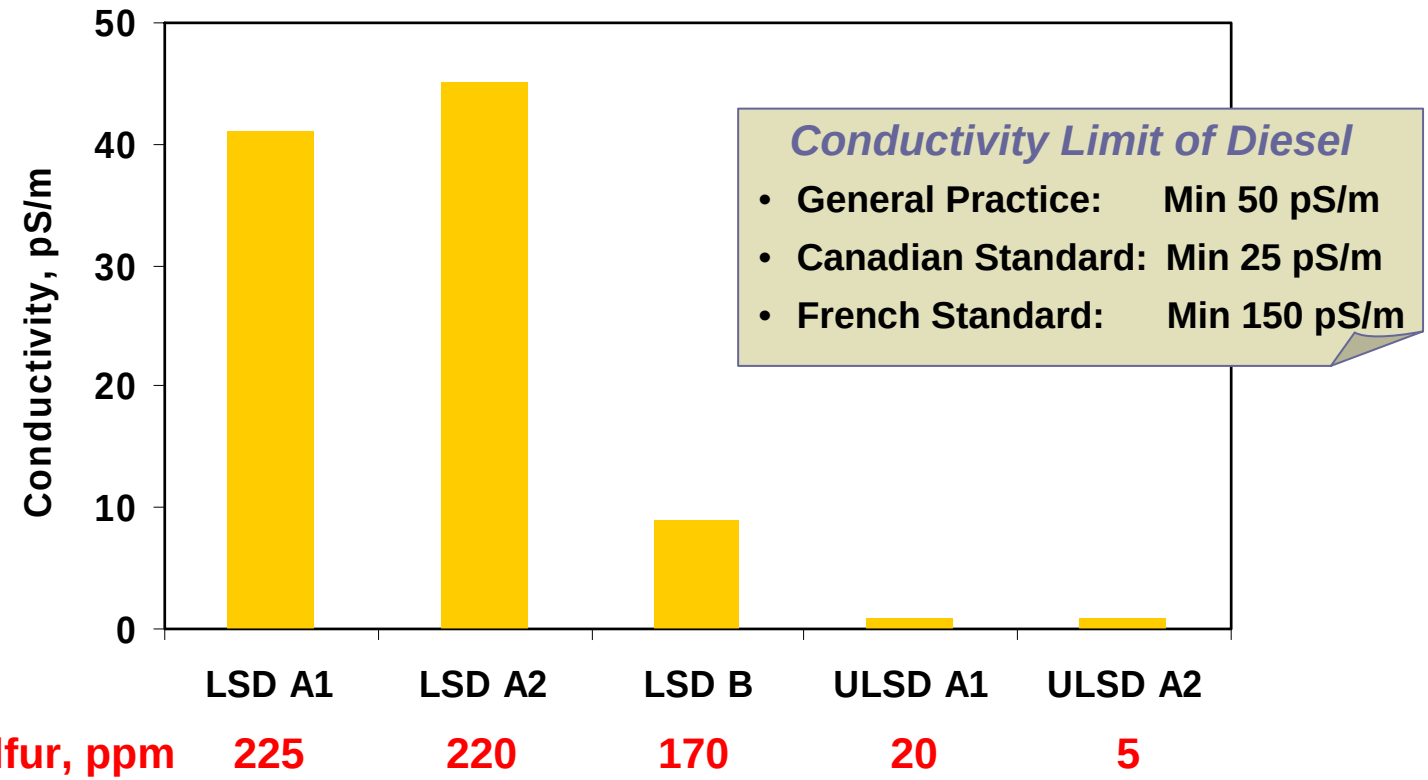
- **Typical cases in which hazardous potentials may accumulate on low conductivity liquids are:**
  - ✓ ***Flow through pipework, valves, reducers***
  - ✓ ***Flow through micro-filters(10 microns or less)***
  - ✓ ***Splashing during loading***
  - ✓ ***Air or vapour bubbling***
  - ✓ ***Pumping***



