

# TACN

## Tetra Amino Copper Nitrate



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Rev.2

## 1. BACKGROUND

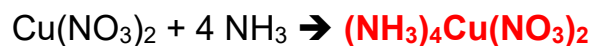
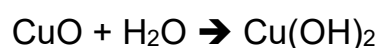
Much has been said and published about the chemical properties of Ammonium Nitrate, especially after the disaster that occurred in the port of Beirut in early August 2020, when more than 2.700 ton of Ammonium Nitrate ended up detonating, causing more than a hundred fatalities and thousands of injuries, in addition to the enormous property damage to the city.

However, a very scarce material is available regarding the chemical reaction between Ammonium Nitrate and copper and its alloys (bronze and brass), which can lead to the formation of an explosive compound called Tetra-Amino-Copper-Nitrate (TACN). This is particularly important in chemical plants where Ammonium Nitrate and its derivatives are handled, as well as in the trucks and machinery used in its transport and handling.

Therefore, this document provides a collection of information about TACN, including its physicochemical properties, usual places of formation and safety recommendations.

## 2. TACN

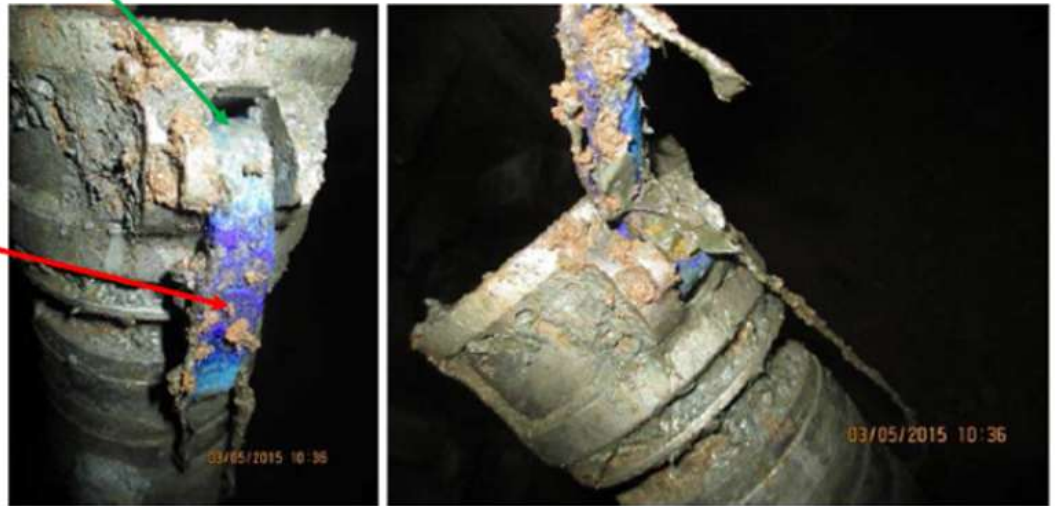
TACN is an explosive compound with an intense blue colour, sensitive to impact when dry, which can be formed according to the following simplified chemical reactions:



When Ammonium Nitrate comes into contact with copper or its alloys, a blueish-green compound is formed, typically Copper Nitrate. However, over time and exposure to air, more intense blue crystals may form together with the Copper Nitrate layer. These more intensely coloured crystals may be TACN. See the following figures:

