An introduction to Lead Nitrate Solution by LogiChem
Pb - Lead

- The word ‘plumbing’ comes from the Latin word for lead plumbum (same goes for the elemental symbol Pb).
  - Plumbum or ‘soft metal’
- The word ‘lead’ comes from an Old English word for the metal.
Metals of Antiquity

- Lead was known to ancient metalworkers
  - It is one of the 7 ‘metals of antiquity’
  - It is a soft silvery-blue metal with a high lustre

A stack of moulded lead ingots displayed at the Musée de l'Arles Antique
Lead in Ancient Egypt

- People used lead long before the rise of the Roman Empire
  - It is easy to extract from ore
    - Lead smelting evidence goes back around 9,000 years ago
  - Ancient Egyptians used lead compounds for:
    - Cosmetics
    - Pigments
    - Medicines
Lead Uses

- Plumbing
- Bullets/musket balls
- Leaded glass & stained glass
- Crucial in the invention of the printing press in the 1430s
- Excellent roofing material
- Used as a shielding in X-ray machines
- As a weight or ballast in boats
- Lead acid car batteries (~½ of the world's lead production)
- Lead provides a good shield against radiation
Lead reacts with other elements and compounds:
- lead acetate,
- lead carbonate,
- lead chloride,
- lead chlorate,
- lead chromate,
- lead hydroxide,
- lead iodide,
- lead nitrate,
- lead oxalate,
- lead oxide (litharge),
- lead sulphate,
- lead sulphide (=galena, the most common lead ore) and
- tetra-ethyl lead (formerly used as an anti-knock compound in petrol)
lead nitrate, lead acetate & lead chlorate are 3 exceptions to the rule that most lead compounds have very low solubility in water

- lead chlorate is too reactive for safe handling
- lead acetate is more expensive than lead nitrate
- lead nitrate has a higher lead content, higher solubility & is less expensive than both the above
  - which is why lead nitrate is the most commonly used source of lead for gold leaching
Lead nitrate is a very stable inorganic compound

- **Molecular Formula:** $\text{Pb(NO}_3\text{)}_2$
- **Molar Mass:** 331.2 g/mol
- **Solubility in Water:** 52 g/100 mL (20 °C)
- **Structural Formula:**
  \[
  \begin{align*}
  &\text{O}^+\text{N}^-\text{O}^- \\
  &\text{O}^-\text{N}^+\text{O}^- \quad \text{Pb}^{2+} \quad \text{O}^-\text{N}^+\text{O}^- \\
  &\text{O}^-\text{N}^+\text{O}^- \\
  &\text{O}^-\text{N}^+\text{O}^- \\
  &\text{O}^-\text{N}^+\text{O}^- \\
  \end{align*}
  \]
Lead nitrate does not occur naturally and is usually produced by means of the following reaction:

\[
3 \text{ Pb} + 8 \text{ HNO}_3 \rightarrow 3 \text{ Pb(NO}_3\text{)}_2 + 2 \text{ NO} \uparrow + 4\text{H}_2\text{O}
\]

Lead feedstock can be in form of ingots, lead shot or scrap such as battery electrodes. Very occasionally other lead compounds are reacted with nitric acid.
Creating Lead Nitrate Crystals

- The final stage is the recovery of the lead nitrate from the reaction mix in the form of fine crystals.
- Crystals are the most convenient form to use.
- Dry lead nitrate is classified as Dangerous Goods:
  - UN No 1469
  - DG Class 5.1 “Oxidising agent” and
  - DG Sub-Class 6 “Toxic”.
When using the Merril-Crowe gold recovery process lead nitrate was commonly added to boost recovery. (Now mostly been replaced by CIP/CIL).

The benefit of lead as a leach enhancer in gold cyanidation has been recognised since the early 80s, but only from mid-90s has lead nitrate as a lead source become widely used in gold cyanidation.

- improves leaching kinetics & increases the quantity of gold recovered from sulphide ores.
Lead Nitrate Solution

• Lead nitrate solution data:
  • Supplied at a concentration of 40% w/v
  • Specific gravity of 1.33
  • Naturally clear but coloured yellow for safety
  • Supplied in delivery sizes
    • 1000L IBC
    • 16.8kL bulk ISOtainer load
It is well known that lead is toxic. Acute lead poisoning symptoms are diarrhoea, kidney damage & muscle weakness. Lead accumulates in the tissues of the body.

Prevent any lead from entering the body.

- Lead can enter the body via:
  - Inhalation of dusts and mists
  - Ingestion
  - Skin contact
Lead nitrate crystals are relatively dense and not very dusty but can still represent a significant inhalation risk.
  - Use of solution greatly minimises this risk.

Lead nitrate solution is not at all volatile.
  - Any evaporation will be in the form of pure water vapour only.

If splashes and drips of lead nitrate solution dry out a dry lead nitrate residue will form.
  - It is important that any spills or leaks of the solution are rinsed away and the rinse water is transferred to a leach tank or to tailings.
• Lead nitrate-containing mist can form if lead nitrate solution is under pressure and is then able to escape from any small apertures
  • To prevent the above hazard the transfer lines and hoses should be regularly checked for wear.
  • The dosing line should be enclosed.

• Lead nitrate in solution has a very limited effect as an oxidiser.
  • Only if there were a fire hot enough to crystallise lead nitrate from the solution these crystals would act as oxidising agents
Ingestion

• With proper care the ingestion of lead nitrate is very unlikely.

• Wear correct PPE
  - After work rinse PPE
  - Wash hands, face, neck and arms
  - Do not drink, eat or smoke near lead nitrate storage or dosing areas.
Lead nitrate and most other forms of lead can be absorbed if in direct contact with the skin.

- Wear correct PPE
- Thoroughly rinse equipment that has been in contact with lead nitrate
- After work rinse PPE
- Wash hands, face, neck and arms
- Do not drink, eat or smoke near lead nitrate storage or dosing areas.

In the event of skin contact
- Immediately remove affected clothing
- Wash affected area thoroughly with potable water.
Dosing Lead Nitrate Safely

• Critical step is safe transfer of lead nitrate from IBCs to storage tank
• Primary hazards associated with this step are spills & drips
  • Hazards can be contained by following correct IBC discharge procedure
  • Wearing correct PPE
  • Thorough rinsing of spills and drips
Because of its toxicity prevent lead nitrate from spilling on to bare earth.

Contain spills in bunded areas.

Lead nitrate in the ore slurry quickly becomes dispersed and the lead is diluted down to very low concentrations.

Lead in the ore slurry becomes insoluble which effectively locks up the lead and prevents leaching of the added lead from the tailings dams.
Conclusion

- Lead nitrate is toxic
  - Always wear PPE
  - Wash down thoroughly afterwards
  - Do not smoke or eat near storage or dosing areas

- With bulk deliveries there is no on-site handling of the product