

### Introduction

**A**t approximately 11:00 PM on May 31, 2017, explosion(s)<sup>1</sup> at the Didion Milling (Didion) facility in Cambria, Wisconsin, resulted in 5 worker deaths and an additional 14 workers injured. Because the event occurred at night, only 19 employees were working within the facility at the time of the incident.<sup>2</sup>

Shortly before the explosion(s) at Didion, workers saw or smelled smoke on the first floor of one of the mill buildings. In trying to find its source, workers focused on a piece of equipment called a gap mill.<sup>3</sup> While inspecting the equipment, workers witnessed a filter connected to an air intake line for the mill blow off, resulting in corn dust filling the air, and flames shooting from the air intake line, followed by one or more explosions.

After the CSB's initial assessment on site, the agency mobilized additional investigators, structural and blast engineers with expertise in dust explosions, and a drone team to enhance its field capabilities. The CSB and its contractors conducted limited entries into a number of the mill buildings<sup>4</sup> and completed ground and elevated surveys of the blast damage in an effort to determine the origins of the event and the possible contributing role of the dust (see call-out box). Based on evidence the CSB collected from the structural damage patterns in the mill buildings and from employee reports of corn dust and fire coming out of the gap mill air intake line just before the explosion(s), the CSB considers the Didion incident to be one or more dust explosions.

This interim Factual Investigative Update provides a multi-perspective narrative of the May 31 event through detailed accounts from Didion workers present in the facility before and during the incident. The CSB's full technical analysis of the incident and its examination of dust management at Didion will be published after it is completed.

1 The events that occurred at Didion conform to the National Fire Protection Association's (NFPA) definition of an explosion, "the bursting or rupture of an enclosure or container due to the development of internal pressure from a deflagration," where deflagration is the "propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium." As defined by NFPA, rooms and/or buildings are enclosures. NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2017, Section 3.3 General definitions.

2 During the day, over 60 people could have been working inside.

3 The piece of equipment was a gap mill which employees called the "South Bauermeister." "Bauermeister" refers to the manufacturer of the gap mill and "South" its relative location to another gap mill nearby which the employees called the "North Bauermeister." A gap mill grinds corn into smaller pieces by forcing the pieces to hit both each other and internal mill components, causing them to break apart through a process known as mechanical impact grinding.

4 Of the 9 buildings (Figure 1 and Figure 2) that made up the Didion facility, 4 had completely collapsed and 5 sustained severe structural damage (Figure 3). The CSB and its contractors entered 4 of the standing buildings, but deemed the fifth building too unsafe to enter.

The dry corn milling process, like the one used at Didion, is inherently a dust-producing operation. Corn dust is combustible and known to be capable of generating overpressures under the right conditions.<sup>5</sup> Dust fires, like all fires, occur when fuel (combustible dust) is exposed to heat (an ignition source) in the presence of oxygen (air).<sup>6</sup> To become an explosion, a dust fire requires two additional elements: dispersion to create a dust cloud and confinement.<sup>7</sup> Burning a dust cloud in the open generally results in a flash-fire and the generation of combustion gases. If that same fire is confined within a building, vessel, or piece of equipment, the expansion of the combustion gases can build up pressure until the enclosure bursts and releases a pressure wave capable of damaging buildings and causing serious human injuries.<sup>8</sup>

Dust explosions are typically classified as either *primary* or *secondary*. A primary, or initial, explosion can trigger secondary explosions when combustible dust or fines that have accumulated on floors or other surfaces are lofted into the air,<sup>9</sup> or when either is thrown into the air from damaged equipment, and ignites. If a sufficient volume of dust or fines are lofted or secondary releases occur, a relatively weak primary explosion can trigger very powerful secondary dust explosions.

5 OSHA requires manufacturers to provide Safety Data Sheets (SDSs) to communicate hazards of their products ([29 CFR 1910.1200\(g\)](https://www.csb.gov/29-CFR-1910.1200(g))). The SDSs that Didion produced for several of its products, including corn bran, flour, grits, and meal, identified that "dust-air mixtures [of these products] may be explosive."

6 Much of the background information here on combustible dust fires and explosions is taken from the U.S. Chemical Safety and Hazard Investigation Board, *Combustible Dust Hazard Study*, 2006-H-1, November 2006, pp 11-16, <http://www.csb.gov/file.aspx?DocumentId=482> (accessed December 20, 2017).

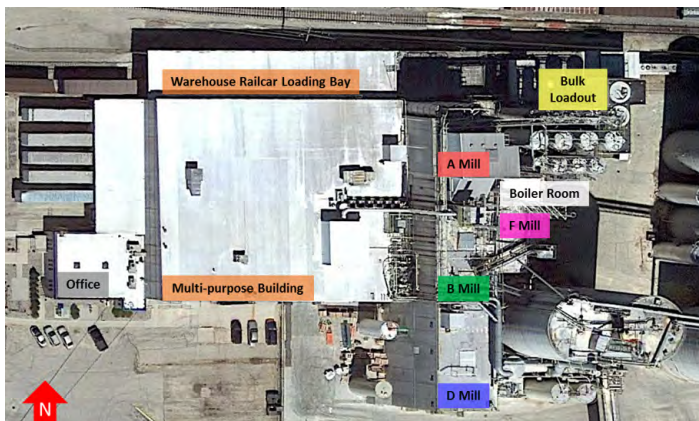
7 A minimum amount of airborne dust is required before an explosion can occur. This is a measured property referred to as the Minimum Explosible Concentration (MEC). As described in National Fire Protection Association (NFPA) Standard 654, the MEC depends on many factors, including a dust's size distribution, chemistry, moisture content, and dust particle shape. NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, 2017, Part A.3.3.19.

8 U.S. Chemical Safety and Hazard Investigation Board, *Combustible Dust Hazard Study*, 2006-H-1, November 2006, pp 11-16, <http://www.csb.gov/file.aspx?DocumentId=482> (accessed January 24, 2018); NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, 2017, Annex A; Kaelin, D.; Prugh, R.; *Explosible Dusts*, US Codes and Standards of Safe Management Practices, *Process Safety Progress* 2006, Vol. 25, No. 4, p 299.

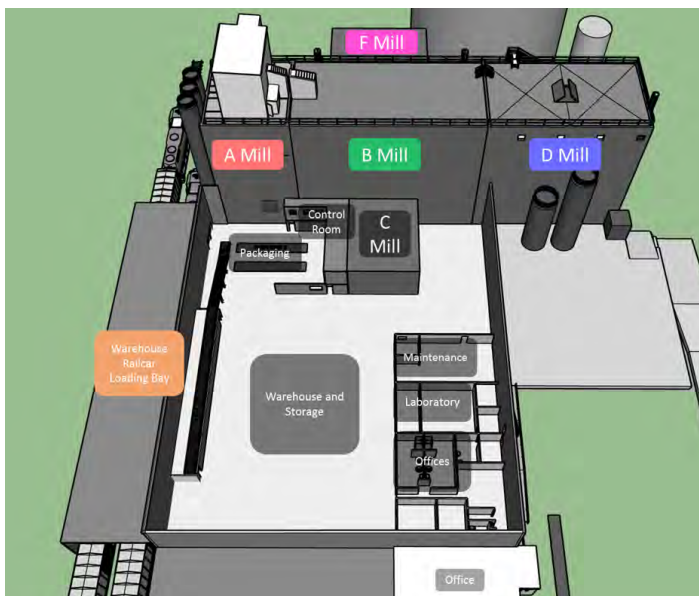
9 NFPA 652 classifies a combustible material according to size thresholds: particulate solid, dust or fines. A particulate solid refers to larger particles that represent a fire hazard, but are unlikely to result in a deflagration (explosion). Dust and fines refer to particles smaller than 500 and 75 microns respectively, and when suspended can result in an explosion. Because of their small size, fines can remain suspended in air for a longer period of time than dust particles, posing a greater explosion hazard. NFPA 652, *Standard on the Fundamentals of Combustible Dust*, 2016, Part A.3.3.7.

