Why Do Some Casthouses Have Catastrophic Explosions While Others Do Not?

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Abstract

Literature has failed to address why catastrophic explosions occur with more frequency in some regions than in others. This gap in knowledge is detrimental, leading to workplaces in certain regions needlessly suffering from explosions that result in significant production losses. Additionally, countless workers are injured or killed due to these incidents. This paper will review the two primary types of molten metal explosions, highlighting recent casthouse explosions and discussing the root causes of each incident. We will examine the factors contributing to these explosions, including the physical and chemical conditions that lead to such events.

Our analysis will argue that in some regions, the high frequency of explosions is directly related to a lack of awareness and education regarding molten metal safety. We will explore how insufficient training, inadequate safety protocols, and a lack of regulatory enforcement contribute to the prevalence of these dangerous incidents.

Furthermore, this paper will provide a comprehensive blueprint for workplaces on how to prevent catastrophic explosions. Failure to be aware of and educated about the causes of molten metal explosions will inevitably result in future casthouses experiencing similar catastrophic events. Therefore, this paper emphasizes the critical need for increased awareness and education to prevent such tragedies and ensure the safety and well-being of workers in the industry.

Keywords: Molten metal Explosions, Safety awareness, Casthouse safety.

1. Introduction

Molten metal explosions of varying degrees of severity have occurred from the very beginning of our industry. These explosions damaged equipment, stopped production, injured and killed workers. Aluminium companies acknowledged that their business was at stake if they could not control this hazard.

Though many aluminium companies researched molten metal explosions. One company, Alcoa pioneered research on this topic and dedicated considerable manpower and resources for decades investigating this hazard. Alcoa scientists were the first to author public scientific papers detailing their work. One of their earliest works "Explosion of Molten Aluminum in Water – Cause and Prevention" by Alcoa scientist George Long in 1957 is still relevant today. Mr. Long's research and the decades of subsequent research studies from Alcoa provided our industry the knowledge on how metal explosions occur [1]. In response, aluminium companies installed engineering controls and revised worker training to mitigate the risk of molten metal explosions in the workplaces. Now many aluminium companies do not experience molten metal explosions. If they do occur, they are Force 1 in size and Force 3 explosions that can destroy a workplace occur in a majority of industry rarely occur.

Unfortunately, catastrophic molten metal explosions are still occurring. Why is that? This author believes they occur because of a lack of awareness and education to this hazard. Many workplaces believe their processes and machinery are safe because they have had no (severe) incidents in the past. It is when a catastrophic explosion occurs that they determine the processes and machinery that they thought were safe were unsafe. It was just by luck that an incident did not occur. This paper will provide the reader with the foundation on why explosions happen and how to prevent them.

It is our sincere hope that for some readers our paper will provide them new knowledge and awareness to molten metal explosions and make their workplace safer.

2. Why Do Explosions Occur?

Explosions occur when water reacts with molten aluminium on a bare substrate of concrete, steel, or stainless steel. There are two reactions, physical or chemical that can result in an explosion.

Physical reaction explosions are common with all molten metals (e.g., brass, copper, steel). Where molten metal covers water, the water molecules expand exponentially in size propelling the molten metal away. It should be noted that the water does not necessarily mean visible water (e.g., puddle of water and/or wet floor). The water can be present in a molecular form and invisible to the naked eye. This is most found with the presence of chemical salts.

Chemical salts enter our workplace by fluxes. Salts also enter on the soles of workers' footwear if rock salt is used on the roadways during winter in colder climate. Chemical salts attract moisture which can result in an explosion upon contact with molten metal. This can also occur with hand and furnace tools that are not properly preheated prior to inserting into a molten bath.

There is no physical change in the metal in this type of explosion. If 100 kg of molten aluminium explodes in a physical reaction, there would be 100 kg of solidified aluminium spread about. There are additional hazards depending on where the molten aluminium lands. Does it land on a combustible (e.g., wood pallet, cardboard box) and start a fire. Does it land on a worker resulting in an injury or fatality.

