TESSENDERLO Kerley

Thio-Sul®

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STORAGE, HANDLING AND TRANSPORTATION GUIDE

HIGH PERFORMANCE LIQUID NITROGEN WITH THIOSULFATE SULFUR

TESSENDERLO Kerley

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ACRONYMS AND ABBREVIATIONS

ATS	Ammonium Thiosulfate Solution
PPE	Personnel Protective Equipment
pH	Potential of Hydrogen
SCBA	Self-Contained Breathing Apparatus
DOT	Department of Transportation
UAN	Urea Ammonium Nitrate (A solution of urea and ammonium nitrate in water)
IBC	Intermediate Bulk Container
NTS	A solution of ammonium thiosulfate with urea ammonium nitrate

PURPOSE

This handbook provides Tessenderlo Kerley International customers with an overview of the properties and handling of Thio-Sul® - ammonium thiosulfate solutions (ATS), and blends in combination with liquid urea ammonium nitrate (UAN). This handbook includes the principles and methods associated with the safe blending, storage, handling and transportation of these materials. It is important to note that the guidance in this handbook is often somewhat general in nature – users have a wide variety of applications, resources and systems and must consequently determine how to handle Thio-Sul and UAN/Thio-Sul blends safely and properly for their own specific applications.

DISCLAMER

The information, recommendations, practices and preferences contained herein are based on data, experience and expertise accumulated by Tessenderlo Kerley International, which is believed to be accurate and relevant. However, no warranty of merchantability, fitness for use, or any other warranty is expressed or is to be implied concerning the accuracy of any data, or applicability or safety of any of the practices and preferences as contained herein. This information is provided on the condition that the person(s) receiving it shall make his/her/their own judgment as to the value of the information presented, and shall assume the full risk for any such use thereof.

THIO-SUL

1. Physical Properties of Thio-Sul

Thio-Sul, Tessenderlo Kerley International's brand of ammonium thiosulfate solution (ATS), is a non–hazardous, liquid inorganic salt solution manufactured from the reaction of ammonia (NH_3) with sulfur (S) or hydrogen sulfide (H_2S). Thio-Sul is marketed exclusively in liquid form.

Thio-Sul is typically sold in bulk, and often shipped via tanker trucks, rail cars and bulk sea vessels. Tessenderlo Kerley International also offers this material in 1000 L IBC containers and 16 000 L flexi bags.

TYPICAL PROPERTIES

- Appearance/color	Clear, colorless to light yellow
- pH range	6.5 - 8.5
- Density range (at 25°C)	1.32 kg/l - 1.35 kg/l
- Salt out temperature (SOT)	+ 4°C
- Crystallization temperature	Approx 0°C
- Recommended minimum storage temperature	8°C
- SO_3 (w/w)	64.9%
- N (w/v) as ammoniacal nitrogen	16%
- S (w/v)	34.6%
- SO_3 (w/v)	86.3%
- N (g/l)* as ammoniacal nitrogen	160
- S (g/l)*	346
- SO_3 (g/l)*	863
- Chemical formula	$(NH_4)_2S_2O_3$

** Based on a typical density of 1.33 kg/l at 25 °C*

Appearance and odor:
Thio-Sul solutions are typically clear, colorless to light yellow. Ammonium thiosulfate may in some cases, have a slight odor.

pH:
Thio-Sul is neutral to slightly alkaline material. The pH of ammonium thiosulfate solutions may vary. Thio-Sul is prone to decomposition if it comes into contact with acidic materials.

Density:
Thio-Sul solutions are heavier than water at all concentrations. Typical 40-45% solutions of ammonium thiosulfate have densities in the range of 1.32 – 1.35 kg/l. The chart in Annex 2 displays the density of ammonium thiosulfate solutions at various temperatures.

Boiling Point/Freezing Point:
Solutions of ammonium thiosulfate have variable boiling and freezing points, dependent on product strength (concentration). The chart in Annex 2 displays the freezing points of ammonium thiosulfate solutions at various concentrations. Annex 2 also contains a graph displaying the salt out temperature (SOT) of ammonium thiosulfate solutions. Tessenderlo Kerley International recommends that Thio-Sul be stored at temperatures of +8 °C or above to avoid any potential problems with salt out.

Solubility:
Solutions of ammonium thiosulfate are completely miscible in water and in solutions of urea ammonium nitrate (UAN).

Compatibility:
Thio-Sul is compatible with N solutions and complete (N-P-K) liquid blends that are neutral to slightly acidic. In addition to its wide adaptability for use in clear liquid blends, it is also well suited for use in suspensions. Thio-Sul cannot be used with acidic (pH <6.0) materials. Thio-Sul is often applied in combination with UAN solutions and aqueous ammonia to supply the sulfur needs of crops, and to stabilize nitrogen.
Before mixing Thio-Sul with any substances (for example pesticides, micronutrients, etc), one should conduct a jar test to check the physical compatibility of the compounds. Please note that physical compatibility does not guaranty chemical combinability of compounds, therefore always follow the manufacturer's recommendations.

Viscosity:
Thio-Sul solutions behave very similarly to water, with typical viscosities of 5-10 cP at 25 °C. Note that viscosity can increase significantly as product approaches its freezing point.

Heat Capacity:
58-60% w/w ammonium thiosulfate solutions have a specific heat capacity of approximately 2.45 kJ/kg/K*. Heat capacity then climbs in a linear manner with water content.

Thermal Conductivity:
58-60% w/w ammonium thiosulfate solutions have a thermal conductivity of approximately 1.84 kJ/m/h/K*

** Source: Uhlmann's Encyclopedia of Industrial Chemistry*

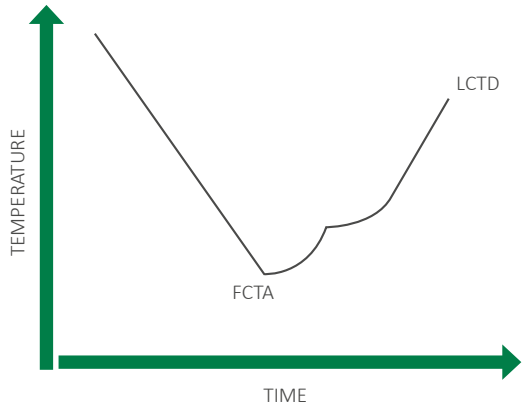
2. Crystallization Temperature and Salt Out Temperature (SOT)

- **Introduction and Definition of Salt Out Temperature**

As solutions of certain liquid fertilizers cool down, a point may be reached where material starts to precipitate or 'salt out' from the solution. This temperature point is often referred to as the 'First Crystal to Appear' (FCTA) or **Crystallization Temperature** (see graph). Once crystals have formed in a solution it is normally possible to re-dissolve them by warming up the solution again. During this warming process, the point at which this last crystal re-dissolves is usually referred to as the 'Last Crystal to Dissolve' (LCTD) or 'Thaw Point'. When cooling, the FCTA point observed for a particular liquid fertilizer will depend on a number of variables. These can include the source and exact composition of the product (manufacturer), the speed at which temperature drops, and how long the temperature remains below the recommended storage temperature. Because of this variability in the FCTA point, the **Salt Out Temperature (SOT)** in most cases for a liquid fertilizer is defined* as the temperature (LCTD) at which the last crystal dissolves (is no longer visible in solution) during rewarming.

Tessenderlo Kerley International uses an industry accepted, documented, and standardized method based on FCTA and LCTD definitions to determine SOT of its liquid fertilizers.

The **Minimum Recommended Storage Temperature** for our liquid fertilizers is generally several degrees higher than the measured SOT and it is a temperature above which, based on practical experience, there should be virtually no risk of salt out. The Salt Out Temperature of Thio-Sul is several degrees lower than the recommended minimum storage temperature and the FCTA point is often even lower than the SOT.



** The LCTD definition of SOT may not be applicable to all liquid fertilizers. In cases where the last crystal does not disappear or where solid remains even after warming to ambient temperature then then SOT may be recorded as the FCTA.*

- **Risk of Salt Out with Thio-Sul Solutions**

As temperatures fall below 8 °C the risk of 'salt out' with Thio-Sul solutions increases. At temperatures well below 8 °C, crystallization is almost certain to take place. It should be noted that in regular storage conditions, there will usually be a differential between the external (outside) temperature and the temperature inside the tank, warehouse or container. It generally takes time, especially for larger tanks, for the product inside to cool down when the outside temperature is below 8 °C. If it the external temperature is cold enough for a long time, then the temperature of the product in the tank will eventually drop below 8 °C, in the end causing salt out to occur, leaving a solid sediment of product crystals. In piping systems such as transfer or load-out lines, this can cause plugging of lines.