Copper Nitrate

TACN



*Presence of TACN on camlock*

Copper Nitrate

TACN



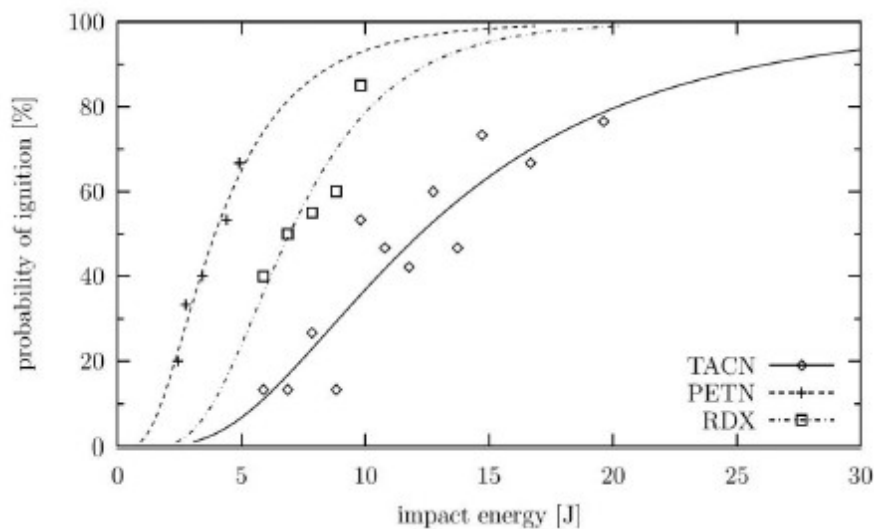
*Presence of TACN in a padlock*



Sample of TACN

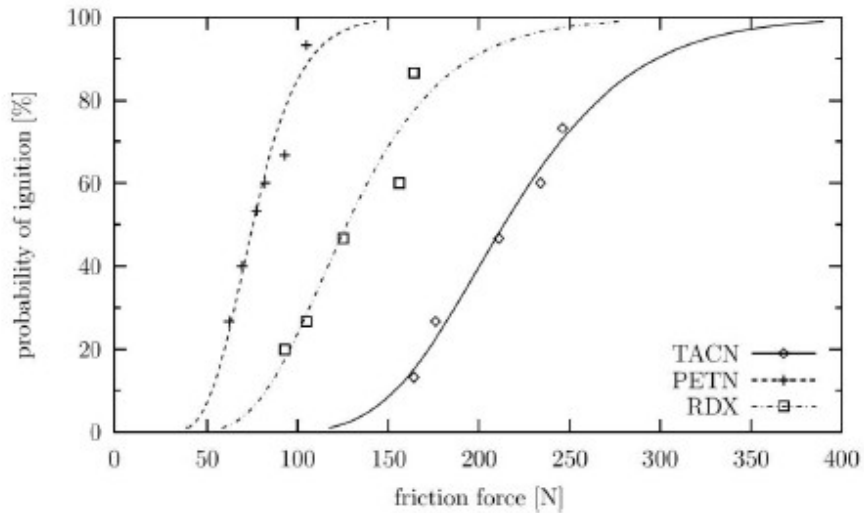
### 2.1 – Sensitivity to IMPACT

The impact sensitivity of TACN is lower than PETN and RDX, but greater than TNT. Tests conducted with various degrees of energy (impact height) showed a sensitivity distribution as shown in the following figure. At low energies, total detonation, partial detonation or just a change in colour of the material may occur.



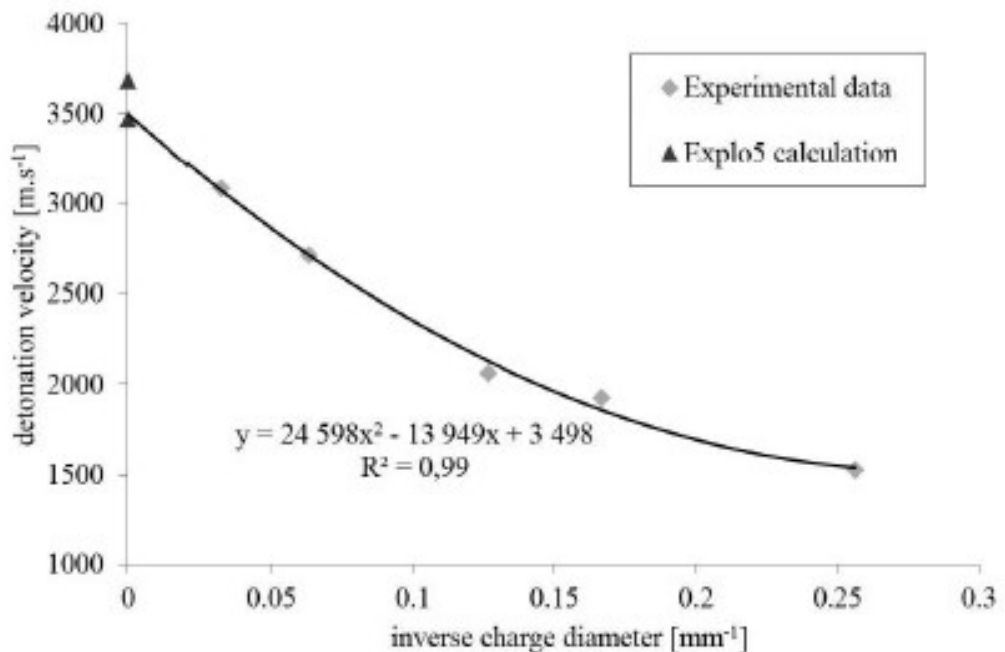
### 2.2 – Sensitivity to FRICTION

TACN is not very sensitive to friction. As in the Impact sensitivity test, TACN was less sensitive to friction than PETN and RDX. The ignition probability of a TACN sample at different friction forces is shown in the following figure:



### 2.3 – VOD

The following figure shows the detonation speed as a function of the inverse of the charge diameter. The maximum detonation speed, obtained by extrapolation of the curve, results in 3,498 m/s (density of 0.87 g/cm<sup>3</sup>), which is consistent with values presented in the literature (3,500 m/s).



## 2.4 – Critical Diameter

Tests conducted with TACN loaded in aluminium tubes with different diameters (31 mm, 16 mm, 8 mm, 6 mm and 4 mm), started with 10 g of SEMTEX 1A (76% RDX + 4.6% PETN), showed detonation positive in all cases. Thus, the critical diameter for TACN is less than 4 mm. For comparative purposes, the critical diameter for RDX with a density of 1.2 g/cm<sup>3</sup> is around 3 mm.