API Recommended Practice, 2003

Conductivity of ULSD

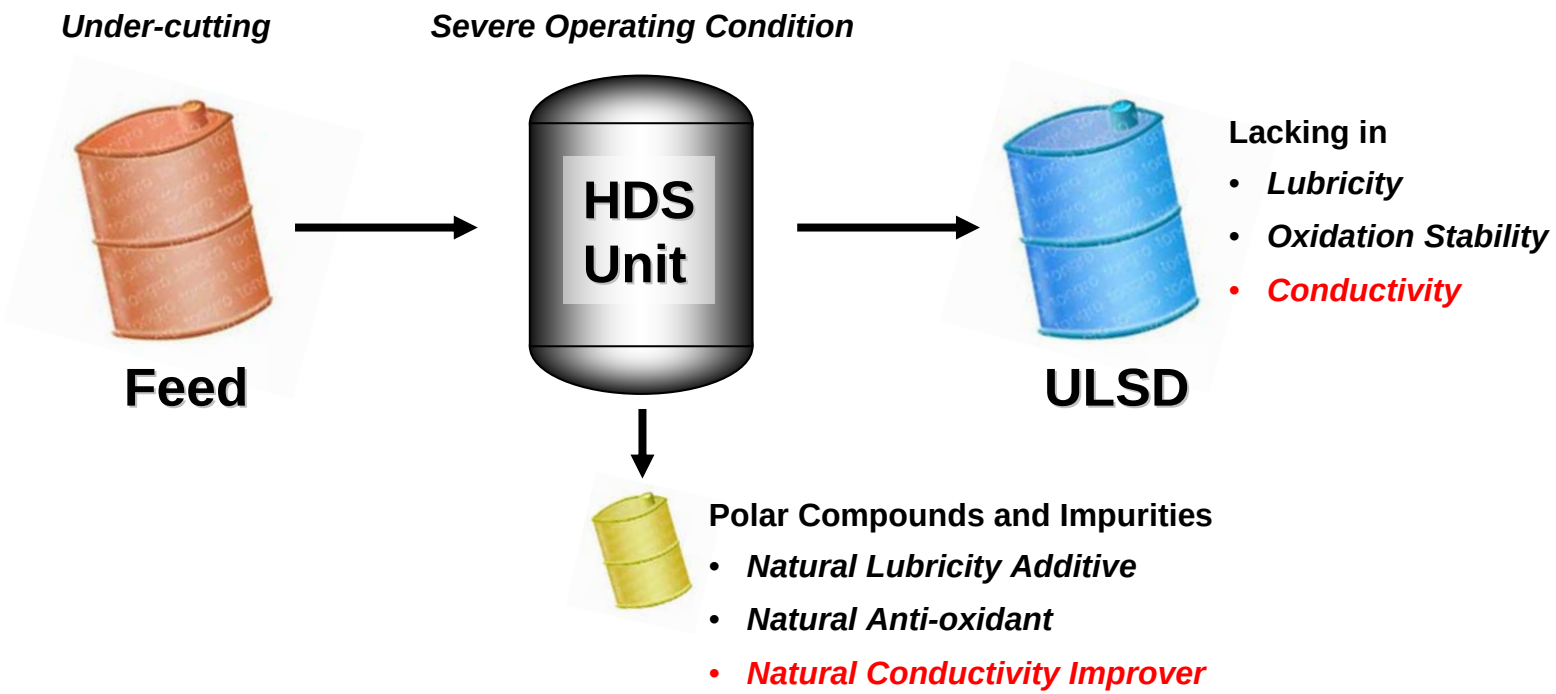
- **ULSDs show extremely low conductivity.**
- **LSD from different refiney can have different conductivity.**