## Post-Incident Consequences And Facility Layout

Milling at Didion began in 1991 when A Mill was constructed at the site. At the time of the incident, milling had expanded to include four other mill buildings: B, C, D, and F (Figure 1). In support of milling operations, Didion built additional structures, including a boiler room, train and truck bulk-loading facility, front office, and another multi-purpose building that housed C Mill, packaging equipment, offices, a laboratory, a maintenance shop, and the mill control room<sup>10</sup> (Figure 1 and Figure 2).<sup>11</sup>



**Figure 1.** Pre-incident overhead view of the Didion corn mill facility.<sup>12</sup> Each building has been highlighted with its own color.



**Figure 2.** The multi-purpose building housed C Mill, packaging equipment, offices, a laboratory, a maintenance shop, and the mill control room.

The explosion(s) caused the complete collapse of the multi-purpose building, the Warehouse Railcar Loading Bay F Mill, and the boiler room, and severely damaged the remaining three mill buildings (A Mill, B Mill and D Mill), bulk loadout, and the front office. Figure 3 depicts the severity of the post-incident damage that various buildings sustained and the approximate locations of workers inside the Didion facility at the time of the incident. Figures 4 and 5 provide pre- and post-incident comparisons of the Didion facility from different locations.

Five workers died as a result of the explosion(s) and collapse of the buildings. Three fatalities occurred at the scene, and two others succumbed to their injuries in the following days. The other 14 workers on shift that night sustained physical injuries that ranged from minor to life-threatening. Many of these injured victims suffered a combination of muscle and skeletal injuries, while others received thermal burn injuries, and one employee suffered amputation.



**Figure 3.** This visual depicts the approximate locations of workers inside the Didion facility at the time of the incident. Circles represent workers who sustained fatal injuries, and the pentagons represent injured workers. Red dotted outlines indicate buildings that had completely collapsed or were severely damaged by the explosions on May 31, 2017. Yellow outlines indicate buildings that were accessible to investigators, but sustained severe damage. B Mill was partially accessible.

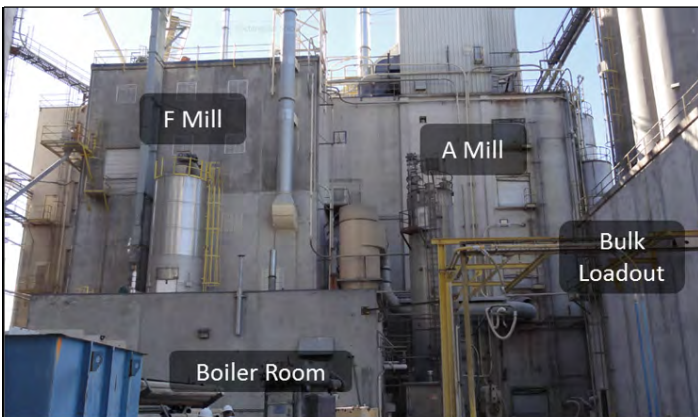
<sup>10</sup> The mill control room housed the computer system that controlled mill operations. It was also called the "mill office."

<sup>11</sup> Throughout this Factual Investigative Update, locations in mill buildings are referenced using the floor level and mill building locations. For example, the first floor in B Mill is called 1B.

<sup>12</sup> Cambria, WI. 43.53838 -89.10212. Google Earth. 2018.



**Figure 4.** Pre- (top) and post-incident (bottom) photos of the west side of the Didion facility.<sup>13</sup>



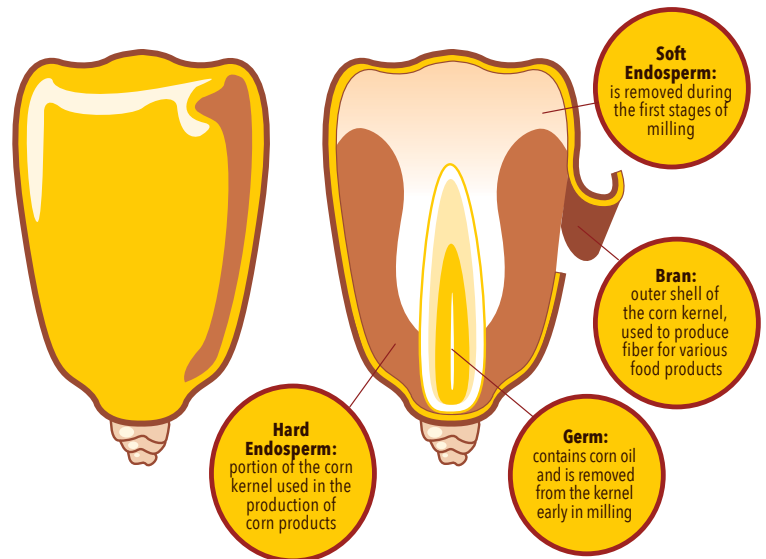
**Figure 5.** East side view of the Didion facility pre-incident taken during the latter part of 2010 (top) and post-incident (bottom) showing the complete collapse of F Mill and the boiler room. The pre-incident photograph shows the facility before the D Mill or the expanded bulk loadout bays were added.

<sup>13</sup> A person provided the top image to the CSB, stating that it came from a Facebook post.

## Didion Milling Overview

Didion operates: a dry corn milling facility and an ethanol production plant in Cambria, Wisconsin; a soybean milling facility and corporate headquarters in Johnson Creek, Wisconsin; and a packaging facility in Markesan, Wisconsin. Although separated by a road, the corn milling facility and ethanol plant were connected by a conveyor, and portions of corn were sent to the ethanol plant to be processed into a separate product.

The dry corn milling process is a system of equipment that cleans, grinds, separates, and conveys bulk solids to produce a variety of corn products (see Appendix A: Simplified Process Flow Description for more detail). The goal of dry corn milling is to separate a kernel of corn into three distinct components – bran, germ and endosperm<sup>14</sup> (Figure 6) – and when required by a customer to reduce their size before shipment.<sup>15</sup> Corn bran is a source of fiber that can be added to cereals, breads, drinks, or other food products. The germ holds the largest percentage of corn oil. The endosperm creates a variety of products ranging in particle size from larger corn grits to smaller-sized corn meal and flour.



