Comparissons of SOT Testing Procedures for "LiquidFertilizers"

Fluid Fertilizer Foundation
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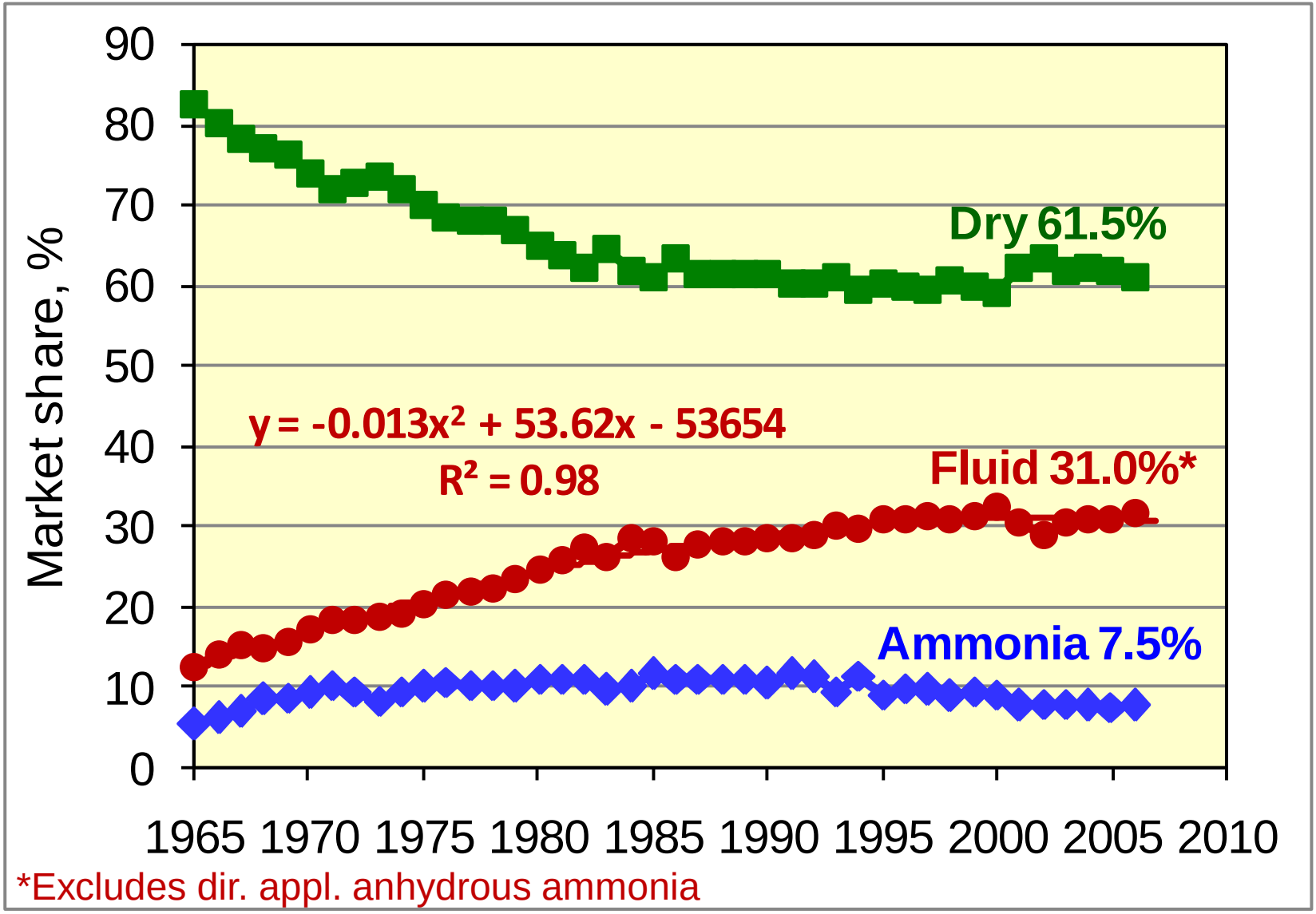
USA fertilizer market share by class.



