SQM

GET TO KNO_3W

POTASSIUM NITRATE

sqmnutrition.com

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Intro to SQM

SQM is a company with worldwide presence in industries essential for human development, through five principal business lines: specialty plant nutrition, lithium, iodine, industrial chemicals and potassium.

Throughout our 50 years of innovation and technological development, we have established ourselves as world leaders in the lithium, potassium nitrate, iodine and thermo-solar salts markets.

We have surpassed the 2 billion US dollar mark in sales, managed by the 20 commercial offices, distributed among five continents, giving us a presence in 115 countries.

Today, not only do we offer quality products and services, but we work together with our clients around the world to achieve the success of their businesses, making SQM a strategic ally.

01.

History

01. History

1926
MARIA ELENA
The Guggenheim family acquires land in El Toco area and opens the Maria Elena nitrate office

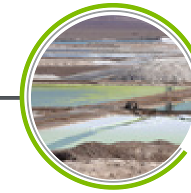
1951
COYA SUR
A nitrate crystallizing plant is built in Coya Sur in order to take advantage of nitrate precipitation from solar evaporation ponds

1968
SQM is created through the merger of Corporación de Ventas de Salitre y Yodo, Compañía Salitrera Anglo Lautaro, Compañía Victoria and the Chilean government

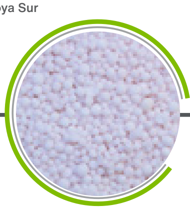
1983
PRIVATIZATION
SQM's privatization process begins, concluding in 1988, and private pension funds acquire an ownership stake

1986
KNO_3
The potassium nitrate facility at Coya Sur begins production using a completely new process designed by SQM

1993
TECHNICAL POTASSIUM NITRATE
Operations begin at a technical grade potassium nitrate facility. SQM completes its first share issuance on international markets through its ADR program



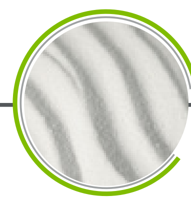
2000
POTASSIUM
SQM expands its potassium chloride production in the Salar de Atacama and builds a new potassium nitrate plant at Coya Sur



2007
PRILLING AND GRANULATION
Production begins at the new nitrate prilling and granulation plant at Coya Sur

2009
JOINT VENTURES
SQM signs new joint ventures with Coromandel (India), Qingdao Star (China) and Roullier (France)

2011
NEW FACILITIES
Production commences in a new potassium nitrate plant in Coya Sur, increasing production by 300,000 tons per year



2012
EXPANSIONS
SQM expands production capacity of potassium products in its facilities in the Salar de Atacama, achieving production of approximately 2 million tons per year

2016
NEW PORT
SQM opens new logistics terminal in Terneuzen, the Netherlands

2018
ANNIVERSARY
SQM increases the total production capacity of potassium nitrate, reaching 1.5 million tons per year. Celebration of the 50th anniversary

01.1. Production facilities locations

In the Atacama Desert,

located between Chile's first and second regions, SQM has exclusive access to the world's best and largest reserves of caliche ore and brines. It possesses the most extensive reserves of iodine and nitrate, as well as the highest concentrations of lithium and potassium on record.

01.2. Potassium nitrate production

SQM produces potassium nitrate from Caliche Ore and Salar Brines, two natural resources found in northern Chile.

Caliche is mined from surface deposits in the Atacama Desert. The Salar brines are pumped from the underground in the Salar de Atacama (Atacama Salt Flat) after which they are transferred to large solar evaporation ponds to physically separate the desired elements. Nitrates are produced after the caliche mineral is crushed and exposed to a leaching process with water. Sodium nitrate is obtained from this leached solution by crystallization. This mixture is then subject to other processes such as crystallization, refining and drying to yield potassium nitrate.

CALICHE ORE

The primary extraction of the mine is done by blasting, followed by mechanical extraction to remove tons of earth and rock. At María Elena, Nueva Victoria and Pampa Blanca, the ore is leached in stocks, obtaining solutions intended primarily to produce iodine. Then, they are transported to solar evaporation ponds where the salts crystallize with high concentrations of nitrate. That's when they are transported by truck to the Coya Sur plants, where they are used in the production process of potassium nitrate.

Once the ore is crystallized, it transforms into white powder, similar to salt. The product is packed in bags as salt, but it can also be processed in the prilling plant of Coya Sur, which allows for direct application to the soil and prevents clogging during shipping. Afterwards, the product is loaded into special wagons to be transported to the port of Tocopilla, the last chilean nitrate port, where it is loaded on board by fully mechanized processes and under strict security procedures.

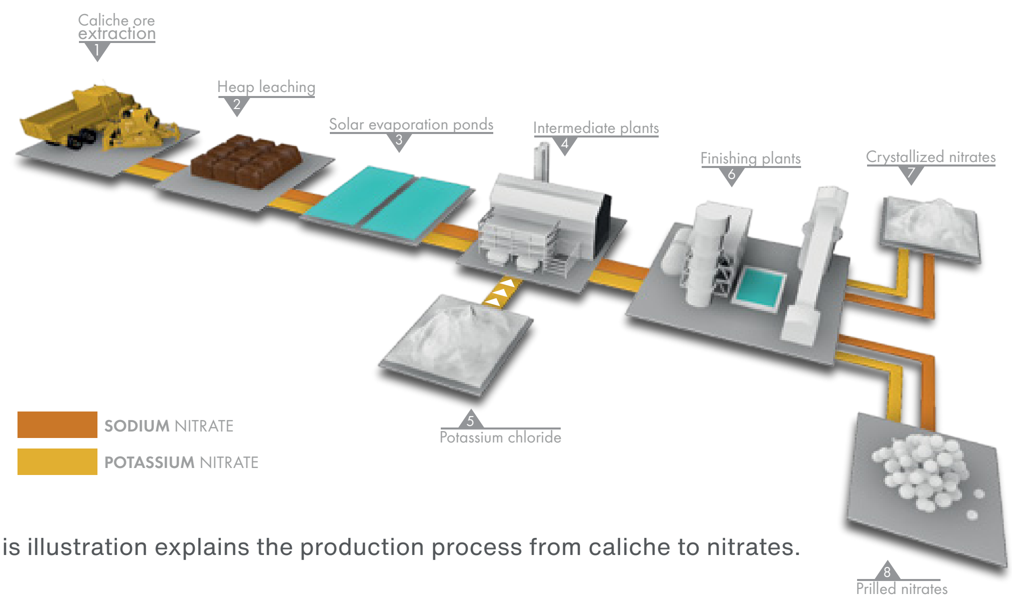
01.2. Potassium nitrate production

SALAR BRINES

Brines, present in concentrated form in the cracks beneath the surface of the Atacama Salt Flat, are extracted from pumping wells that are strategically situated in various parts of the Atacama Salt Flat. After being extracted, the brines are pumped to huge evaporation ponds. There, they rest under the desert sun, to increase their concentration. The evaporation rate here is very high, around 10 liters per square meter per day. The concentration is permanently monitored in each of the ponds. Over time the remaining brines are pumped away, and the salt is harvested.

THE SALTS DEPOSITED IN THE EVAPORATION PONDS ARE APPROPRIATELY HARVESTED AND TRANSPORTED.

Then, after crushing, froth flotation, drying and compacting processes, potassium chloride, potassium sulphate and boric acid are obtained.



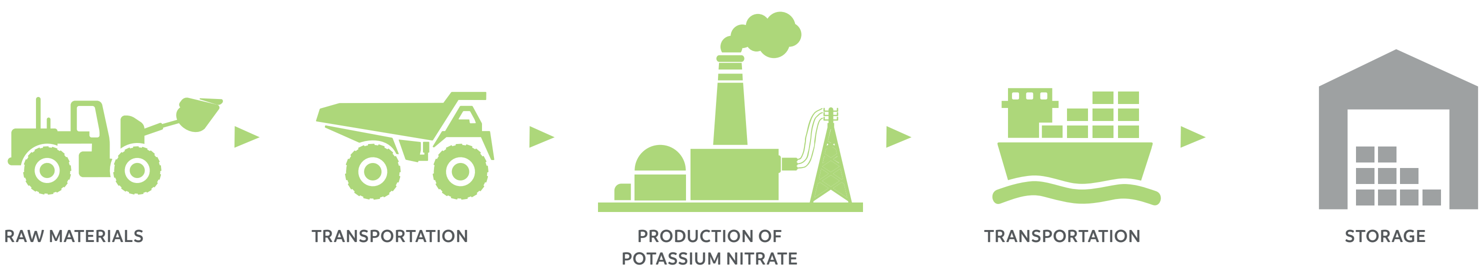
*This illustration explains the production process from caliche to nitrates.

01.3. Lowest carbon emissions

SQM'S POTASSIUM NITRATE PRODUCTION PROCESS HAS THE LOWEST GREENHOUSE GAS EMISSIONS OF THE INDUSTRY

Potassium nitrate is an important source of nitrogen and potassium – two macronutrients essential to plant life. Due to its ready bioavailability as nitrogen source and water solubility, potassium nitrate is particularly suitable for use in modern horticulture in fertigation.

The use of potassium nitrate produced by SQM, obtained from Caliche ore and natural brines by environmentally friendly processes, such as solar evaporation ponds, rather than its synthetic ammonia derived counterpart, contributes thereby to overall sustainability.



Source: Arthur D. Little BENELUX, 2014

02.

Benefits of potassium nitrate

02. Benefits of potassium nitrate

Potassium nitrate is composed only of 100% plant nutrients, which are readily absorbed by the plant's root system. Potassium nitrate does not contribute undesirable ions, such as chloride, the excess of secondary elements, like sulfur, which might cause unnecessary soil salt buildup.

EFFICIENT PLANT NUTRITION

KNO_3 improves crop development and tolerance to adverse abiotic or biotic stress.

INCREASES CROP YIELD

KNO_3 increases the profitability of the farmer's investment.

PREVENTS SOIL SALINIZATION

K^+ and NO_3^- are fully absorbed by the plant, following crop demand.

INCREASES QUALITY

KNO_3 increases the quality of the harvested produce.