**Figure 6.** Main parts of a corn kernel. (Modified from Corn Refiners Association)

The Didion corn mill was normally scheduled to run in two 12-hour shifts from 6 AM to 6 PM, 365 days a year,<sup>16</sup> with worker tasks

- <sup>14</sup> Endosperm can be further categorized as soft endosperm and hard endosperm. The soft endosperm is sent to the ethanol plant while the hard endosperm is converted into other corn products.
- <sup>15</sup> It should be noted that if Didion processed whole grain corn, it would grind the whole corn kernel. No effort would be made to separate the different components.
- <sup>16</sup> Didion also had routine shutdowns scheduled for maintenance, cleaning, and fumigation.

falling into one of the categories described in Table 1. The various work groups—superintendents, millers, packers, loaders, lab technicians, and maintenance technicians—generally participated in daily shift exchange meetings to obtain a status report from the departing shift. Each group held its own changeover meeting, and then the superintendent would coordinate activities between the groups throughout the shift.

**Table 1.** Job titles and basic descriptions for corn milling responsibilities at Didion. For all the positions, additional duties not identified in this table could also be assigned on an as-needed basis.<sup>†</sup>

Job Title	Position Description	No. on Duty the Night of May 31, 2017
Superintendent	Coordinated the work activities and resources necessary for the milling, packaging, and loading of products.	1
Miller	Set up, operated, monitored, and troubleshoot milling equipment; monitored and maintained product specifications; and cleaned the mill buildings.	3
Packer	Operated product packing equipment, which included filling and sealing product bags, loading bags into railcars, and cleaning the warehouse or other areas in the mill.	6
Loader	Inspected, loaded, and unloaded the bulk pneumatic trucks and railcars used to transport products.	4
Forklift Operator	Inspected, loaded, and unloaded van trucks used to transport products and organized the warehouse.	1
Lab Technician	Performed qualitative and quantitative laboratory tests.	2
Maintenance Technician	Performed unplanned and preventive maintenance activities to lessen the likelihood of equipment failure.	2
<b>Total Employees on Duty</b>		<b>19</b>

<sup>†</sup>One of the Packers, Maintenance Technicians, and Loaders were designated as “Crew Leader.” They generally had the same job description as the others, but also had some additional oversight duties. The categories could be broken down into more specific job titles, but will be referenced only generally in this Report.

## Incident Description

Of the 14 survivors, the CSB spoke with 10. The following incident description presents their perspectives immediately before and during the incident.<sup>17</sup> Each narrative in this section begins anew and takes the reader through the event. Because it was not possible to attach timestamps to various activities, they should be viewed chronologically as summarized in Figure 7.<sup>18</sup>

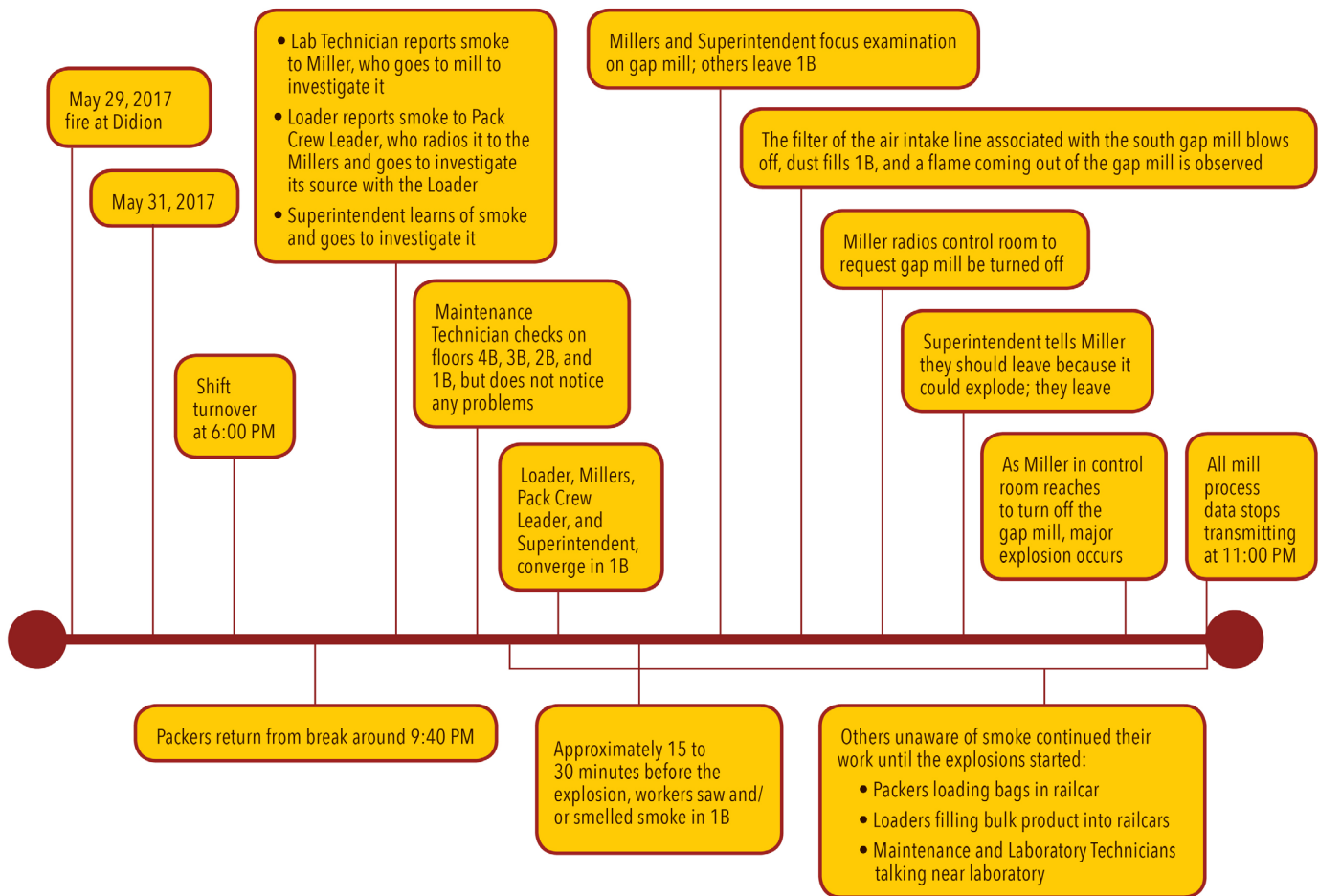
Several consistent themes emerged:

1. Workers believed the conditions at the mill on the night of the incident were “normal,” and up until just moments before the explosion(s), workers either were unaware of any problems or assumed their troubleshooting efforts would reveal a typical and manageable situation.
2. Approximately 15 to 30 minutes before the explosion, workers saw and/or smelled smoke in 1B.
3. Just before the incident, individuals were walking around various levels in A and B Mills, and no one observed any other problems beyond the smell of smoke.
4. In trying to find the source of the smoke, observations led workers to focus on a gap mill<sup>19</sup> in 1B that was part of the bran system.
5. After inspecting the gap mill, workers witnessed an air filter from the air intake line of the mill blow off, releasing corn product and flames from inside the equipment into the air, followed by multiple explosions throughout the milling facility.

<sup>17</sup> In talking with these individuals, variations between their narratives emerged. Their perspectives give context to the reality each of them faced at the time, and no single account is judged post-incident as more accurate than another. Furthermore, many of the individuals expressed concern that they could not remember exactly what happened, as is quite typical for individuals who have gone through a traumatic event such as what was experienced at Didion.