SK's Test Results

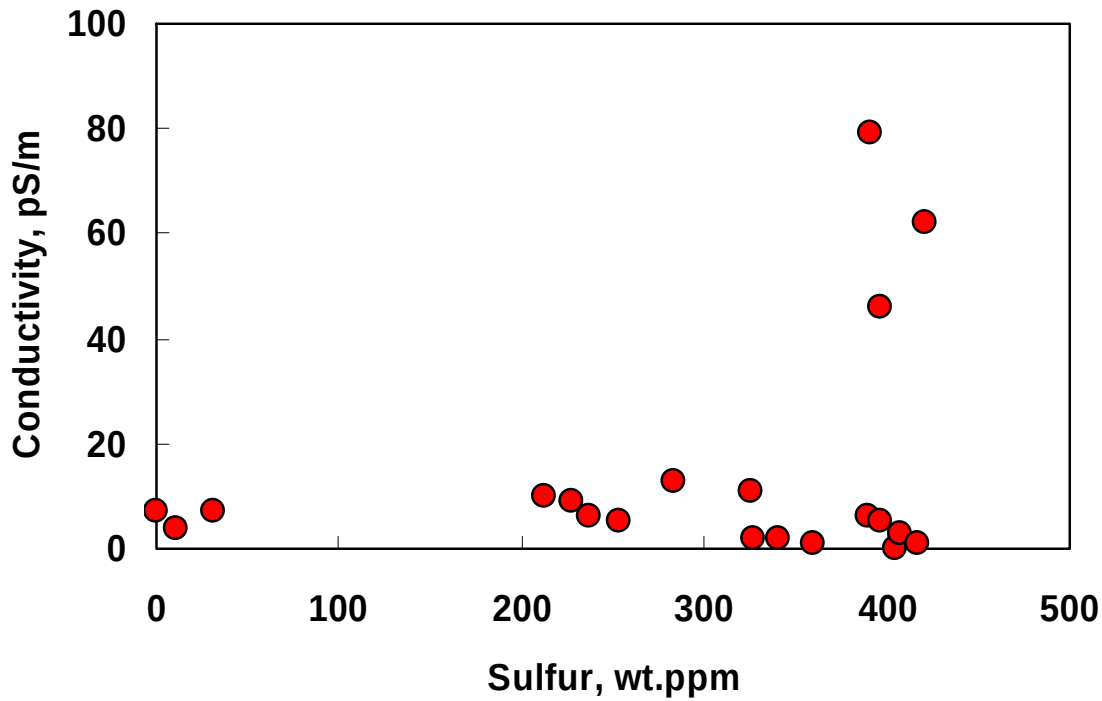
Conductivity of ULSD

- **Gas oil should undergo severe operating condition.**
- **Removed are polar compounds and impurities which improves lubricity, oxidation stability and conductivity.**



Sulfur vs. Conductivity

- **Low sulfur fuels all had very low conductivity.**
- **Higher sulfur fuels could have high or low conductivity.**
- **Sulfur content is not a reliable guide to conductivity, but ULSD fuels should be expected to have very poor conductivity.**



Octel, Risk Management of Ultra Low Sulfur Ground Fuel

Contents

Risk Assessment

- **The Inherent Risk Factor**

Category	Risk Factor	Conductivity	Sulfur
A	Low	C > 50	-
B-1	Standard	C < 50	S > 500
B-2		10 < C < 50	S < 500
C-1	Increased	C < 10	50 < S < 500
C-2		Unknown	S > 50
D	High	C < 10	S < 50

Shell Global Solutions, Risk Management: Electrostatic Ignition in Fuel

- **The Possibility of a Flammable Atmosphere**

Switch Loading	• **The practice of loading a low vapor pressure product into a tank which previously contained a high vapor pressure product.** ***e.g. Loading diesel after gasoline***
Splash Loading	• **The practice of allowing fuel to free fall or to impinge at high velocity on a tank wall, bottom or liquid surface while loading.** ***e.g. Top loading into tank truck***

API Recommended Practice, 2003

Preventive Measures

To avoid and prevent :

Charge Generation	• Avoid splashing and misting operations. • Limiting flow rates. • Avoid pumping fuels with dispersed water or solids.
Charge Accumulation	• Use sufficient residence time downstream of pumps and filters. • Use bonding and grounding to prevent buildup of potential. • Add antistatic additive to raise conductivity.
Spark Discharge	• Remove or ground spark promoters in tanks and vessels. • Take care to avoid loose metal objects in the compartments.
Flammable Atmosphere	• Avoid switch loading and top loading(splash loading). • Displace air with nitrogen or other inert gas.