Data source: Commercial Fertilizers, AAPFCO & TFI

IPNI

Liquid Fertilizers

Fertilizer	Grade
Triazone N Fertilizer	28-0-0
Ammonium Thiosulfate	12-0-0-26S
UAN-28	28-0-0
UAN-30	30-0-0
UAN-32	32-0-0
Ammonium Polyphosphate	10-34-0
Potassium Thiosulfate	0-0-25-17S

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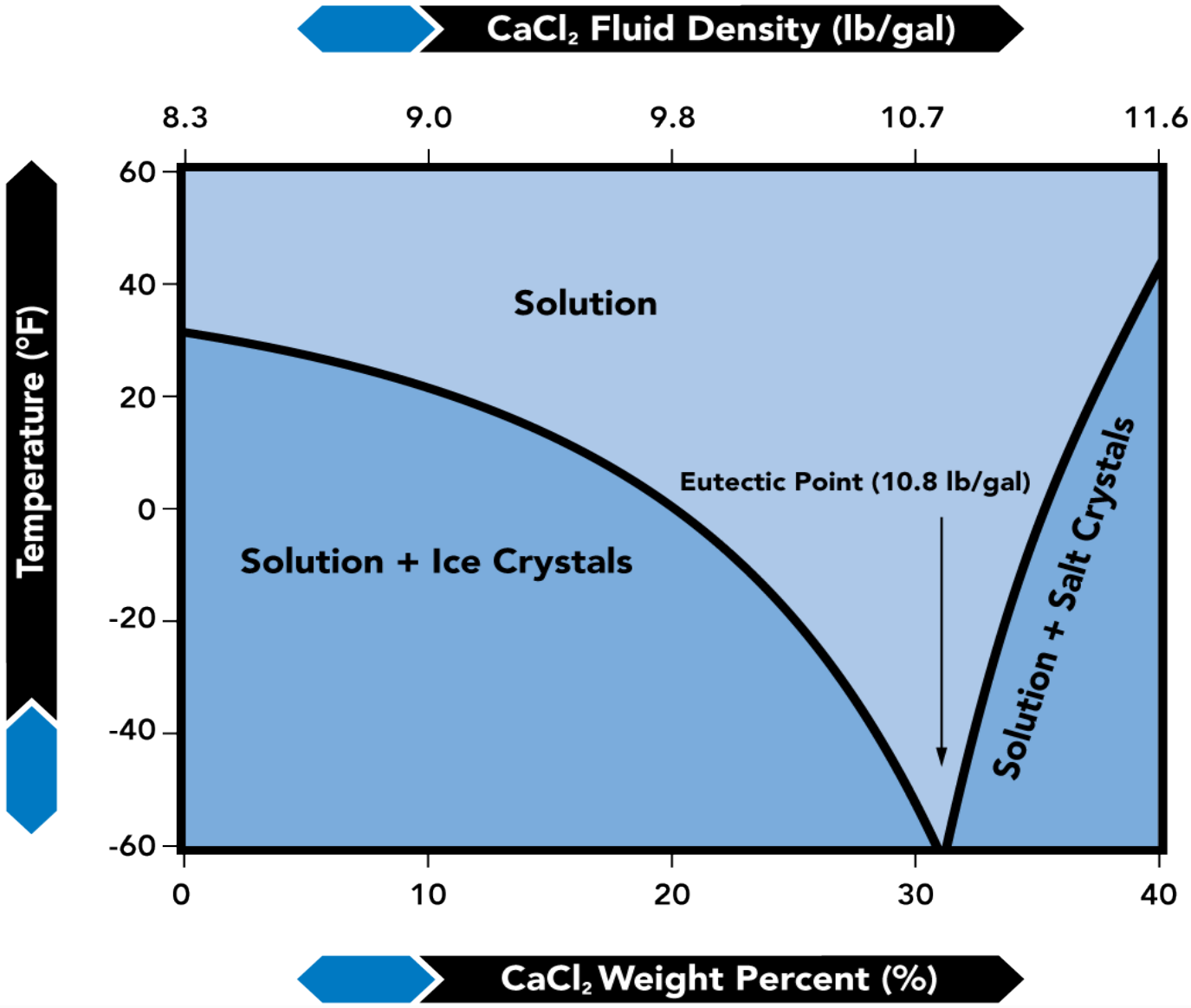
Liquid Fertilizers

