REDUCE THE COST OF CORROSION UNDER INSULATION (CUI)

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SUMMARY: Existing coatings for use in high temperature, insulated environments have practical and technical limitations. This paper explores the performance benefits of a new coating technology known as Alkylated Amine Technology (AAE). Extensive testing has shown this technology to mitigate several issues with older products including; over application, application temperature constraints and UV stability.

Keywords: Steel, Corrosion Under Insulation (CUI), Alkylated Amine Technology (AAE), Epoxy Phenolic, High Temperature, Productivity.

1. INTRODUCTION

Many industries including oil and gas, petrochemical and mining, require the transport of high temperature fluids in processing areas. Transport lines are commonly insulated to maintain product temperature and pumpability and the insulation of these lines creates a set of conditions which can result in rapid corrosion: high temperatures with available water and salts. This corrosion is known as Corrosion Under Insulation (CUI).

To prevent this rapid corrosion, a range of strategies have been adopted including the use of: epoxy phenolic, inorganic zinc, aluminium silicone, zinc-based epoxies and other inorganic coatings. Epoxy phenolic coatings have been the dominant technology in mitigating CUI, however, as with other high temperature technologies, this technology has limitations and has been improved on with the introduction of Alkylated Amine Technology (AAE).

2. CHALLENGES WITH OLD TECHNOLOGY

Epoxy phenolic coatings are hard, dense and when applied in good conditions provide excellent protection for steel. However, there are many conditions where the practical performance of these coatings is limited:

- Application at low temperatures can lead to incomplete cure;
- Application of excessive thickness in conjunction with high temperatures can result in cracking and therefore system failure; and
- UV induced erosion creates a challenge for painted steel which is unprotected while waiting for installation.

Figure 1: Epoxy phenolic stress cracking around bolted areas

3. COMPLEXITY REDUCTION

Figure 2: An applicator paint store with a large range of products from multiple manufacturers.

While epoxy phenolic coatings are the dominant technology, they are commonly used in conjunction with other coatings on the same site, increasing complexity for both owner an applicator.

From an owner standpoint, this complexity brings extra cost in terms of understanding products before specification, maintenance of product data in safety databases and in some cases ordering of material.

From an applicator point of view, there is added complexity in ensuring the correct steel is painted with the specified product.

4. ALKYLATED AMINE TECHNOLOGY

In response to industry demands for more simple and robust coatings, Alkylated Amine Technology was developed. The technology overcomes many of the challenges faced with epoxy phenolics and delivers excellent low temperature cure, high tolerance to overbuild and increased UV stability.

