Investigation Update

September 2022

This document provides an update on the CSB investigation of the December 8, 2020, incident at Optima Belle LLC in Belle, West Virginia. The investigation is ongoing. Complete findings, analyses, and recommendations, if appropriate, will be detailed in the CSB's final investigation report.

Incident Summary

At approximately 10:00 p.m. on December 8, 2020, while dehydrating a chlorinated isocyanurate compound inside a double cone dryer, the dryer exploded at the Optima Belle LLC (Optima Belle) chemical facility in Belle, West Virginia. The chlorinated isocyanurate compound is referred to by several names, including sodium dichloroisocyanurate (NaDCC) dihydrate and chlorinated dry bleach (CDB-56®) [1].

Figure 1. *Post-incident photo of the Optima Belle process building and area where the dryer unit was installed (Credit: CSB)*

The explosion resulted in significant damage to the dryer unit (**Figure 1**). Debris from the explosion struck a methanol pipeline owned by Belle Chemical Company at a co-located facility not owned by Optima Belle,[a] causing a fire. Another large fragment landed approximately 1,000 feet off-site on U.S. Route 60, causing reported damage to two vehicles. The driver of one of the vehicles, a Kanawha County resident, also reported having leg pain after hitting the large object on the road.

One Optima Belle employee was fatally injured, and two others were evaluated for respiratory irritation.

Background Information

- The sodium dichloroisocyanurate dihydrate, *NaDCC dihydrate,* is a dry white powder containing approximately 56% available chlorine (by weight) and approximately 13% moisture (by weight). It is a dihydrate[b] containing two water molecules that are part of its crystalline structure.
- Hydrates can be removed from NaDCC dihydrate by heating (*dehydration*). The first hydrate can start to be removed from NaDCC dihydrate at temperatures greater than 40°C (104°F) [2]. After the hydrates are removed, the NaDCC dihydrate becomes sodium dichloroisocyanurate (NaDCC), also a dry white powder.
- Optima Belle offers chemical toll manufacturing services and is a tenant at The Chemours Company Belle site in

[a] The Chemours Company Belle site in Kanawha County in Belle, West Virginia, houses multiple tenants including Belle Chemical Company and Optima Belle LLC. Belle Chemical Company and Optima Belle are separate entities. Belle Chemical Company's methanol piping ran external to the Optima Belle's process building, where the dryer unit was installed.

[b] A hydrate is a material that contains a water molecule within its crystallization structure. A monohydrate exists when one molecule of water is present. A dihydrate comprises two molecules of water. The water molecules generally release when heated.

Kanawha County.[a]

- Clearon Corporation (Clearon) is the manufacturer of CDB-56® and contracted Optima Belle to dehydrate four approximately 8,800-pound trial batches at the Optima Belle facility.
- The explosion occurred during the first trial batch.

Hazards Associated with NaDCC dihydrate and NaDCC

- NaDCC dihydrate is a moisture-sensitive strong oxidizing agent that can cause a decomposition reaction when heated or exposed to small amounts of water.[b] According to Clearon's safety data sheet, the decomposition temperature is 240°C (464°F) to 250°C (482°F).
- Self-accelerating decomposition reactions at temperatures ranging between 45°C (113°F) to 65°C (149°F) have been measured for NaDCC dihydrate [3].
- Nitrogen trichloride (NCl3) is a decomposition product of NaDCC, which detonates when the concentration becomes high enough [4, p. 3]. NCl3 may readily explode when subjected to temperatures of 60°C (140°F) or higher [4, p. 2].

Dehydration Process Used for the CDB-56®

- A double cone dryer (*ASME code stamped*)[c] constructed of Hastelloy C276 (**Figure 2**)[d] operating under vacuum (below atmospheric pressure) was used to heat and dehydrate the CDB-56® in the batch operation. Other connected process equipment included a vessel configured with a condenser to collect the water leaving the dryer, a scrubber, and an eductor[e] to create vacuum conditions.

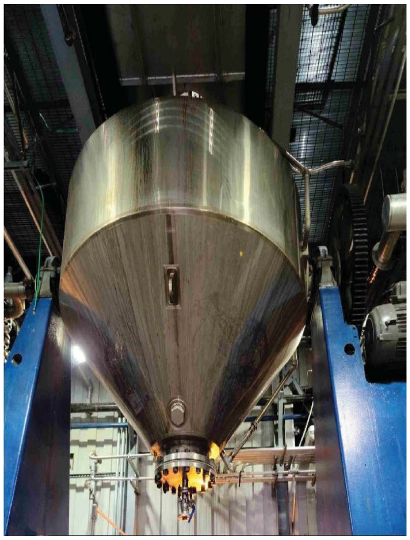

Figure 2*. Optima Belle's double cone dryer pre-incident (Credit: Optima Belle)*

- Steam was applied to the dryer's heat transfer jacket for indirect heating[f] of the chlorinated material inside the dryer as it rotated. The available saturated steam from the steam header to the double cone dryer's jacket was regulated to 30 pounds per square inch gauge (psig) and operated at approximately 134°C (273°F), thus heating the dryer's internal temperature to a maximum of approximately 130°C (266°F) by design,[g] which was below the prescribed decomposition temperature listed on the CDB-56® safety data sheet and aligned with the dryer heating temperatures included in the Clearon's Toll Manufacturing Technology Package and Optima Belle's Procedure for the CDB-56® batch. The technology package stated, "heat dryer to a temperature

[a] Toll manufacturing is a process where a third-party company is outsourced or contracted to provide manufacturing services in their equipment to a customer. The customer often provides the raw materials to the third-party company.