- Easier to prepare
- Easier to apply
- Applies easily to the irrigation lines
- Can be blended with other nutrients in one application
- Furthers 4R Crop Nutrition
- Disadvantage - May salt out in cold temperatures

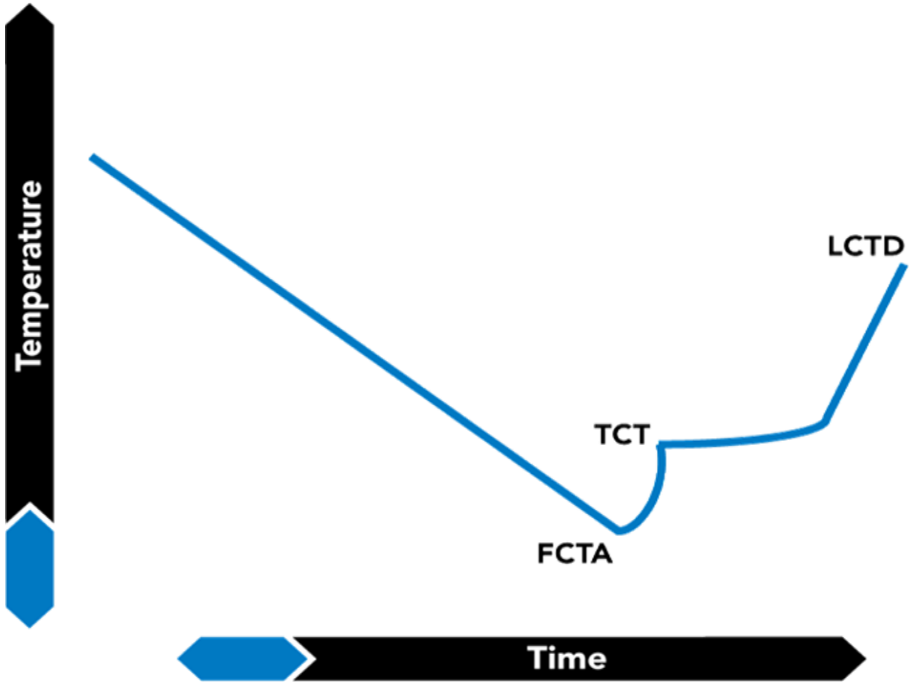
Crystallization Temperature:
The crystallization temperature is the temperature at which a solid phase begins to form, resulting in a mixture of solid particles and solution. These solids may be salt crystals or water crystals (ice).

Figure 1 shows a typical crystallization temperature curve for a Salt solution. Note that the left side of the curve slopes downward with increasing salt concentration levels. This side of the curve is labeled *Solution + Ice Crystals*. It represents the freezing point of the salt, where ice crystals would begin to form. The right side of the curve is labeled *Solution + Salt Crystals*. It represents the phase boundary of the salt, below which salt crystals begin to form. The minimum point where the two curves intersect is known as the *eutectic point*. It is the point at which the minimum crystallization temperature can be realized. In essence, it is the lowest temperature at which a solid free solution can exist.