There is no chemical change in the product or its composition in this case. Crystals can be re-dissolved upon heating (and preferably mixing) of the product. However, heating and mixing is not always convenient during storage or bulk transportation.

The risk of salt-out can be mitigated by:

- Insulation and/or heating of containers or storage tanks so as to maintain the product temperature at 8 °C or higher
- Increasing the loading temperature of the product to prevent cooling below salt-out temperatures during transportation
- Heating the product prior to unloading (to minimize the risk of crystallization)

All of the above are typical ways to keep product temperature above the salt out temperature (SOT). Other regular engineering practices can also be applied. Crystallization should be avoided as it can potentially take a long time for crystals to redissolve in a large, non-stirred or non-heated storage tank or other container.

Another way to mitigate salt-out is the reduction of the SOT by using a (pre-) blend with UAN for storage or transportation. For more information regarding the blending with UAN and the SOT temperatures of different blends, please go to blends section of this document.

An alternative way to lower the SOT of a concentrated salt solution like Thio-Sul is to add some water in order to take the solution further away from its saturation point. This works up to the point where the solution becomes very diluted and will move towards the freezing point of water (0 °C). However, it should be noted that corrosion rates in regular carbon steel will increase for diluted Thio-Sul solutions. Therefore, this solution is typically not recommended.

WATER AND THIO-SUL BLEND RATIOS AND THE SOT TEMPERATURES
(Typical SOT's determined at Tessenderlo Kerley International's Laboratory)

THIO-SUL – WATER	SOT (°C)
0 – 100	0
10 – 90	-1
20 – 80	-3
30 – 70	-6
40 – 60	-8
50 – 50	-11
60 – 40	-16
70 – 30	-20
80 – 20	-17
90 – 10	-7
95 – 5	1
98 – 2	3
99 – 1	5
100 – 0	7

Blending Thio-Sul with water should be done in the following manner:

- First, pour in half of the total amount of water required,
- Add in all of the Thio-Sul and start stirring in a circular pattern,
- Add the rest of the water to the mix and stir until blended.

Salting out in storage tanks can result in expensive cleaning costs – the risk of this increases when using other inferior quality ATS products

Other measures can also be taken in order to decrease the risk of salting out:

Paint the external portion of the tank a dark color, such as black, dark blue, or dark green. Dark colors absorb more light converting it to heat. This will increase the internal temperature of the product in the tank, however the risk of overheating in summer should also be taken into account.

Large volumes of product cool down slower than smaller volumes, therefore reducing the risk of the salting out.

After crystallization of Thio-Sul has occurred, raising the product temperature will speed up the dissolution of crystals. At higher temperatures, this process should be relatively rapid but at lower temperatures it will take longer (possibly days).

The rate at which the solution returns to the normal liquid form will also depend of the amount of crystallization that has occurred inside the liquid. Agitation (stirring) of the solution will also help speed up the process, as will heating. The dissolution process is also faster if the Thio-Sul is blended with UAN at the same time, due to the dilution effect. In the worst case, where crystals do not redissolve, they can eventually be physically removed (and redissolved/recycled), although this process can be time consuming and laborious.

Although, generally speaking, there is no chemical change in the product or its composition after a salt out incident, multiple cycles of precipitation and dissolving are best avoided. In cases where this happens, there is a higher risk of partial decomposition of Thio-Sul.

3. Safety Data Sheet

More information on the physical properties, hazards, PPE requirements, first aid procedures, spill containment/mitigation operations and other information of concern regarding Thio-Sul can be found in the product safety data sheets (SDS), which can be found in Annex 1. The reader is strongly encouraged to review the information presented in the SDS. Some of this information is contained in the body of this handbook, and some is supplemented with additional detail and discussion. Customers should maintain a current copy of the product SDS on hand and in accessible locations, as required, so that any employee has access to the basic and key information on Thio-Sul at any required time.

UAN (UREA AMMONIUM NITRATE) SOLUTIONS

UAN is not sold by Tessenderlo Kerley International, but is often blended with Tessenderlo Kerley International's Thio-Sul, which helps stabilize the nitrogen in the resulting blend, whilst at the same time providing a source of valuable sulfur.

UAN solutions are typically sold in bulk, and often shipped via tanker trucks, rail cars and bulk sea vessels. UAN is also offered by some suppliers in 1000 l IBC containers (packaging with different volumes). In some cases, a corrosion inhibitor may be added to the final solution to protect the steel in storage tanks.

1. Physical Properties of UAN

TYPICAL PROPERTIES	UAN 28	UAN 30	UAN 32
Total N (w/w)	28%	30%	32%
Total N (g/l)*	358	390	422
Nitrogen content (w/w) as a percentage of the total N present in the product			
Urea (w/w)	28 – 32%	30 – 34%	33 – 37%
N (w/w) as ureic nitrogen	13 – 15%	14 – 16%	15 – 17%
Ammonium nitrate (w/w)	37 – 43%	40 – 46%	42– 48%
N (w/w) as ammoniacal nitrogen	6.5 – 7.5%	7 – 8%	7.5 – 8.5%
N (w/w) as nitrate nitrogen	6.5 – 7.5%	7 – 8%	7.5 – 8.5%
N (w/w) as free ammonia	0.03 – 0.05%	0.03 – 0.05%	0.03 – 0.05%
Urea (g/l)	358 – 410	390 – 442	436 – 481
N (g/l)* as ureic nitrogen	166 – 192	182 – 208	198 – 224
Ammonium nitrate (g/l)*	474 – 550	520 – 598	554 – 634
N (g/l) as ammoniacal nitrogen	83 – 96	91 – 104	99 – 112
N (g/l) as nitrate nitrogen	83 – 96	91 – 104	99 – 112
N (g/l) as free ammonia	0.4 – 0.6	0.4 – 0.6	0.4 – 0.6
	UAN 28	UAN 30	UAN 32
Appearance / Color	Clear, with a slight tint		
pH range	1.5 – 7.5		
Density range at 16-20 °C (kg/l)	1.27 – 1.29	1.29 – 1.31	1.31 – 1.33
Chemical Formula	CH_4N_2O/NH_4NO_3 (urea/ammonium nitrate)		
Recommended minimum storage temperature	Product temperature minimum 5°C above listed salt-out temperature		
Salt out temperature (SOT)†	-17 °C	-10 °C	-2 °C
Freezing temperature	-26 °C	-26 °C	-26 °C
	After defrosting the properties of UAN solutions are completely restored		

** Based on a typical density of 1.28 kg/l (UAN 28); 1.30 kg/l (UAN 30) and 1.32 kg/l (UAN 32) all at 16 °C*
† The difference between the UAN grades is the slight increase of water content going from UAN 32 to UAN 28, which as a result reduces the SOT.

Appearance:
UAN solutions are typically clear with a slight tint.

pH:
UAN is a neutral material, with pH generally in the range of 6.5 to 7.5. The pH of UAN solutions may vary with manufacturer.

Density:
UAN solutions are heavier than water at all concentrations. The chart in annex 3 provides further information on the variation of density with solution strength (concentration) and temperature. Typical 28-32% solutions of UAN have densities of about 1.27 – 1.33 kg/l.

Boiling Point/Freezing Point:
Solutions of UAN have variable boiling and freezing points, dependent on product strength. The chart in Annex 4 displays the freezing points of UAN solutions at various concentrations. Annex 4 also contains a graph displaying the crystallization (salt out) points of UAN solutions. Tessenderlo Kerley International recommends that UAN be stored at a temperature of at least 4 °C above the typical salt-out temperature of the solution to avoid potential problems with salt out.

Solubility:
Solutions of UAN are completely miscible in water and in solutions of Thio-Sul.

Compatibility:
UAN is fully compatible with Thio-Sul. Before mixing UAN with any other products, please contact manufacturer for specific recommendations.

Viscosity:
UAN solutions behave very similarly to water, with viscosities of around 5 cP at 20 °C. Note that viscosity can increase significantly as product approaches its freezing point.

Heat Capacity:
Nominal 28-32% UAN solutions have a heat capacity of approximately 3.77 kJ/kg-K. Heat capacity then climbs in a linear manner with water content.

Thermal Conductivity:
Nominal 28-32% UAN solutions have a thermal conductivity of approximately 0.58 watt/m-K.

THIO-SUL AND UAN BLENDS

Urea ammonium nitrate (UAN) solution is an effective and balanced source of nitrogen. It can easily be blended with Thio-Sul and the resulting mixtures are simple to use.