SAVES WATER

Improves water use efficiency and decreases water requirement of the crop.

SUSTAINABLE PRODUCTION PROCESSES

SQM carries its opetation in harmony with the environment.

02.1. Fertigation overview

FERTIGATION

The practice of supplying nutrients to a crop through an irrigation system is known as fertigation. There are several advantages of supplying nutrients through an irrigation system.

THE ADVANTAGES INCLUDE:

1. *Supplying the nutrients only to the soil volume where roots are actively growing.*
2. *Nutrients are applied accurately and uniformly to the treated area.*
3. *In general, lower fertilizer application rates can be used due to increased efficiency.*
4. *Nutrient usage can be tailored to the crop's requirements throughout the growing season.*
5. *Allows the efficient distribution and application of micronutrients.*
6. *Crop foliage remains dry, which helps to reduce foliar pathogens and leaf burn.*
7. *Soil compaction is avoided because heavy equipment never enters the field.*
8. *The crop is not damaged by root pruning, breaking of leaves, or bending over.*
9. *Usually, less labor and energy are needed to apply nutrients.*

USING POTASSIUM NITRATE FOR FERTIGATION

Ultrasol® K Plus in crystalline form is a highly water soluble fertilizer. This makes it the preferred source of potassium for use through irrigation systems, including drip, microjet, or sprinkler.

> ***Potassium nitrate is more than twice as water soluble than potassium sulfate. Thus, faster solubility and higher final analysis are achieved.***

At water temperatures above 70°F, KNO_3 is also more soluble than potassium chloride (KCl).

Potassium nitrate can be combined with other fertilizer components to produce excellent liquid solutions. Potassium nitrate and calcium nitrate make an excellent nutrient solution that supplies additional calcium and potassium at the same time, all in a 100% nitrate nitrogen source. High analysis solution fertilizers (i.e. 10-0-10 is a much higher analysis than a 4-0-4) have higher salting out temperatures, and this should be considered when developing nutrient solutions from mixed fertilizer sources.

USING POTASSIUM NITRATE FOR BROADCAST AND BANDED APPLICATIONS

Qrop® KS/KN in prilled form was created to be applied where growers require dry applications. It can also be blended with all other dry materials. A common misconception is that Qrop® KS/KN cannot be blended with urea. This is simply not true. Qrop® KS/KN is regularly blended with urea and DAP to make complete NPK blends.

Using Qrop® KS/KN in a complete blend, such as 16-16-16, increases the nitrate to ammonium ratio. Its soluble nature also makes it the ideal form for in-season sidedress or topdress applications. It is roughly 2.5 times more soluble than potassium sulfate. If your crop is deficient in K, expect a relatively fast crop K response when using Qrop® KS/KN as a topdress material.

03.

Product offerings

ULTRASOL® K PLUS

Ultrasol® K Plus is a free- flowing, water soluble fine crystalline powder. It can be mixed with all water-soluble fertilizers. It is also compatible with the majority of pesticides in foliar application.

Ultrasol® K Plus can be used to cover the potassium needs of a crop without supplying excess of sulphate or chloride. Applications are foliar or injection.

QROP® KS/KN

Qrop® KN is SQM's prilled potassium nitrate. It is a virtually chloride free potassium source. Qrop® KN is not a hazardous product according to the Department of Transport nor the Occupational Safety and Health Administration. Its uniform and consistent particle size make it ideal for blending with other dry fertilizers such as urea, MAP and ammonium sulfate.

ULTRASOL®UTION K

Ultrasol®ution K is pure potassium nitrate in liquid form. Its crystal-clear solution, and compatibility all other water-soluble fertilizers and most pesticides, makes Ultrasol®ution K 3-0-10 and 2.7-0-9 an ideal source for liquid blending or tank mixing in the field.

ULTRASOL® K PLUS ACID

Ultrasol® K Plus Acid has the same low EC, high purity, balanced nutrition and compatibility characteristics of potassium nitrate, but with a strong acidifying power. Safe and convenient handling compared to liquid acids.

It acts as a tank mix acidifier with nutritional value. Keeps drip lines, nozzles, filters and injectors clean.

When applied in fertigation, its acidic pH helps improve nutrient availability under high soil and water pH situations. It helps keep trace elements available for plant uptake and prevents precipitates of calcium and magnesium phosphates.

When used in a foliar application, its low pH acidifies the spray tank solution, which helps to improve nutrient availability, nutrient uptake by the leaf, translocation of K within the plant, and the stability of the majority of pesticides.

04.

Safety and security guidelines for storage, transportation and handling of potassium nitrate and potassium nitrate-based fertilizers

04. Safety and security guidelines for storage

The purpose of these guidelines is to outline regulatory requirements and best practices for the safety and security of Potassium Nitrate (PN) and Potassium nitrate-based fertilizers (PNBF) in storage, transportation and handling when use in agriculture.

This guidance considers only solid products and does not include potassium nitrate solutions. Other nitrate salts can also be used in conjunction with potassium nitrate, but these mixtures are not addressed in this guidance.

Potassium nitrate is stable at normal handling and storage conditions and does not have the possibility of dangerous reactions under normal conditions of use. By itself, potassium nitrate does not pose a safety risk: Potassium nitrate is not explosive and cannot propagate combustion or cause spontaneous ignition, does not have a risk of a dust explosion, and is thermally stable. Upon mixing or in contact with combustible material, an ignition source is necessary to initiate a fire, and the fire will propagate faster than in a situation where only combustible material is present. In summary, although crystalline potassium nitrate may intensify fire as an oxidizer, it cannot, by itself, detonate, deflagrate, or burn.

Potassium nitrate
CAS Number: 7757-79-1
EC Number: 231-818-8
Physical form: Solid, crystals or prills.

04.1.1. TRANSPORT OF HAZARDOUS MATERIALS 49 C.F.R

Under the 49 C.F.R. § 172.101 potassium nitrate is listed in the hazardous materials table as Class 5, Division 5.1, PG III, Oxidizer, UN 1486. PG III are oxidizers that pose a minor danger, or are low hazard. This entry may only be used for potassium nitrate as unique nitrate- nitrogen source and classified as oxidizer under 49 C.F.R. It must be noted that where additional elements are added such as Mn, Cu and Zn, these mixtures require evaluation to consider if additional hazard classes are applicable.

Crystalline potassium nitrate is an oxidizer. Non-crystalline forms of potassium nitrate and potassium nitrate based fertilizers marketed in non-crystalline forms may be evaluated to determine if the criteria for Division 5.1 (oxidizer) is met when tested in accordance with O.1 or O.3 tests (UN Manual of Tests and Criteria). If it can be demonstrated that products do not meet the criterial of any hazard class, these products may not be regulated under 49 C.F.R. Parts 105 – 180. Usually, a particle size distribution of 90% above 1 mm, will exhibit no oxidizing properties in the UN tests, therefore, Qrop® KN (prilled potassium nitrate) 12-0-46 is not an oxidizer.

> ***Oxidizing capacity depends largely on the particle size distribution.***

PN and PNBFs within the scope of Division 5.1 (Oxidizer), are regulated under DOT's 49 C.F.R. § 172.800 security regulations. Facilities must have a DOT security plan, including transportation security training for employees.

04.1.2. *TRUCK*

The following applies to PN and PNBFs within the scope of Division 5.1 (Oxidizer). Motor carriers must comply with hazardous materials requirements at 49 C.F.R. Parts 177 and 397. Motor carriers must maintain financial responsibility as required by 49 C.F.R. § 387.9.

Employee drivers should possess a current, state-issued commercial driver's license with a hazardous materials endorsement as required under 49 C.F.R. § 383.121. and should have received hazardous materials training as required by 49 C.F.R. § 172.704.

The parking of vehicles under or near a bin for any purpose other than loading or unloading PN of the bin is prohibited. The engine should be shut off while under a PN bin except as needed for loading or unloading operations. Wheel chocks should be used, and the ignition key removed when loading or unloading PN from a bin when the vehicle is unattended. After loading is completed and loading equipment has been property disconnected, the vehicle should immediately be moved to a location at least 50 feet from the bin.

Incoming shipments of PN should be unloaded and secured the same day that they are delivered. Shipments should not be accepted after hours.

Fork trucks, tractors, front-end loaders and other internal combustion powered equipment must not remain unattended in a building where PN is stored. Fueling of mobile equipment should be performed at a minimum of 50 feet away from PN storage facilities. Owners/operators should implement a Proof-of-Delivery program for all truck shipments (bulk or bagged) of PN.

04.1.3. RAIL

Rail transporters must comply with applicable DOT hazardous materials regulations at 49 C.F.R. Part 174.

Rail cars should arrive at the rail siding with the shipper's security seals affixed to all top hatches and bottom gates.

All shipper seal serial numbers should be checked to ensure they match the bill of lading for the rail car. If any seal number is incorrect, the owner/operator should call the shipper. If any seal shows signs of tampering or unauthorized removal, the shipper and local law enforcement should be contacted immediately.

If any shipper's security seal is removed from the top hatches of a rail car by the rail siding operator to gain access for any reason, the rail siding operator's security seal should be affixed to the hatch.

04.1.4. VESSEL/BARGE

In addition to compliance with 49 C.F.R. Part 176, owners / operators shipping PN by vessel/barge should consider applicable provisions of 46 U.S.C. § 70103 for "certain dangerous cargo".

The Maritime Transportation Security Act (MTSA) regulations are found at 33 C.F.R. Part 105.

04.1.5. OCCUPATIONAL SAFETY AND HEALTH ACT AT 29U.S.C 654 (A) [1]

Chemical manufacturers and importers must identify hazards of the chemicals they produce or import. All employers with hazardous chemicals in their workplace must have labels and safety data sheets for their exposed workers, and train them to handle the chemicals appropriately as stated in 29 C.F.R. § 1910.1200 (Occupational Safety and Health Administration (OSHA) Hazard Communications Standard (HAZCOM 2012)).

