Performance of Protective Coatings on Small Steel Bridges Subject to Bushfires

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ABSTRACT

Small steel bridges are often located in remote areas which are difficult to access for maintenance or repair. A durable corrosion resistant coating is usually specified for the steel, however the extent of coating damage and difficulty of coating repair due to bushfire activity is often overlooked. Bushfires rarely have sufficient flame duration or high enough intensity to compromise the structural integrity of the steel bridge members, therefore the majority of the time between the bushfire and the bridge being returned to service might be spent restoring the protective coating.

This paper explores the temperature tolerance of common protective coatings and assesses their suitability for specification in bushfire areas. Suggested methods to inspect these coatings after exposure to bushfires are also presented, along with repair recommendations based on the outcomes of previous events.

INTRODUCTION

Recent history in Australia has shown the devastation caused by bushfires to bridges, homes, and human life (1). Public awareness to the dangers of bushfires has risen as the number of fires have increased, with more Australians in bushfire regions developing fire response plans to protect their homes and lives. The National Construction Code (NCC) (2) requires land that is designated, under the power of legislation, as being subject or likely subject to bushfires to satisfy special requirements and Australian Standards exist for the design, construction, and testing of building materials in these areas (3) (4) (5).

Small bridges are often used in bushfire prone areas to provide road access or passage over creeks or steep terrain on walking trails. Steel is commonly used due to the ease and speed of construction and the ability to achieve larger spans. Corrosion protection of small steel bridges is important to maintain both structural performance and aesthetics over time, with protective coatings the most common form of corrosion protection. Durability is a key component when selecting protective coatings, especially in remote areas where maintenance is more expensive.

PROTECTIVE COATINGS

Hot Dip Galvanizing

Hot dip galvanizing involves submerging steel in a bath of molten zinc, resulting in a metallurgical reaction and bond forming between the steel and zinc. During this reaction, zinc-iron alloy layers form at the surface as seen in Figure 1 (6), which have different hardness and melting points. Different Australian Standards exist for hot dip galvanizing based on the method used and coating thickness requirements. Batch hot dip galvanizing to AS/NZS 4680 (7) is usually performed on fabricated ferrous articles, structural sections and hollow sections, and involves submerging articles in a bath of molten zinc. The time the article spends in the bath depends on its design and thickness, with typical times ranging between 2 and 8 minutes. The required thickness of the coating depends on the thickness of the steel being galvanized and the specified coating thicknesses in AS/NZS 4680 (7) are the highest of the various galvanizing Standards and consequently have the highest durability, as seen in

Table 2.

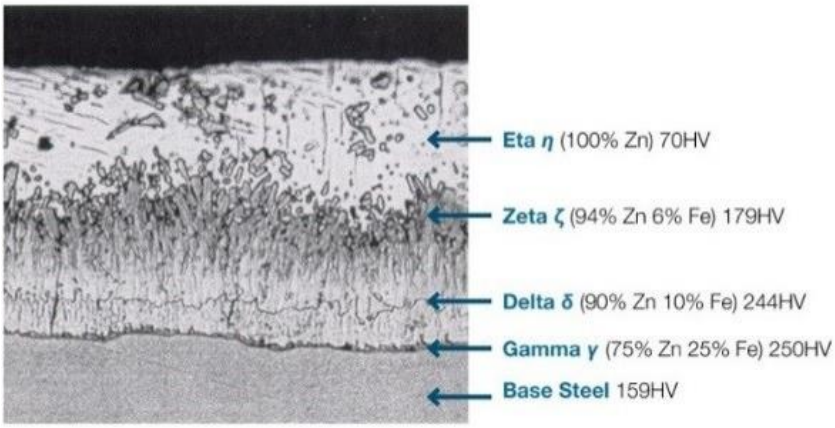

Figure 1. Photomicrograph showing the cross-section of a hot dip galvanized coating with measured Vickers Hardness Values.