<sup>18</sup> Five individuals sustained fatal injuries and the four others did not respond to the CSB’s requests for interviews. It should be acknowledged then that there may be other details missing from the narratives presented here.

<sup>19</sup> Gap mills grind corn into smaller pieces by forcing the pieces to hit each other and internal mill components, causing them to break apart through a process known as mechanical impact grinding.



**Figure 7.** Timeline of select pre-incident activities. Computer data from the night of the incident indicates that the Packers' break likely ended ~9:40 PM and that the explosion occurred at 11:00 PM when data transmissions in the mill ended. It was not possible to attach timestamps to the various activities, so they are depicted chronologically here.

## Packers' Perspective

The Packers were preparing to start bagging the next scheduled product after a break when a Loader called the Pack Crew Leader<sup>20</sup> over the radio and said he saw smoke coming out of a door leading to 1B;<sup>21</sup> however, another Packer who heard this radio transmission recalled the Loader saying that he smelled, rather than saw, smoke. The Pack Crew Leader told the Loader he would let the Millers know about the smoke and then went to investigate its source with him. They did not find any smoke but saw the Superintendent and another Miller also checking for the smoke source. Assuming they had it under control, the Pack Crew Leader returned to the control room to work on a production report. When the Pack Crew Leader arrived at the control room, another Packer and Miller were also present.

<sup>20</sup> The Pack Crew Leader helped with regular Packer duties, but also had additional oversight responsibilities such as turning the packing systems on, monitoring them, and helping communicate production needs to the other Packers.

<sup>21</sup> The night shift had finished bagging pre-gelatinized corn flour, which is a binding agent used in food products such as cereals, snack foods, or pastas.

Three radio channels were used at the mill. Millers, Maintenance, and Lab Technicians were on the same channel, while Packers and Loaders each had their own separate channel. The two Packers in the control room overheard a radio call from the Miller in 1B to the Miller in the control room indicating the source of the fire was found, but that there was no smoke. They then heard a request for the Miller in the control room to turn off a gap mill. Just as the Miller used the computer system to turn it off, the explosion occurred. The time was just after 11:00 PM.

A blast wave from the explosion pushed the Packers and the Miller in the control room toward the warehouse. The Packers did not see any fire, but the air and little pieces of concrete that hit them were hot. One of the Packers remembers feeling the air come rushing very hard at him twice, one right after one another. Then he and the others in the control room attempted to leave, having to force open the door to the staircase that led to the warehouse. From there, they escaped by walking on top of the warehouse roof that had collapsed.

Two other Packers had been loading product bags into a railcar on the north side of the Warehouse Railcar Loading Bay (Figure 1). They did not have radios and were unaware of the conversations concerning smoke in the mill. One of these Packers noted that before the explosion, it was a “really quiet, really calm night.”

One of the Packers remembered hearing a “big, big bang” and as he turned to ask the other Packer about the noise, he was thrown. The Packer woke up on the ground in a tunnel-like area that had been created when the roof had collapsed onto the railcar. After he regained consciousness, he heard another large explosion. He saw the other Packer he had been working with trapped under the rail car they had been filling. He stayed with this Packer and shouted for help until others arrived to rescue him.

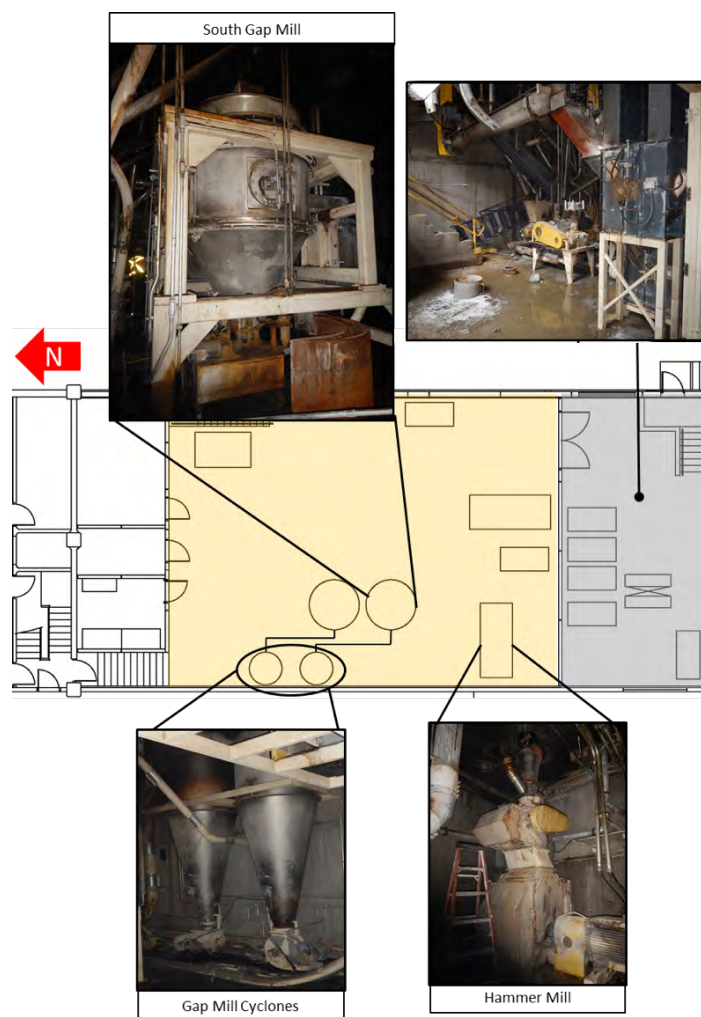
### Millers’ Perspective

Three Millers were working the night shift. They divided responsibilities so that one (Miller A)<sup>22</sup> took the lead walking around the mill and ensuring the equipment was running without product backups or other problems. Another (Miller B) monitored and cleaned the first two floors, which included taking product samples and measuring production rates<sup>23</sup> every couple of hours.<sup>24</sup> The third (Miller C) focused on the upper floors and product storage bins.<sup>25</sup> His responsibilities also included taking product samples every couple of hours and cleaning the upper floors.<sup>26</sup>

At approximately 10:30 PM, as some of the Millers were returning from a break, Miller C was preparing for a product change in one of the lines. Miller C collected his scheduled samples, manually switched a feedstock bin,<sup>27</sup> and was returning to the control room when he heard someone say on the radio that there was steam or smoke coming out of 1B.

Miller B also remembered receiving a radio call just after break from someone saying that it smelled like smoke in the mill. Afterwards, one of the laboratory technicians entered the control room and told Miller B that she smelled smoke. Miller B checked the computers to see if there was an alarm, if any equipment had shut down, or if there were indications of any other problems, but he did not find any.

Miller B proceeded to check on the second floors of A, B, and D mills (2A, 2B, and 2D). He went to 2B first, and although he could smell smoke, he could not see where it was coming from. He thought the smoke smelled different from burning corn product, more like a belt or bearings were burning.<sup>28</sup> Miller B then went to the first floor of A Mill, but he did not see or smell any smoke. From there, he walked to a room in 1B (grey room, Figure 8) and inspected various pieces of equipment for burned belts or other problems, but again, did not find any.