Chemical reactions are where aluminium chemically bonds with oxygen in water (H_2O) releasing Hydrogen in the form of energy. In the aftermath of a chemical reaction explosion the workplace is covered in a fine white powder of aluminium oxide. Scientists have determined that 1 kg of molten aluminium in a chemical reaction will result in an equivalent of 3 kg of tnt in force. In the earlier example of 100 kg of molten aluminium in a chemical reaction would generate 300 kg of tnt in force. There would be no solidified metal left, only white aluminium oxide powder.

$$2Al+3H_20 \rightarrow Al_2O_3+3H_2 \quad (1)$$

The Aluminium Association has administered a molten metal incident reporting system for the past forty years that defines the different explosions as Force 1, Force 2, and Force 3, which are characterized as follows (Guidelines for Handling Molten Aluminum, 2016 [2]).

Low → Severe

Guidelines	Force 1	Force 2	Force 3
Property Damage	None	Minor	Considerable
Light	Minimal	Flash	Intense
Sound	Short cracking	Loud Report	Painful
Vibration	Short and sharp	Brief rolling	Massive structural
Metal Dispersion	<15 feet	>15 to 50 feet	>50 feet

Figure 1. Explosion rating force criteria.

Force 1 explosions, also called "steam explosions" or "pops", occur when molten metal traps water that quickly turns to steam. These explosions are characterized by metal thrown a short distance, up to about 4.5 meters, with minimal to no property damage.

Force 2 explosions are violent steam explosions. As with Force 1 explosions, water is trapped and turns to steam instantaneously. In a Force 2 case, the water is trapped by the molten metal and pressure builds to the point that considerably more metal is thrown a greater distance, 4.5–6 meters. This type of explosion can often reach the plant's roof. There may be some accompanying equipment damage.

Force 3 explosions are usually catastrophic events arising from the chemical reaction of molten metal with oxygen from water, air or both. They are characterized by considerable property damage and metal dispersed more than 15 meters away. Often the metal has disappeared and what remains is a white powder – aluminium oxide.

Started in 1980 by the Aluminum Association (USA), Molten Metal Incident Reporting Program (MMIR) resulted from requests within the industry to develop a program where companies could learn from one another on an anonymous basis about molten metal explosions (Annual Summary of Molten Metal Incidents, 2023 [3]). The MMIR has been a valuable safety tool for companies around the globe. There are currently 300 reporting plants worldwide that submit a detailed report (minus any company identification) when they experience an explosion. The Association states, "This report, while not a statistical representation of the industry due to its reliance on voluntary self-reporting, continues to bring awareness to the predominant hazards that result in explosions during molten aluminum management." This paper will highlight some of the MMIR's data to illustrate the severity of the hazards discussed.

3. Common Reasons for Explosions

Spills can occur for a myriad of reasons including failure of a potline line cell, trough cracked, overflowing drain pans, crucible failures, spills from crucibles, furnace overflows, and overflow from a casting table. Each of these instances can result in molten metal falling onto the bare concrete floor or steel floor plating causing an explosion. Another hazard can occur during transport by a vehicle where the molten metal spill, onto the vehicle and catches it on fire.

