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CAN THE ALUMINIUM INDUSTRY LEARN FROM ANOTHER INDUSTRY'S CATASTROPHE?

Alex W. Lowery[1a], Terry Bateman[2b], Joe Roberts[3a]
[1]Wise Chem LLC, P.O. Box 97147, Pittsburgh, Pennsylvania, 15229, USA
[2]Pyrotek Pty. Ltd. 147-149 Magowar Rd Girraween NSW 2145, Sydney Australia
Pyrotek Inc., 9503 E. Montgomery Avenue, Spokane Valley, Washington 99206 USA

[a]alex.lowery@wisechem.net, [b]terbat@pyrotek-inc.com, [c]joerob@pyrotek-inc.com

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Abstract

On April 20, 2010, an explosion rocked the Deepwater Horizon in the Gulf of Mexico. Resulting in the deaths of 11 workers. Over 400,000 pages of evidence were collected during the investigation for the root cause of the explosion[5].

"What emerges is stark and singular fact: crew members died and suffered terrible injuries because every one of the Horizon's defenses failed on April 20. Some were deployed but did not work. Some were activated too late, after they had almost certainly been damaged by fire or explosions. Some were never deployed at all.[1]"

Parallels with the aluminium industry standout when comparing the Deepwater Horizon disaster (e.g., violent explosions, damaged equipment, worker deaths and worker injuries). The list of aluminium industry catastrophes is not short: Binzhou Weiqiao Aluminum (Photo2), Reynolds Alabama, Alcan France, etc.

Aluminium plants, just as deepwater oil rigs, value training and safety measures to prevent accidents from occurring. But, on April 20, 2010 every safety measure employed failed, could the safety measures employed in a casthouse to prevent a molten metal steam explosion fail too?

Introduction

The intent of this paper is not to place blame and/or responsibly for the Horizon disaster and the loss of life. The desire of the authors is to hopefully illustrate that the root causes that may have lead to the Deepwater Horizon explosion may be present in the aluminium industry today. In particular, the cast houses in the primary side of the Aluminium industry.

After the Horizon accident, numerous United States' federal government agencies began investigating the accident. Two agencies; the U.S. Coast Guard, as well as the US Chemical Safety Board (CSB) investigated the accident[3]. Whereas the US Coast Guard is a well known federal agency the Chemical Safety Board is not. The CSB is an independent federal agency charged with investigating industrial chemical accidents. Headquartered in Washington, DC, the agency's board members are appointed by the U.S. President and confirmed by the U.S. Senate. Their mission statement includes "The CSB conducts root cause investigations of chemical accidents at fixed industrial facilities. Root causes are usually deficiencies in safety management systems, but can be any factor that would have prevented the accident if that factor had not occurred. Other accident causes often involve equipment failures, human errors, unforeseen chemical reactions or other hazards. "

Both agencies investigated the accident; held public meetings and released transcripts of the meetings as well as preliminary reports on the causes of the accident. A final report was issued on April 29, 2010 by the US Department of Interior in junction with the USCG.

Photo 1 Deepwater Horizon Explosion in Gulf of Mexico on April 20, 2010. 11 deaths.

Safety Management Systems

Safety Management Systems (SMS) is a systematic and explicit approach defining the activities by which safety management is undertaken by an organization to achieve acceptable or tolerable safety[10]. The importance of SMS in the aluminium industry is well known. Many aluminium companies state that safety is the most important goal. This is reinforced with the number of aluminium companies that have gone out of business following a severe molten metal steam explosion. The aluminium industry has to be commended on their approach to open communication between organizations in the industry. It is not uncommon if an accident occurs at one company, that other companies will be made aware of the accident and the root cause of that accident. For example, a number of years ago a cast house had a fatality when a casting assistant fell into a high water pit unnoticed. That worker went unnoticed for a period of time. When their absence was noted, investigation found that the worker slipped and feel

into the pit. Instead of keeping that tragic accident within their own organization. That firm broached the subject at an industry organization meeting. This opened a dialogue throughout the industry and resulted in companies around the world of addressing pit guarding. It is unknown how many injuries and lives have been saved because that firm decided to speak out about their own accident to prevent other accidents from occurring.

The objective of a Safety Management System is to provide a structured management approach to control safety risks in all operations. An effective safety management must take into account the organization's specific structures and processes related to safety of operations.