1. Physical Properties of the Thio-Sul and UAN blends

Thio-Sul and UAN blends offer a balanced source of sulfur and stabilized nitrogen. Various combinations are possible although the most popular blends contain from 10 to 30% of Thio-Sul. Some typical properties of three such blends are given in the table below:

Typical pH, density, turbidity and SOT of selected Thio-Sul/UAN32 blends

(Source: Tessenderlo Kerley International laboratory data)

BLEND	SOT (°C)	VISCOSITY		ROOM TEMPERATURE (20 °C)			
		TORSION	mPa.s	VISUAL APPEARANCE	TURBIDITY	PH	DENSITY (KG/L)
15 wt% Thio-Sul / 85 wt% UAN32	-2	15.9	9.5	Clear	1.8	7.6	1.3254
20 wt% Thio-Sul / 80 wt% UAN32			9.5	Clear			
25 wt% Thio-Sul / 75 wt% UAN32	-4	15.8	9.5	Clear	1.4	7.7	1.3266
30 wt% Thio-Sul / 70 wt% UAN32	-2	15.7	9.4	Clear	1.9	7.7	1.3268

Under laboratory conditions, samples of these three Thio-Sul/UAN blends were stored at room temperature during 1 year in order to evaluate their stability. The three prepared blends were visually still clear after 1 year. Density and pH do not change either, only a minor increase in turbidity was measured.

2. Nutrient Content of the Blends

One of the advantages of these NTS blends is that they can be produced with different proportions of nutrients.

Mixtures of Thio-Sul with UAN 28

Thio-Sul % (w/w)	UAN 28 % (w/w)	Total N % (w/w)	Total S % (w/w)	N (% w/w) (nitrate)	N (% w/w) (ammoniacal)	N (% w/w) Urea
10	90	26.4	2.6	6.3	7.5	12.6
15	85	25.6	3.9	5.95	7.75	11.9
20	80	24.8	5.2	5.6	8.0.	11.2
25	75	24.0	6.5	5.25	8.25	10.5
30	70	23.2	7.8	4.9	8.5	9.8

Mixtures of Thio-Sul with UAN 30

Thio-Sul % (w/w)	UAN 30 % (w/w)	Total N % (w/w)	Total S % (w/w)	N (% w/w) (nitrate)	N (% w/w) (ammoniacal)	N (% w/w) Urea
10	90	28.2	2.6	6.75	7.95	13.5
15	85	27.3	3.9	6.375	8.175	12.75
20	80	26.4	5.2	6.0	8.4	12
25	75	25.5	6.5	5.625	8.625	11.25
30	70	24.6	7.8	5.25	8.85	10.5

Mixtures of Thio-Sul with UAN 32

Thio-Sul % (w/w)	UAN 32 % (w/w)	Total N % (w/w)	Total S % (w/w)	N (% w/w) (nitrate)	N (% w/w) (ammoniacal)	N (% w/w) Urea
10	90	30	2.6	7.2	8.4	14.4
15	85	29	3.9	6.8	8.6	13.6
20	80	28	5.2	6.4	8.8	12.8
25	75	27	6.5	6	9	12
30	70	26	7.8	5.6	9.2	11.2

Further information on the salt out temperatures of blends of UAN with Thio-Sul can be found in Annex 5, along with data on the variation of pH and density with the compositon of the blend. The properties and behavior of the blend of UAN with Thio-Sul will depend on the quality of the UAN used. Tessenderlo Kerley International cannot be held responsible for the quality of the UAN supplied and used in such blends and how its properties and composition may affect the blend.

3. Guidelines for Blending Thio-Sul with UAN

Blending Thio-Sul with UAN should be done in this way:

- First pour in half of the total amount of UAN/water required,
- Add in all of the Thio-Sul,
- Add in all of the UAN or water and start stirring in a circular pattern,
- Add the rest of the water/UAN to the mix and stir until blended.

4. Precautions for Blending Thio-Sul with UAN

- Thio-Sul is compatible with UAN and most other fertilizer solutions.
- In absence of specific recommendations and data, do a jar test before mixing large quantities.
- Thio-Sul can be blended with UAN or urea solution in any ratio to supply nitrogen and sulfur.
- The addition of water to the mixture may be helpful to maintain blend stability.
- When also blending with micronutrients trial blends should be made before mixing large amounts.
- Blends containing Thio-Sul should not be acidified below a pH of 6.0.
- When working with a new formulation or application method always do a small test plot before treating the whole field.

SHIPPING AND TRANSPORTATION

Tessenderlo Kerley International supplies Thio-Sul principally in bulk, via railcar, tank-truck, or in isotainers, as do most suppliers of UAN solutions. Thio-Sul is not classified as a dangerous substance according to the criteria of Regulation (EC) No 1272/2008 and hence from a transport labelling perspective is not classified as dangerous according to the same regulation.

RECOMMENDATIONS AND REQUIREMENTS FOR STORAGE

1. Intermediate Bulk Container

For Thio-Sul or Thio-Sul/UAN solutions supplied in 1000 l IBC's or drums or totes, care should be taken with storage. Products must be stored in cool, dry conditions in a well-ventilated area out of direct sunlight, ensuring that the temperature does not fall below 8 °C or rise above 49 °C. Above 50 °C the risk of corrosion as well as product decomposition increases. Storage conditions must also meet the local regulatory requirements. Keep the product away from flames/heat. Do not store near acids or other acidic materials. Observe normal hygiene standards. Keep container tightly closed. Ammonium thiosulfate may release ammonia gas over time, which is an irritant. The site should be clearly labelled as required by the locally applicable regulations. Scheduled routine preventative maintenance should be in place for plant, equipment and vehicles.

Please carefully review the SDS in the Annex 1 to obtain more detailed information regarding the storage conditions and safety measurements.

2. Small Containers

Small containers (drums, jugs) should be stored in cool, dry, well-ventilated areas out of direct sunlight. Small containers, 200 l drums or less, can develop high vapor pressures if left exposed to direct sunlight for very long time. Such exposure can compromise the integrity of the drums resulting in a safety risk: personnel opening such drums could be exposed to a hazardous or toxic atmosphere upon opening the drum. Do not store near acids or other acidic materials.

3. Bulk Storage

Thio-Sul and Thio-Sul/UAN bulk solution storage systems should be designed to assure not only safe off-load and product use, but also reliability and ease of maintenance. The design criteria listed below should be considered in any storage system project. Do not store near acids or other acidic materials.

- **Location of Storage Tanks**

Storage tanks should be located in easy-to access, open air locations, with good natural ventilation. Review as well the likely traffic pattern and intended mode of delivery relative to tank location – minimize congestion/traffic in the area, and provide for appropriate road access and accommodate the turning radius required for any truck traffic. Consider the need for emergency vehicle access to the storage area, including fire-fighting equipment, in any design.

Diked areas should be designed in accordance with the appropriate local regulations – this often means oversizing the dike to hold a required percentage more in volume than the largest tank in the diked area, and in providing more than one point of ingress/egress.

- Note also that dike height may result in the diked area being classified as a confined space. Additionally make sure you consider any sumps/drainage/collection points – isolate Thio-Sul and Thio-Sul/UAN solutions from any incompatibles here as well, and prevent the ability of these materials to run off into sewers or waterways. Isolation and Insulation of Storage Tanks

Isolate Thio-Sul and Thio-Sul/UAN storage tanks from heat and combustible materials, and any material/chemical on site that can potentially react with them – avoid especially storage with any acids, as inadvertent mixing could result in decomposition of the Thio-Sul. Tanks should typically be located inside of a diked area to control any inadvertent releases of product.

It is advised to store the product at a temperature above its salt-out temperature. In colder climates, it is therefore recommended that storage tanks are insulated and if needed equipped with a heating system, either inside the tank or on a recirculating piping system, especially if Thio-Sul will be stored in cold conditions for an extended period of time. The shape of the tank will also have an impact on

the risk of salt out due to the temperature differential between the solution at the top and the bottom of the tank and in the center of the tank compared to the inner surface of the tank. For a tall narrow shaped tank there could be a temperature difference of several degrees between the material the top of the tank and that at the bottom. This could partially help to slow down the rate of salt out.

Whereas it typically takes longer for product in larger storage tanks to cool down, smaller tanks or piping systems with stagnant product (e.g. load-out lines) can cool down quickly. Whereas it typically takes longer for product in larger storage tanks to cool down, smaller tanks or piping systems with stagnant product (e.g. load-out lines) can cool down quickly. In cold weather conditions where the risk of crystallization increases, these smaller systems should be emptied, or insulated and/or heated (e.g. heat tracing) to prevent product from crystallizing.

4. Transportation

During the transportation of Thio-Sul, guidelines similar to the above have to be taken into account: product should be kept above its salt-out temperature, either through insulation or heating, or by pre-blending product with UAN so as to reduce the salt-out temperature. Thio-Sul rail cars or tanker trucks going to colder areas should ideally be insulated and have heating coils. They can be reheated prior to unloading to bring crystals back into solution in case the product would have cooled off during transportation.

