Corrosion Technical Bulletin 6

August 2021. Revision 6.
This issue supersedes all previous issues.

Development of aluminium/zinc/magnesium alloy-coating for next generation ZINCALUME® steel with Activate® technology

INTRODUCTION

In 2013, after 17 years of testing and development, BlueScope introduced its patented Activate® technology[1]. This technology is used in the coating of next generation ZINCALUME® aluminium/zinc/magnesium alloy coated steel ("AM") and next generation COLORBOND® prepainted steel to make them more durable and more resilient than the established ZINCALUME® aluminium/zinc alloy coated steel ("AZ") and the established COLORBOND® steel products.

PURPOSE

As AM superseded AZ from August 2013, the purpose of this Technical Bulletin is to outline the primary differences between AM and its predecessor AZ. A wide variety of test methodologies have been used for assessing and understanding accelerated and long-term coated steel performance and durability. These methods are also briefly introduced.

AM vs. AZ

AZ had been manufactured by BlueScope since 1976. The coating composition of AZ was approximately 55% aluminium, 1.5% silicon and the balance zinc.

AM provides performance benefits as a result of coating structure and composition changes that facilitate enhanced durability in most environments. The coating composition of AM is approximately 55% aluminium, 2% magnesium, 1.5% silicon and the balance zinc.

COATING STRUCTURE

The microstructure of the AZ coating (Figure 1a) typically consists of aluminium-rich areas (dendrites) in a zinc-rich matrix (interdendritic regions). Needle-like particles of silicon are also present within the zinc-rich regions. A thin alloy layer of Zn-Al-Si-Fe is formed at the steel interface which bonds the coating to the base steel.

Figure 1: Typical microstructures of AZ and AM coatings in cross-section.

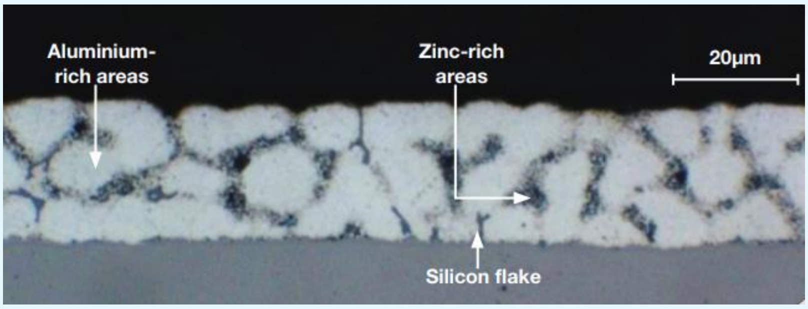


Figure 1a: ZINCALUME® steel AZ150 (superseded)