**Figure 8.** Partial equipment layout and photos in 1B identifying and denoting the locations of the south gap mill and a cyclone connected to gap mill’s product output stream (see Figure 10 and footnote 29 for further explanation), a hammer mill and a room (grey) containing various pieces of equipment that Miller B inspected for burned belts or other problems.

22 Miller A was fatally injured as a result of the incident.

23 Production rates are also referred to as “check weights,” which are reported in pounds per hour and based on current product flow rate measured in seconds.

24 This included A1, B1, A2, B2, and C2.

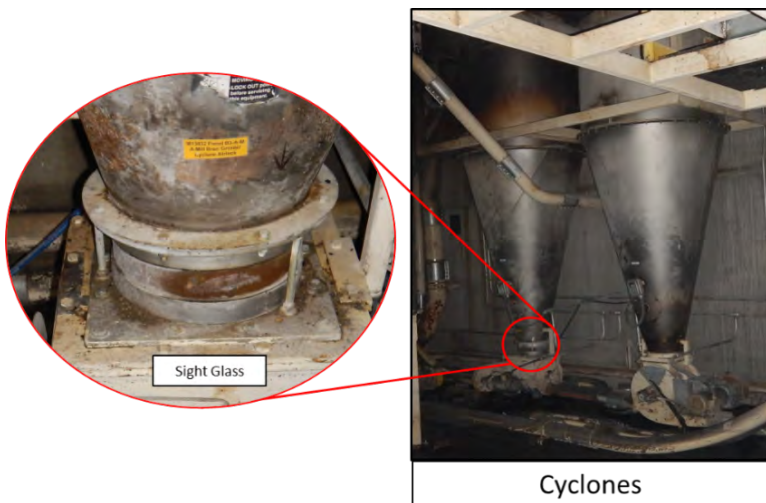
25 Bins are concrete storage silos used to hold raw corn and finished products. They are also used at Didion as temporary holding locations to allow for product switches.

26 This included 4A – 6A, 3B and 4B.

27 The Miller was switching from product storage Bin 18 to product storage Bin 1, both of which contained corn grits.

28 Rubber belts are used in equipment to transfer power from a motor to the equipment. If the equipment stops rotating and the motor is not shut off, the rubber belt can get hot and begin to burn.

Miller B was returning to the second floor when he noticed a small amount of smoke in another room in 1B (yellow room, Figure 8), but he could not tell where it was coming from. He and another co-worker who had come to look for the smoke source checked a hammer mill and they assessed it to be running well (Figure 8). They also visually confirmed that product was flowing well through a nearby gap mill (Figure 8) by inspecting a sight glass on a cyclone connected to the mill's product output stream (Figure 9).<sup>29</sup>



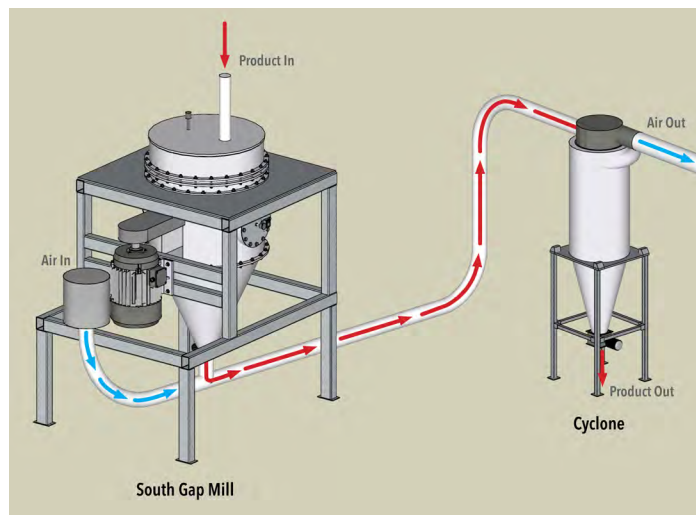
**Figure 9.** The cyclone highlighted here is connected to the south gap mill (Figure 8). A sight glass at the bottom of the cyclone allows workers to see if product is flowing.

However, Miller B then saw a mixture that looked like dust or smoke being thrown out of the area near the gap mill's product inlet (Figure 10). The gap mill was designed to have product fall through the mill and exit through the bottom,<sup>30</sup> so when it happened, Miller B could not understand why product was flowing in the wrong direction (Figure 10). Miller B called over the radio to request that Miller C shut down the south gap mill through the computer system in the control room,<sup>31</sup> but within seconds of the conversation, there was a loud noise and more smoke and dust came out near the area of the gap mill. At this point, the Superintendent told him it could explode and that they should run. Miller B then quickly left 1B to head toward the control room on the second floor, but while he was on the stairs between the first and second floor, there was an explosion and a large quantity of dust filled the air around him.

<sup>29</sup> The sight glass was a clear plastic ring located at the bottom of the cyclone connected to the output of the south gap mill. A cyclone is designed to separate product from the air stream leaving a piece of equipment. The collected product is discharged out of the bottom of the cyclone and the air through the top exhaust.

<sup>30</sup> A negative pneumatic transfer line then routes the product to the cyclones.

<sup>31</sup> Miller A, who was trying to turn off the gap mill, told the CSB that the explosion occurred just as he reached for the computer mouse to do so.



**Figure 10.** Diagram of the south gap mill. Miller B witnessed a mixture that looked like dust or smoke coming out near the top of the mill (red box). The design of this mill uses an exhaust fan to draw air through the inlet filter (blue arrows, left), product from the bottom of the mill (red arrows) through a cyclone where the product falls to the bottom of the cyclone, and the air containing fine corn dust (blue arrow, right) continues out of the top to a dust collection system.

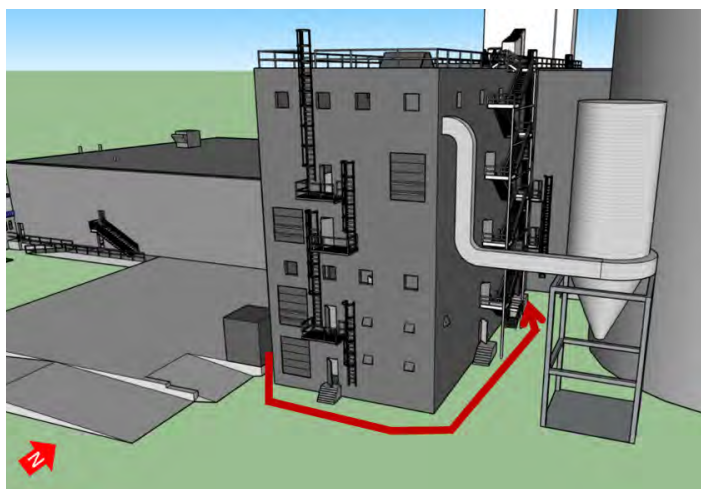
Looking for an escape, Miller B opened the door to 2B, but visibility was low because of dust and/or smoke. He saw a lot of flames in 2B, so he turned around and tried to get to the control room. As he turned, he heard a stronger explosion and noted "this is when everything happened"— he felt fire coming from 1B up toward him in the stairwell and "everything" then began exploding.