The same shipping conditions and rules which apply to Thio-Sul can be applied for Thio-Sul/UAN mixtures whilst noting that the salt out temperatures will be different. For more details please see Section 1.2 (Crystallization and Salt Out).

Guidelines for materials of construction can be found in section 5.4.

Since Thio-Sul is not classified as dangerous according to the criteria of Regulation (EC) No 1272/2008, the product is not subject to ADR, RID, AND or IMDG dangerous goods regulations for transport. Thio-Sul solutions have no UN number. For bulk sea transport where other specific regulations may apply please consult with an expert.

5. Materials of Construction

Material compatibility for full strength Thio-Sul is shown in Table 8. Tessenderlo Kerley International has been using carbon/mild steel for product storage at ambient conditions successfully for many years. It is generally acceptable over the lifetime of the equipment: 20-30 years lifetime of carbon steel equipment is common.

For optimal corrosion resistance the brackets one can apply a lining or coating to carbon steel storage or transportation equipment. Alternatively, other materials of construction like stainless steel (grade 304 minimum) can be used (see Table).

Tessenderlo Kerley International recommends the use of stainless steels (grade 304 minimum) for storage tanks and transfer lines/equipment that will come in contact with Thio-Sul and Thio-Sul/UAN solutions. That said, other materials may be used and provide good service:

- **Storage tanks:** Carbon/mild steel vessels can be used, but as mentioned there is a higher risk of corrosion to such materials. Corrosion increases remarkably at elevated storage temperature and hence use of such steels in higher temperature service is not recommended. If vapor space corrosion is potentially a concern then Tessenderlo Kerley International recommends, as a minimum, installation of an appropriate epoxy type lining in the vapor space and roof of any carbon/mild steel tank. Aluminum tanks can also be used for storage tanks or tanker cars for transportation.

- **Transfer Lines/Wetted Equipment:** As for storage tanks, carbon/mild steel can be used for transfer lines/equipment. Again, the referenced temperature limitations should be noted. Stainless steel (304 or higher) will show even better corrosion resistance.

- **Non-Metallics:** Many non-metallics (i.e. HDPE, or FRP with an appropriate resin) provide good service in both storage and transfer line/equipment applications. Tessenderlo Kerley International recommends paying specific attention to possible fracture of the vessel or line due to inadvertent impact, with resulting loss of containment, or inadvertently subjecting these materials while in service to excess temperature, weakening the material with possible failure.

- **Gaskets/Seals:** Tessenderlo Kerley International generally recommends the use of the PTFE/Teflon/EPDM family of elastomers for gasket materials and seals, which provide good chemical resistance over a wide temperature range. Spiral-wound 316 stainless steel metal gaskets also provide good service. Gasket and seal selection should always reflect the needed service temperature, as well as the resiliency requirement of the seal.

Both Thio-Sul and Thio-Sul/UAN must be stored in tanks which do not contain copper, brass, zinc, or alloys made of these metals. The same is true for the piping and valves that are used in the system. Each tank that is not specifically designed for liquid fertilizer storage should be examined before using it for storing Thio-Sul and Thio-Sul/UAN solutions.

The compatibility of Thio-Sul with common materials

STAINLESS STEEL 304	STAINLESS STEEL 316	CARBON STEEL **	ALUMINUM	FRP AND GRP	NON-METAL PP/HDPE XPLE	EPOXY LINED
G/E	E	G	G	E	E	*

E – Excellent: essentially little to no corrosion evident
G – Good: some corrosion evident, manageable (**)
C – Conditional service: consult Process Engineering
N – Insufficient Data available for a confident recommendation, or Non- Compatible: Do Not Use
PP/HDPE/XLPE – polypropylene, high density polyethylene/cross linked PE
FRP – Fiberglass reinforced plastic
GRP – Glass reinforced plastic

** Epoxy Phenolic liners generally provide excellent protection; however, not all liners are suitable for all products; consult Process Engineering for specific applications*
*** Specifically for full strength Thio-Sul and carbon steel, very limited corrosion has been observed. Carbon steel is successfully used throughout the US and Europe for ATS storage and transportation (by rail, truck or vessels). If anything, the tank vapor space would be most sensitive to corrosion, mostly due to water vapor pressure at higher temperatures. Under normal conditions, carbon steel storage tank lives of 20-30 years are typical. It should be noted that lower strength ATS solutions (diluted with water) will strongly reduce the corrosion resistance of carbon steel. Nonmetallic and fiberglass tanks should have UV protective coatings applied to limit tank damage from sunlight.*

6. Corrosion Mitigation

Thio-Sul and Thio-Sul/UAN solutions can be corrosive to some materials when stored. Poor corrosion preventive measures may cause serious damage. Mixing UAN, which has been produced by different manufacturers, may decrease the ability of anticorrosion inhibitors to prevent the risk of corrosion, as different inhibitors may not be as effective together as they would be by themselves at the full strength.

Below are some steps, which may have help to prevent corrosion of the storage tanks:

- Drain and clean the storage tanks no less than once every two years
- Check the quality of the UAN which is used for mixing with Thio-Sul
- Use adequate materials of construction, or use special coating or corrosion-resistant lining materials
- Always follow the manufacturer's storage recommendations

7. Mechanical Design

Ensuring safety, operability and ease of maintenance is key aspect of good design. You should consider the following in the design of any storage tank/transfer system:

- **Volume:** Is the tank/system large enough to provide for comfortable inventory relative to operational usage rate and the delivery cycle? Do you have enough inventory to continue operations if weather/road/rail conditions affect the delivery schedule?

- **Number of Tanks:** You may wish to consider having two or more smaller storage tanks, in place of a single, large vessel – a second tank affords you the opportunity to remove one vessel from service for maintenance and/or inspection while maintaining operations with the other.

- **Tank Access:** Consider the installation of multiple manways on any storage tanks to facilitate entry/inspection and good ventilation when removed from service. Hinged manways allow fast access.

8. Emission Control

Thio-Sul storage tanks are typically directly vented to atmosphere without any emission control. Even though it is typically not the case, please check local regulations as to verify if the tank vent is considered an emission point.

CONCLUSIONS

Tessenderlo Kerley International has considerable expertise in the design, construction, commissioning and operation of Thio-Sul production units, terminal storage systems and transfer operations. In addition, over the years both in the USA and Europe, we have also built up valuable expertise in the blending, storage and transport of UAN and Thio-Sul mixtures, by working closely and in collaboration with our customers, who produce such blends. These solutions are becoming an increasingly popular source of liquid stabilized nitrogen with the added benefit of slow release sulfur in the thiosulfate form. We look forward to consulting with you about any specific needs you may have. Please contact your Tessenderlo Kerley International representative to arrange for any such support.

ANNEXES

The Information provided in annexes 2 to 5 is based on limited lab tests and is provided for indicative purposes only.

Annex 1: Safety Data Sheet (SDS) for Thio-Sul

SAFETY DATA SHEET

Based upon Regulation (EC) No 1907/2006, as amended by Regulation (EU) No 2015/830
A safety data sheet is not required for this product under Article 31 of REACH. This SDS has been created on a voluntary basis.

THIO-SUL®

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1. Product identifier

Product name : THIO-SUL ®
Synonyms : ammonium thiosulfate, solution; ammonium thiosulphate, solution; ATS, solution

Registration number REACH : 01-2119537325-41-0003
Product type REACH : Substance/mono-constituent

1.2. Relevant identified uses of the substance or mixture and uses advised against

1.2.1 Relevant identified uses

Fertiliser
Photographic chemical

1.2.2 Uses advised against

No uses advised against known

1.3. Details of the supplier of the safety data sheet

Supplier of the safety data sheet

Tessenderlo Group NV
Troonstraat 130
B-1050 Brussel
☎ +32 13 61 12 11
🖷 +32 13 61 19 99
sds.responsible@tessenderlo.com

1.4. Emergency telephone number

24h/24h (Telephone advice: English, French, German, Dutch) :
+32 14 58 45 45 (BIG)

SECTION 2: HAZARDS IDENTIFICATION

2.1. Classification of the substance or mixture

Not classified as dangerous according to the criteria of Regulation (EC) No 1272/2008

2.2. Label elements

Not classified as dangerous according to the criteria of Regulation (EC) No 1272/2008

2.3. Other hazards

No other hazards known

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

3.1. Substances

Name REACH Registration No	CAS No EC No	Conc. (C)	Classification according to CLP	Note	Remark
ammonium thiosulfate 01-2119537325-41	7783-18-8 231-982-0	55%≤C≤65%			Mono-constituent

3.2. Mixtures

Not applicable

SECTION 4: FIRST AID MEASURES

4.1. Description of first aid measures

General:

If you feel unwell, seek medical advice.

After inhalation:

Remove the victim into fresh air. Respiratory problems: consult a doctor/medical service.