Potassium nitrate and potassium nitrate-based fertilizers suggested classification and labelling according to the criteria of Appendix B to 29 C.F.R. 1910.1200 are presented in **Figure 1.**

	Potassium nitrate crystals and potassium nitrate-based fertilizers meeting the criteria of the O.1/O.3 UN test	**Potassium nitrate and potassium nitrate- based fertilizers not meeting the criteria of the O.1/O.3 UN test**
Classification	Oxidizing solids. Category 3	Not classified
Hazard Pictogram(s)		Not applicable
Signal word	Warning	Not applicable
Hazard statements	May intensify fire; oxidizer	Not applicable
Precautionary statements	Keep away from heat. - No smoking. Keep/Store away from clothing, combustible materials, flammable materials, reducing materials, strong acids. Take any precaution to avoid mixing with clothing, combustible materials, flammable materials, reducing materials, strong acids. Wear protective gloves, eye protection, face protection. In case of fire: Use any suitable mean for extinguishing surrounding fire. Spray water for small fires. For large fires flood with abundant water to extinguish. Dispose of contents/container to hazardous or special waste collection point, in accordance with local, regional, national and/or international regulation.	Not applicable

Figure 1*. PN/PNBF Hazard Classification according to Hazcom 2012.*

[1] Since these Guidelines focus on safety and security, we do not address the Clean Air Act's "General Duty Clause" herein.

04.1. Safety regulations

Owners/operators performing welding, cutting and brazing operations near or around potassium nitrate must ensure that facilities have implemented a “hot work” program consistent with OSHA requirements at 29 C.F.R. § 1910.252.

Oxidizing solids may intensify fire. Storage and handling precautions include avoiding flammable and combustible materials or substances such as wood chips, charcoals, diesel fuels and oils. Ensure that all electrical components/ systems are in compliance with the National Electrical Code.

Ensure that the facility has implemented a Lock Out/Tag Out program in accordance with 29 C.F.R. § 1910.147. Facility access points should be posted “NO SMOKING, NO OPEN FLAMES.” All facility access points should be posted with a NFPA 704 warning sign of at least 15in. x 15in. and visible to fire responders and police from at least 150 feet. The sign must also have four diamonds, each at least 7.5in., with the appropriate colored background. “OX” should be in the bottom diamond in black lettering on a white background[2].

Ensure that the facility has implemented a Lock Out/Tag Out program in accordance with 29 C.F.R. § 1910.147.

Owners/operators of facilities should develop a written emergency plan in accordance with 29 C.F.R. § 1910.120 for responding to releases of PN/PNBF, or substantial threats of releases of PN/PNBF, and provide training to employees who are charged with implementing the emergency plan. Plans should be specific to the facility and community and specific as to when a fire is considered to have involved PN.

Owners/operators should provide local emergency responders with current copies of SDSs and review appropriate fire response. Further, owners/ operators should annually conduct exercises with local emergency responders to train personnel on how to carry out proper emergency response and to revise the plans, as necessary. Distributors should provide information to customers describing the hazards associated with PN/PNBF, steps for its proper management and housekeeping requirements, and information regarding regulatory requirements for the safe storage of the material.

[2] *NFPA 704/2017*

04.2.1. GENERAL REQUIREMENTS

All PN/PNBF storage sites should consider various government agency chemical advisories on the safe storage, handling, and management of the material PN. Owner/operators of PN storage sites should be aware that these advisories will be updated, as necessary, with any information as it becomes available.

Smoking, open flames, and unauthorized sparking or flame-producing devices should be prohibited in the immediate area. Keep potassium nitrate away from combustible or flammable materials. PN decomposes at temperatures higher than 1112 °F / 600 °C.

In case of fire, spray water for small fires. For large fires, flood with abundant water.

Owners/operators of PN storage sites should ensure that facilities are in full compliance with applicable requirements of the Emergency Planning and Community Right to Know Act. 42 U.S.C. §§ 11001 – 11050.

Storage areas should be inspected regularly by an individual(s) trained to identify potential hazards and ensure that all safety control measures are being properly implemented. Any hazards should be addressed immediately.

Potassium nitrate is classified in NFPA 400 class 1 oxidizer. Where applicable, attention must be paid to the requirements of this Standard in facilities storing quantities of more than 4000 pounds. For specific requirements, please consult NFPA 400.

Notification warnings

Buildings and bins where PN is stored should be marked with a "fire diamond" hazard rating meeting the standards of NFPA 704. The NFPA fire diamond should be situated in compliance with state and local regulations. The fire diamond sign must be clearly visible to first responders, police, and other individuals attempting to access the area.

The contents of each bin should be clearly identified by the proper shipping name of the material, "POTASSIUM NITRATE" written in 2- inch high capital letters (at minimum), located below the NFPA fire diamond.

The NFPA diamond codes for potassium nitrate is recognized to be:

Health Hazard (Blue)	1
Flammability (Red)	0
Reactivity (Yellow)	0
Other	(OX)

PN is a U.S Department of Homeland Security (DHS) chemical of interest listed in appendix A of the Chemical Facility Anti-Terrorism Standards (CFATS) as a theft-diversion security risk. For purposes of the CFATS program, PNBF are also regulated with a Screening Threshold Quantity of 400 pounds.

Further How-to additional guidance on CFATS compliance is included in Section 4.5 of this document.

PN and PNBF in vessels and waterfront facilities are regulated as certain dangerous cargo in 33 C.F.R. 126.28 and, therefore, are also regulated by the U.S. Coast Guard in 33. C.F.R. Part 105 (maritime security requirements). These facilities are regulated under the Maritime Transportation Security Act and exempt from the CFATS program.

04.3.1. STORAGE FACILITIES

Owners/operators must comply with applicable regulations promulgated by DHS at 6 C.F.R. Part 27 and the U.S. Coast Guard at 33 C.F.R. Part 105, as well as applicable state and local requirements.

The owner/operator must file a Top-Screen with DHS within 60 days of the facility coming into possession of PN in a packaged form at a quantity of 400 pounds[3] or above. DHS may then ask the facility to conduct a Security Vulnerability Assessment (SVA)[4]. If required to complete an SVA, the facility must file the SVA and Site Security Plan (SSP) or Alternative Security Program (ASP) through DHS's Chemical Security Assessment Tool (CSAT) within 120 days[5].

Access by visitors, service subcontractors, and third-party transporters should be approved by management.

All PN storage facilities should institute a system for accountability of bulk PN. Accurate inventory records and accounting for product shrinkage should be maintained.

Owners/operators of storage facilities should document and report unexplained losses, thefts, or otherwise unaccounted-for shortages of PN to the local FBI field office, as well as local law enforcement.

Report all suspicious behavior to an appropriate supervisor or, if unavailable, to local law enforcement. Owners/operators should maintain regular communications with local law enforcement agency(ies) and should encourage regular patrols in the area of the facilities.

Owners/operators should make provisions to prevent unauthorized persons from accessing the PN storage area, especially during non-business hours.

[3] 6 C.F.R. Pt. 27, App. A
[4] 6 C.F.R. § 27.215
[5] 6 C.F.R. § 27.210(a)(2) and (3); 81 Fed. Reg. 47001 at 47003 ("the SVA start date and due date will be the same as the SSP start date and due date, respectively")

04.4. Best practices

04.4.1. *TRANSACTION BEST PRACTICES*

- PN should not be sold directly to facility employees;
- Procedures should be established for reporting suspicious activities at any facility site;
- There should be no cash sales transactions for PN from manufacturing sites;
- Customer should be required to show a valid, government issued ID;
- Records should be kept of all PN customers; and
- Any new PN customers should be vetted against national terror databases

04.4.2. *SHIPMENTS BEST PRACTICES*

- All truck, rail and barge shipments of PN should be tracked for confirmed receipt at the intended destination.
- Any significant disappearance or theft should be reported to the Federal Bureau of Investigation.

04.5. How-to comply with CFATS

04.5.1. *CFATS IN A NUTSHELL*

All commonly used nitrate fertilizers, including calcium nitrate and calcium ammonium nitrate, potentially can be misused as explosive precursors because of their oxidizing potential[6]. Even materials that are not explosives, such as potassium nitrate, can be used for illicit purposes because of their oxidizing properties. Urea ammonium nitrate solution has also been identified as an explosive precursor. According to a study published in 2018 by the U.S. National Academy of Sciences, potassium nitrate has not been used for illicit purposes.

The Chemical Facility Anti-Terrorism Standards (CFATS) is a special program focused on security at high-risk chemical facilities. The Cybersecurity and Infrastructure Security Agency (CISA) manages the CFATS program. Under CFATS, any establishment or individual that possesses or plans to possess any of the more than 300 chemicals of interest (COI) at or above the listed Screening Threshold Quantity (STQ) must report their chemical holdings to CISA via an online survey, known as Top-Screen. CISA uses the Top-Screen information a facility submits to determine if the facility is considered high-risk and must develop a security plan.

Facilities must submit a Top-Screen within 60 days of coming into possession of the COI in an amount at or above the STQ. Currently, the list of COI commonly used as fertilizers includes only those in Table 1.

Table 1. *Common Fertilizers Identified as COIs*

Ammonia (CAS Number 7664-41-7)
Ammonium nitrate (CAS Number 6484-52-2)
Potassium nitrate (CAS Number 7757-79-1)
Sodium nitrate (CAS Number 7631-99-4)

Full list of COIs available at: https://www.cisa.gov/publication/cfats-coi-list
An overview of CFATS process is available at: https://www.cisa.gov/cfats-process

04.5.2. *CFATS STEP BY STEP*

CFATS applies to any facility possessing potassium nitrate in packaged form at a quantity of 400 pounds or above. The following steps will briefly guide you through the process and they are summarized in **Figure 2.**

[6] National Academies of Sciences, Engineering, and Medicine 2018. Reducing the Threat of Improvised Explosive Device Attacks by Restricting Access to Explosive Precursor Chemicals. Washington, DC: The National Academies Press. https://doi.org/10.17226/24862.

04.5. How-to comply with CFATS

Check if your facility is statutorily excluded from CFATS.