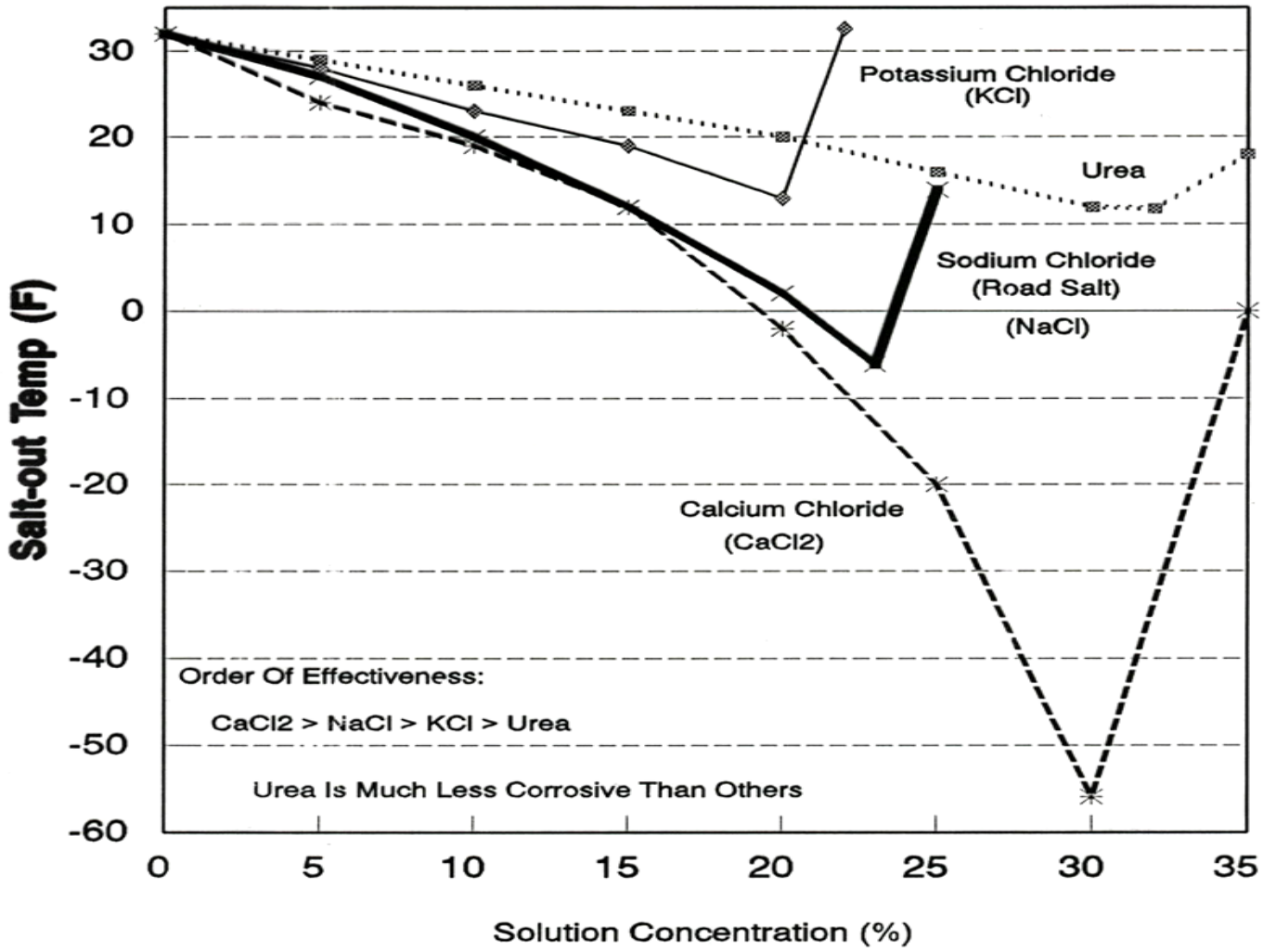

CaCl₂ Fluid Density (lb/gal)
8.3
9.0
9.8
10.7
11.6
Temperature (°F)
60
40
20
0
-20
-40
-60
Solution
Eutectic Point (10.8 lb/gal)
Solution + Ice Crystals
Solution + Salt Crystals
0
10
20
30
40
CaCl₂ Weight Percent (%)

Typical Crystallization curve

- FCTA = First Crystal to Appear
- TCT = True Crystallization Temperature (the formation of salt crystals generates a small amount of heat, which causes a slight rise in the solution's temperature)
- LCTD = Last Crystal to Dissolve



EFFECT OF SALTS ON FREEZING POINT



Fertilizer Solutions

Salt-out is an issue in many environments and SOT should be known

- Warm water has ability to dissolve more salts than cold water
- Salt-out occurs when salt content exceeds solubility at a given product temperature
- Crystals form on tank walls as temperature cools
- Eventually salts accumulate at tank bottom
- Salts will re-dissolve with sufficient heat and recirculation

SOT Measurement Methods

- There are multiple methods used to measure SOT – which makes product comparissons difficult
- Lack of consistency among methods and no standards:

