

Investigation Update

September 2024

This document provides an update on the CSB investigation of the May 30, 2024, incident at the TS USA Liquid Nitriding Facility in Chattanooga, Tennessee.

Incident Summary

- On May 30, 2024, at approximately 9:00 a.m., a molten mixture of sodium hydroxide and sodium nitrate (“molten salt”) was accidentally released, fatally injuring one employee at the Techniques Surfaces USA (“TS USA”) Liquid Nitriding facility in Chattanooga, Tennessee. Additionally, one employee sustained a minor injury.

Background Information

- TS USA is a wholly owned subsidiary of HEF USA, headquartered in Springfield, Ohio [1]. HEF USA is a wholly owned subsidiary of the HEF Group, headquartered in Andrézieux-Bouthéon, France [1, 2, 3]. TS USA operates metal treatment facilities in Springfield, Ohio; Kearney, Nebraska; Phoenix, Arizona;^a Kennebunk, Maine;^b and Chattanooga, Tennessee [1]. HEF Group owns numerous facilities throughout the world, including several locations in Mexico, China, India, and Brazil [2].
- The TS USA Liquid Nitriding facility in Chattanooga, Tennessee, began operations in September 2017 and was designed for processing large and heavy parts requiring nitriding [4].
- Nitriding is a process that hardens and improves the wear resistance of iron and steel materials by diffusing nitrogen into the surface [5, p. 322, 6, p. 680]. Liquid nitriding is a process whereby components are submerged in molten (liquefied) nitrogen-containing sodium and potassium salts^c to achieve the desired surface enhancement [6, p. 680].^d
- TS USA’s liquid nitriding process begins with a pre-heating step where excess moisture is removed, and the metal parts are heated. Once heated, the metal parts are submerged, via crane, in a nitriding bath containing molten sodium and potassium salts at approximately 1,100 degrees Fahrenheit (°F). Once the nitriding step is completed, an operator transfers the parts to an oxidizer bath containing a mixture of

^a The Phoenix, AZ facility operates under the name TS WEST [1].

^b The Kennebunk, ME facility operates as TS Northeast Coatings Technology, a wholly owned subsidiary of HEF Group [1].

^c The nitriding process uses cyanide and cyanate salts to provide the nitrogen for the thermo-chemical reaction to strengthen the metal parts [6, p. 680].

^d Liquid nitriding is “not a coating or plating: it is a diffusion process that modifies/transforms the surface of the treated component” [1].

800 °F molten sodium hydroxide and sodium nitrate [7]. The metal parts are then cooled and washed through a series of quenching and rinse baths, which removes residual salt from the parts.^a

- Sodium hydroxide, also known as lye or caustic soda, is a highly corrosive, water-reactive, strong base (high pH) that causes damage when in contact with human tissues, including the eyes, skin, and respiratory system. Sodium hydroxide is a white solid at room temperature and melts at 604 °F. Sodium hydroxide is non-combustible [8].
- Sodium nitrate is a strong oxidizer that accelerates the burning of combustible materials. It is a white crystalline solid at room temperature and melts at 584 °F [9].

Incident Description

- On May 29, 2024, TS USA completed its liquid nitriding process to improve the wear resistance of five 316 stainless steel rollers (**Figure 1**) for a new customer.^b At the end of the work day, the rollers were left in the hot water rinse bath,^c which was a common practice at the facility.^d
- The next morning, at 7:09 a.m.,^e a TS USA operator used an overhead crane to remove the rollers from the water rinse bath and position them vertically to drain.^f
- At 7:20 a.m., the plant manager moved the rollers to the end of the process line and placed them on the floor to cool down.
- The plant manager and a supervisor examined the rollers that had been left untouched on the floor for over an hour, which was sufficient time for them to cool down.^g They noticed that a drain hole on one of the rollers was still leaking water and appeared to be clogged or obstructed, possibly with solidified oxidizer salt. The plant manager attempted to clear the obstruction but was unsuccessful. They also noticed that the same roller was hot to the touch.
- Shortly after, the plant manager called the process engineer, who worked remotely, for guidance on melting the salt and clearing the obstruction. The process engineer recommended reintroducing the



Figure 1. Five rollers on a rack for treatment. (Credit: TS USA)

^a The liquid nitriding process may include optional finishing steps such as polishing after the rinse, before preparing a part for return to a customer.