Section 2101 of the CFATS Act of 2014 defined excluded facility as: a facility regulated under the Maritime Transportation Security Act of 2002; a public water system as defined in the Safe Drinking Water Act; a Treatment Works as defined in the Federal Water Pollution Control Act; a facility owned or operated by the Department of Defense or the Department of Energy; and a facility subject to regulation by the Nuclear Regulatory Commission.

If you are not excluded and possess PN or PNBF packaged form at or above 400 pounds, submit a Top-Screen.

Complete the Chemical-terrorism Vulnerability Information (CVI) Training

https://www.cisa.gov/cvi-authorized-user-training
Register yourself and your facility in the Chemical Security Assessment Tool (CSAT)
https://csat-registration.dhs.gov/
Submit your Top-Screen survey via CSAT
https://www.cisa.gov/csat-top-screen

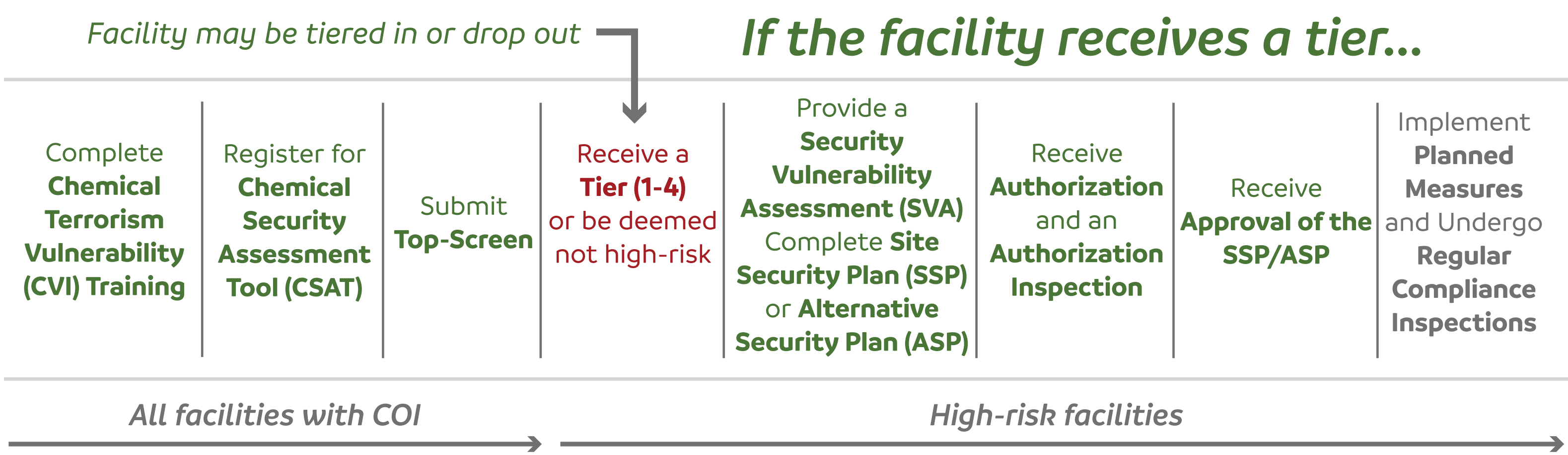


Figure 2. Diagrammatic scheme of the CFATS process. Adapted from https://www.cisa.gov/cfats-process.

CISA reviews your Top-Screen using a risk-based methodology.

Facilities are then either:

- Determined to be a high-risk facility and ranked into Tiers (1, 2, 3 or 4), or
- Determined not to be a high-risk facility and not regulated by CFATS.

If your facility is determined to be a high-risk facility, you must submit a Security Vulnerability Assessment (SVA) and a Site Security Plan (SSP) or an Alternative Security Program (ASP) meeting Risk-based Performance Standards (RBPS).

There are 18 RBPS addressing different security items such as perimeter security, access control, personnel security, etc. These standards are available at https://www.cisa.gov/risk-based-performance-standards. A security plan is tailored to its tier level, risk and particular circumstances.

CISA Chemical Security Inspectors perform an authorization inspection at the facility prior to approving the SSP or ASP.

CISA will make an initial determination whether the SSP or ASP satisfy the CFATS regulation. If satisfied, CISA will issue a Letter of Authorization and a CISA Inspector will then schedule an Authorization Inspection.

Once your plan is approved, the facility implements the agreed-upon security measures.

CISA inspectors will conduct reoccurring compliance inspections to ensure that facilities continue to fully implement approved security measures.

05.

Preparation of liquid fertilizers

The solubility and salting-out temperatures of individual fertilizers and blends of fertilizers in water are the critical points in satisfactory fluid fertilizer production. This is especially true of clear liquid fertilizers. Since every fertilizer has its own specific properties, each solution must be considered individually.

SOLUBILITY

How well a fertilizer goes into solution, or how much can be completely dissolved by water. This change from the physical to the liquid state is dependent on the characteristics of the outer layer of molecules of the fertilizer. Fertilizers have a wide range of solubilities, which are affected by a number of factors.

TEMPERATURE

Generally, as the temperature increases so does the solubility. This effect can be much more pronounced in the nitrate fertilizers (potassium nitrate, sodium nitrate, calcium nitrate, etc.) than the other materials.

OTHER FERTILIZERS

Generally, combining urea with nitrate fertilizers (ammonium nitrate especially) increases the solubility of the mixture over the solubility for either fertilizer solution alone. Micronutrients generally have low solubilities unless sequestered with polyphosphates. Chelates help keep micros in solution.

pH

Certain pH points avoid precipitation formation, this can improve solubility when blending different nutrients. A pH value below 6 maximizes solubility avoiding precipitation formation.

POLYPHOSPHATES

Ammonium polyphosphate sequesters (holds them in solution) iron, aluminum, magnesium, and other impurities. Polyphosphates will also increase the solubility of micronutrients.

CLEANLINESS OF WATER

The purer the water, the less solids, and the less material there is to act as crystallization nuclei and reduce the solubility of concentrated solutions.

SATURATED SOLUTION

The fertilizer solution is holding as much fertilizer as it can without precipitates forming, i.e., it is at its most concentrated state or maximum solubility.

SALTING OUT

The temperature at which crystals in a saturated fertilizer solution form, and the fertilizers begin to precipitate. The temperature for salting out is a few degrees below the saturation temperature. Salting out factors are the same as for those listed under solubility.

Table 1. Names and analyses of commonly used fertilizers

Full name	Common name	Analysis	Physical state
Potassium nitrate	KNO_3	13.7-0-46	Solid
Ammonium nitrate	AN	34-0-0	Solid
Urea solution	Urea solution	20-0-0	Liquid
Urea ammonium nitrate	UAN 32	32-0-0	Liquid
Ammonium sulfate solution	AS	8.4-0-0-9.6(S)	Liquid
Ammonium polyphosphate	APP	10-34-0	Liquid
Ammonium thiosulfate	ATS	12-0-0-26(S)	Liquid
Potassium thiosulfate	PTS	0-0-25-17	Liquid
Calcium thiosulfate	CaTS	0-0-0-10-6	Liquid
Magnesium thiosulfate	MgTS	0-0-0-10(S)-4(Mg)	Liquid
Calcium ammonium nitrate solution	CAN 17	17-0-0-8.8(Ca)	Liquid
Calcium nitrate solution	CN 9	9-0-0-11	Liquid
Phosphoric acid	White acid	0-61-0	Liquid
Phosphoric acid	Green acid	0-52-0	Liquid
Monoammonium phosphate	MAP	12-61-0	Solid
Monopotassium phosphate	MKP	0-52-34	Solid
Potassium sulfate	SOP	0-0-52-18	Solid
Potassium chloride	KCl	0-0-60	Solid
Potassium acetate	K-Acetate	0-0-13	Liquid
Potassium hydroxide	KOH	0-0-30	Liquid

05.2. Solubilities of common potassium fertilizers and potassium nitrate

The dissolution of potassium nitrate (13.7-0-46) in water provides a true solution, that is, it is not a suspension that must be continuously agitated. The amount that can be dissolved varies according to the water temperature. It is repeated here as a comparison to other common potassium fertilizers (Table 2). Notice that the solubility of potassium nitrate is more affected by temperature than other common potassium sources.

Table 2. *Solubilities in pounds per 100 lbs of water at different temperatures of dry potassium salts used or formed in the formulation of fluid fertilizers.*

Temp. (°F)	Potassium Nitrate	Potassium chloride	Potassium sulfate	Monopotassium phosphate
lbs/100 lbs H_2O				
32	13.0	28.0	7.4	14.2
35	14.3	28.5	7.9	15.0
40	16.6	29.3	8.5	15.8
45	18.8	30.2	9.0	16.8
50	21.0	31.0	9.2	17.8
55	24.0	31.8	10.0	19.0
60	27.1	32.7	11.1	20.2
65	30.1	33.5	11.6	21.5
70	33.5	34.3	12.1	22.9
75	37.4	35.2	12.5	24.9
80	40.3	36.0	12.7	25.5
85	45.2	36.8	12.8	27.4

NOTE: To convert to lbs of product per gallon of water, divide the above values by 12 as 12 gallons of water weighs 100lbs.

EXAMPLE: At 50 °F, the solubility of potassium nitrate is 21 pounds per 100 pounds of water. This is equal to 21/12 = 1.75 pounds per gallon of water.

NOTE 2: lbs/100 lbs water = kg/100 kg of water.

05.3. Solubility and dissolution speed

When potassium nitrate is dissolved, the water temperature drops (endothermic reaction), and it takes some time until dissolution is complete. Agitation, initial water temperature, and the physical form of potassium nitrate used will all effect the speed of dissolution. It is suggested that if you are mixing at high concentration to utilize a boiler for hot water. See tables 3 and 4.

Table 3. *The effect and duration of dissolving KNO_3 on water temperature at 68 °F with agitation.*

lbs KNO_3 per 100 gal H_2O	Lowest water temperature		Complete dissolution	
	°F	After	°F	After
83	46	2 min	55	1 min
167	48	2 min	53	8 min
250	46	1 min	67	53 min

Table 4. *The effect and duration of dissolving KNO_3 on water temperature at 68 °F without agitation*

lbs KNO_3 per 100 gal H_2O	Complete dissolution
	After
83	24 hours
167	30 hours
250	5 days

05.4. Preparing liquid potassium nitrate

Table 5. The required amount of KNO_3 to prepare one ton of solution at different K_2O levels and the additional supplied N.