The U.S. Coast Guard's report on the Deepwater Horizon accident stated the following (note Transocean was the rig owner). "The investigation has shown that over a period of years and in the time period immediately preceding the casualty, Transocean had a history of deficiencies in the area of safety. These weaknesses include (1) a history of poor maintenance and failure to address it in a timely manner; (2) a history of other casualties that were never properly investigated and addressed; (3) a failure to establish a system to ensure that the Bridge was aware of the location of all personnel engaged in repair work in order to warn them of emergencies; (4) a failure to provide sufficient training and knowledge to onboard management and crew regarding safety; (5) a failure to require that systems and personnel emphasize maximize emergency preparedness; and (6) a failure to employ risk assessment."[5,11]

A number of the deficiencies listed above could easily describe some casthouses in the aluminium industry. Poor maintenance has plagued the aluminium industry recently. The reason is three fold. The recession has forced companies to layoff off personnel and not fill positions of workers who retire. Leaving some facilities are short handed in the maintenance department. Overtime is commonly not approved. Second, the budgeting process for maintenance activities is not done properly by many companies. For instance a lot of firms repair safety pit coatings as needed, sometimes extending the recoat time until funds can be allocated for the project. Studies have shown that an bare area as small as 5 cm x 5 cm that has exposed the substrate under the safety coating can be an ignition source for a molten metal explosion. Other firms understand that the advantage of budgeting for periodic recoating of tooling and casting pit walls allows them to follow their SMS. Third reason for poor maintenance in aluminium casthouses is an attitude problem. The belief that production is more important than maintenance. Facilities are hesitant to have a scheduled maintenance shutdown. It is these facilities which suffer from repeated equipment breakdowns that ultimately effect production. Poor maintenance practices in the long term cost more to rectify, and increase the likelihood of an injury.

The USCG report noted a history of other accidents that were never properly investigated and addressed aboard the drilling rig prior to the explosion[2]. A precursor to severe molten aluminium steam explosions almost always were smaller explosions. These small explosions were never properly investigated. The explosions occurred more often, and with greater force. All molten aluminium steam explosions no matter how small should be investigated for their root cause. Once the root cause has been determined, steps can be altered to eliminate the reoccurrence of an explosion.

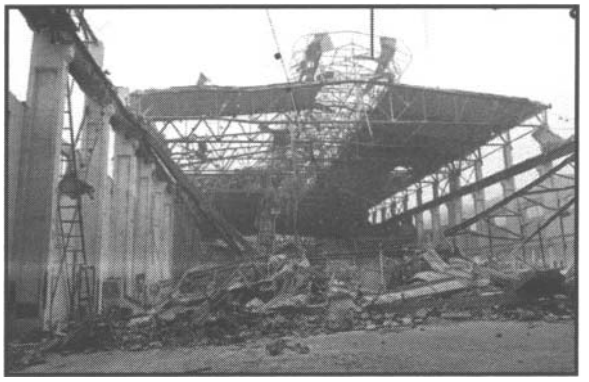

Photo 2 Explosion on August 20, 2007 at Binzhou Weiqiao Aluminum Company, in China. 9 workers were killed, and 64 injured.

The Deepwater Horizon was noted "for a failure to establish a system to ensure that...of all personnel engaged in repair work in order to warn them of emergencies". Most casthouses have flashing lights and/or horns to warn when a cast is occurring. But, unfortunately there are numerous facilities that do not have some visual and audible safety indicator to warn of a cast occurring. Many facilities do not limit nonessential personnel from being in the vicinity of a casting pit in the process of a cast. There have been several occurrences of molten aluminum steam explosions injuring nonessential personnel.

The aluminium industry has done a commendable job on safety training of all casthouse personnel. However, many seasoned casthouse personnel are retiring. Their replacements are trained as required, but the training cannot replace the years of experience their former coworkers had.

Since the very beginnings of continuous casting of Aluminium alloys water has played a very important and sometimes destructive role in the process[4]. Since the casting of Aluminium alloys through water-cooled moulds suspended above a pit partially filled with water there have been metal spills that have resulted in molten metal falling into the pit and contacting concrete, steelwork and water. Whilst most of these occurrences probably passed without anyone noticing, some resulted in major explosions causing equipment damage and in some instances serious injury or death. Many other instances resulted in reactions situated between these 2 extremes. By far the most common causes of molten metal falling into a casting pit are bleed outs or yo-outs. A bleed-out is when metal escapes the mold: normally near the start of a cast when the shell ruptures.

Yo-out is metal spill that occurs at the start of the cast when severe butt curl allow molten metal to spill over the lip of the shell causing it to remelt and thus allowing molten metal to escape.

In the early days casters would try to stop bleed-outs and yo-outs by damming the holes in the shell with asbestos wool, ceramic

fibre or pieces of scrap Aluminium in an attempt to cause the leaking metal to freeze and seal the hole. Another popular technique, still used in some casthouses, is to plug the spout or feeder to the offending ingot. Whilst all of these have the ability to stem the metal flow there is an associated risk of failure which then has the potential to cause a molten metal explosion often whilst the casting operator is standing over the pit trying to stem the flow. These days the most popular, and perhaps the safest option is abandon the casting area and remotely abort the cast in a safe and orderly manner.

