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Aluminium Times

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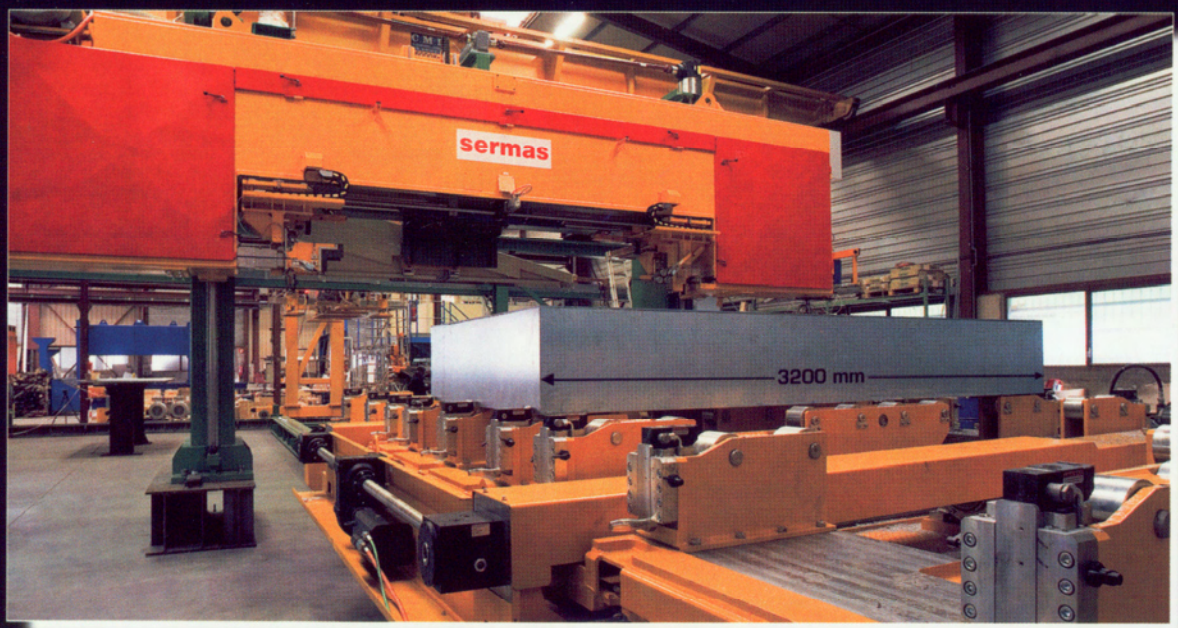

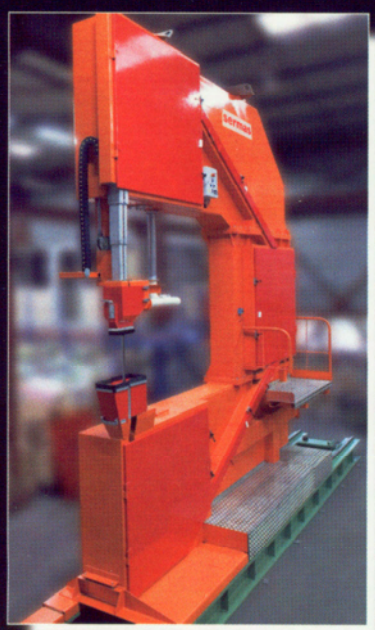

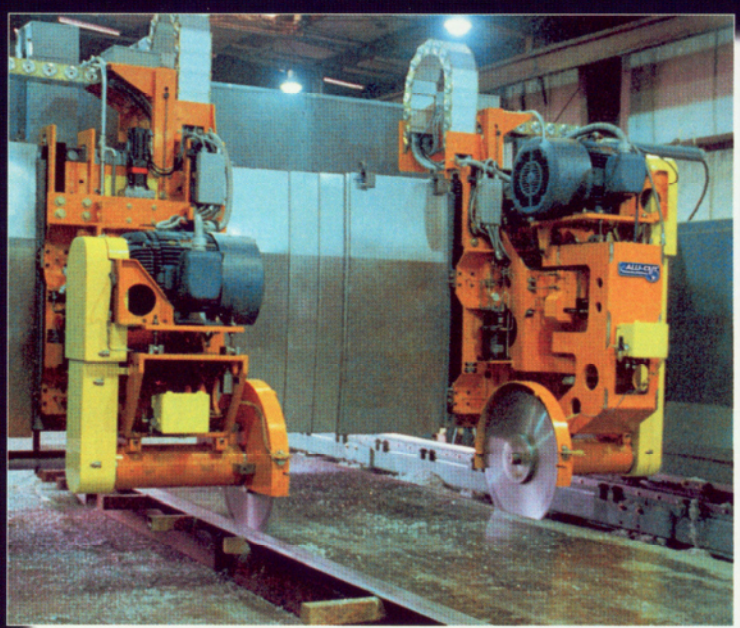

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Safety coatings reduce risk of molten aluminium explosions