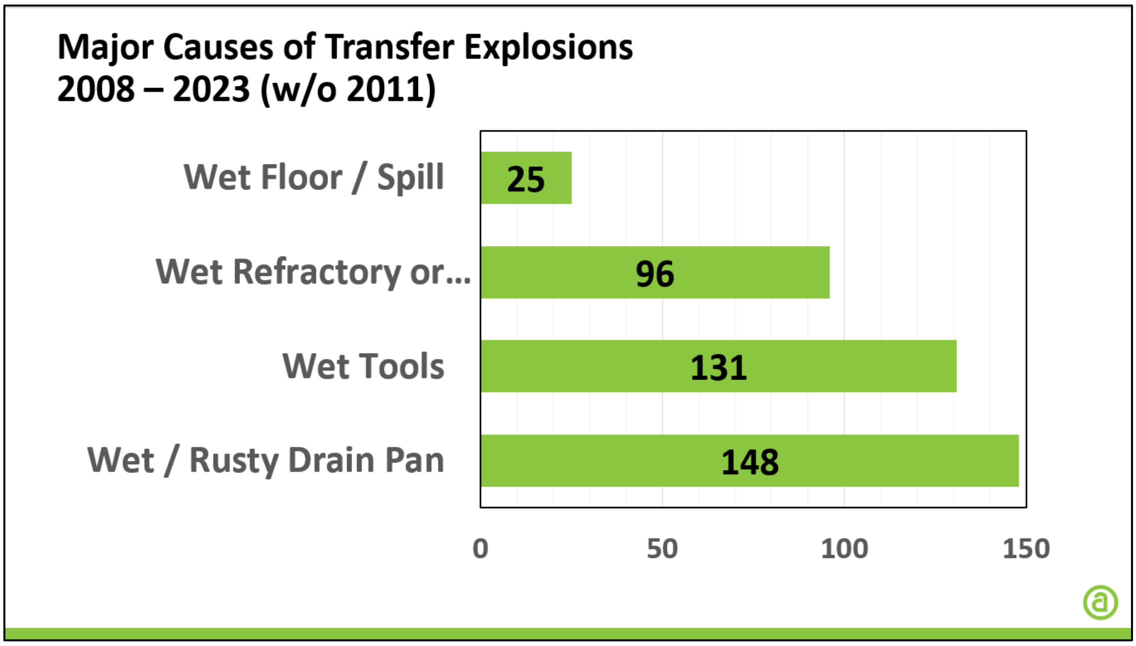

Figure 2. Metal transfer explosions – major causes 2008 – 2023.

Hand or furnace tools were the number one reason reported in the MMIR for transfer explosions in 2023. These tools are used every shift for a variety of tasks from sampling, skimming, alloying, etc. If that tool is "wet" an explosion will result. The MMIR reported over 25 explosions from "wet tools" in 2023 and more than 400 over the past 45 years. Tools can become wet either through exposure to moisture (stored outside or near an open door), or when tools come into contact with chemical salts. Chemical salts are found throughout our casthouses in fluxes. In colder climates salt is used on roadways and tracked into the casthouses on the sole of the workers footwear. Salts naturally attract moisture from the air. Any horizontal surface in a casthouse, on top of dc casting stations, concrete floors, edge of troughing, etc. is contaminated with salts. Please note it is impossible to visually inspect a tool for salt contamination because salt contamination occurs on a molecular level.

Drain pans are an overlooked area that have generated a considerable number of explosions. The MMIR lists 371 reports of explosions from drain pans over its history. The Guidelines for Handling Molten Aluminum states "Drain pans should be clean, dry and warm before the cast is started." (Guidelines for Handling Molten Aluminum, 2016 [2]).

There are two kinds of drain pans: production and (in case of) emergencies. Production drain pans are used throughout the shift and emptied after each cast. Emergency drain pans are used infrequently. Some casthouses mainly use their emergency drain pans only once a month. This use is usually the result of an aborted cast, an issue with the filter box, or another irregular event.

Explosions from drain pans can occur when there is trash placed in them, not cleaned and oiled properly, or have cracks in them. Trash should never be placed in a drain pan because it will gather moisture and when contacted by molten metal generate an explosion.

One common incident is when one shift cracks a drain pan and sets it aside. The following shift cracks another drain pan and replaces it with the previous drain pan saying the "crack(s) is not too bad". An explosion occurs when molten metal is poured in. The Guidelines for Handling Molten Aluminium state "cracked pans should be repaired or replaced". Pans should be inspected and if cracks are larger than 3 mm be removed from service. If the cracked pans cannot be properly repaired, they should be cut in half to prevent any future shifts from using them.

Drain pans need to be properly blasted and oiled. The Aluminum Association's Casthouse Safety Workshop states the following products should be used to use on drain pans (Nall, 2024) [4]:

- Canola Oil (non-food grade can be used)
- Other DC Casting Lubricants
- PyroDraw HVI46 (Pyrotek)
- Total Nevastane Clear 68 (pharmaceutical grade),
- Shell Morlina S2BL22 4
- Phillips 66 Spindle Oil 22

Some companies have applied Wise Chem E-212-F or E-115 to their emergency drain pans ensuring they will be ready for use and eliminates the need to be oiled.

Figure 3: Wise Chem E-212-F coated drain pan.

4. Coatings – Safety Pit – Hand/Furnace Tools

The importance of properly maintaining the safety coatings that are applied on steel substrate (e.g. casting table), concrete (e.g, casting pit, adjacent maintenance pit, under furnaces, etc.), and stainless steel (e.g., casting pit and tooling) is sometimes overlooked by casthouses. Coatings play an important role in preventing explosions if molten metal comes into contact with a substrate either through a trough overflowing, spill from drainpan, bleedout of mould, furnace lining failure, etc. (Wells, 2024 [5]).