Precautions for Tank Truck Operations

Category A: ***Implement the basic minimum precautions***

- **The vehicle and loading arm must be electrically bonded.**
- **Ensure people do not become charged.**
- **Avoid splash loading.**

Category B: ***Implement 'A' and the following loading conditions***

V: Product Velocity, m/s
D: Diameter, m

Loading Condition	VD(m^2/s)
Top loading without ASA(antistatic additive)	< 0.38
Top loading with ASA(antistatic additive)	< 0.5
Bottom loading without central conductors and without ASA	< 0.38
Bottom loading with compartment suitable for high speed loading, or with ASA	< 0.5

e.g. Loading Speed: 2,000 liter/min
Pipe Diameter: 4 inch
→ **0.42 m^2/s**

Category C&D: ***Implement 'A', 'B' and one of the following***

- **Use a antistatic additive.**
- **Use a safe loading rate(VD≤0.1).**
- **Eliminate the flammable atmosphere.**

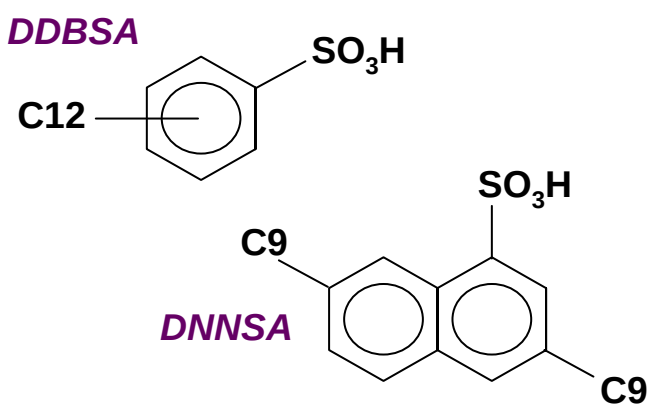
Shell Global Solutions, Risk Management: Electrostatic Ignition in Fuel

Additive Solutions

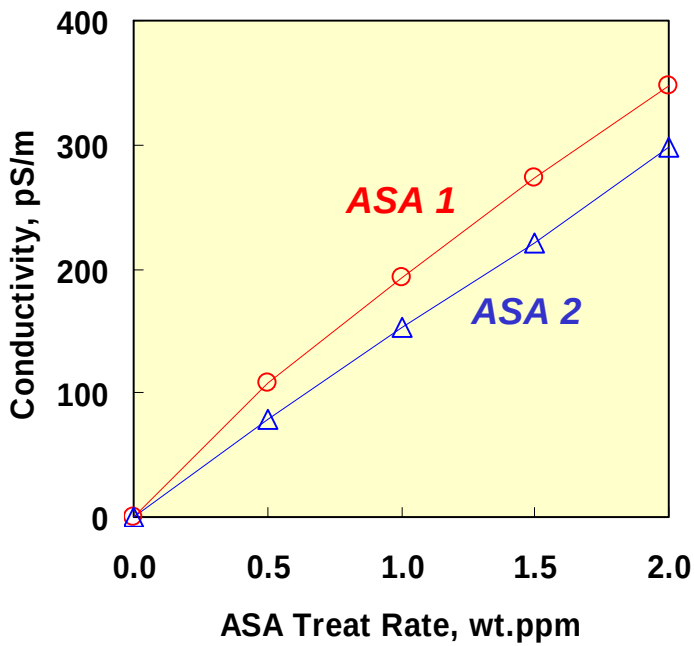
- **ASA increase the rate of charge dissipation, resulting in a reduction of electrostatic discharges.**
- **Hydrocarbon-soluble polymers, metallic salts or nonmetallic salts.**