1. Dauncy & Still Optical Method, J. F. Luternauer, J. Agri. Food Chem. 1967, 15(3), 543-546
2. Polythermal/Thawing Method, Kadam, et.al., Chem. Engineering Science, 1970, Vol 2, 2012, 10-19
3. ASTM D97
4. UAN (CF)

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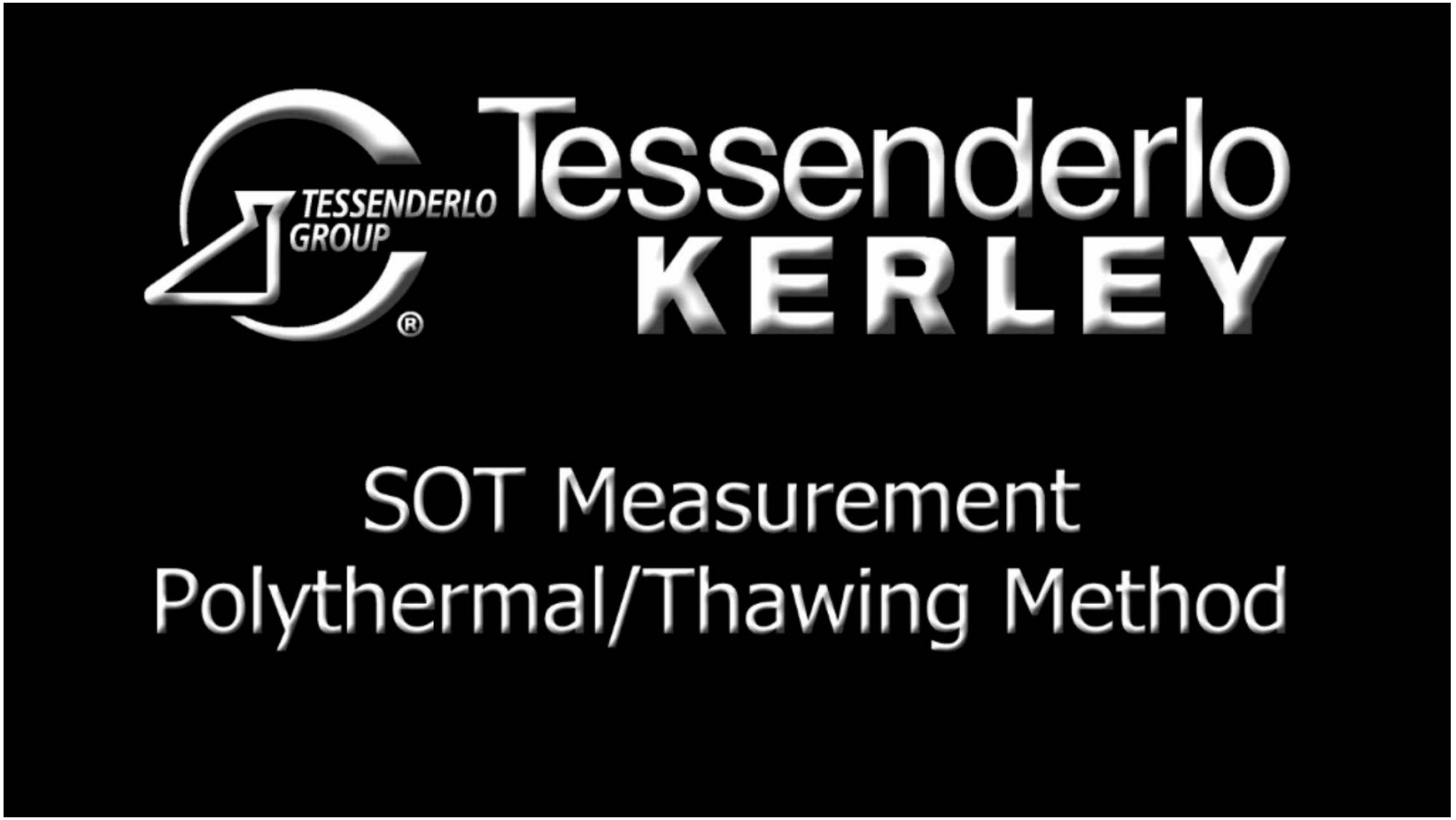
SOT Measurement Methods