^b All five rollers were on one rack/figure during the nitriding process.

^c TS USA personnel told the CSB that it was not uncommon to leave parts in the water rinse bath at the end of the workday.

^d The CSB was told the rollers were left in the water rinse bath on May 29, 2024, to rinse the salt out of them.

^e TS USA's workday starts around 7:00 a.m.

^f Times are based on the surveillance video that TS USA provided the CSB.

^g Some of the rollers on the rack had cooled and were not hot to touch.

rollers directly into the oxidizing bath, bypassing the preheat, due to concerns about potential damage to the rollers and the process equipment.

- Approximately 5 minutes later, at 8:46 a.m., the plant manager discussed the plan to rework the rollers with the line operator based on guidance from the process engineer. The operator was instructed to reintroduce the rollers back into the oxidizing bath without preheating.
- At 8:51 a.m., the operator lowered the rollers into the oxidizing bath. The rollers were submerged by 8:54 a.m.
- At 8:58 a.m., chemicals^a erupted from the oxidizing bath (**Figure 2**), releasing molten salt into the processing area.



Figure 2. Surveillance image showing the eruption of molten salt (Credit: TS USA)

- The released molten salt engulfed and fatally injured one employee.^b The ejected molten salt contacted various combustible materials, triggering multiple fires inside the building due to the molten salt exceeding the autoignition temperature^c of the ignited materials.

^a While sodium nitrate and sodium hydroxide are crystalline, white solids at room temperature, the molten mixture is bright green.

^b At the time of the incident, the operator was wearing an aluminized jacket, hard hat, and face shield.

^c Autoignition temperature is “the lowest temperature at which a fuel/oxidant mixture will spontaneously ignite under specific test conditions” [10].

Path Forward

- The CSB is continuing to gather facts and analyze several key areas, including:
 - The cause of the molten salt eruption
 - Hazard Analyses of Liquid Nitriding Processes
 - TS USA's Hazard Identification Program
 - TS USA's Safety Management Systems
 - HEF and TS USA's Corporate Governance of Safety Programs
 - Regulatory and Industry Guidance for Liquid Nitriding Facilities
- The investigation is ongoing. Complete findings, analyses, and recommendations, if appropriate, will be detailed in the CSB's final investigation report.

References

- [1] HEF Durferrit USA, "HEF in the US Currently Operates Through Five Different Channels," [Online]. Available: https://www.hefusa.net/about_us_HEF_USA.html. [Accessed 09 July 2024].
- [2] HEF Durferrit USA, "HEF Group," [Online]. Available: https://www.hefusa.net/about_us.html. [Accessed 09 July 2024].
- [3] HEF Groupe, "History/Presentation," [Online]. Available: https://www.hef.fr/en/presentation_en.html.
- [4] HEF Durferrit USA, "News," [Online]. Available: <https://www.hefusa.net/news.html#September>. [Accessed 09 July 2024].
- [5] J. L. Dossett, "Chapter 18. Problems Associated with Heat Treated Parts," in *ASM Handbook, Volume 11A, Analysis and Prevention of Component and Equipment Failures*, ASM International, 2021, pp. 307-325.
- [6] ASM International, "Chapter 45. Liquid Nitriding of Steels," in *ASM Handbook, Volume 4A, Steel Heat Treating Fundamentals and Processes*, ASM International, 2013, pp. 680-689.
- [7] HEF Durferrit USA, "Liquid Nitriding Process," [Online]. Available: https://www.hefusa.net/salt_bath_nitriding_liquid_nitriding/clin_process_steps.html. [Accessed 09 July 2024].
- [8] CAMEO Chemicals, "Sodium Hydroxide, Solid," [Online]. Available: <https://cameochemicals.noaa.gov/chemical/9073>. [Accessed 12 July 2024].
- [9] CAMEO Chemicals, "Sodium Nitrate," [Online]. Available: <https://cameochemicals.noaa.gov/chemical/1509>. [Accessed 12 July 2024].
- [10] Center for Chemical Process Safety | American Institute of Chemical Engineers, "Autoignition temperature," [Online]. Available: <https://www.aiche.org/ccps/resources/glossary/process-safety-glossary/autoignition-temperature>. [Accessed 8 August 2024].