Continuous galvanizing is commonly used on sheet products to AS 1397 (8) and tube products to AS/NZS 4792 (9), where the steel is continuously moved through a molten zinc bath without stopping. The typical coating thickness can usually be modified based on the speed the steel moves through the bath and commonly used coating thicknesses along with the resulting durability can be seen in

Table 2. Given the time spent in the zinc is much shorter than the batch hot dipping process, the coating usually consists mostly of pure zinc, with little presence of alloy layers.

The galvanizing process creates a complete barrier of zinc and zinc-iron ally layers between the steel and atmosphere to prevent the corrosion of the steel and provide a coating harder and more damage resistant than other protective methods. If small areas of the steel become exposed cathodic protection is provided by the adjacent zinc coating, protecting the exposed steel from corrosion. The life until first maintenance of galvanized coatings depends on the thickness achieved, and the corrosivity of the environment. The estimated life to first maintenance is given in AS/NZS 2312.2 (10) based on the minimum coating thickness requirements of the Standards, which can be seen in

Table 2. Given the low labour requirements in applying zinc coatings to steel and their durability, they are often cheaper on an initial cost basis and usually cheaper on a lifecycle costing basis than other protective coating methods (11).

Paint

Protective paint systems are also commonly used to protect small bridges in bushfire areas. The first coat is typically zinc rich primer to provide protection to the steel, which consists of zinc that may be suspended in a range of different resins or binders. Three paint systems from AS/NZS 2312.1 (12) that are commonly used to protect small bridges from corrosion will be investigated in this paper, with the systems and their estimated lives to first maintenance from AS/NZS 2312.1 (12) seen in Table 3. It should be noted that the durability numbers from the Standard are defined as 2% of the paint surface showing visible rust and the aesthetic component of the paint system (such as colour and gloss) may require maintenance well before this time.

Paint systems offering passive fire protection, such as intumescent paints which char when exposed to fire and protect steel for extended periods are not discussed in this paper. However, these systems usually perform excellently when the steel requires extensive fire protection, or it is deemed to be in an area where a fire would be particularly harsh. For small bridges the higher cost of applying many coats of intumescent paint might not be justified against the risk of a bushfire occurring and the fact that its structural integrity might not be compromised in a typical bushfire.

Durability in Atmospheric Environments

The durability of the coating system is of great importance for small bridges, especially in remote locations where access for maintenance is difficult.
AS 4312 (13) allows the corrosivity of the environment to be determined based on the location of the site, with descriptions of the corrosivity categories given in Table 1.

Table 1. Corrosivity Categories and Examples per AS 4312

AS 4312 CORROSIVITY CATEGORY		**GENERIC EXAMPLES**	**SPECIFIC EXAMPLES**
CX	Severe surf shore-line	Surf beach shoreline regions with very high salt deposition.	Some Newcastle beaches
C5	Surf Sea-shore	Within 200 m of rough seas & surf beaches. May be extended inland by prevailing winds & local conditions.	More than 500 m from the coast in some areas of Newcastle
C4	Calm Sea-shore	From 200 m to 1 km inland in areas with rough seas & surf. May be extended inland by prevailing winds & local conditions.	All coasts
		From the shoreline to 50 m inland around sheltered bays. In the immediate vicinity of calm salt water such as harbour foreshores.	
C3	Coastal	From 1 km to 10 km inland along ocean front areas with breaking surf & significant salt spray. May be extended inland to 50 km by prevailing winds & local conditions.	Metro areas of Perth, Wollongong, Sydney, Brisbane, Newcastle, & the Gold Coast
		From 100 m to 3 – 6 km inland for a less sheltered bay or gulf.	Adelaide & environs

		From 50 m to 1 km inland around sheltered bays.	Port Philip Bay & in urban & industrial areas with low pollution levels
C2	Arid/Urban Inland	Most areas of Australia at least 50 kilometres from the coast.	Canberra, Ballarat, Toowoomba & Alice Springs
		Inland 3 – 6 km for a less sheltered bay or gulf.	Adelaide & environs
		Can extend to within 1 km from quiet, sheltered seas.	Suburbs of Brisbane, Melbourne, Hobart
C1	Dry indoors	Inside heated or air-conditioned buildings with clean atmospheres.	Commercial buildings

Table 2. Coating thicknesses per relevant galvanizing Standard and the estimated life to first maintenance per AS/NZS 2312.2 (mod).