The history of our industry changed when the Aluminum Association (USA) spearheaded an industry wide effort to research molten metal explosions in 1968. From that initial research and subsequent studies, the use of specific coatings to prevent molten metal explosions was identified in the "Investigation of Coatings Which Prevent Molten Aluminium/Water Explosions" final report by León, Richter & Levendusky [6].

The Aluminum Association's "Guidelines for Handling Molten Aluminum" lists specifically coatings that were tested and "found to be effective in preventive molten metal water explosions where molten metal comes into contact with water on steel, concrete (or stainless steel) following bleedouts and spills during bleedouts and spills during direct chill casting". These approved coatings are Wise Chem E-212-F, Wise Chem E-115, Carboline Multi Gard 955CP, and Courtaulds Intertuf 132HS products. It was noted that the coating Rustoleum Red, "did not prevent explosions". The elimination of untested coatings in our industry will make any casthouses that currently use them safer. It will also protect workers from injuries and fatalities.

The maintenance and reapplication of approved safety coatings is required because the coating wears away after repeated molten metal contact. The bare substrate beneath the coating eventually becomes exposed with repeated exposure to molten metal. Industry backed scientific studies proved that the minimum bare area to generate an explosion on a steel or concrete substrate is 5 cm x 5 cm. Periodic maintenance of the safety coating should be completed and recoat of the casting pit every 16-20 months, and tooling every 12-16 months. These times can be reduced due to frequency and volume of molten metal contact. It is a good idea to inspect the casting pit walls after a large bleedout and repaint if necessary.

Figure 4. Hand tools covered with solidified aluminium.

It is important to reiterate that many aluminium companies have incorporated the use and maintenance of the approved safety coatings into their molten metal safety program. For example, if we look at the six smelters in the Middle East that produced 6 454 738 tonnes of aluminium in 2024. Each smelter uses and maintains Wise Chem coating on their steel, concrete and stainless-steel substrates. They never had a Force 3 explosion because when a bleedout occurs the molten metal comes into contact with the Wise Chem coating that prevents the explosion from occurring.

Hand or furnace tools also needs to be applied and maintained regularly with specific coatings. There are a variety of coatings that can be applied to hand and furnace tools. They prevent rust from occurring or provide a physical barrier from the rust and molten metal. George Stavnes, Global Products Manager of Pyrotek states "we only recommend alkaline or neutral pH coatings which will not create flash rusting (although neutral may create some cosmetic flash rust spots)." Please note that all tools regardless of have been coated or not need to be preheated before being used in molten metal to drive off any surface moisture.

5. Recent Explosions

For the past twenty-five years at least one large Force 3 explosion has occurred annually. Even though each explosion has its own unique root causes to why it occurred, explosions do have have similarities.

In the 2024, four explosions occurred in The People's Republic of China (PRC), at vertical direct chill billet casting stations, resulting in over 180 000 t of production being lost. These explosions occurred on February 18, July 9, July 26, and August 9. They caused 15 deaths and 38 injuries. The death toll could have increased after each incident as workers may have eventually succumbed to their injuries and their deaths were not included in the total fatality count.

Figure 5. July 9, 2024 Fujian Province explosion.

There are four characteristics common in each of the explosions this paper will review: insufficient safe operating procedures (SOPS), length of worker shifts, hydraulic or steel cable operated tables and, lack of approved safety pit coatings.

5.1 July 9, 2024 Explosion

An explosion occurred in Fujian Province at a 30 000-tonne aluminium company. Two workers were killed, and one was injured (Hongwei, 2024 [7]). The explosion occurred around 16:00 on the afternoon of July 9. The No. 2 deep well with 32 billets with a diameter of 227 mm were being cast. The subsequent investigation aided by video camera was able to determine what occurred just prior to the explosion.

Various local and provincial government organizations investigated the cause (Investigation report, October 28, 2024). They released an investigative report. "The workshop was completed in March 2012, with a construction area of 5029.8 square meters. The melting and casting workshop has a total of 4 melting furnaces (melting and holding furnaces), 3 deep casting wells. Among them, 1# and 2# furnaces correspond to 1# well, 2# and 3# furnaces correspond to 2# well, 3# and 4# furnaces correspond to 3# well. The workshop has 4-25-tonne fixed smelting furnaces (1#, 2#, 3#, 4#), equipped with 3 30-tonne wire rope basket casters" (Investigation report, October 28, 2024 (8).