[b] The CDB-56® Technical Product Bulletin states, "[c]ontamination with moisture or other foreign materials… may start a chemical reaction."

[c] The dryer was designed for 30 psi (pounds per square inch) and full vacuum (FV).

[d] Hastelloy is "a widely used alloy of nickel, molybdenum, and chromium used for process equipment. It provides good resistance to wet chlorine, hypochlorite bleach, ferric chloride, and nitric acid [5]."

[e] The eductor is a device that pulled vapor from the dryer to decrease the dryer pressure below atmospheric pressure.

[f] Indirect-heating is when the heat is transferred to a material as it contacts a heated surface instead of immersing a material directly into a heating media, i.e., direct-heating [6].

[g] Optima Belle's steam is not capable of heating the dryer above the 200°C temperature discussed during the process hazard analysis.

range of approximately 100 – 130°C [(212°F – 266°F)], and no more than 140ºC [(284ºF)]. Note: Somewhat lower temperature may achieve drying [dehydration] if the unit is under vacuum." The procedure specified an internal dryer temperature of 120°C (248°F) and not to allow the internal temperature to increase beyond 130°C (266°F).

- To control the jacket temperature on the dryer, steam or cooling water could be selected manually through hand valves with the feed to the jacket, then regulated automatically through the Distributed Control System (DCS).

Incident Description

- Optima Belle production employees added approximately 8,810 pounds (four bags each containing between 2,199 to 2,208 pounds) of CDB-56® to the dryer during the morning of Tuesday, December 8, 2020. At approximately 12:30 p.m.,[a] the employees started the dryer's rotation, reduced the pressure inside the dryer to vacuum conditions, applied a slight nitrogen purge inside the dryer, and slowly added saturated 30 psig steam (approximately 134°C (273°F)) to the jacket.
- As prescribed in Optima Belle's Procedure, the dryer was stopped every thirty minutes for a sample to be taken of the powder, which was then visually inspected and examined for water content to monitor the dehydration progress. Later in the day, a decision was made to lengthen the time between samples.
- An Optima Belle supervisor told the CSB that concerns were raised about the dryer temperature not rising fast enough and the product moisture content not decreasing as expected that afternoon. At approximately 5:04 p.m., steam flow and the dryer rotation were stopped to troubleshoot the dryer's jacket.
- While troubleshooting, the supervisor noticed excessive condensate/water in the dryer's jacket through a sight glass. He and other Optima Belle employees manually drained the jacket. Once the water was drained from the jacket, the rotation was re-started at approximately 6:00 p.m., steam was re-introduced to the jacket, and the internal dryer temperature began to rise as expected.
- At 7:20 p.m., a sample of the powder—which was analyzed both for moisture content and visual consistency—indicated approximately the same moisture level as previous samples but failed its visual inspection. Dark specks were observed in the white powder.
- At approximately 8:13 p.m., after consulting with Clearon remotely,[b] Optima Belle stopped the steam flow, stopped the dryer's rotation, and raised the dryer pressure to atmospheric pressure to investigate the cause of the dark specks observed in the samples. At this time, the dryer's internal temperature was slowly increasing (**Figure 3**).[c] The lab analyzed the last sample at 8:25 p.m., which also failed visual inspection. A vacuum was again pulled on the dryer using the eductor at approximately 8:37 p.m.
- With the product continuing to fail visual inspection due to the dark specks in the powder, Optima Belle and Clearon planned to take one final sample of the powder from inside the dryer and then allow the dryer to continue rotating for the remainder of the night until the team could regroup in the morning.
- At 9:50 p.m., the dryer's rotation had not been re-started, and the internal temperature rapidly increased to a maximum recorded temperature of approximately 108°C (226°F) (**Figure 3**). The temperature was monitored via

[a] Both Optima Belle and Clearon employees were present at this time.

[b] The Clearon employees/representatives left the Optima Belle site around 5:30 p.m.

[c] In order to inspect both valves on the dryer, the dryer had to be rotated 180 degrees. This rotation occurred at approximately 8:33 p.m.

the DCS.

- The dryer exploded shortly after this temperature measurement.