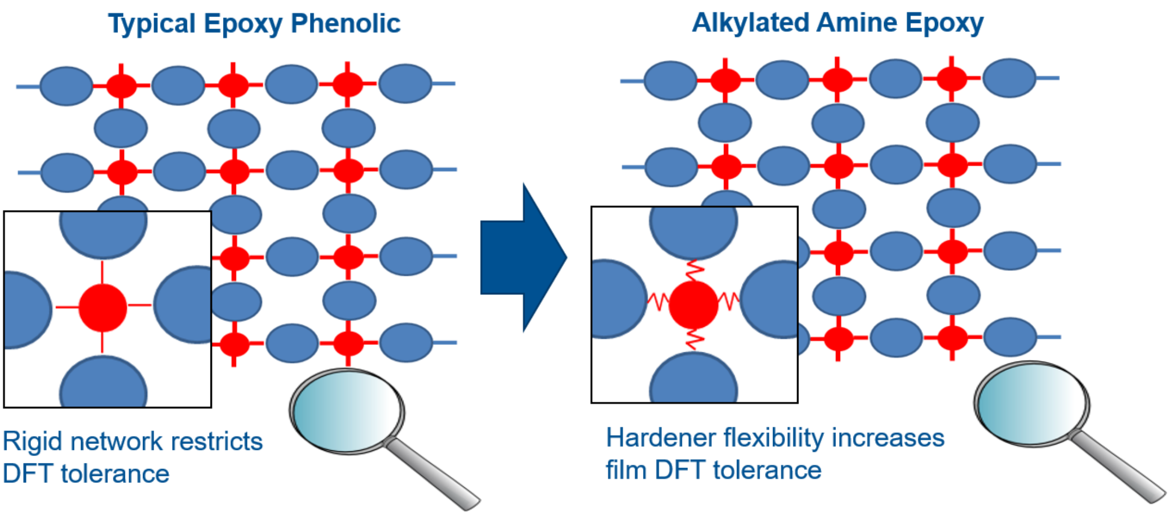


Figure 3: Diagram of cross-linking in traditional epoxy phenolics and Alkylated Amine Technology.

Above is a simplified diagram of the chemical cross-linking network for both epoxy phenolic and AAE. AAE technology creates a less rigid network than epoxy phenolic coatings, allowing for greater coating flexibility and tolerance to over-application.

5. THICKNESS CONSIDERATIONS

Broadly speaking, as coatings are applied at higher thicknesses internal tension increases. However, in practice most coatings can be applied in excess of the recommended thickness without performance issues, although specific technologies such as epoxy phenolics and inorganic zinc have low tolerance to over application. An example of over-applied epoxy phenolic after heating is shown below.

Standard Epoxy Phenolic
2 x 175µm (7mils)

Standard Epoxy Phenolic
2 x 225µm (9mils)

Alkylated Amine Epoxy
2 x 350µm (14 mils)

Figure 4: epoxy phenolic and AAE technology after heat-testing (stoving) above recommended thicknesses. This cracking may not be visible in an application yard and could occur when first heat is applied in service.

Panels in figure 4 were all applied in laboratory conditions and once cured were subjected to the following test cycle: heat to 200 °C for 8 hours, cool to ambient for 16 hours and repeat the cycle 5 times. A typical specification for an epoxy phenolic is 2 x 100µm dry film thickness (DFT) and at 75% greater than coating recommended thickness failure is evident in this test routine. The effect is more pronounced at 125% greater than specified thickness.

AAE withstands the same conditions at substantially higher thickness due to the enhanced flexibility of this technology. While in actual service the conditions experienced by a coating can exceed those in this test and repeated over hundreds of cycles, AAE here is shown to perform at a thickness >250% of a typical 2 x 125µm DFT specification. This is important as in complex areas, such as valves and pipe intersections, maintaining a tight specification thickness as required by epoxy phenolic is challenging and may not be possible in all situations. It is in these areas where traditional epoxy phenolic coatings are likely to experience cracking and hence premature corrosion.

6. INCREASED PRODUCTIVITY AND USE IN COOL ENVIRONMENTS

Facilities requiring high temperature coatings are found all around the world, including some very cold regions. Typical epoxy phenolic coatings require a steel temperature of 10 °C to cure adequately.

This proves a challenge for applicators in many regions, but especially for those in mild climatic regions who don't have heating capacity and those maintaining existing lines globally. AAE not only cures down to – 5 °C but also yields increased productivity in more commonly experienced daytime temperatures.

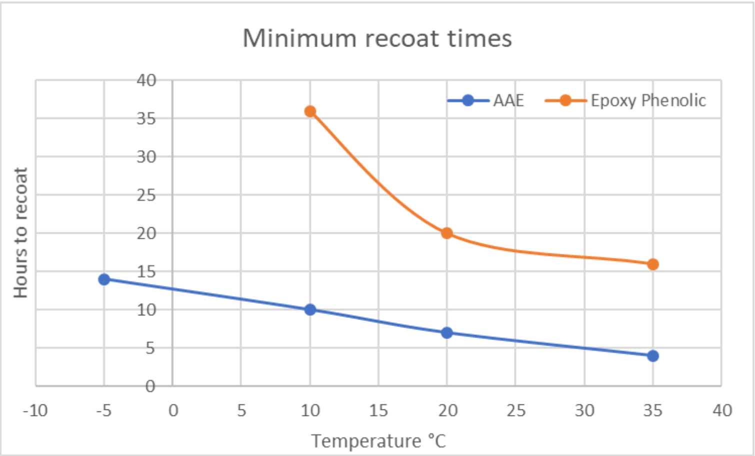


Figure 5: Minimum recoat times of AAE and epoxy phenolic coatings.