### Superintendent's Perspective

The Superintendent had been working in the Superintendent's Office<sup>32</sup> when he decided to conduct a walkthrough of the mill. He went to the control room where he heard people speaking in Spanish over the radio, and it was relayed to him that someone saw or smelled smoke in mill; he does not speak Spanish himself. Based on his previous experience, the worst he had seen when someone reported smoke in the mill was a burning belt or motor.

There were two access doors to the control room, one through the mill and the other through the warehouse. To check for smoke outside, the Superintendent walked through the warehouse and around the south end of D Mill toward the east side of B Mill, where he entered 1B from the stairs next to a metal garage door (Figure 11). He did not find any smoke outside, but as soon as he opened the door to 1B, he saw thin smoke lingering on the ceiling. The smell was unfamiliar to him, so he started to worry.

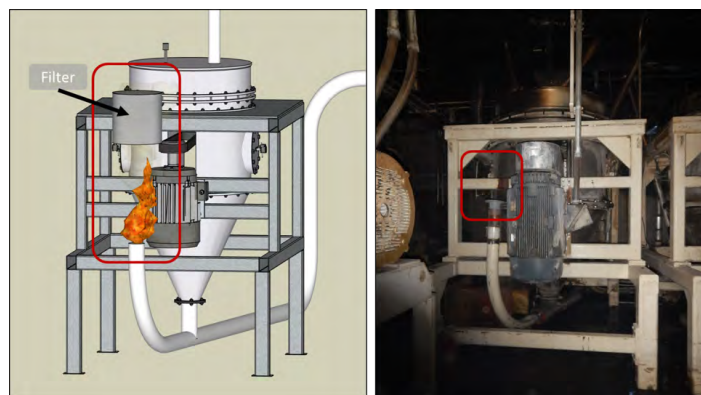
<sup>32</sup> The Superintendent Office was located near the laboratory.



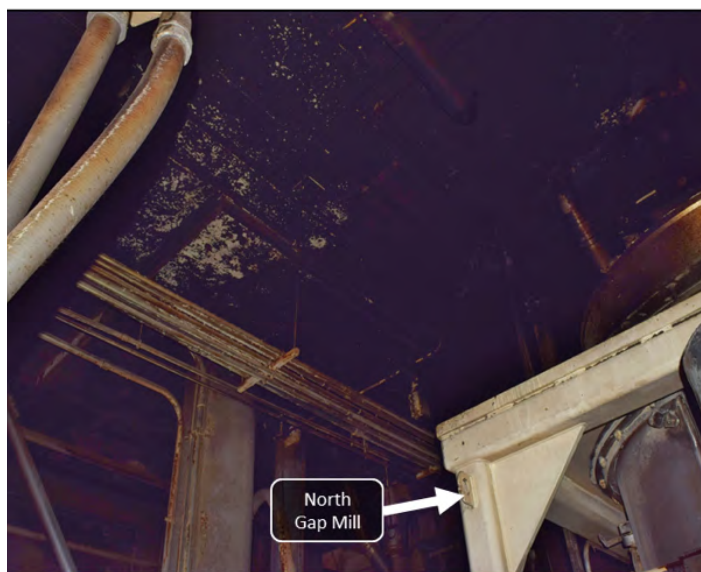
**Figure 11.** The Superintendent walked (red arrows) the south side of D Mill and entered 1B from a door the east side.

As he entered 1B, he saw a Loader come in from Bulk Loadout and a Packer with Millers A and B enter from the mill. They all began to inspect the area, feel equipment, and look for the source of the smoke, but could not find it. The Superintendent remembers Miller A saying that he thought the south gap mill felt slightly warmer than the north gap mill in the room,<sup>33</sup> and he waved the Superintendent over to feel it himself. The Superintendent agreed, but he was not concerned; he believed if something was burning in the steel south gap mill, it would be “hot to the touch,” but this was not the case.

Everyone else left the room as the Superintendent and Miller B continued to inspect and find no problems with other equipment in 1B. Suddenly the Superintendent heard a “huge boom” and then a constant roar. When he looked toward the sound, he saw the filter from the south gap mill air intake line flying in the air and a three- to four-foot flame shooting out from the same line (Figure 12).<sup>34</sup> Based on what he saw, the Superintendent thought the initial boom might have knocked dust off the horizontal pipes that ran along the ceiling, which began misting down (Figure 13). The flame was visible for four to five seconds, and then it sucked back in. About five seconds later, the flame shot back out.



**Figure 12.** The Superintendent saw the filter from the south gap mill air intake line flying in the air and a three- to four-foot flame shooting out from the same line (red box, left image). The post-incident photograph (right) shows the filter missing (red box).



**Figure 13.** Example of overhead horizontal pipes in 1B near the gap mill.

<sup>33</sup> North and south refer to the relative orientation of the two gap mills to one another.

<sup>34</sup> Post-incident, the CSB observed that the filter from the south gap mill was missing from the intake suction line.

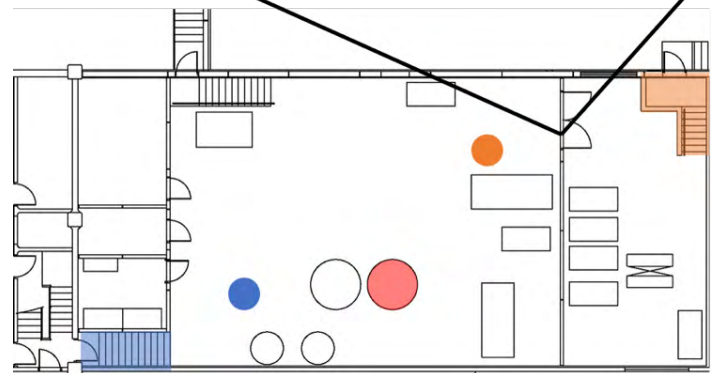
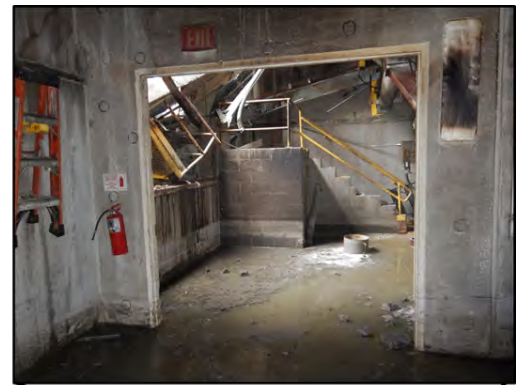




**Figure 14.** Image taken by a Didion worker of the May 29, 2017 fire. The structure on the roof of the building emitting smoke is a dust collector.

Two days before the incident, Didion experienced a fire in a dryer, which is part of its “Expander 5” system inside C Mill. Equipment was damaged as a result of the fire, but no one was injured. The fire department was called, and the plant evacuated after workers believed they would not be able to extinguish the fire on their own. The fire progressed to a dust collector on the roof of B Mill (Figure 14), which the fire department eventually put out with the aid of a ladder truck. The Expander 5 line remained shut down afterwards; Didion was actively investigating the cause of the fire when the May 31, 2017 incident occurred.