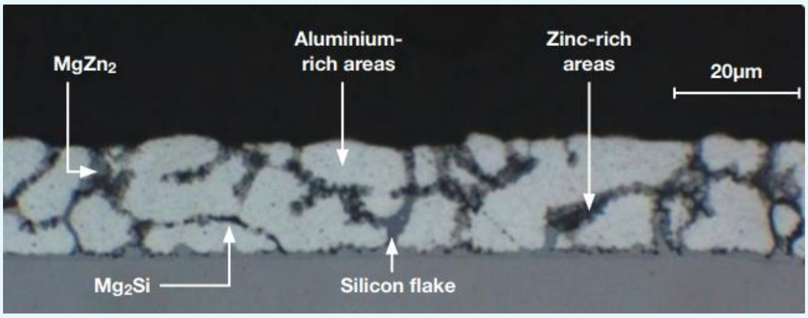


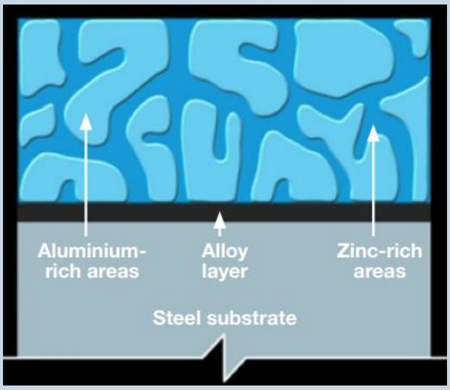
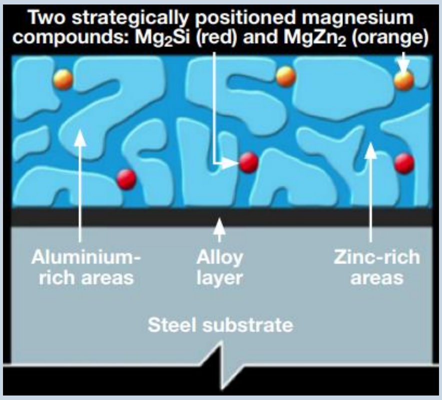
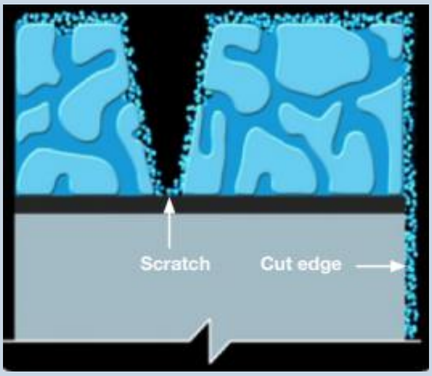
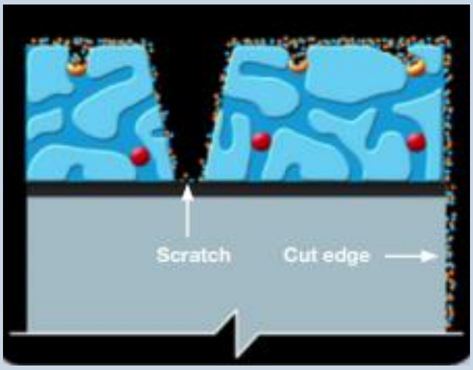
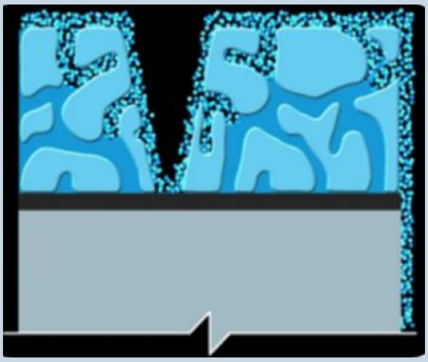
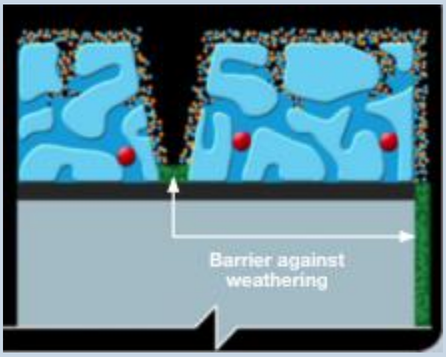
Figure 1b: Next generation ZINCALUME® steel AM125

The microstructure of the AM alloy coating (Figure 1b) also contains aluminium-rich areas in a zinc-rich matrix. However, the zinc-rich region also contains fine particles of magnesium-zinc ($MgZn_2$) and magnesium silicide (Mg_2Si). Careful process control ensures that most of the magnesium silicide is positioned towards the bottom portion of the coating layer (close to the base steel), while most of the magnesium-zinc is positioned towards the top portion of the coating layer. This positioning is an important factor in enabling the improved corrosion resistance of the AM coating.

CORROSION PROTECTION MECHANISMS

The key purpose of the metallic coating on any coated steel product is to protect the base steel against corrosion. The AM coating protects the base steel more effectively than AZ because it uses more efficient corrosion protection mechanisms. This is illustrated in Table 1 (next page).

Table 1: Comparison between corrosion protection mechanisms of the AZ coating and the AM coating over normal service life.

Superseded ZINCALUME® aluminium/zinc alloy-coated steel	Next generation ZINCALUME® aluminium/zinc/magnesium alloy-coated steel
1. The entire metallic coating firstly provides barrier protection to the steel.	1. The entire metallic coating firstly provides barrier protection to the steel. Magnesium compounds ($MgZn_2$) are positioned at the top of the metallic coating to favourably modify the initial corrosion products at the onset of weathering, when they are most vital for sacrificial protection.
	
2. At cut edges and scratches, the zinc-rich interdendritic region, which is exposed to the atmosphere, corrodes preferentially providing sacrificial protection to the steel base. The resulting corrosion product then fills the cavities in the coating and inhibits further corrosion.	2. At cut edges and scratches, the $MgZn_2$ provides a more robust corrosion product and improves the sacrificial protection to the steel substrate. Magnesium silicide (Mg_2Si) particles in the interdendritic channels act as additional barriers to slow corrosion and restrict corrosion pathways to the steel substrate.
	
3. The aluminium-rich dendrites provide barrier protection while the zinc-rich region corrodes. Once the zinc-rich region has been exhausted, the aluminium-rich dendrites corrode slowly to provide limited sacrificial protection.	3. The presence of the Mg_2Si activates the aluminium-rich regions once weathering of the coating is at an advanced stage. This activation provides improved and more efficient sacrificial protection of the steel base and resists red rusting for longer in more severe environments.
	

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SUMMARY

BlueScope has undertaken extensive research and testing in order to develop the AM coating for next generation ZINCALUME® steel with Activate® technology and next generation COLORBOND® steel with Activate® technology. The development process has resulted in a thorough understanding of the fundamental corrosion protection mechanisms of AM as well as its performance in a variety of service conditions and building applications.

RELATED BLUESCOPE TECHNICAL BULLETINS

For more information on the performance of AM in service, please refer to:

Technical Bulletin TB-10
Cut edge and bend protection of next generation ZINCALUME® steel and COLORBOND® steel

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