Working under demanding conditions with hazardous materials and processes certainly constitutes severe HSE risks. For example, incidents of molten metal explosions in production plants can be disastrous in terms of employees' lives and also in relation to plant, property, and environmental and collateral damage. Here, Alex W. Lowery, General Manager, Wise Chem LLC, examines the background and causes of such incidents, along with certain preventive measures centred on special safety coating products, which are used effectively in production practice.

1: The Force 3 explosion which took place on August 20, 2007 at Binzhou Weiqiao Aluminum Company, in The People's Republic of China, when 16 employees were killed, and 64 injured

The first molten metal explosion to be reported occurred in an aluminium casthouse over 60 years ago. Tests were carried out soon afterwards to determine the actual circumstances and root cause of the incident. It was concluded that the explosion had been due to a bleed-out during a direct chill casting operation.

Subsequently, an investigation was conducted to determine if any preventive measures could be instituted to prevent such explosions. Results showed that certain organic coatings, such as Wise Chem E-212-F, were effective in preventing molten metal explosions, whereas some other organic coatings, in fact, could even initiate and promote these incidents.

Fifteen years ago, the U.S. Department of Energy together with the Aluminum Association, repeated the procedures to investigate the root cause of the molten metal explosions. Testing revealed that an initiator or trigger had to be involved for a molten metal explosion to occur. The tests also identified three additional coatings that could afford protection against such explosions.

Whenever two liquids, with widely different temperatures, come into contact, an explosion can result. This is purely a physical phenomenon, but with aluminium there is an additional concern because it is a very reactive element that has a strong chemical attraction for oxygen, as evidenced in its naturally-occurring compounds. Just as a large an amount of energy is required in reduction cell electrolysis to break down the aluminium-oxygen bonds of its oxide form to produce metallic aluminium. This energy is released dramatically if the metal is able to recombine with the oxygen from either water or air. The energy released when 0.5 kg of aluminium fully reacts with oxygen, according to the reaction equation set out below, is equivalent to detonating 1.4 kg of trinitrotoluene (TNT).

$$2Al+3H_2O = Al_2O_3+H_2 + Energy$$

Explosion force defined

There are three distinctly-different types of explosions that can occur when molten aluminium comes in contact with water. The Aluminum Association has administered a molten metal incident reporting system for the past 20 years and this defines the different levels of explosion as Force 1, Force 2, and Force 3, characterised as follows:

- Force 1 explosions, also referred to as "steam explosions" or "pops", occur when molten metal traps water, which is quickly converted to steam. These explosions are characterised by metal thrown a short distance, usually up to about 4.5 m and often in amounts less than 4.5 kg, with minimal or no property damage.
- Force 2 explosions are violent steam incidents. As with a Force 1 explosion, water is trapped and turns to steam instantaneously. But in this case, the water is trapped by the molten metal and pressure builds up to the point where considerably more metal is thrown a great distance, between 4.5-6 m, often up to the roof of the plant. There is also possibly some accompanying equipment damage.
- Force 3 explosions are catastrophic events arising from reaction of molten metal with oxygen from water, air or both. These incidents are characterised by considerable property damage and metal being ejected more than 15 m. Often, the molten metal disappears completely and what remains is a white powder – aluminium oxide. An example of the disastrous consequences of a Force 3 explosion is shown in Fig 1 and Fig 2.

2: A more general view of the explosion at Binzhou Weiqiao Aluminum Company

3: The Jumbo E 115 repair kit

Targeted investigations

For more than 60 years, studies of molten aluminium-water explosions have been conducted within companies' in-house laboratories, at government establishments and at independent facilities, to understand all aspects of these types of explosions. Some of the earliest tests were performed by George Long in the late1950's at Alcoa's Research Laboratories in New Kensington, Pennsylvania. Long pioneered experimental methods for investigating aluminium-water and steam explosions. In his experiments, various

4: Applying the coating E-212-F to aluminium

quantities of molten aluminium were poured over submerged surfaces, coated or uncoated and the elimination or occurrence of explosions was determined empirically. Much of Long's research knowledge is still relevant today, and forms the basis for the current regimes for preventing molten metal explosions in casting pits.