Desired % K_2O	% Solution	Required KNO_3 (lbs)	Added water (lbs)	Added water (gals)	lbs KNO_3 per gal	Equivalent lbs per 100	Salt out temperature (°Fahrenheit)	% N	% K	Analysis ($N-P_2O_5-K_2O$)	pH
1.0	2	43.5	1956.5	234.6	0.19	18.53	16.6	0.3	1.0	0.3-0-1	9.5
2.0	5	87.0	1913.0	229.4	0.38	37.91	20.6	0.6	2.0	0.6-0-2	9.8
3.0	7	130.4	1869.6	224.2	0.58	58.19	24.8	0.9	3.0	0.9-0-3	9.9
4.0	10	173.9	1826.1	219.0	0.79	79.43	29.3	1.2	4.0	1.2-0-4	9.9
5.0	12	217.4	1782.6	213.7	1.02	101.71	33.9	1.5	5.0	1.5-0-5	10.1
6.0	15	260.9	1739.1	208.5	1.25	125.10	38.8	1.8	6.0	1.8-0-6	10.1
7.0	18	304.3	1695.7	203.3	1.50	149.69	43.9	2.1	7.0	2.1-0-7	10.1
8.0	21	347.8	1652.2	198.1	1.76	175.58	49.3	2.4	8.0	2.4-0-8	10.2
9.0	24	391.3	1608.7	192.9	2.03	202.86	55.0	2.7	9.0	2.7-0-9	10.2
10.0	28	434.8	1565.2	187.7	2.32	231.67	61.0	3.0	10.0	3-0-10	10.2
11.0	31	478.3	1521.7	182.5	2.62	262.11	67.3	3.3	11.0	3.3-0-11	10.2
12.0	35	521.7	1478.3	177.2	2.94	294.35	74.0	3.6	12.0	3.6-0-12	10.2
13.0	39	565.2	1434.8	172.0	3.29	328.55	77.6	3.9	13.0	3.9-0-13	10.2
14.0	44	608.7	1391.3	166.8	3.65	364.88	88.7	4.2	14.0	4.2-0-14	10.2

NOTE: The volume of water used in these calculations is the amount that needs to be added to the fertilizer to get to the desired analysis. It is not the volume of the solution. One ton of the 3-0-11, for example, would require more than 181 gallons. In fact, the final solution of this blend would be around 204 gallons.

A general rule of thumb is that in cool (not cold) to luke-warm water, two (2) lbs of KNO_3 will dissolve in one (1) gallon of water. The analysis of this blend will be close to a 3-0-9 (actually a 2.6-0-8.7).

DENSITY OF LIQUID POTASSIUM NITRATE

The volume changes for the final solution because the fertilizer displaces water as it goes into solution. The more concentrated the solution, the more water that is displaced.

One ton of 3.3-0-11, for example, requires more than 182.5 gallons. However, the final solution of this blend will be around 205.5 gallons.

The difference is the added volume and the final volume should really be determined empirically. However, in most cases, the final volume is 1.15 to 1.25 times the added volume (an increase in volume of 15%-25%).

Another rule of thumb is that most liquid fertilizers weigh about 10 lbs (3-0-10 weighs 9.72 lbs per gallon). This makes it easy to determine rates in pounds when all you know is the volume being applied.

05.5. Blending tips

When the temperature drops, a more concentrated solution will precipitate earlier than a less concentrated one, therefore, when low temperatures prevail, lower concentrated solutions are preferred, like a 2.1-0-7 rather than a 4-0-13.

FOLIAR APPLICATION

Potassium nitrate is compatible with most, but not all, pesticides. A small batch should be mixed in a glass jar to check for incompatibilities. Common foliar applications consist of 10-30 lbs. potassium nitrate per acre depending on crop and potassium concentration in leaf tissues. When mixing potassium nitrate with other materials add potassium nitrate to the tank first, then pesticides and finally adjuvants.

"IN FIELD" OR "ON FARM" BLENDING

If planning on making liquid potassium nitrate on the farm without hot water or agitation remember to keep the concentration of potassium nitrate low (i.e 1-0-5 or 2-0-7). Recall the process of making liquid potassium nitrate is an endothermic reaction and the water temperature will drop as the reaction is taking place. Even at low analyses expect an extended period of time before the dry potassium nitrate is fully solubilized and a clear solution exists.

BLENDING WITH DRY SOLUBLE FERTILIZERS

First, add potassium nitrate to desired concentration of water and agitate. Start adding the liquid potassium nitrate to the tank when it is about half full, then start adding the other fertilizers. Continuously agitate or circulate the solution while adding the remaining water and fertilizer.

BLENDING WITH OTHER LIQUID FERTILIZERS

First, dissolve and agitate KNO_3 to desired concentration as a base (Table 5 potassium nitrate solubility chart) then add additional liquid fertilizers and water to desired nutrient level (splash blending).

After the KNO_3 and the other fertilizers are dissolved, allow the solution to settle until a clear solution is obtained. Decant clear solution above the settled insolubles. If the solution will be used for drip systems and fertigation, the solution should be filtered through a 50-200 mesh screen.

Optimal solution conditions: start with water temperature between 140 and 180 °F, agitate for 30 minutes. if using very cold water, up to 24 hours may be needed for all material to completely dissolve (this applies mostly when very high concentrations are being used, 1 to 3 lbs. fertilizer per gallon).

SPLASH BLENDING VS HOT BATCH BLENDING

Splash blending is blending two or more liquid fertilizers together that have already been prepared and exist in stock tanks.

When storing liquid potassium nitrate, use a potassium nitrate liquid blend that suits your region. For example, in very warm, humid climates you may be able to keep a stock tank of 3.3-0-11. In climates where cooler temperatures are prevalent, a 2.7-0-9 remains in solution without falling out. Remember, the salt out temperature is based on the temperature of the solution, not the ambient temperature.

Hot batch blending is making liquid KNO_3 and immediately blending to another liquid fertilizer. This method allows you to use a higher concentration of liquid KNO_3 because blending with another liquid fertilizer drops the salt out temperature. Hot batch blending involves mixing a high concentration of liquid potassium nitrate (i.e. 4-0-13 with a salt out of 77°F) with another liquid fertilizer. It is important that the temperature of potassium nitrate solution is kept well above 77°F when mixing.

The graphs and tables in section 6 show examples of hot batch blending using potassium nitrate solution 4-0-13 with other commonly used liquid fertilizers.

05.6. Compatibility with other fertilizers

Table 6. Compatibility of KNO_3 with other fertilizers in solution.

Fertilizer	Compatibility	Fertilizer	Compatibility
Nitric acid	C	Calcium nitrate	C
Urea	C	Magnesium nitrate	C
25S,28S solutions	C	Phosphoric acid	C
UAN 32	C	MAP	C
Ammonium sulfate	C	DAP	C
Ammonium nitrate	C	10-34-0	C
Sulfates of Fe, Zn, Cu, Mn	C	CAN 17	C
Magnesium sulfate	C	CN 9	C
Monoammonium phosphate	C	Potassium thiosulfate	C
NpHuric	C	Ammonium thiosulfate	C
Chelates of Fe, Zn, Cu, Mn	C	Magnesium thiosulfate	C
Calcium thiosulfate	C		

C= compatible
R= reduced compatibility in concentrated solutions (reduced solubility)

In general, potassium nitrate is very compatible with other fertilizer materials used to produce liquid solutions. Some precipitation of potassium sulfate may occur when high amounts of sulfates of ammonium, magnesium, iron, copper, manganese, and zinc are added to concentrated solutions of potassium nitrate.

It should be noted that when a third fertilizer is added to the solution, the compatibility should be checked. For example, while potassium nitrate is individually compatible with ammonium sulfate and calcium nitrate, calcium nitrate will react with any soluble sulfate and produce insoluble materials. Thus, a combination of KNO_3, ammonium sulfate, and calcium nitrate would not be compatible (in a liquid fertilizer).

06.

Compatibility charts

06.1.1. UREA SOLUTION (20-0-0)

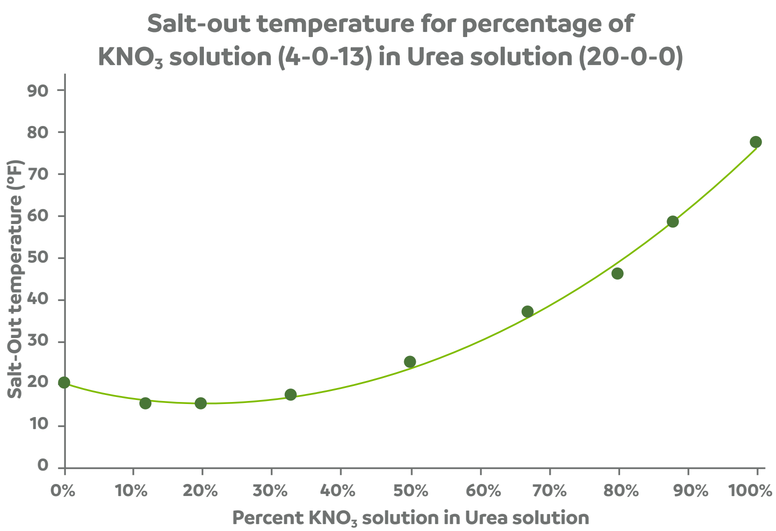


Figure 1. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Urea Solution 20-0-0.