The report identified specific issues with this workplace's safe operating procedures that contributed to the incident. The report stated "full training is not fully implemented, and the team leaders only gave oral job instructions based on their experience. Full operating procedures training and assessment failed to ensure that workers were familiar with safety production rules and regulations." The report leaves out possible ramifications when training is only verbal, where one worker may train another worker differently based on their experiences. In addition, the worker performing the training may unintentionally instruct the trainee on how to skip steps. To prevent this from occurring, all safe operating procedures need to be written down and reviewed during training. This would force/require the instructor to review each of the written SOPs to the trainee. Minimizing the teaching of skipping steps or procedures.

The report also cited that employees "work(ed) in two shifts 24 hours a day, from 6:20 to 17:20." Though the investigative report did not explore fatigue as a contributing factor. It should be noted that the explosion occurred at 16:00, nearly 10 hours into the shift. The report also does not state how many days in a row the employees work prior to a day off.

The wire ropes were made of galvanized steel (6X37), with a specification of 19.5 mm. Each wire rope was composed of six strands, each with 37 individual wires (e.g., 6X37) with a diameter of 19.5 mm. The casting station was raised and lowered by four steel wire ropes. Past incidents in The People's Republic of China commonly cited wire rope failure when contacted by molten metal as a contributing factor of an explosion. However, investigative findings for this explosion state this was not the case in this explosion. As "Through accident site investigation, personnel interviews, expert research and inference, we can eliminate the sudden disaster "wire rope". During, the investigation it was observed that all "wire ropes were all broken. It is assumed that the ropes were severed because of the explosion.

Finally, the investigative report continues "we can eliminate the sudden disaster, injury, physical illness, natural gas explosion, abnormal power outage, cooling water blockage."

The report cites one deceased workers' actions as the main reason for the explosion occurring. The worker "adjusted the flow rate of the aluminum liquid through the flow channel gate three times, causing the liquid level to fluctuate and the cooling intensity to be uneven. As a result, the aluminum liquid in the crystallizer was pulled out before it was completely crystallized, resulting in aluminum leakage." The longest ingot length is 6570 mm and the shortest is 6480 mm, with a length difference of 90 mm.

Though the investigative report states clearly the actions and inactions of the workers that resulted in a bleed out, the report fails to discuss why the explosion occurred. The explosion resulted with molten metal pouring into the casting well for over one minute. The molten metal must have come into contact with bare steel, concrete, or stainless-steel substrate resulting in an explosion. The molten metal has also come into contact with a coating that was not approved by the Aluminum Association (USA) for the prevention of molten metal explosions.

Though that statement may read controversial. It should be noted that bleedouts occur routinely without a molten metal explosion of severity. In this incident “all three casting wells were cracked and the equipment was completely damaged.” The difference between this workplace and other workplaces is the proper use and maintenance of Wise Chem safety coatings.

5.2 July 26, 2024 Explosion

An explosion occurred in Henan Province at a 60 000-tonne aluminium company, five workers were killed, and fourteen were injured on July 26, 2024 [8] (Qi'an, 2024 [9]).

The explosion occurred around 16:30 on the afternoon of July 26, at the #B deep well 32 billets with a diameter of 203 mm were being cast. The subsequent investigation does not state if video camera footage was used to determine what occurred just prior to the explosion.

Figure 5. July 26, 2024 Henan Province explosion.

The provincial and local governments released a joint investigative report (Investigation report, December 2024). It states that aluminium workshop was completed in stages. Casting stations were identified in the report as #A, #B, #C. Casting stations #A & #B were “completed and put into operation in November 2021”. While casting station #C was “completed and put into operation in July 2023”.

The melting and casting workshop has a total of 3–20 tonne fixed gas smelting furnaces, 3 deep casting wells (length 2.2 m × width 2.2 m × depth 10 m. One casting well was not put into use), 2 sets of single drum wire rope winch casting systems. Each furnace corresponded to a casting well, #A, #B, #C.