Long determined that certain surfaces, such as rusted steel, gypsum and lime, promoted violent explosions, whilst other surfaces, such as polished steel and aluminium and those with organic coatings, were relatively resistant to spontaneous explosions. Subsequent studies found that an organic coating, Tarset Standard (TS), was the most practical medium available at that time to prevent molten metal explosions. Unfortunately, over time, Tarset Standard was shown not to adhere well to wet concrete walls of casting pits. In response, Wise Chem E-212-F was introduced to the market, because of its effective adherence in these situations. Subsequent testing showed that Wise Chem E-212-F offered the necessary protection required to prevent molten metal explosions.

Due to environmental regulations, the manufacturer subsequently discontinued the production of Tarset Standard and so the aluminium industry was left with just one available organic coating that had been thoroughly tested — Wise Chem E-212-F. The Aluminum Association, in conjunction with aluminium companies and coating manufacturers, sponsored a programme of testing at Alcoa's Technical Center. The objective was not to find a replacement for Wise Chem E-212-F, but to identify additional environmentally-friendly coatings for application in the aluminium industry.

Two explosion test methods were performed for each additional new coating – a standard explosion test and a shock impact test.

The standard explosion test was performed utilising an 0.028 cu m open steel box and the prospective coatings were applied to the interior surface. The open-topped steel container was filled with approximately 15 cm of water and a clay/graphite crucible, containing 23 kg of molten aluminium at 760°C, was positioned 40 cm above the open container. Metal was released through an 8 cm diameter opening at the bottom of the crucible. One particular coating initially passed the test because it prevented an explosion, but then failed when it combusted and produced sizable flames after a few seconds in contact with the molten aluminium.

In the past, some molten metal-water explosions that were investigated were found to have resulted from a mechanical shock prior to the explosion. The researchers added a swinging hammer that would provide extra force on impact with the steel container, in order to further investigate the effect this would have on risks of explosion.

Safety coatings pass the test

Four coatings passed the standard explosion test: Wise Chem E-212-F; Wise Chem E-115; Multigard 955CP, and Intertuff 132.

Larger explosions, and some instances, multiple incidents, were generated when the shock impact test was performed on bare substrates. Each of the three new coatings that passed the standard explosion test also passed the shock impact test. Each coating was tested only once due to budget constraints. Plant accidents in the past have demonstrated that the effect of a protective coating can be overridden by a sufficiently large shock during the casting process.

Further studies have shown that a bare exposed area as small as 100 sq cm of substrate can initiate an explosion. Consequently, the maintenance of the existing coating surfaces is an integral part of preventing molten aluminium-water incidents. With feedback and input from the aluminium industry, certain coating manufacturers developed repair kit versions of their products, Fig 3, to enable easy maintenance and repair of the existing coating surfaces to be carried out.

For some unknown reason, certain aluminium companies still do not use any protective coatings on steel or concrete substrates that could come into contact with molten metal.

Over the past 60 years, numerous studies have proved repeatedly that certain protective coatings prevent molten aluminium-water explosions. Injuries and deaths attributed to these type of explosions can be reduced dramatically, or even eliminated with the use of certain protective coatings, such as Wise Chem E-212-F.

Reader Reply No.120

Wise Chem E-115 and E-212-F

Wise Chem is an amine epoxy material that provides a high-performance, two-component, multi-purpose coating, which is truly surface-tolerant.

Wise Chem coatings require only a single-coat application that cures quickly and adheres well to itself. Tested by the Aluminum Association, they are proven to create an effective safety barrier between a wet substrate and molten aluminium to reduce the risk of molten aluminium explosions.

The coating is effective in inhibiting rust formation on exposed steel components and also develops excellent adhesion to damp surfaces. This allows casting pits to be coated without waiting for the walls to fully dry, which also minimises process down time.

Product Advantages:

- Single-coat application in most conditions
- Exceptional chemical resistance
- Suitable for short periods of immersion in concentrated acids and alkalis
- Unharmed by splash, spillage, or fumes of petroleum products, alkalis, acids, alcohols and other solvents
- Excellent adhesion to damp surfaces
- Suitable for both salt and fresh water immersion
- High solids and high film build.

Wise Chem E-115 and E-212-F are also both available in the form of Patch Kits, as 1-litre tubs, designed especially for smaller-scale jobs and repairs. The contents, as supplied to customers, are pre-measured and ready to mix in the correct proportions.

Wise Chem products are supplied by Pyrotek Inc. under licence from the manufacturer.

Reader Reply No.120A