After skin contact:

Rinse with water. Soap may be used. Take victim to a doctor if irritation persists.

After eye contact:

Rinse immediately with plenty of water. Remove contact lenses, if present and easy to do. Continue rinsing. Do not apply neutralizing agents. Take victim to an ophthalmologist if irritation persists.

After ingestion:

Rinse mouth with water. Consult a doctor/medical service if you feel unwell.

4.2. Most important symptoms and effects, both acute and delayed

4.2.1 Acute symptoms

After inhalation:

No effects known.

After skin contact:

ON CONTINUOUS EXPOSURE/CONTACT: Tingling/irritation of the skin.

After eye contact:

No effects known.

After ingestion:

Nausea. Vomiting. Diarrhoea.

4.2.2 Delayed symptoms

No effects known.

4.3. Indication of any immediate medical attention and special treatment needed

If applicable and available it will be listed below.

SECTION 5: FIREFIGHTING MEASURES

5.1. Extinguishing media

5.1.1 Suitable extinguishing media:

Adapt extinguishing media to the environment for surrounding fires.

5.1.2 Unsuitable extinguishing media:

Not applicable.

5.2. Special hazards arising from the substance or mixture

On burning: release of toxic and corrosive gases/vapours (nitrous vapours, sulphur oxides). On heating: release of toxic and corrosive gases/vapours (ammonia, sulphur oxides).

5.3. Advice for firefighters

5.3.1 Instructions:

Dilute toxic gases with water spray.

5.3.2 Special protective equipment for fire-fighters:

Gloves. Safety glasses. Protective clothing. Reactivity hazard: compressed air/oxygen apparatus. Reactivity hazard: gas-tight suit. Heat/fire exposure: compressed air/oxygen apparatus.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures

No naked flames.

6.1.1 Protective equipment for non-emergency personnel

See heading 8.2

6.1.2 Protective equipment for emergency responders

Gloves. Safety glasses. Protective clothing. Reactivity hazard: compressed air/oxygen apparatus. Reactivity hazard: gas-tight suit.

Suitable protective clothing

See heading 8.2

6.2. Environmental precautions

Contain released product, pump into suitable containers. Plug the leak, cut off the supply. Take account of toxic/corrosive precipitation water.

6.3. Methods and material for containment and cleaning up

Take up liquid spill into absorbent material, e.g.: sand/earth. Scoop absorbed substance into closing containers. Clean contaminated surfaces with an excess of water. Wash clothing and equipment after handling.

6.4. Reference to other sections

See heading 13.

SECTION 7: HANDLING AND STORAGE

The information in this section is a general description. If applicable and available, exposure scenarios are attached in annex. Always use the relevant exposure scenarios that correspond to your identified use.

7.1. Precautions for safe handling

Keep away from naked flames/heat. Observe normal hygiene standards. Keep container tightly closed.

7.2. Conditions for safe storage, including any incompatibilities

7.2.1 Safe storage requirements:

Storage temperature: 8 °C - 49 °C. Keep container in a well-ventilated place. Keep out of direct sunlight. Meet the legal requirements.

7.2.2 Keep away from:
Heat sources, oxidizing agents, (strong) bases, (strong) acids, metals.

7.2.3 Suitable packaging material:
Carbon steel, stainless steel, HDPE.

7.2.4 Non suitable packaging material:
Copper, zinc, bronze.

7.3. Specific end use(s)

If applicable and available, exposure scenarios are attached in annex. See information supplied by the manufacturer.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1. Control parameters

8.1.1 Occupational exposure

a) Occupational exposure limit values
If limit values are applicable and available these will be listed below.

b) National biological limit values
If limit values are applicable and available these will be listed below.

8.1.2 Sampling methods

Product name	Test	Number
Sulfites, & Sulfates	NIOSH	6004

8.1.3 Applicable limit values when using the substance or mixture as intended
If limit values are applicable and available these will be listed below.

8.1.4 Threshold values

DNEL/DMEL - Workers
ammonium thiosulfate

Effect level (DNEL/DMEL)	Type	Value	Remark
DNEL	Long-term systemic effects inhalation	350 mg/m³	

DNEL/DMEL - General population
ammonium thiosulfate

Effect level (DNEL/DMEL)	Type	Value	Remark
DNEL	Long-term systemic effects inhalation	104 mg/m³	
	Long-term systemic effects oral	13 mg/kg bw/day	

PNEC
ammonium thiosulfate

Compartments	Value	Remark
Fresh water	0.78 mg/l	
Marine water	0.078 mg/l	
STP	100.1 mg/l	

8.1.5 Control banding
If applicable and available it will be listed below.

8.2. Exposure controls

The information in this section is a general description. If applicable and available, exposure scenarios are attached in annex. Always use the relevant exposure scenarios that correspond to your identified use.

8.2.1 Appropriate engineering controls
Keep away from naked flames/heat. Carry operations in the open/under local exhaust/ventilation or with respiratory protection.

8.2.2 Individual protection measures, such as personal protective equipment
Observe normal hygiene standards. Do not eat, drink or smoke during work.

a) Respiratory protection:
Respiratory protection not required in normal conditions.

b) Hand protection:
Gloves.

- materials (good resistance)
Neoprene.

c) Eye protection:
Not required for normal conditions of use.

d) Skin protection:
Protective clothing.

8.2.3 Environmental exposure controls:
See headings 6.2, 6.3 and 13

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on basic physical and chemical properties

Physical form	Liquid
Odour	Ammonia odour
Odour threshold	No data available
Colour	Colourless to yellow
Particle size	Not applicable (liquid)
Explosion limits	Not applicable

Flammability	Non-flammable
Log Kow	Not applicable (mixture)
Dynamic viscosity	0.0047 mPa.s ; 25 °C
Kinematic viscosity	No data available
Melting point	No data available
Boiling point	98.9 °C - 104.4 °C
Evaporation rate	No data available
Relative vapour density	No data available
Vapour pressure	24 hPa ; 21.1 °C
Solubility	Water ; soluble
Relative density	1.32 - 1.35
Decomposition temperature	No data available
Auto-ignition temperature	Not applicable
Flash point	Not applicable
Explosive properties	No chemical group associated with explosive properties
Oxidising properties	No chemical group associated with oxidising properties
pH	6.5 - 8.5

9.2. Other information

Minimum ignition energy	Not applicable
SADT	Not applicable
Solidification (freezing) point	7 °C
Absolute density	1320 kg/m³ - 1350 kg/m³

SECTION 10: STABILITY AND REACTIVITY

10.1. Reactivity

No reactions to be expected under normal conditions of use.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

Reacts with (strong) oxidizers.

10.4. Conditions to avoid

Precautionary measures

Keep away from naked flames/heat.

10.5. Incompatible materials

Oxidizing agents, (strong) bases, (strong) acids, metals.

10.6. Hazardous decomposition products

Reacts with (some) bases: release of toxic and corrosive gases/vapours (ammonia, sulphur oxides). Reacts with (some) acids: release of toxic and corrosive gases/vapours (sulphur oxides). On heating: release of toxic and corrosive gases/vapours (ammonia, sulphur oxides). On burning: release of toxic and corrosive gases/vapours (nitrous vapours, sulphur oxides).

SECTION 11: TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

11.1.1 Test results

Acute toxicity

THIO-SUL ®

No (test)data available

Judgement is based on the relevant ingredients

ammonium thiosulfate

Route of exposure	Parameter	Method	Value	Exposure time	Species	Value determination	Remark
Oral	LD50	OECD 425	> 2000 mg/kg bw		Rat (female)	Read-across	
Dermal	LD50	Equivalent to OECD 402	> 2000 mg/kg bw	24 h	Rabbit (male / female)	Read-across	
Inhalation (dust)	LC50	Equivalent to OECD 403	> 5.5 mg/l air	4 h	Rat (male / female)	Read-across	

Conclusion

Not classified for acute toxicity

Corrosion/irritation

THIO-SUL ®

No (test)data available

Judgement is based on the relevant ingredients

ammonium thiosulfate

Route of exposure	Result	Method	Exposure time	Time point	Species	Value determination	Remark
Eye	Not irritating	Equivalent to OECD 405		24; 48; 72 hours	Rabbit	Experimental value	
Skin	Not irritating	Equivalent to OECD 404	4 h	24; 48; 72 hours	Rabbit	Read-across	

Conclusion

Not classified as irritating to the skin
Not classified as irritating to the eyes
Not classified as irritating to the respiratory system

Respiratory or skin sensitisation

THIO-SUL ®

No (test)data available
Judgement is based on the relevant ingredients
ammonium thiosulfate

Route of exposure	Result	Method	Exposure time	Observation time point	Species	Value determination	Remark
Dermal	Not sensitizing	OECD 429			Mouse (female)	Experimental value	