The investigative report cites multiple failures in the workplace’s safe operating procedures (SOPS) “Lack of awareness, failure to seriously implement the safety production responsibility system for all employees, safety production rules and regulations.” In addition, the report highlights the "supervision and inspection of the unit's production safety work is not thorough, and the deep well casting process is not sound." (Investigation report, December 2024 (10)

The report concludes that "Insufficient risk awareness leads to failure of key links and key equipment in deep well casting process. Lack of deep understanding of risks and lack of understanding of the impact of the "two furnaces and one well" production model on wire ropes."

While acknowledging that each of the previous issues listed above contributed in some manner individually or collectively to the explosion occurring, the report fails to explore and explain how each of those issues contributed to the explosion occurring. This lack of clarity diminishes the positive impact this report could have had on the aluminium industry in preventing similar explosions from occurring in the future.

This workplace adopted a 24-hour work system, with two shifts and two operations, each shift had 4 workers. The day shift working hours were 07:00-19:00, night shift working hours 19:00-07:00 the next day. The shift change is carried out once every 15 days. On the day of the incident, the #B casting well completed three cast prior to the explosion occurring.

The investigative report did not explore fatigue as a contributing factor. It should be noted that the explosion occurred at 16:30, over 9 hours into the shift. Nor does it state how many days since the employees had a day off. The report stated the workplace rotated shifts "every 15 days". It is unknown where July 26th falls in the shift rotation calendar. Worst case scenario would be that July 26 was the first day of the new shift rotation. As that would be the first day that they switched their sleep schedule. Disruptions in sleep patterns can result in workers being tired during work hours. Tiredness can lead to workers not being mentally sharp.

The wire ropes were made of galvanized steel (6×29Fi+IWR), with a specification of 20 mm. Each wire rope was composed of six-strand wire rope with 29 wires that are fillers (F) and independent wires (i) and an independent wire rope core (IWRC). This type of wire rope is known for its high strength and durability making it suitable for demanding applications like lifting, pulling, and securing heavy loads. Nevertheless, one of the wire ropes failed.

On August 8, 2024, samples of the broken wire rope were taken for inspection, and the results showed: "As the aluminum rod is cast, its length and weight increase, and the wire rope on the southwest side may (have been) stressed. Broken wires or strands appear at the concentrated point and eventually (broke). After the break, other wire ropes suddenly bear too much weight. The remaining three wire ropes broke while they were stretched straight. The weight exceeds the actual weight that the wire rope can bear but is lower than the breaking force of the wire rope."

The investigative report concluded "The direct cause (of the explosion) is that the steel wire rope used in the accident casting well contains sulfide inclusions, which reduces the steel wire rope (capacity). An energy spectrum analysis showed "the suffer content in the inclusions of the steel wire matrix as 2.2%".

Dr. Muharrem Yilmaz metallurgist from Kocaeli University in İzmit, Turkey tested inclusions in steel wire rope failures. In Muharrem's study, "Failures During the Production and Usage of Steel Wires" [11]. sulfides were limited to a "maximum 0.040 % in quantity for the best quality steel". The steel wire(s) tested after this workplace explosion had 50 times the amount of sulfide inclusions as the maximum allowed in Dr. Yilmaz's study. In his study "The most important wire rod defects during the steel production are namely non-metallic inclusions (sulphides, oxides, silicates or compounds of several of these substances)." These defects can lead to premature failure.

This investigative report creates confusion regarding the wire rope. In so much the report states that "On October 7, 2023, the (aluminium plant) buyer contacted a merchant ... to purchase a 20mm diameter steel core wire rope." The confusion is two-fold, the report does not state if the purchased wire was installed in #B casting well prior to the explosion, and #B casting well was installed and began operating in November 2021. We assume if the steel wire rope #B well was replaced with the purchased steel wire rope the report would have noted that.

Regardless, the investigative report incorrectly lists the failure of the southwest corner rope as the "direct cause" of the explosion. The failure of the steel wire rope did not cause the explosion. It was a contributing factor in the explosion. The investigative report fails to explain and explore why the explosion occurred. The report states when the steel wire rope failed it caused "the aluminum rod to separate from the crystallizer and a large amount of aluminum liquid on the mold plate instantly poured into the casting. In the well, a large amount of hydrogen and heat were generated in the narrow and limited space of the casting well, causing an explosion." Though the statement "hydrogen and heat were generated…causing an explosion" is correct and represented in the chemical equation below. The statement fails to address why the chemical Equation (1) occurred.