Over the years casters have developed techniques to limit butt curl and this has largely eliminated the occurrence of the Yo-out. Bleed-outs on the other hand continue to be common as they are caused by a multitude of problems. Following a major explosion at a Reynolds plant in September 1967 where 6 workers died the Aluminium industry initiated studies to determine how and why molten metal explosions occur. These studies identified certain conditions that contributed to the occurrence of molten metal explosions, these included submersion under water, contact with wet rust steelwork, wet concrete and shock / vibration. During the course of the studies it was discovered that certain organic coatings (e.g., Wise Chem E-212-F, and E-115) can prevent the explosive reactions by providing a safety barriers between the Aluminium and the substrate. Most companies now use these organic safety coatings on various parts of the casting pit: the spray box, bottom block holder, platen, walls and floor. When used in conjunction with the various techniques employed to prevent bleed-outs the occurrence of molten metal explosions can be minimised. It should be remembered that the safety coating is the pit's last line of defence, if all else fails the safety coating provides the best protection to prevent a molten metal explosion. If this coating is missing, damaged or not maintained the effectiveness of the safety coating will be compromised reducing the protection afforded to the casting pit and more importantly the casters themselves.'

Most explosions are reported to be caused by bleed outs and aborted casts. There are a plethora of reasons for these. It is a difficult for a casting operator to control all of the casting variables through the change of seasons[8]. Computer controls have gone a long way towards understanding and addressing these problems. However, explosions still can occur.

A casting operator has two options for the operator, abort the cast and avoid the head of the ingot falling below the bottom of the mould. Or plug off the affected ingot/billet and to keep casting. When a bleed out has occurred it is important to remove any metal adhering to the bottom block holder, platen, pit walls and guide rails if the platen has external guides. Failure to do increases the likelihood of an explosion if another bleed out occurs. Depending on the root cause of the bleed out several successive casts may be affected until the cause is identified and corrected. When individual ingots/billets are plugged off there is the potential for the plug to leak or fail completely. When this happens it should be treated the same as a bleed out and any metal from the leak should be removed before the next cast. Wise Chem safety coating is the last line of defense to reduce the likelihood of a molten metal explosion.

If the coating is compromised by damage or an adherence of metal for example, its effectiveness in preventing an explosion will also be compromised[7]. Following a bleed out the safety coating should be inspected and if necessary repaired prior to the next cast.

Conclusion

On April 20, 2010, 11 workers died in the Deepwater Horizon explosion in the Gulf of Mexico. The investigations that followed thereafter focused on the root cause of the explosion. The government agencies report listed numerous reasons that contributed to the explosion. Those contributing factors are present in casthouse today. Constant vigilance is needed to prevent a molten metal explosion from occurring, preventing injuries, and in the worst case loss of life.

References

1. D. Barstow, S. Saul (2010) "Deepwater Horizon's Final Hours. *New York Times.* December 25.
2. Report of Investigation into the Circumstances Surrounding the Explosion, Fire, Sinking and Loss of Eleven Crew Members Aboard the Mobile Offshore Drilling Unit Deepwater Horizon in the Gulf of Mexico. Volume I: 2010.U.S. Coast Guard report MISLE Activity Number: 3721503 Washington, D.C. U.S. U.S. Coast Guard
3. U.S. Chemical Safety and Hazard Investigation Board Public Hearing, Regulatory Approached to Offshore Oil and Gas Safety, December 15, 2010, Washington. D.C. Transcripts by Nea; R. Gross & Co.
4. S. G Epstein, (1991) 'Causes and Prevention of Molten Aluminium Water Explosion," Light Metals 1991
5. Addendum to Final Report for U.S. Dept. of the Interior, Bureau of Ocean Energy Mgmt. Regulation and Enforcement. 2011 Report No. EP030842 Washington, DC, U.S. Dept. of the Interior
6. R.P. Taleyarkhan, V. Georgevich, and L. Nelson, (1997) "Fundamental Experimentation and Theoretical Modelling for Prevention of Molten Metal Explosion in Casting Pits, Light Metal Age 1997
7. D.D. Leon, R.T. Richter, and T. L. Levendusky, (2001) "Investigation of Coatings Which Prevent Molten Aluminum/Water Explosions," Light Metals 2001
8. "Guidelines for Handling Molten Aluminium, Third Edition,"
9. BP Deepwater Horizon Oil Spill Final Report January 2011 U.S. Coast Guard Report Washington, D.C. U.S. U.S. Coast Guard
10. Definition of Safety Management System (2011) Retrieved April 14, 2011, from

http://www.skybrary.aero/index.php/Safety_Management_System#Definition
11. The Bureau of Ocean Energy Management of Ocean Energy Management, Regulation and Enforcement, Report Regarding the Causes of the April 20, 2010 Macondo Well Blowout, September 14, 2011