7. ANTI-CORROSIVE PERFORMANCE

Epoxy phenolic and other existing high temperature solutions have been available for several decades and have met market acceptance. To ensure AAE technology can deliver the same long-term performance achieved by well applied existing epoxy phenolic technology, accelerated testing has been performed, benchmarking AAE against epoxy phenolic.

Laboratory prepared panels were subjected to anti-corrosive, heat resistance and UV erosion testing. Anti-corrosive testing followed ISO12944-9:2018 cyclic aging for 25 weeks and panels were exposed to 200 °C for 6 months in separate tests.

System	1 - Alkylated Amine Epoxy	2	3	4	5	6	7
Photos							
Rust creep	5.3 mm	7.7 mm	7.7 mm	8.1 mm	8.8 mm	8.1 mm	3.3 mm
Defects	None	None	None	None	None	None	Ri5

Figure 6: Results of AAE panels subjected cyclic aging testing. Panels 2-7 are epoxy phenolic coatings.

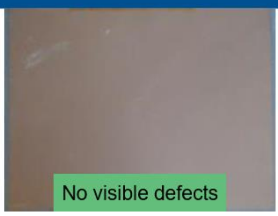
System	1 – Alkylated Amine Epoxy	2	3
Photos (and close-up where defects were observed) Results after 6 months exposure	 No visible defects	 No visible defects	 Lens x30 Significant cracking after 6 weeks
4	**5**	**6**	**7**
 Significant cracking after 12 weeks	 No visible defects	 No visible defects	 Lens x30 Minor cracking after 3 weeks

Figure 7: Panel appearance after 6 months at 200 °C. Panels 2-7 are coated in epoxy phenolic.

While most high temperature lines are insulated when in service, some areas remain exposed to UV and prior to construction painted pipe may be exposed to UV for extended periods. Erosion rates are important for coatings where the initial thickness is low. For an epoxy phenolic coating with an initial specified thickness of 200 µm total DFT, loss of coating thickness will begin to affect anti-corrosive performance if left unchecked.

Erosion resistance of AAE and epoxy phenolic was tested using 48, three-hour cycles consisting of 2 ½ hours of UV-A exposure, 30 minutes of water spray followed by 24 hours of condensation. Results showed that the epoxy phenolic coatings tested consistently lost 80-100 µm in this test, whereas AAE lost less than 40 µm.