At this point, the Superintendent overhead Miller B talking on the radio in Spanish. He thought Miller B was trying to get someone to shut off the cyclone’s exhaust fan, but he feared this could take too long because the fan would need time to wind down—and he believed that there would still be suction and fire that whole time. The Superintendent told the CSB that because of a fire on the previous Monday (Figure 14), he imagined the flames traveling to one of the bigger dust collectors in the mill, and that made him want to leave the room rather than try and extinguish the fire. He yelled to get out of the room, and Miller B waved back in acknowledgement. They did not try and put the flame out, and left the same way they came in (Figure 15).



**Figure 15.** After flames shot out of the air intake line to the south gap mill (red circle), the Superintendent (orange circle) left the room using the staircase in the southeast corner of the building (orange) which led outside. Miller B (blue circle) evacuated the room using the staircase leading to the control room (blue). The photograph shows a collapsed structure covering the staircase that the Superintendent used to leave 1B.

As the Superintendent left 1B, he could still hear Spanish being spoken over the radio. He was frustrated because he could not interject the radio conversation to tell people to evacuate. Just as he stepped outside, the radio channel cleared and he attempted to make an announcement, but at that moment, a significant explosion occurred. The Superintendent ran, and as he passed

under the dry grit filter (Figure 16),<sup>35</sup> another explosion occurred over top of him and knocked him down to the ground. The Superintendent described the chaotic situation:

“You know, the building, as I was running, I was looking behind me and the whole building was just, there were fireballs and stuff. It just kept exploding. Just sounded like thunder, like constant thunder. And I saw concrete and stuff blast. I just, I thought I was the only one that made it. I thought the whole place was done, you know.”



**Figure 16.** South side of D Mill. As the Superintendent (orange dot) was evacuating the Mill he ran under the dry grit filter (red box) as an explosion knocked him down.

He ran to a parking lot. While talking with one of the truck drivers there, another explosion occurred, and he saw a fireball he estimated to be over 100 feet high coming from the area near the control room.

### Maintenance and Laboratory Technicians’ Perspective

Shortly before the first explosion, maintenance and laboratory technicians had walked through various parts of A and B Mills and did not recall seeing anything unusual. Two Maintenance Technicians (Tech A and Tech B) were working and one of them, Tech A, had been on 4B greasing fans. Previously being a miller, he picked up the habit of checking all the floors on his way down, which he did as he walked to the maintenance office in the warehouse. He did not notice any problems and did not see the other workers checking the south gap mill in 1B. Around this same time, a Lab Technician walked through the warehouse to packaging

<sup>35</sup> The dry grit filter was one of several dust collectors at Didion.

to collect samples from both of the pack lines. She then signed some paperwork in the control room before returning to the lab. The Lab Technician did not notice anything unusual during this trip.

As Tech A returned to the maintenance office, he saw Tech B talking with the Laboratory Technician in the laboratory and stopped to have a short conversation with them.<sup>36</sup> Afterwards, he returned to the office, and just as he sat down, an explosion occurred. The Maintenance Technicians did not remember hearing a discussion of any problems over the radio, though the Laboratory Technician recalled hearing someone ask for a piece of equipment to be turned off just before the explosion. After the explosion, Tech A found himself blocked in his chair by concrete that had fallen around him. He was able to move some loose material and created a space to crawl. Eventually he saw the cell phone light from one of the Laboratory Technicians and made his way toward the lab.

During this time, Tech B crawled out of the laboratory through a small opening. Over the radio he told the group left in the lab that their best option was to go west, so the group made their way over the fallen roof of the warehouse. A policeman helped bring a ladder so the group could climb down from the top of a trailer that had been parked near the warehouse.

Tech A did not recall hearing an explosion, but rather he felt and heard hot air rushing in around him. After he met up with the Lab Technicians, he did hear an explosion and saw flames go to the top of the mill. The Laboratory Technician, though, remembered hearing a big boom and then feeling everything starting to shake and material falling around her, but Tech B who had been in the laboratory with her did not recall hearing an explosion. Instead, he described a roar before concrete and dust fell and surrounded him.

After getting away from the warehouse rubble, Tech B met up with an employee that had heard the explosion from home<sup>37</sup> and came back to the facility to help. They heard two Packers shouting for help because one of them had been pinned by a railcar in the Warehouse Railcar Loading Bay. Tech B worked with a Loader to move one of the railcars so that firefighters could get water to an area of the mill that was burning close to where the Packer was trapped. While near the railcars, he heard another explosion in the area indicated on Figure 17. After moving the railcar, he shut off the main gas line.

<sup>36</sup> The Laboratory Technicians were having a problem with a metal detector, and Tech B was talking to them about it.

<sup>37</sup> This individual stated that he lived in Cambria, which is approximately 0.4 miles from Didion Milling.



**Figure 17.** Approximate location (gold star) of the second explosion after the collapse of the mill buildings.

### Loader's Perspective

The Loaders were preparing to fill a rail car in Bulk Loadout when an explosion occurred. One Loader was in the locomotive looking east over the railcar, while at least one other Loader was on top of the railcar so he could direct when it needed to be moved. Then with “a snap of the fingers,” a short, loud boom rocked the railcar. The Loader in the locomotive saw a cloud of smoke and flames at the west end of the rail tunnel and his cab filled with smoke (Figure 18). He got out of the rail car and moved to the front of the bays when two other Loaders came out toward him with burns. They tried to find one of the other Loaders who had been last seen loading a trailer in the center bay when he walked out with most of his clothes burned away.<sup>38</sup> They knew he was badly hurt so they walked with him toward the road in search of an ambulance. Once there, one of the Loaders heard another explosion coming from the area indicated in Figure 17.



**Figure 18.** Post-incident images of the rail and truck loading “tunnels”. At the time of the incident, Loaders were working in the rail tunnel and witnessed fire and flames coming from the west end tunnel.

### Emergency Response

The first phone calls about the incident were received at 11:01 PM, and the first alarm at the Cambria Volunteer Fire Department sounded at 11:03PM. Even before arriving on scene, and after hearing firsthand reports from emergency responders already onsite, the Cambria Volunteer Fire Chief called in extra resources, including other fire departments and heavy rescue teams.<sup>39</sup> After arriving on scene at 11:10 PM, the Fire Chief called in further resources to assist with the extensive damage of the collapsed buildings and the large fire in the mill.<sup>40</sup> Consistent with other witness accounts, the Fire Chief also saw a large fireball come from

<sup>38</sup> This individual eventually succumbed to his burns.

<sup>39</sup> The Fire Chief reported to the CSB that he called in extra resources before arriving on scene because of pre-planning and site visits.

<sup>40</sup> In total, over 200 first responders from 20 local fire departments, multiple EMS crews, and Wisconsin Urban Search and Rescue responded to the incident at Didion.

the center of the collapsed warehouse (Figure 17). The various emergency responders formed three groups: search and rescue, fire suppression, and Emergency Medical Services (EMS). Each group was led by a different fire chief, while the Cambria Fire Chief managed the entire scene. For about the next four hours, the groups worked together to conduct search and rescue, control and extinguish any remaining fires, and evacuate injured workers.

All Fire and EMS (Emergency Medical Service) units cleared the scene on Friday, June 2, 2017, at just before 2 PM. None of the over 200 first responders at the site were injured at any time during the response. After the incident, the overall response was called “textbook”; one fire chief told the CSB, “for you to run this scene and not have anybody get hurt, that’s phenomenal.”