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	58	6-0-11
80%	46	8-0-10
67%	37	9-0-9
50%	25	12-0-7
33%	17	15-0-4
20%	15	16-0-3
12%	15	18-0-2
0%	20	20-0-0

06.1.2. UAN 32

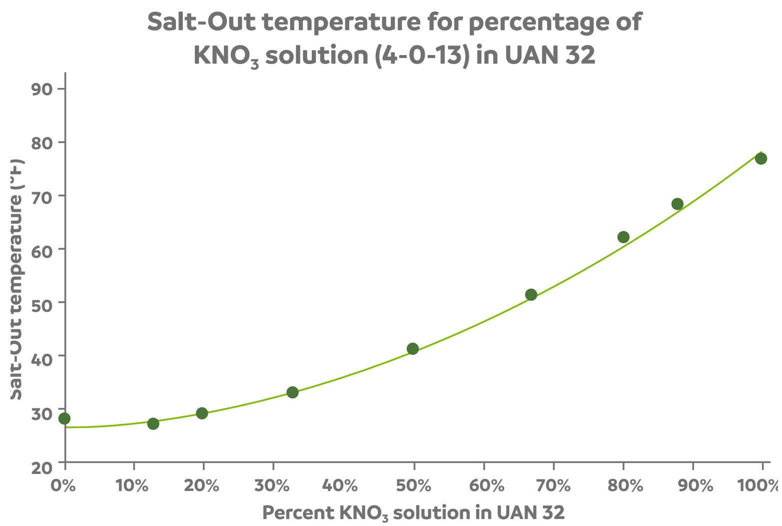


Figure 2. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and UAN 32

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	68	7-0-11
80%	62	10-0-10
67%	51	13-0-9
50%	41	18-0-7
33%	33	23-0-4
20%	29	26-0-3
13%	27	28-0-2
0%	28	32-0-0

06.1.3. 40% AMMONIUM SULFATE SOLUTION

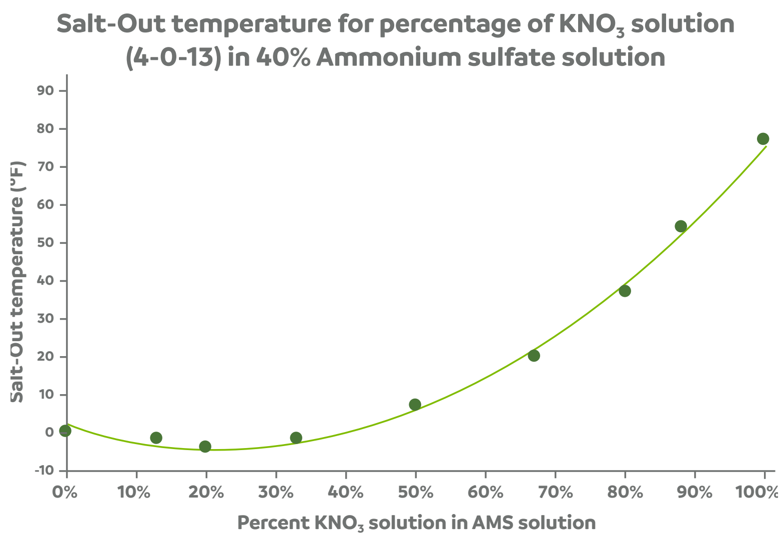


Figure 3. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and 40% Ammonium Sulfate Solution.

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	54	5-0-11-1
80%	37	5-0-10-2
67%	20	5-0-9-3
50%	7	6-0-7-5
33%	-2	7-0-4-6
20%	-4	8-0-3-8
13%	-2	8-0-2-8
0%	0	8-0-0-10

06.2.1. *APP (AMMONIUM POLYPHOSPHATE) 10-34-0*

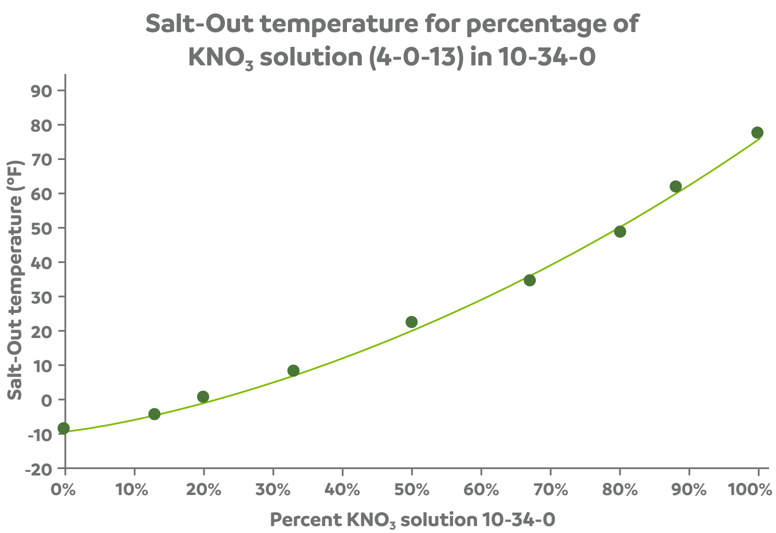


Figure 4. *Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and 10-34-0*

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	61	5-4-11
80%	48	5-7-10
67%	34	6-11-9
50%	22	7-17-7
33%	8	8-23-4
20%	0	9-27-3
12%	-5	9-30-2
0%	-10	10-34-0

06.2.2. *WHITE PHOSPHORIC ACID*

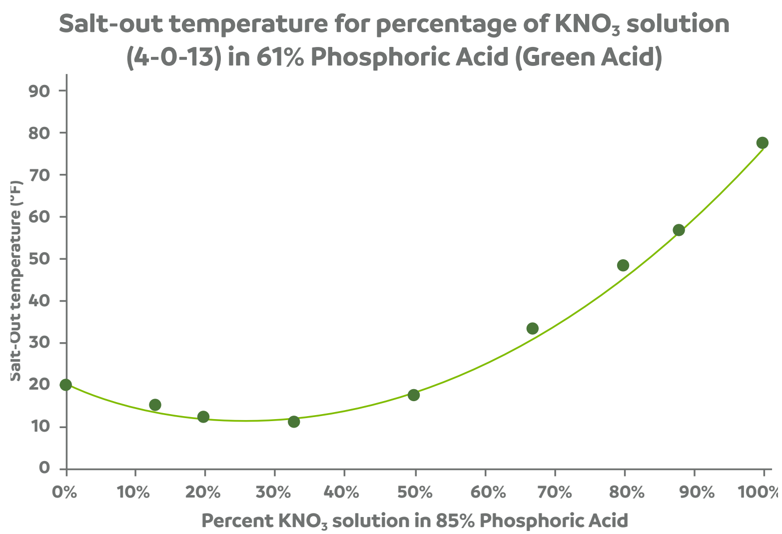


Figure 5. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and White Phosphoric Acid.

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	56	4-7-11
80%	48	3-12-10
67%	33	3-20-9
50%	17	2-31-7
33%	11	1-41-4
20%	12	1-49-3
13%	15	1-53-2
0%	20	0-61-0

06.2.3. GREEN PHOSPHORIC ACID

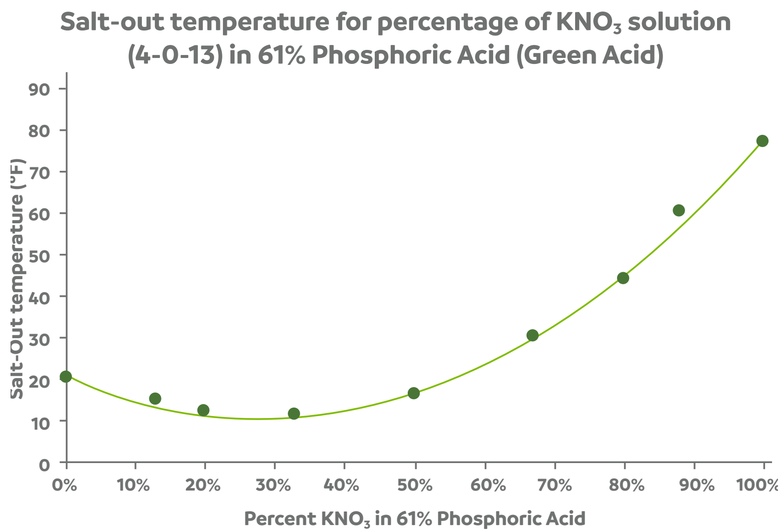


Figure 6. Salt-Out Curve for Potassium Nitrate Solution and Green Phosphoric Acid

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	60	4-6-11
80%	44	3-10-10
67%	30	3-17-9
50%	16	2-26-7
33%	11	1-35-4
20%	12	1-42-3
13%	15	1-45-2
0%	20	0-52-0

06.3.1. *AMMONIUM THIOSULFATE*

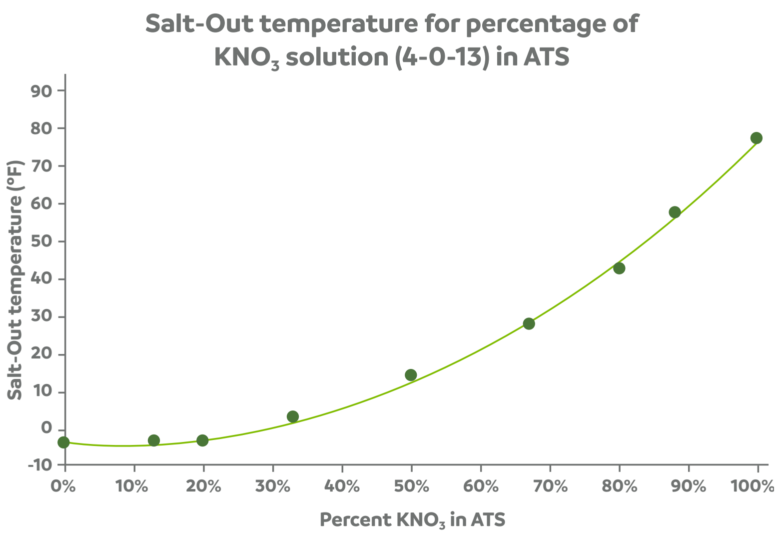


Figure 7. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Ammonium Thiosulfate Solution 12-0-0 26.