Conclusion

Not classified as sensitizing for inhalation
Not classified as sensitizing for skin

Specific target organ toxicity

THIO-SUL ®

No (test)data available
Judgement is based on the relevant ingredients
ammonium thiosulfate

Route of exposure	Parameter	Method	Value	Organ	Effect	Exposure time	Species	Value determination
Oral (repeated exposure)	NOAEL	Other	108 mg/kg bw/day		No effect	104 week(s)	Rat (male / female)	Read-across
Oral (repeated exposure)	NOAEL	Other	> 955 mg/kg bw/day		No adverse systemic effects	104 week(s)	Rat (male / female)	Read-across

Conclusion

Not classified for subchronic toxicity

Mutagenicity (in vitro)

THIO-SUL ®

No (test)data available
Judgement is based on the relevant ingredients
ammonium thiosulfate

Result	Method	Test substrate	Effect	Value determination	Remark
Negative with metabolic activation, negative without metabolic activation	OECD 471	Bacteria (S.typhimurium)	No effect	Experimental value	
Negative with metabolic activation, negative without metabolic activation	OECD 476	Mouse (lymphoma L5178Y cells)	No effect	Experimental value	
Negative with metabolic activation, negative without metabolic activation	Equivalent to OECD 473	Chinese hamster ovary (CHO)	No effect	Experimental value	

Conclusion

Not classified for mutagenic or genotoxic toxicity

Mutagenicity (in vivo)

THIO-SUL ®

No (test)data available
Judgement is based on the relevant ingredients

Conclusion

Not classified for mutagenic or genotoxic toxicity

Carcinogenicity

THIO-SUL ®

No (test)data available

Judgement is based on the relevant ingredients

ammonium thiosulfate

Route of exposure	Parameter	Method	Value	Exposure time	Species	Effect	Organ	Value determination
Oral (drinking water)	NOAEL	Carcinogenic toxicity study	> 2500 mg/kg bw/day	24 month(s)	Mouse (male / female)	No effect		Read-across

Conclusion

Not classified for carcinogenicity

Reproductive toxicity

THIO-SUL ®

No (test)data available

Judgement is based on the relevant ingredients

ammonium thiosulfate

	Parameter	Method	Value	Exposure time	Species	Effect	Organ	Value determination
Developmental toxicity	NOAEL	Equivalent to OECD 414	> 400 mg/kg bw/day	10 day(s)	Rat	No effect		Read-across
Maternal toxicity	NOAEL	Equivalent to OECD 414	> 400 mg/kg bw/day	10 day(s)	Rat	No effect		Read-across
Effects on fertility	NOAEL	3 generation study	> 955 mg/kg bw/day	104 week(s)	Rat (male / female)	No effect		Read-across

Conclusion

Not classified for reprotoxic or developmental toxicity

Toxicity other effects

THIO-SUL ®

No (test)data available

Chronic effects from short and long-term exposure

THIO-SUL ®

No effects known.

SECTION 12: ECOLOGICAL INFORMATION

12.1. Toxicity

THIO-SUL ®

	Parameter	Method	Value	Duration	Species	Test design	Fresh/salt water	Value determination
Acute toxicity fishes	LC50		770 mg/l	96 h	Salmo gairdneri	Static system		Literature study
Acute toxicity crustacea	LC50		77 mg/l	96 h	Mysidacea	Static system		Literature study
Toxicity aquatic micro-organisms	EC50		3000 mg/l		Bacteria			Literature study; Fermentation tube

Judgement of the mixture is based on the relevant ingredients

ammonium thiosulfate

	Parameter	Method	Value	Duration	Species	Test design	Fresh/salt water	Value determination
Acute toxicity fishes	LC50	ASTM	510 mg/l	96 h	Lepomis macrochirus	Static system	Fresh water	Experimental value; Nominal concentration
Acute toxicity crustacea	EC50	Other	230 mg/l	48 h	Daphnia magna	Static system	Fresh water	Experimental value; Nominal concentration
Toxicity algae and other aquatic plants	EC50	OECD 201	> 100 mg/l	72 h	Pseudokirchneriella subcapitata	Static system	Fresh water	Experimental value; GLP
Toxicity aquatic micro-organisms	NOEC	OECD 209	≥ 1000 mg/l	3 h	Activated sludge			Experimental value; GLP

Conclusion

Not classified as dangerous for the environment according to the criteria of Regulation (EC) No 1272/2008

12.2. Persistence and degradability

Biodegradability: not applicable

12.3. Bioaccumulative potential

THIO-SUL ®

Log Kow

Method	Remark	Value	Temperature	Value determination
	Not applicable (mixture)			

ammonium thiosulfate

Log Kow

Method	Remark	Value	Temperature	Value determination
	No data available			

Conclusion

Does not contain bioaccumulative component(s)

12.4. Mobility in soil

No (test)data on mobility of the components available

12.5. Results of PBT and vPvB assessment

The criteria of PBT and vPvB as listed in Annex XIII of Regulation (EC) No 1907/2006 do not apply to inorganic substances.

12.6. Other adverse effects

THIO-SUL ®

Fluorinated greenhouse gases (Regulation (EU) No 517/2014)

None of the known components is included in the list of fluorinated greenhouse gases (Regulation (EU) No 517/2014)

Ozone-depleting potential (ODP)

Not classified as dangerous for the ozone layer (Regulation (EC) No 1005/2009)

SECTION 13: DISPOSAL CONSIDERATIONS

The information in this section is a general description. If applicable and available, exposure scenarios are attached in annex. Always use the relevant exposure scenarios that correspond to your identified use.

13.1. Waste treatment methods

13.1.1 Provisions relating to waste

European Union

Hazardous waste according to Directive 2008/98/EC, as amended by Regulation (EU) No 1357/2014 and Regulation (EU) No 2017/997.
Waste material code (Directive 2008/98/EC, Decision 2000/0532/EC).
02 01 08* (wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing: agrochemical waste containing hazardous substances).
09 01 04* (wastes from the photographic industry: fixer solutions). Depending on branch of industry and production process, also other waste codes may be applicable.

13.1.2 Disposal methods

Immobilize the toxic or harmful components. Precipitate/make insoluble. Remove to an authorized dump (Class I). Remove waste in accordance with local and/or national regulations. Hazardous waste shall not be mixed together with other waste. Different types of hazardous waste shall not be mixed together if this may entail a risk of pollution or create problems for the further management of the waste. Hazardous waste shall be managed responsibly. All entities that store, transport or handle hazardous waste shall take the necessary measures to prevent risks of pollution or damage to people or animals. Do not discharge into drains or the environment.

13.1.3 Packaging/Container

European Union

Waste material code packaging (Directive 2008/98/EC).
15 01 10* (packaging containing residues of or contaminated by dangerous substances).

SECTION 14: TRANSPORT INFORMATION

Road (ADR), Rail (RID), Inland waterways (ADN), Sea (IMDG/IMSBC), Air (ICAO-TI/IATA-DGR)

14.1. UN number

Transport	Not subject

14.2. UN proper shipping name

14.3. Transport hazard class(es)

Hazard identification number	
Class	
Classification code	

14.4. Packing group

Packing group	
Labels	

14.5. Environmental hazards

Environmentally hazardous substance mark	no

14.6. Special precautions for user

Special provisions	
Limited quantities	

14.7. Transport in bulk according to Annex II of Marpol and the IBC Code

Annex II of MARPOL 73/78	Not applicable, based on available data

SECTION 15: REGULATORY INFORMATION

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

European legislation:

European drinking water standards (Directive 98/83/EC)

ammonium thiosulfate

Parameter	Parametric value	Note	Reference
Ammonium	0.5 mg/l		Listed in Annex I, Part C, of Directive 98/83/EC on the quality of water intended for human consumption.
Sulphate	250 mg/l		Listed in Annex I, Part C, of Directive 98/83/EC on the quality of water intended for human consumption.

National legislation The Netherlands

Waterbezwaarlijkheid	B (5); Algemene Beoordelingsmethodiek (ABM)

National legislation Germany

WGK	1; Classification water polluting based on the components in compliance with Verwaltungsvorschrift wassergefährdender Stoffe (VwVwS) of 27 July 2005 (Anhang 4)

15.2. Chemical safety assessment

A chemical safety assessment has been performed.