1. Cooling/Thawing Method

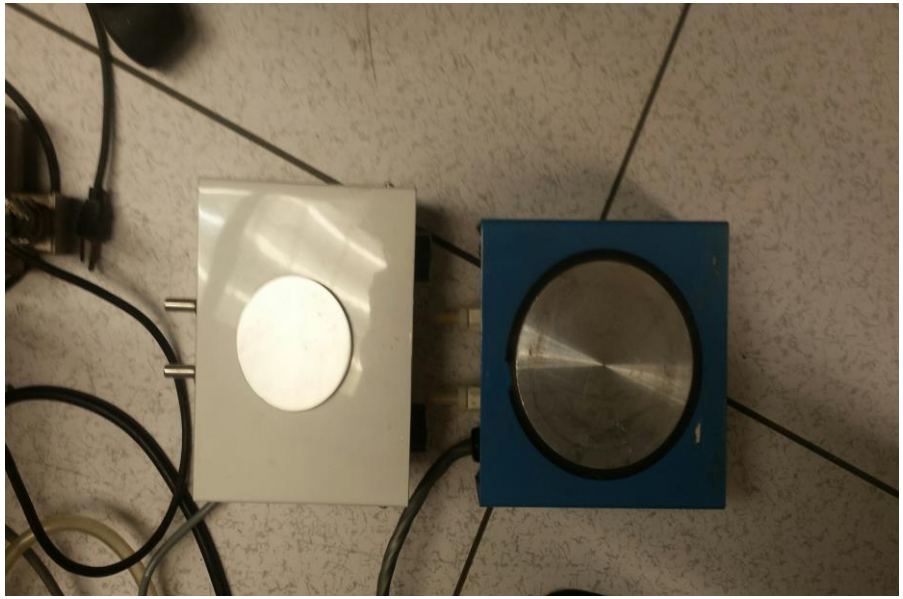
SOT Measurement Methods

2. Poly thermal Method (TVA)



ASTM D97 Pour Point

CF-UAN (B. WHITE PROVIDED)



Salt Out Temperatures (SOT)

- We have tried SOT of a commonly used blend of ATS & UAN, namely 15-0-0-20S with two different in house methods:
- SOT of Ammonium Thiosulfate is 42º F
- SOT of UAN 32 is reported to be 32º F
- Accurate SOT measurement in critical

	Source 1	Source 2	Source3
pH	6.95	7.2	7.76
Sg @ 20º F	1.35	1.351	1.344
%N	12.09	12.12	11.91
%ATS	57.63	57.03	57.35
$\%SO_3$	2.64	2.02	2.29
%Alkalinity as NH_4OH	1.12	0.84	1.1
SOT ºC Polythermal Method	**8.4 (47.1 ºF)**	**7.3 (45 ºF)**	**6.5 (43.7 ºF)**
SOT ºC cooling/thawing	**6 (42.8 ºF)**	**7 (44.6 ºF)**	**5 (41 ºF)**
15-0-0-20 (UAN 32)			
gm ATS	153.9	157	155.5
gm UAN 32	35.6	34.3	35.9
gm Water (DI)	10.5	8.7	8.6
SOT ºC Polythermal Method	**- 31.7 (-25.05 ºF)**	**-33 (-27.4 ºF)**	**-32 (-25.5 ºF)**
SOT ºC cooling/thawing	**-16.5 (2.3 ºF)**	**-13.5 (7.7 ºF)**	**-15 (5 ºF)**
15-0-0-20 (UAN 28)			
gm ATS	153.9	157	155.5
gm UAN 32	40.7	39.2	41
gm Water (DI)	5.4	3.8	3.5
SOT ºC Polythermal Method	**-33 (-27.4 ºF)**	**-32.7 (-26.86 ºF)**	**-32 (-25.5 ºF)**
SOT ºC Cooling/thawing	**-17 (1.4 ºF)**	**-13 (8.6 ºF)**	**-16 (3.2 ºF)**

SOT MEASUREMENT METHOD

NEEDS FOR UNIVERSAL/HARMONIZED METHOD?