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	57	5-0-11-3
80%	42	6-0-10-5
67%	27	7-0-9-9
50%	13	8-0-7-13
33%	2	9-0-4-17
20%	-4	10-0-3-21
12%	-4	11-0-2-23
0%	-5	12-0-0-26

06.3.2. *POTASSIUM THIOSULFATE*

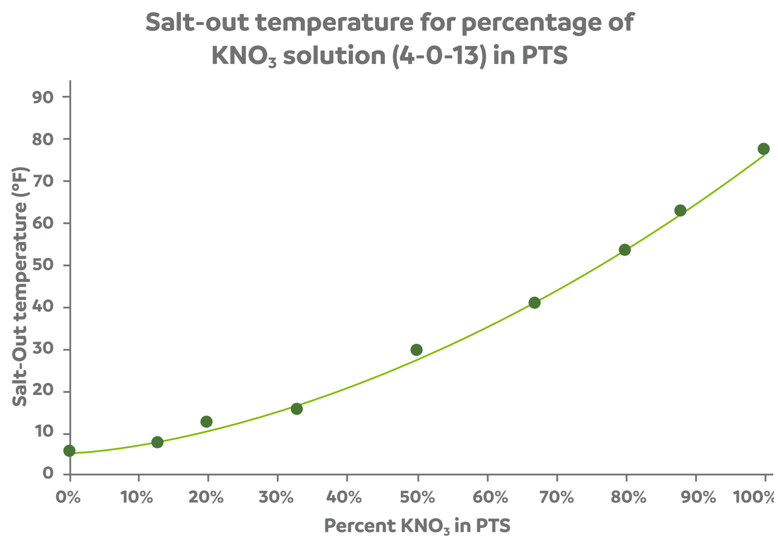


Figure 8. *Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Potassium Thiosulfate Solution 0-0-25 17.*

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	62	4-0-14-2
80%	53	3-0-15-3
67%	40	3-0-17-6
50%	29	2-0-19-9
33%	15	1-0-21-11
20%	12	1-0-23-14
13%	7	1-0-23-15
0%	5	0-0-25-17

06.3.3. CALCIUM THIOSULFATE

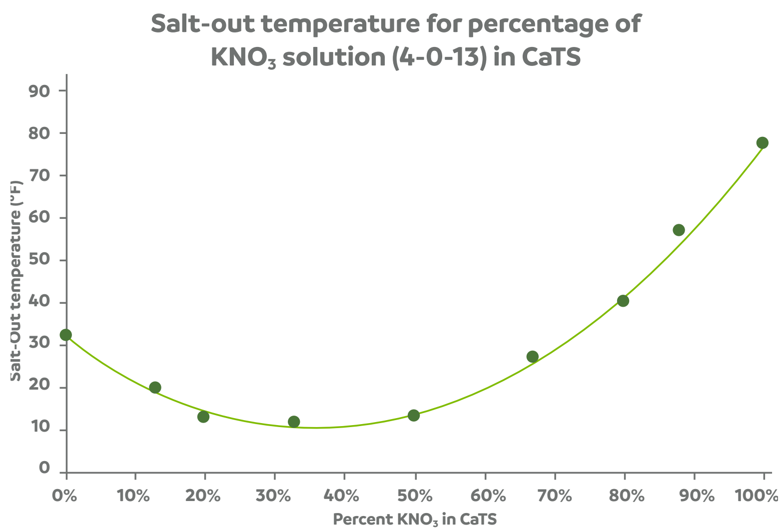


Figure 9. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Calcium Thiosulfate Solution

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	56	4-0-11-1-0.7
80%	40	3-0-10-2-1.2
67%	27	3-0-9-3-2
50%	13	2-0-7-5-3
33%	11	1-0-4-7-4
20%	13	1-0-3-8-4.8
12%	20	1-0-2-9-5.2
0%	32	0-0-0-10-6

06.3.4. *MAGNESIUM THIOSULFATE*

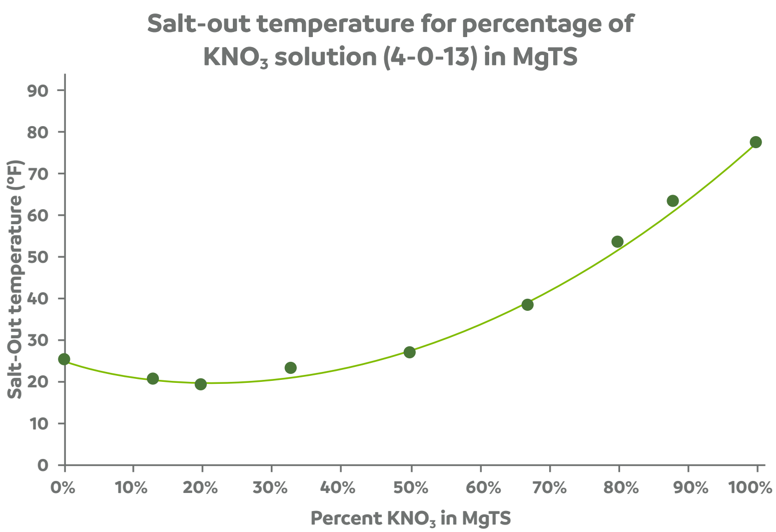


Figure 10. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Magnesium Thiosulfate Solution

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	63	4-0-11-1-0.5
80%	53	3-0-10-2-0.8
67%	38	3-0-9-3-1.3
50%	27	2-0-7-5-2
33%	23	1-0-4-7-2.7
20%	19	1-0-3-8-3.2
13%	20	1-0-2-9-3.5
0%	25	0-0-0-10-4

06.4.1. CALCIUM AMMONIUM NITRATE

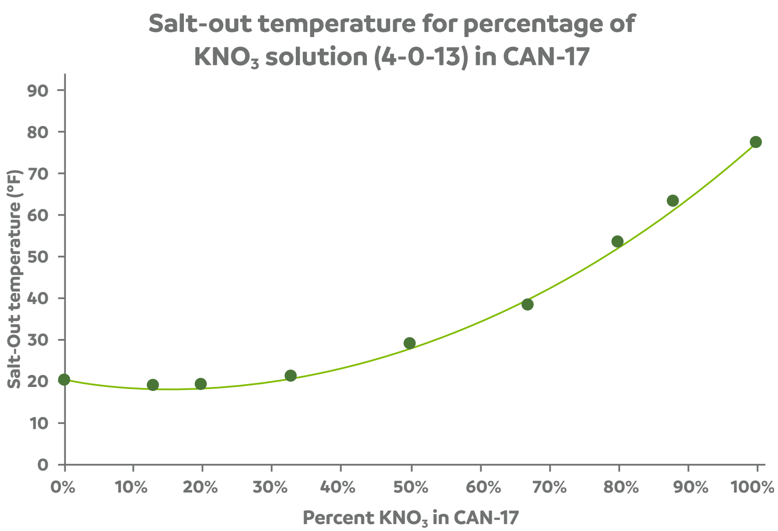


Figure 11. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Calcium Ammonium Nitrate Solution 17-0-0 -8.8

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	63	6-0-11-1
80%	52	7-0-10-1.8
67%	38	8-0-9-2.9
50%	29	11-0-7-4.4
33%	21	13-0-4-5.9
20%	19	14-0-3-7
12%	19	15-0-2-7.7
0%	20	0-0-0-10-4

06.4.2. *CALCIUM NITRATE*

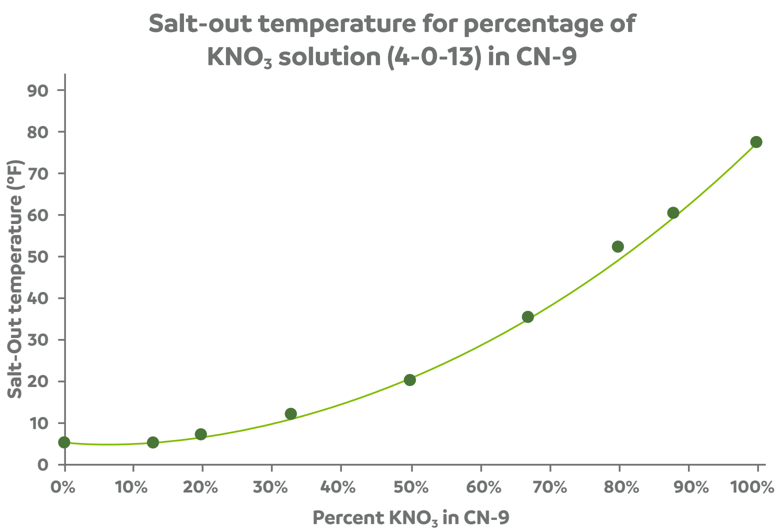


Figure 12. *Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Calcium Nitrate Solution 9-0-0 - 11*

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	60	5-0-11-1.3
80%	52	5-0-10-2.2
67%	35	6-0-9-3.6
50%	20	7-0-7-5.5
33%	12	7-0-4-7.4
20%	7	8-0-3-8.8
13%	5	8-0-2-9.6
0%	5	9-0-0-11

06.5. Acidic sulfates

06.5.1. SULFURIC ACID

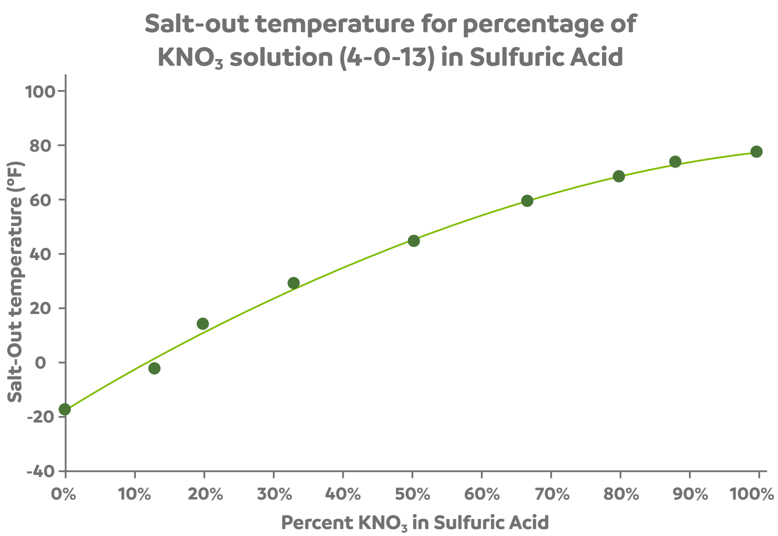


Figure 13. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and Sulfuric Acid

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	73	4-0-11-3.7
80%	68	3-0-10-6.2
67%	59	3-0-9-10.2
50%	44	2-0-7-15.5
33%	29	1-0-4-20.8
20%	14	1-0-3-24.8
12%	-2	1-0-2-27
0%	-17	0-0-0-31

06.5.2. NPHURIC 15/49

Some mixes with NpHuric 15/49 showed levels of precipitation, primarily because of the formation of potassium sulfate, a thermodynamic sink for aqueous reactions, and the smaller percentage of solvating water compared to the other tested products/chemicals.