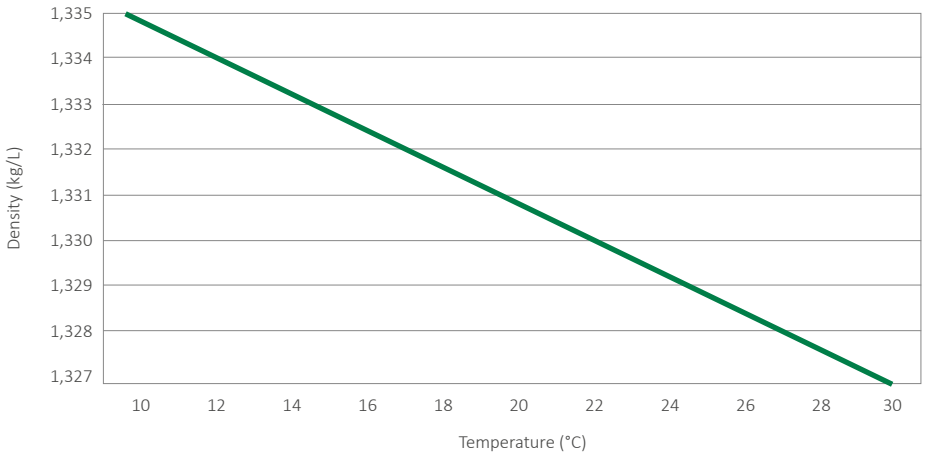
SECTION 16: OTHER INFORMATION

(*)	INTERNAL CLASSIFICATION BY BIG
ADI	Acceptable daily intake
AOEL	Acceptable operator exposure level
CLP (EU-GHS)	Classification, labelling and packaging (Globally Harmonised System in Europe)
DMEL	Derived Minimal Effect Level
DNEL	Derived No Effect Level
EC50	Effect Concentration 50 %
ErC50	EC50 in terms of reduction of growth rate
LC50	Lethal Concentration 50 %
LD50	Lethal Dose 50 %
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative & Toxic
PNEC	Predicted No Effect Concentration
STP	Sludge Treatment Process
vPvB	very Persistent & very Bioaccumulative

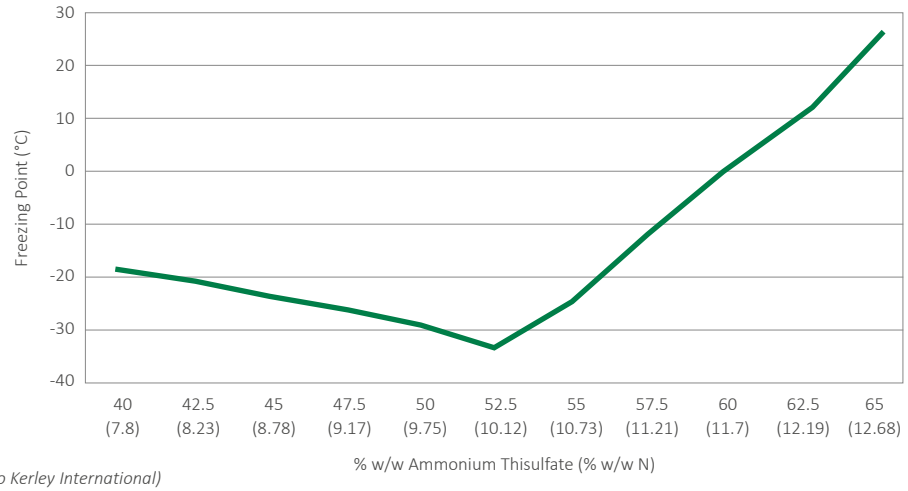
The information in this safety data sheet is based on data and samples provided to BIG. The sheet was written to the best of our ability and according to the state of knowledge at that time. The safety data sheet only constitutes a guideline for the safe handling, use, consumption, storage, transport and disposal of the substances/preparations/mixtures mentioned under point 1. New safety data sheets are written from time to time. Only the most recent versions may be used. Unless indicated otherwise word for word on the safety data sheet, the information does not apply to substances/preparations/mixtures in purer form, mixed with other substances or in processes. The safety data sheet offers no quality specification for the substances/preparations/mixtures in question. Compliance with the instructions in this safety data sheet does not release the user from the obligation to take all measures dictated by common sense, regulations and recommendations or which are necessary and/or useful based on the real applicable circumstances. BIG does not guarantee the accuracy or exhaustiveness of the information provided and cannot be held liable for any changes by third parties. This safety data sheet is only to be used within the European Union, Switzerland, Iceland, Norway and Liechtenstein. Any use outside of this area is at your own risk. Use of this safety data sheet is subject to the licence and liability limiting conditions as stated in your BIG licence agreement or when this is failing the general conditions of BIG. All intellectual property rights to this sheet are the property of BIG and its distribution and reproduction are limited. Consult the mentioned agreement/conditions for details.

Annex 2:

- **Variation of Thio-Sul Density with Temperature**

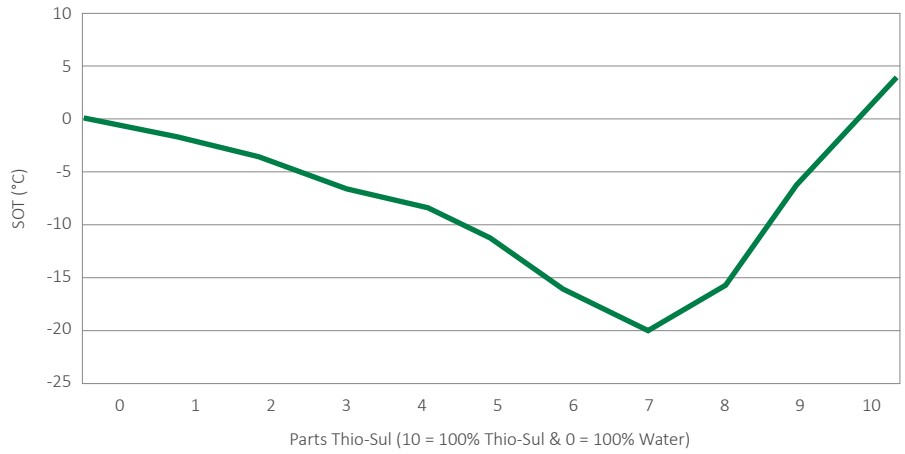


- **Freezing Points of Ammonium Thiosulfate Solutions at Various Concentrations.**



(Source: Tessenderlo Kerley International)

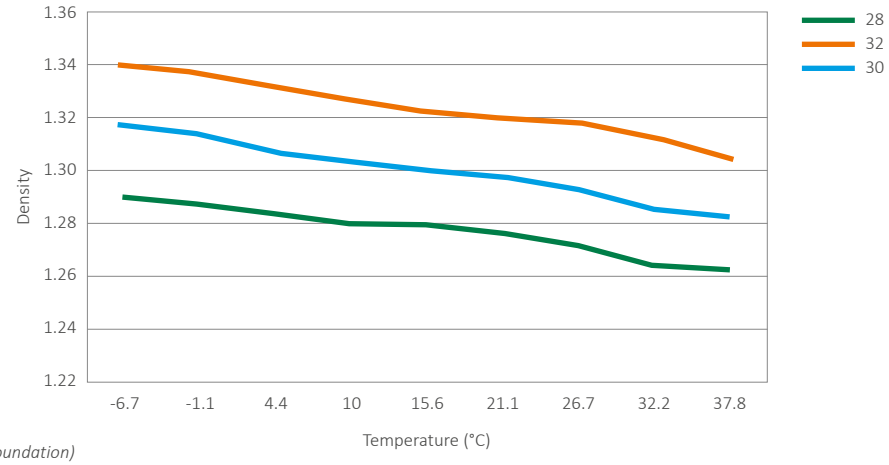
- **Variation in Salt Out Temperature (SOT) of Ammonium Thiosulfate Solutions with Dilution**



(Source: Tessenderlo Kerley International)

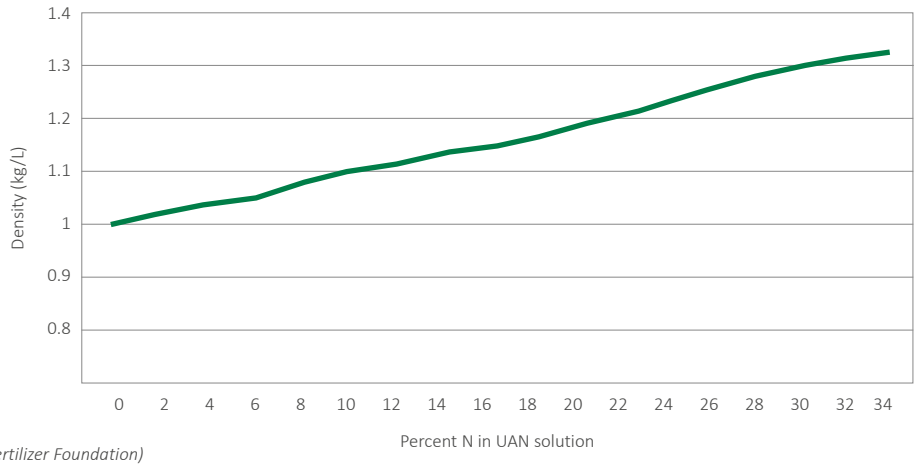
Annex 3:

- **Variation of UAN Density with Solution Strength (concentration) and temperature.**



(Source: US Fluid Fertilizer Foundation)

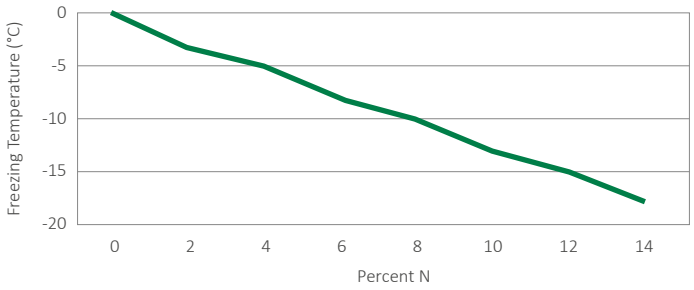
- **Variation of UAN Density with Solution Strength (concentration) at 25 °C.**



(Source: US Fluid Fertilizer Foundation)

Annex 4:

- **Freezing Temperature of UAN Solutions In Water at Different Nitrogen Concentrations**



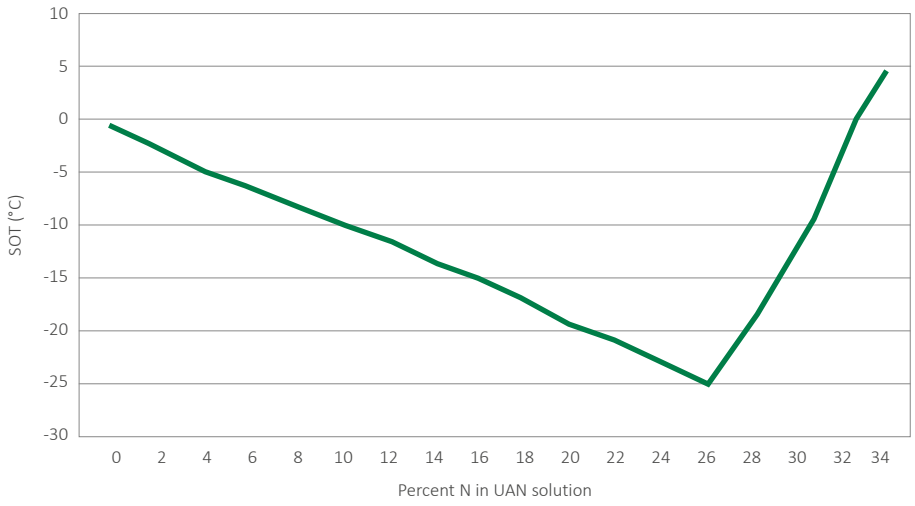
(Source: US Fluid Fertilizer Foundation)

- **UAN Solution Dilution Table**

UAN GRADE	28-0-0	30-0-0	32-0-0	UAN GRADE	28-0-0	30-0-0	32-0-0
UAN DENSITY	1.28	1.30	1.32	UAN DENSITY	1.28	1.30	1.32
% N IN SOLN.	L OF UAN SOLUTION PER 100 L WATER			% N IN SOLN.	L OF UAN SOLUTION PER 100 L WATER		
0	0.0	0.0	0.0	8	31.3	28.0	25.3
2	6.0	5.5	5.1	10	43.4	38.5	34.4
4	13.0	11.8	10.8	12	58.6	51.3	45.5
6	21.3	19.2	17.5	14	78.1	67.3	58.9

(Source: Tessenderlo Kerley International)

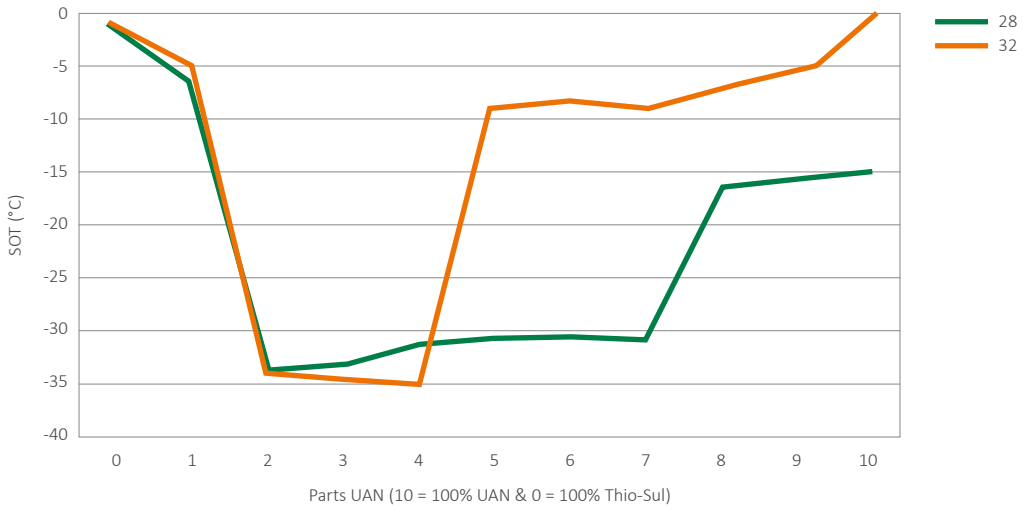
- **Salt Out Temperature of UAN solutions at various concentrations.**



(Source: US Fluid Fertilizer Foundation)

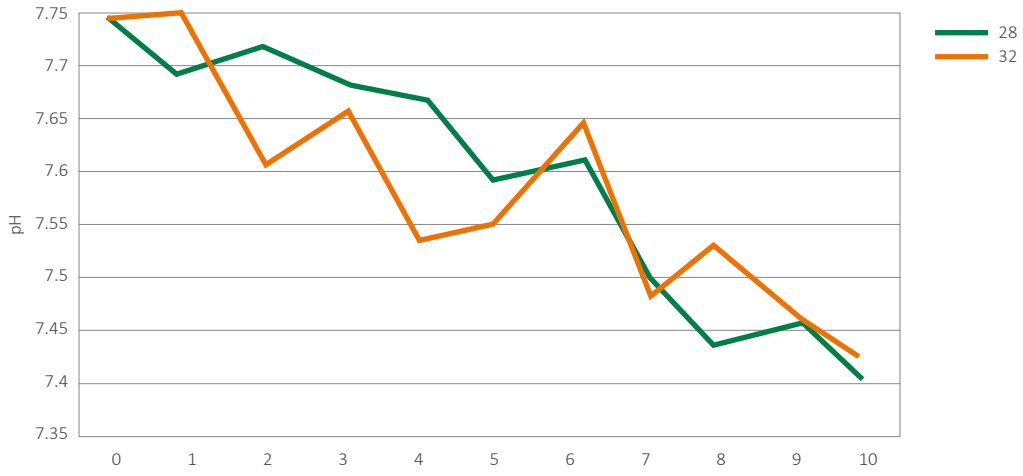
Annex 5:

- **Salt Out Temperatures (SOT) of blends of UAN with Thio-Sul**



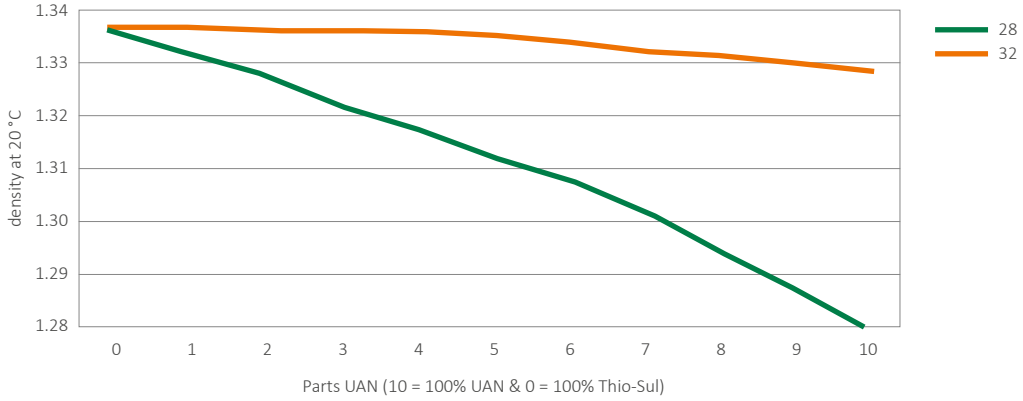
(Source: Tessenderlo Kerley International)

- Variation of blend pH with composition



(Source: Tessenderlo Kerley International)

- Variation of blend density with composition



(Source: Tessenderlo Kerley International)

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