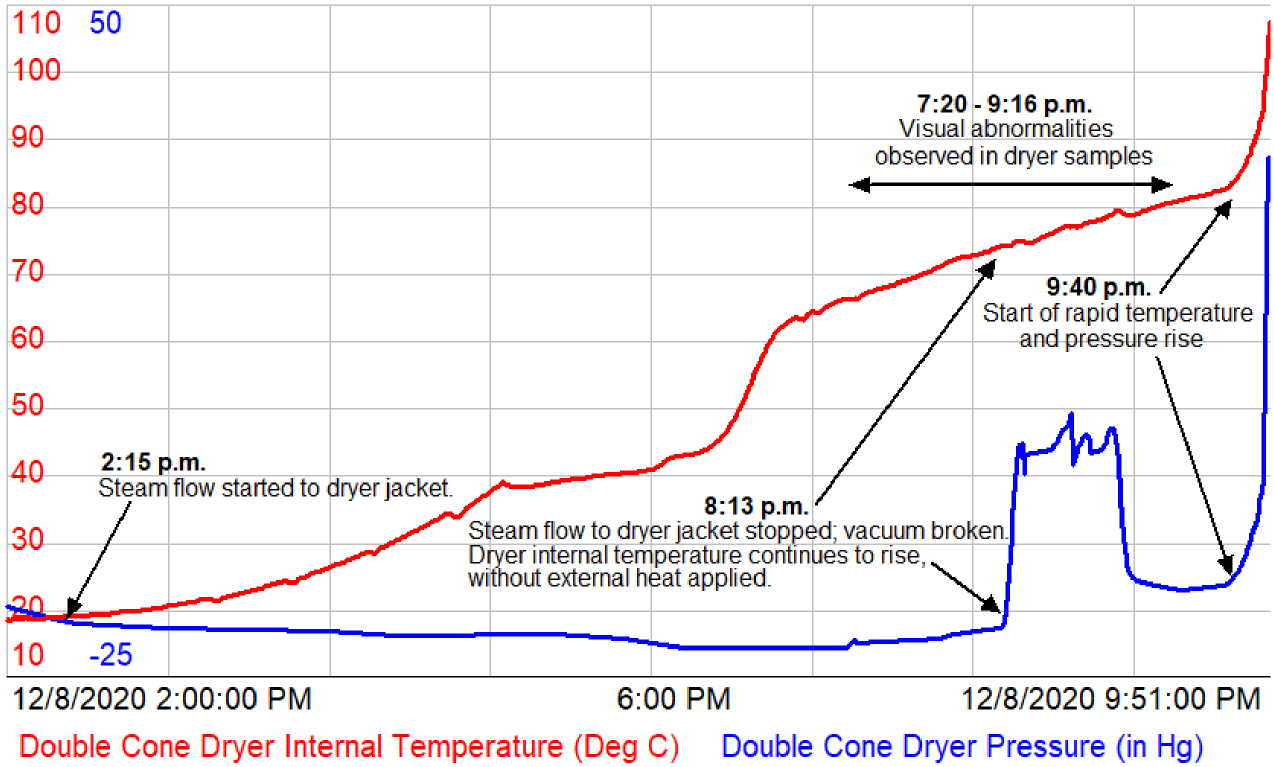

Figure 3. *Dryer Operating Conditions on December 8, 2020 (Credit: CSB)*

Path Forward

The CSB is continuing to gather facts and analyze several key areas, including:

- Conditions or source(s) that could initiate a NaDCC dihydrate decomposition reaction
- Provisions and safety precautions needed to recognize and prevent a self-accelerating decomposition reaction and prevent a similar incident from occurring
- Analyzing the results of the material that was in the dryer unit

The investigation is ongoing. Complete findings, analyses, and recommendations, if appropriate, will be detailed in the CSB's final investigation report.

References

[1] "CDB-56 (sodium dichloroisocyanurate dihydrate)," Clearon Corp., 2021. [Online]. Available: http://www.clearon.com/products/cdb-56. [Accessed 23 February 2021].

[2] Kuznesof, Paul M.; 61st Joint FAO/WHO Expert Committee on Food Additives (JECFA), "Sodium Dichloroisocyanurate (NaDCC – anhydrous and dihydrate) Chemical and Technical Assessment (CTA)," 2004. [Online]. Available: http://www.fao.org/fileadmin/templates/agns/pdf/jecfa/cta/61/NaDCC.pdf. [Accessed 23 February 2021].

[3] Whitmore, M. W.; IChemE Symposium Series no. 134, "Estimation of Stability Temperatures From Differential Thermal Analysis and Thermal Activity Monitor Data in Combination," 19 - 21 April 1994. [Online]. Available: https://www.icheme.org/media/10373/xii-paper-42.pdf. [Accessed 23 February 2021].

[4] "U.S. Patents - Process For Producing Sodium Dichloroisocyanurate," 3 October 1978. [Online]. Available: https://patents.google.com/patent/US4118570A/en. [Accessed 23 February 2021].

[5] C. Schaschke, A Dictionary of Chemical Engineering, Oxford University Press, 2014.

[6] Fuller, Warren O. and Abbé, Paul O.; Powder and Bulk Engineering, "How to Choose a Vacuum Dryer," 1999. [Online]. Available: https://www.chemicalprocessing.com/assets/Media/MediaManager/HowChooseVacuumDryer.pdf. [Accessed 8 January 2021].