Chemistry of ASA

Olefin-acrylonitrile copolymers
Acrylonitrile copolymers/Polyamines
Olefin-sulfur dioxide copolymers/Polyamines
Alkylphenol-formaldehyde condensates
Vinyl ether-maleic anhydride copolymers
Dodecylbenzenesulfonic acid(DDBSA)
Dinonylnaphthylsulfonic acid(DINNSA)



Conductivity Improvement by ASA

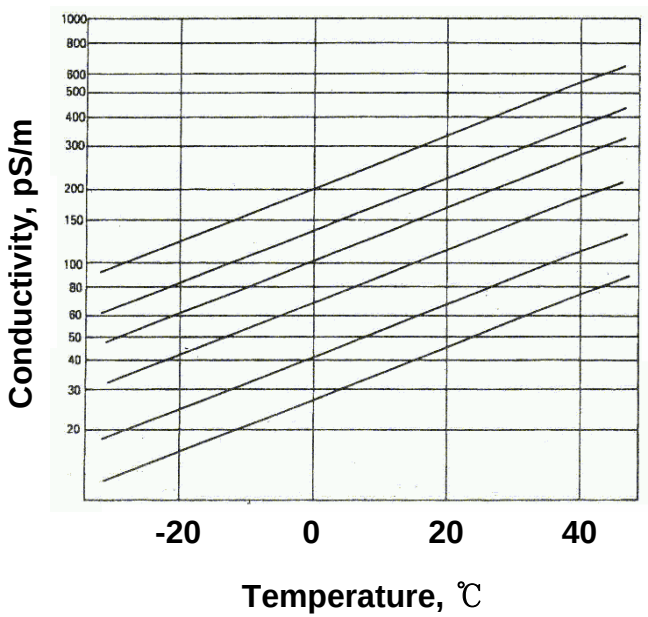


SK's Test Results

Additive Solutions

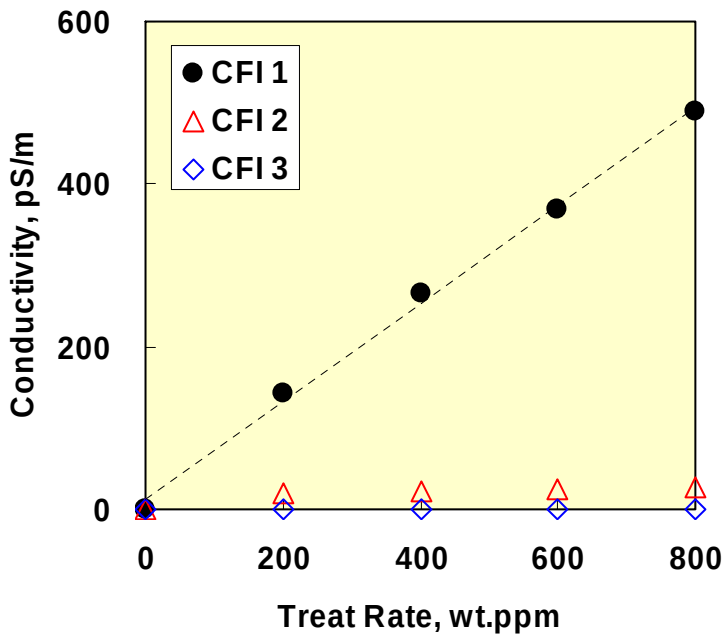
- **Fuel temperature affects conductivity because viscosity change affects the rate at which charge can be conducted through fuel.**
- **Some cold flow improvers(CFI) contribute to conductivity improvement, which can compensate for increased risk during winter season.**

Temperature vs. Conductivity



H. Walmsley, Journal of Electrostatics, 27 (1992) 13-29

Conductivity Improvement by CFI



SK's Test Results

SK Corporation

Thank You For Your Attention