## 2.5 – SUMMARY of TACN Properties

Property	Value
Molecular Formula	H <sub>12</sub> N <sub>6</sub> O <sub>6</sub> Cu
Molecular Mass (g/mol)	255,67
Enthalpy of Formation (kJ/mol)	- 828
Enthalpy of Combustion (kJ/mol)	- 644
Cristal Density (g/cm <sup>3</sup> )	1,91
Melting Point (°C)	215
Start of Exothermic Decomposition (°C)	271
Detonation Temperature (°C)	330
Equivalent TNT (TNT = 1,00)	0,81
Friction Force for 50% detonation (N)	214
Impact Energy for 50% detonation (J)	11,4
VOD @ dens. = 0,87 g/cm <sup>3</sup> (m/s)	3.500
Critical Diameter – Aluminium tube (2 mm thick) (mm)	< 4

### 3. PLACES WHERE TACN CAN BE FORMED

As previously mentioned, TACN can be formed when copper or its alloys come into contact with an aqueous solution of Ammonium Nitrate. This does not mean that Ammonium Nitrate in its solid form (prill, dense, etc.) is free from this phenomenon, since in environments with humidity above 59% and at 30 °C Ammonium Nitrate reaches its Critical Relative Humidity and begins to absorb water from the atmosphere. Note that water absorption increases with decreasing ambient temperature.

Some places where TACN formation is possible, if copper or its alloys are present, include:

- Installations for the production, transfer, storage or use of Ammonium Nitrate Solution;
- Installations for the production, transfer, storage or use of bulk Emulsions based on Ammonium Nitrate where the emulsion may break;
- Installations for the production, transfer, storage or use of bulk Ammonium Nitrate-based Watergels;
- Installations for the production, transfer, storage or use of Emulsions or Packaged Watergels, based on Ammonium Nitrate;
- Any place where Ammonium Nitrate dust may spill or accumulate on copper or alloy surfaces.

This list includes storage tanks (including trucks), transfer pumps, valves and pipes, instruments, electrical wiring (including electric motors and combustion engines), electrical panels, grounding cables, camlocks and others.

### 4. SAFETY RECOMMENDATIONS

As industrial grade Ammonium Nitrate is considered insensitive to detonators and as it is very unlikely that TACN will be found in large quantities in industrial facilities, the greatest risk associated with the presence of TACN comes down to a small localized detonation, but with the potential to cause serious injuries to people handling contaminated equipment such as TACN.

When occurring on the outside of equipment, TACN can be quickly located and removed. However, when present in internal parts of equipment, which are not visible or difficult to access, the danger is not so obvious and therefore, it is essential that maintenance personnel have extensive knowledge about TACN and never use tools that promote impact or heat when working on equipment that is suspected of being contaminated with TACN.

TACN is unlikely to be formed when copper or its alloys are in contact with "Water-in-Oil" emulsions (typical of bulk explosive emulsions). However, it must be considered that emulsions can "break" over time or due to other factors, which would allow Ammonium Nitrate to come into contact with copper, enhancing the formation of TACN.

To reduce the risks of TACN formation, the following recommendations must be observed:

- Always keep the work area free of residues containing Ammonium Nitrate.
- Do not allow the use of equipment and accessories made of copper, bronze or brass in areas where Ammonium Nitrate or products made from Ammonium Nitrate are present. Choose alternatives in stainless steel, aluminium or plastic. If there is no alternative, ensure that equipment and accessories are protected by a layer of paint and undergo frequent inspections and maintenance to detect TACN formation in its early stages.
- Train personnel who work in areas where there is Ammonium Nitrate so that they are capable to identify the presence of TACN and know how to proceed in relation to decontamination processes. When in doubt whether a certain bluish crystal is Copper Nitrate or TACN, always assume it is the worst case and treat it as if it were the explosive material.
- If you find any equipment or material suspected of containing TACN, do not dry clean it with abrasive material (scraping or using an abrasive brush).
- The preferred and definitive decontamination process is to burn the equipment/material that is contaminated, which must be done by qualified personnel for such activity and in an appropriate location. Therefore:

- o If the equipment or material is small enough so you can safely remove it, take it to a suitable area to burn it.
- o If it is not possible to remove the equipment or material, or it is impossible to burn it, proceed as follows:
  - Wash the contaminated part/equipment with a 10% NaOH solution (use appropriate PPE). This procedure should transform TACN into TACH (Tetra-Amino-Copper-Hydroxide). During the washing, ammonia gas will be released and, therefore, the process must be carried out in a well-ventilated area.
  - As TACN is not very sensitive when it is wet, once the equipment or material is well moistened with the NaOH solution, it is possible to use a brush with soft plastic bristles to help remove the crystals. The brushing process must be carried out under a constant flow of NaOH solution.
  - Note that this cleaning method only eliminates material that is exposed/visible and is not effective in eliminating TACN that may be in inaccessible areas of the equipment.
  - The crystals, together with the NaOH solution used for cleaning must be heated (to promote the decomposition of TACN and TACH), neutralized with HCl and discarded in accordance with local environmental procedures.
  - If it is decided to disassemble parts of the equipment, it is important to be very cautious if processes involving friction are to be used (cutting, unscrewing, etc.); this must be done under a constant flow of NaOH solution.

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- *Tetra-Amine-Copper-Nitrate – Explosives Notes – R. Morony – 1999*
- *Private notes from the author.*



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