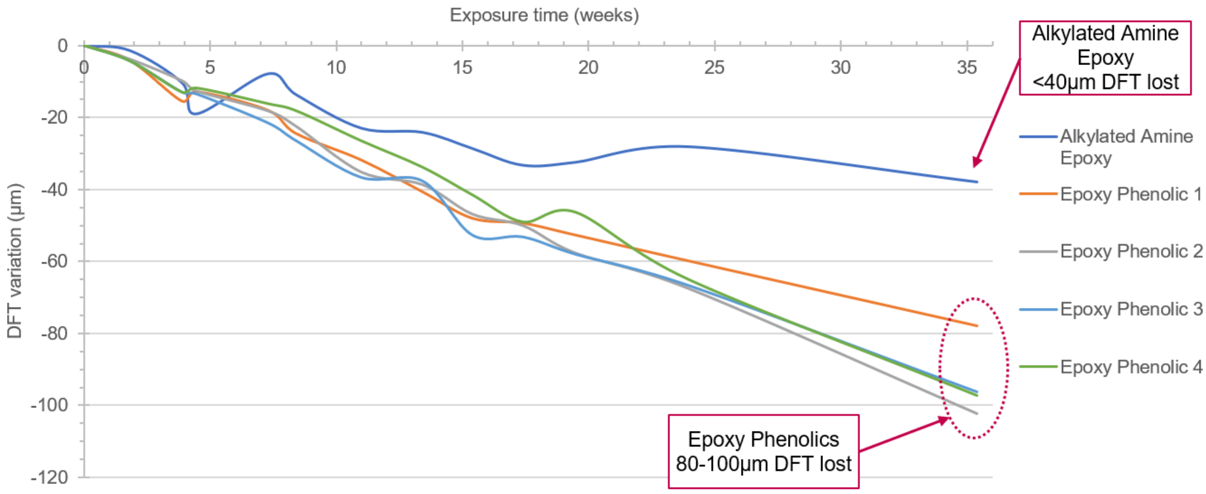


Figure 8: coating thickness lost after 1 week of accelerated UV testing.

8. HEAT RESISTANCE

ISO 19277 is a test designed to screen and provide side by side assessment of high temperature coatings. In this test, coated pipes are insulated and heated from one end such that a temperature differential occurs along the length of the pipe section. In this test, coating breakdown at higher temperatures is visually obvious.

In the results shown to the right in Figure 9, AAE shows a higher level of film integrity at 300 °C (for the period of the test) than epoxy phenolic.

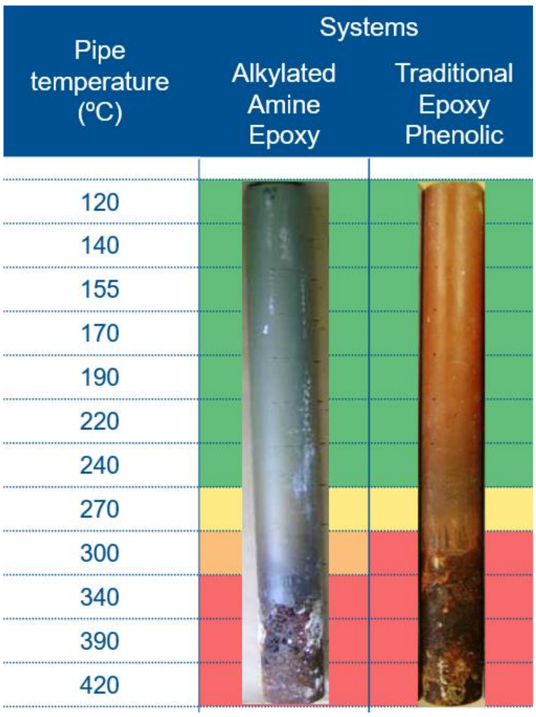


Figure 9: ISO 19277 Test results

9. CONCLUSION

Epoxy phenolic coatings have served to protect high temperature piping across a wide range of industries for decades. Alkylated Amine technology is a step-change improvement from traditional technology. All comparative testing of Alkylated Amine Technology to date indicates better and more robust performance in terms of thickness tolerance, anti-corrosive performance, low temperature application, UV resistance and short-term heat resistance. When all these improvements are considered, the new technology reduces the risk of corrosion under insulation and ultimately reduces costs throughout construction and maintenance of high temperature plant.

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10. REFERENCES

All testing and results shown in this paper were completed in-house by AkzoNobel in Newcastle, United Kingdom. AkzoNobel laboratories in Newcastle are accredited by the United Kingdom Accreditation Service, Testing Laboratory No. 8460. This accreditation demonstrates technical competence within a defined scope and confirms the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF Communiqué dated January 2009).

11. AUTHOR DETAILS

R. Milgate is the Marketing Manager for Australasia, AkzoNobel International Marine and Protective Coatings. He is responsible for new product introduction, promotion and new product technical support.