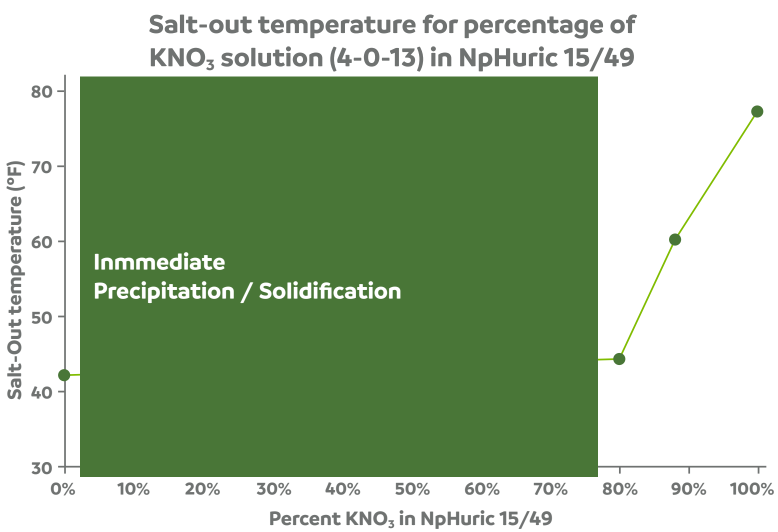


Figure 14. Salt-Out Curve for Potassium Nitrate Solution 4-0-13 and NpHuric 15/49

% KNO_3 solution (4-0-13) in the fertilizer solution mix	Avg salt-out temp (°F)	Final analysis
100%	77	4-0-13
88%	60	5-0-11-1.9
80%	44	6-0-10-3.2
67%	incompatible	15-0-0-16
50%	incompatible	N/A
33%	incompatible	N/A
20%	incompatible	N/A
13%	incompatible	N/A
0%	42	15-0-0-16

07.

Calculations

07.1. Preparing liquid solutions

The trick here is to remember to work with weight and not volume. To calculate the required weight of potassium nitrate needed to prepare one (1) ton of a solution at various K_2O levels, use the equation:

y = (2000 * x)/46.0

where:

y = required amount of KNO_3, in pounds
x = desired K_2O level in liquid solution

For example, if a solution with 8% K_2O is desired, it will require:

y = (2000 x 8)/46.0
y = 348 lbs of KNO_3

the amount of another nitrogen fertilizer to use with potassium nitrate is based on the amount of potassium nitrate used for potash:

y = (2000 * x)/46.0 (same equation as before)
y = weight of potassium nitrate
x = desired potash concentration

The result from this equation is plugged into the next to get the amount of nitrogen fertilizer needed:

(%N – (y* x/2000)) * 2000/z

$$\frac{\%N(2000) - y(x)}{Z} = \text{wt. of other fertilizer (lbs)}$$

%N = the desired nitrogen concentration
y = weight of potassium nitrate, in lbs (from equation 1, above)
Z = nitrogen content of 2nd fertilizer, in percent (%)
x = Nitrogen content of potassium nitrate

07.2. Other equations

Determine the amount of calcium nitrate needed to add to a KNO_3 solution to make a 7-0-7:

1. DETERMINE THE AMOUNT OF KNO_3 NEEDED TO HAVE 7% K_2O PER TON:

y = (2000 x 7)/46
y = 304 lbs of KNO_3

2. DETERMINE THE WEIGHT OF CN 9 (CN 9 IS 9% N):

(7 – (304*13.7/2000)) * 2000/9
=1092 lbs CN 9

3. THE AMOUNT OF ADDITIONAL WATER NEEDED TO MAKE ONE TON OF THIS SOLUTION:

2000 lbs – (304 lbs + 1092 lbs) = 604 lbs
604 lbs/8.35 lbs per gal = 72.69 gals

4. THE APPROXIMATE SALT-OUT TEMPERATURE:

Water contribution from CN 9

y = (2000 x 9)/15.5
y = 1161 lbs of $Ca(NO_3)_2$ in one ton of CN 9
1161/2000= 58% dry $Ca(NO_3)_2$ and 42% water
1092 pounds of CN 9 * 42% = 458.64 lbs water / 8.35 = 54.9 gallons water

304 lbs/(72.69 gals + 54.9 gals) = 304 lbs /127.59 gallons = 2.38 lbs KNO_3 per gal

Below is the reference solubility curve equation of potassium nitrate:

y = 0.048x - 0.61
y = lb KNO_3 /gal
x = temperature in °F
2.38 = 0.048x – 0.61
(2.38 + 0.61)/0.048 = 62.3 °F

(***NOTE*** that the addition of other fertilizer may increase or decrease the solubility of pure KNO_3.)

07.2. Other equations

If the weight of a fertilizer and the volume of water are known, the resulting analysis can be determined from the follow equation:

%nutrient = (X)(C)/((gals * 8.35) + X)

where:

- **%nutrient = the final nutrient concentration of the element in question**
- **X = the weight of the fertilizer material**
- **C = the nutrient concentration of the fertilizer**
- **gals = gallons of water added to tank**

For example, if a grower adds 20 lbs. of KNO_3 and 80 gallons of water to a 100-gallon tank, what Is the K_2O concentration?

$$\%K_2O = \frac{20 \times 0.46}{(80 \times 8.35) + 20}$$

$$= 9.2/688$$

$$= 0.0133 \quad \text{or} \quad = 1.33\ \%\ K_2O$$

The final volume of this mix will be about:

80 * 1.15 = 92 gallons

08.

Reference tables and charts

Table 1. Salt Index values for some K sources from the Jackson method and those being reported in Crop Protection Handbook (CPH) and Western Fertilizer Handbook (WFH).

K source	Jackson	Typical fertilizer grade % K_2O level
K chloride	149.6	60-62
K sulfate	111.2	50-52
K nitrate	97.6	45-46
K mag	64.8	22
K thiosulfate	63.2	25

Determined by Southern Environmental Testing, Florence, Alabama.
**The Jackson method to obtain salt index values are based on measuring electrical conductance.*

08.2. Humidity chart

Table 2. Critical relative humidities of pure salts and mixtures at 30 °C (86 °F).

	Calcium nitrate	Ammonium nitrate	Sodium nitrate	Urea	Ammonium chloride	Ammonium sulphate	Diammonium phosphate	Potassium chloride	Potassium nitrate	Monoammonium phosphate	Monocalcium phosphate	Potassium sulphate
Calcium nitrate	46.7											
Ammonium nitrate	23.5	59.4										
Sodium nitrate	37.7	46.3	72.4									
Urea	-	18.1	45.6	72.5								
Ammonium chloride	-	51.4	51.9	57.9	77.2							
Ammonium sulphate	-	62.3	-‡	58.4	71.3	79.2						
Diammonium phosphate	-	59*	-	62*	-	72*	82.5					
Potassium chloride	<22.0	67.9‡	66.9‡	**60.3**	73.5	71.3‡	79*	84.0				
Potassium nitrate	**31.0**	**59.9**	**64.5**	**65.2**	**67.9**	**69.2**	-	**78.6**	**90.5**			
Monoammonium phosphate	52.8‡	58.0	63.8	65.2	-	75.8	78*	72.8‡	59.8	91.6		
Monocalcium phosphate	46.2	52.0	68.1	65.1	73.9	87.7	78*	-‡	87.8	88.8	93.6	
Potassium sulphate	76.1‡	69.2‡	73.3‡	71.5	71.3	81.4	77*	81	87.8	79.9	-‡	96.3

* Approximate values obtained by TVA (Tennessee Valley Authority) (Ref. 3). Other data are from literature.
‡ Unstable salt pair; the value given is for the stable pair.

Reference

[At 65.2% humidity, KNO_3 and urea will begin to absorb moisture. In contrast, see a blend with urea and KCl with a critical relative humidity of 60.3%. See highlighted boxes.]

08.3. Ultrasol®ution K conversion table

Table 3. Gallons of Ultrasol®ution K added to tank based on desired dry KNO_3 foliar rate per 100 gallons

Fertilizer	Desired dry KNO_3 foliar rate per 100 gallons					
	5	10	15	20	25	30
50	1.1	1.1	1.7	2.2	2.7	3.2
100	2.2	2.2	3.3	4.4	5.4	6.5
150	3.2	3.4	5.0	6.6	8.2	9.7
200	4.3	4.5	6.7	8.8	10.9	12.9
250	5.4	5.6	8.3	11.0	13.6	16.1
300	6.5	6.7	10.0	13.2	16.3	19.4
350	7.5	7.9	11.7	15.4	19.0	22.6
400	8.6	9.0	13.3	17.6	21.7	25.8
450	9.7	10.1	15.0	19.8	24.5	29.0
500	10.8	11.2	16.7	22.0	27.2	32.3
550	11.8	12.4	18.3	24.2	29.9	35.5
600	12.9	13.5	20.0	26.4	32.6	38.7
650	14.0	14.6	21.7	28.6	35.3	42.0
700	15.1	15.7	23.3	30.8	38.1	45.2
750	16.1	16.9	25.0	33.0	40.8	48.4
800	17.2	18.0	26.7	35.2	43.5	51.6
850	18.3	19.1	28.3	37.4	46.2	54.9
900	19.4	20.2	30.0	39.6	48.9	58.1
950	20.5	21.4	31.7	41.8	51.7	61.3
1000	21.5	22.5	33.3	44.0	54.4	64.5