## Potential Dust Sources at Didion and Path Forward

As the narratives in this report indicate, workers observed dust clouds at Didion moments before the explosion(s) occurred on the night of the incident. Two potential sources of the observed dust clouds are:

- Dust and product thrown into the air from equipment damaged by an overpressure event, like the one that caused the air intake line of the gap mill to blow off, or some other failure, and
- the lofting or knocking of fugitive dust into the air that had accumulated on floors, overhead piping, and other horizontal surfaces inside the mill.

To determine which source(s) might have contributed to the incident, the CSB is examining witness testimony, post-incident damage patterns, and computer modeling of the propagation of fire and explosion(s) in the mill.

The milling process at Didion was complex. Many product streams passed through various pieces of equipment in different mills and on different floors multiple times before bagging and shipping.<sup>41</sup> Workers reported that as product passed through the mill and packing area, dust could be released in several ways: leaking equipment or pipes, opening equipment for maintenance, or product spilling from a broken packaging bag. Workers’ job responsibilities included cleaning and those interviewed described how they performed these activities daily. Reported amounts of dust in the mill on the day of the incident rely upon individual perceptions, which varied widely among Didion employees. While some Didion employees described the plant as “dusty,” others indicated it was “clean.” These opinions ranged from observations that the plant was “spic and span” to “I was covered in [dust] every day.”

The CSB’s computer modeling<sup>42</sup> as part of the investigation into the Didion incident will provide some quantitative context to the various dust levels individuals reported. It will identify an approximate amount of suspended corn dust that would have been necessary to cause the level of damage at Didion. The CSB’s efforts will help explain what likely happened at Didion. More broadly, it may yield learnings affecting the design and construction of equipment and buildings that might be subjected to dust explosion hazards.

The CSB has developed an equipment inspection protocol and is working with Didion and others<sup>43</sup> to examine the gap mill from which workers saw flames emanating just before the explosions. Additionally, combustible dust testing of several samples has begun, and the results will help complete explosion and damage assessment modeling of the incident. The CSB also continues to interview Didion workers and examine company documents to better understand their efforts to manage and control dust. The CSB aims to explore the conditions that influence the safe management of dust and the challenges associated with dust explosion prevention in order to seek new opportunities for meaningful safety change.

<sup>41</sup> See Appendix A: Simplified Process Flow Description for more detail.

<sup>42</sup> Specifically, the CSB is developing a three-dimensional computational fluid dynamics (CFD) model based upon field measurements from post-incident damage, architectural and structural drawings, and dust testing results.

<sup>43</sup> The CSB strives for a collaborative approach to testing. In this case, the CSB considers Didion’s interests, legal counsel representing workers and their families affected by this tragedy, and manufacturers of various pieces of equipment utilized at the mill.

## Appendix A: Simplified Process Flow Description

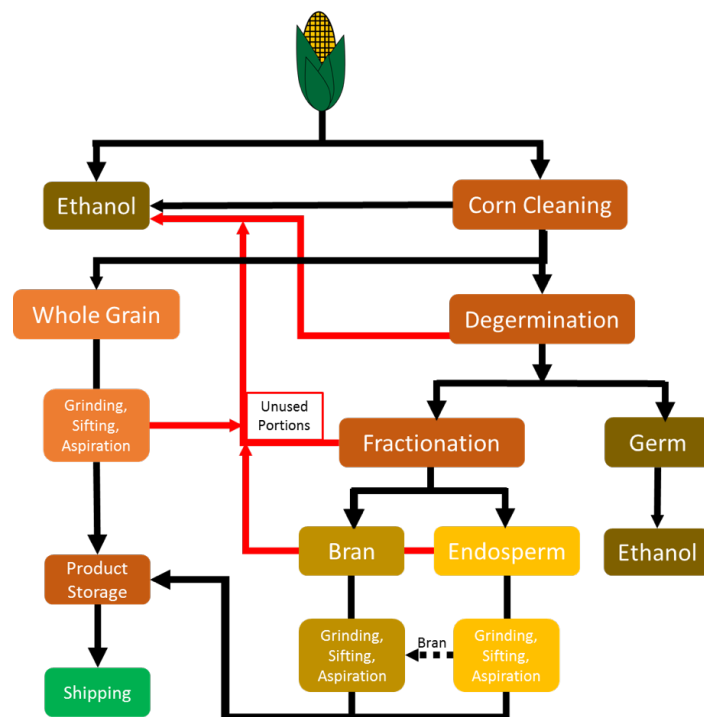
A summary of the Didion milling process is shown in Figure 19. Raw corn begins the milling process by getting cleaned in the F mill. During cleaning, equipment separates cobs, stalks, and debris like rocks and dirt from the whole corn kernels.<sup>44</sup> The kernels then enter a tempering bin, where they soak in water to be softened,<sup>45</sup> which eases separation of the bran, germ, and endosperm. After soaking, pin mills<sup>46</sup> shatter the corn kernels into big pieces to separate the bran and endosperm from the germ in a process called de-germination. Other equipment removes the germ from the process stream and sends it to the ethanol plant.

These remaining pieces of bran and endosperm are separated by size and type in a process generally referred to as fractionation. In the first steps of fractionation, soft endosperm flour falls out of the broken kernel, while the harder portion of the endosperm as well as the bran are transported<sup>47</sup> to a different section in B mill.<sup>48</sup> The fractionation process then reduces the size of the corn using roller mills<sup>49</sup> where the hard endosperm falls away from the bran. This to allows an aspirator<sup>50</sup> to separate the hard endosperm and bran into individual process streams.

Bran is very lightweight, and so it is easy to transport using air blowers. Blowers transport it to D Mill, where a dryer removes excess moisture added during the tempering process. Using a series of sifters, grinders, and aspirators in D and B Mills, the size of the bran is reduced until it reached customers' size and density requirements, after which, it is transported to the proper product bin.

The endosperm follows a similar process. Blowers transport it to D Mill for drying, and then to A Mill where more sifters and grinders reduce its size. Again, after the desired particle size is reached, the blowers transport it to the proper product bin. During this process, some stray bran is reclaimed using aspirators and redirected to the bran system in D Mill.

Once milling is complete, finished product is stored in a series of bins within A Mill and Bulk Loadout, where workers either load it onto trucks and railcars for transportation, or package before shipping.



**Figure 19.** Didion receives raw corn from local farmers. The kernels are separated into three components: bran, endosperm, and germ. The germ is removed early in the process and sent to the ethanol plant. The bran and endosperm are further separated and ground until they meet customer requirements. Product is then stored until ready for transportation to customers. Throughout the process, corn material not used to make food products is sent to the ethanol plant.

44 Waste corn, such as dust and broken kernels, are sent to the ethanol plant to be fermented.

45 This is also called tempering.

46 A rotary pin mill causes the corn to pass through multiple pins or blocks, impacting the corn and reducing the particle sizes.

47 The various corn streams are moved either mechanically with equipment like conveyor belts and bucket elevators, or pneumatically using air pressure to blow the material from one process to the next.

48 Although not described in the text, most of the fractions are sent first to a dryer to remove the moisture that had been added in the previous step.

49 Roller mills use pairs of cylindrical rollers or cylindrical rolls against flat plates to grind product.

50 An aspirator is a device that uses an air stream to remove light particles from heavier ones based on their differences in densities and shape.