Over decades of scientific study researchers learned that explosions can only occur when molten metal and water interact on a substrate. Hypothetically, if molten aluminium was dropped into a bottomless pit filled with water. The chemical equation above would never occur. The molten aluminium would eventually solidify and become inert. Why do explosions occur?

As previously explained, explosions occur when molten aluminium and water interact on a bare substrate of steel, concrete or stainless steel. Explosions can also occur when molten metal interacts with water on nonapproved Aluminum Association (USA) safety pit coating. That is the direct cause of this explosion when molten metal interacted with water on a bare substrate or with a non- approved safety pit coating. It was not the failure of the steel wire rope.

Bleedouts in small and large volumes of molten metal happen countless times across the industry and no explosion occurs because those workplaces were using Wise Chem or another approved safety pit coating. This workplace chose not to use any approved safety pit coating.

6. Conclusion

Machinery and equipment to process molten aluminium is similar in design throughout the globe. Nevertheless, there appears to be vast contrast in safety at workplaces. On one side there are workplaces that rarely, if ever, suffer a molten metal explosion. While on the other hand there are workplaces that have routinely experience molten metal explosions. In 2024, there were four catastrophic explosions in The People's Republic of China. Why?

This paper reviewed why explosions happen, and briefly reviewed the research behind the prevention of molten metal explosions. It should be noted that research involving molten metal explosions in the aluminium industry occurred continuously over 40 years by industry backed, governmental, and university studies. The research findings are public and many companies have used that information as the foundation for their molten metal safety program.

In this author's opinion the reason why some workplaces have explosions and others do not depend on if they follow all the industry's best practices toward safety. Please note a workplace cannot follow only some of the industry's best practices. Why? Because they will blow up. One must follow all of them, to create

This paper reviewed and explored the basics of why molten metal explosions occur. There are many more topics or issues we did not review that can result in molten metal explosions, such as during charging or transfer of molten metal. Regardless, all the hazards that can either individually or collectively result in a molten metal explosion are reviewed in the Aluminum Association's "Guideline for Handling Molten Aluminium".

This document is a useful reference and was compiled with industry input. It is the basis for the molten metal safety programs in the largest and safest aluminium companies in our industry. We are confident that if the four aluminium companies that exploded followed the contents in the "Guidelines for Handling Molten Aluminium". The 2024 explosions that killed 15 and injured 38 workers would have either been prevented or minimized with no loss of life and few injuries.

7. Recommendations

The stark contrast in the quality of information provided in the investigations after each explosions needs to be addressed. It appears that some provinces in China have access to seasoned industry experts, while others do not. This is clearly shown in the July 9 explosion report when compared to the July 26th explosion report. The July 9 report was very detailed while the other lacked specifics. Unfortunately, both reports shared the apparent lack of knowledge on why explosions occurred. The July 9th explosion result was attributed to a worker speeding up the process by three times. While the July 26th explosion was attributed to a steel wire rope breaking. Both reasons were contributing factors, but neither was the cause of the explosion. The explosion occurred because molten metal interacted with water on a bare substrate or on a coated substrate that was not an approved safety coating. That was the reason for each explosion.

We would be remiss if we failed to mention unconfirmed reports that the People's Republic of China federal government will issue new regulations later in 2025 pertaining toward steel wire rope casting stations. These regulations will either make continued use of steel wire rope casting stations impossible or ban them out right.

It should be noted that steel wire rope casting stations are in use around the world and operated safely for decades. No doubt there is a fear that one or more steel wire ropes will be severed from fatigue or by a molten metal stream from a bleedout. But these incidents do not result in an explosion because the steel tooling and concrete pit walls are coated with Wise Chem safety pit coatings.

8. Acknowledgements

I would be remiss if I did not mention the countless number of workers who have died in workplace incidents as a result of a molten metal incident. It is my sincere hope that this paper will be used to make a workplace safer and prevent a recurrence.

This author would like to express gratitude to a multitude of contacts throughout the globe whose kindness and hospitality has afforded this author with the knowledge presented in this paper.

Especially, Alcoa for all that they have done in researching and identifying the causes of molten metal explosions. Without Alcoa's steadfast commitment to safety, many of our best practices toward safety would have occurred much later at the cost of countless injuries and fatalities.

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