SYSTEM	**REFERENCE STANDARD**		**STEEL THICKNESS**	**MINIMUM AVERAGE COATING MASS & THICKNESS**		**CORROSIVITY CATEGORY[1] & CALCULATED LIFE (MIN-MAX, YEARS)**				
			mm	**g/m²**	**μm**	**C2**	**C3**	**C4**	**C5**	**CX**
Batch HDG	AS/NZS 4680	HDG390	>1.5 to ≤3.0	390	55	78->100	26-78	13-26	6-13	2-6
		HDG500	>3.0 to ≤6.0	500	70	>100	33-100	16-33	8-16	2-8
		HDG600	>6.0	600	85		40->100	20-40	10-20	3-10
		HDG900*	>>6.0	900	125		60->100	30-60	15-30	5-15
		Centrifuged	< 8.0	250	35	50->100	17-50	8-17	4-8	1-4
			≥ 8.0	390	55	79->100	26-79	13-26	7-13	2-7
	AS/NZS 1214	All	All	360	50	72->100	24-72	12-24	6-12	2-6
HDG sheet	AS 1397	Z350	≥1.0 to ≤3.2	140	20	29->100	10-29	5-10	2-5	1-2
		Z450	≥1.5 to ≤3.2	180	25	36->100	12-36	6-12	3-6	1-3
HDG tube	AS/NZS 4792	ZB135/135	≥1.6 to ≤6.0	135	19	27->100	9-27	5-9	2-5	1-2
		HDG300	≥2.0 to ≤5.9	300	42	60->100	20-60	10-20	5-10	1-5
	AS 4750	ZE50	≥2.0 to ≤5.9	50	7	10-70	3-10	2-3	1-2	0-1

Table 3. Paint system details and estimated life to first maintenance per AS/NZS 2312.1

SYSTEM DETAILS PER AS/NZS 2312.1						Durability				
System Designation	**Surface Preparation**	**1st Coat**	**2nd Coat**	**3rd Coat**	**Total DFT**	**C2**	**C3**	**C4**	**C5-M**	**T**
ACC5	Sa 2½	75 µm zinc rich primer	125 µm high build epoxy	50 µm acrylic 2-pack	250 µm	25+	15-25	10-15	5-10	15-25
IZS1	Sa 2½	75 µm inorganic zinc silicate, solvent-borne	-	-	75 µm	25+	15-25	10-15	5-10	15-25
PUR4	Sa 2½	75 µm zinc rich primer	125 µm high build epoxy	50 µm poly-urethane gloss	250 µm	25+	15-25	10-15	5-10	15-25

BUSHFIRES

Properties of the Fire

Bushfires have a very different temperature profile to typical cellulosic fires that occur in buildings. AS 3959 (3) is an excellent resource covering the construction of buildings in bushfire-prone areas, with much of the information useful for small bridges. The Standard contains both a simplified and detailed method to determine the bushfire attack level (BAL), which measures the severity of a building's potential exposure to ember attack, radiant heat, and direct flame contact. The flame temperature is assumed to be 1090K (870ºC) by the Standard, with the BAL dependant on which state and jurisdiction the site is in, the type and distance to vegetation, and the effective slope of the ground. Bushfires typically have an intense heat that moves quickly through the region, with information on bushfire simulation for testing materials given in AS/NZS 1530.8.1 (4) for radiant heat and small flame, and AS/NZS 1530.8.2 (5) for large flame.

Although the Standard aims to improve the performance of buildings in bushfires, it concedes there can be no guarantee that a building will survive a bushfire given variation in vegetation management, unpredictable nature and behaviour of fire, and extreme weather conditions. It is also noted that the combustion of materials and coatings during a bushfire may present a health risk when they emit smoke and selection of materials should be considered in relation to potential health risk in a bushfire if people or animals will be close. Bushfire testing has found decorative coatings and copper chrome arsenate (CCA) treated wood can release benzene and formaldehyde which are both human carcinogens (14). Significant levels of arsenic can also be released when CCA treated wood burns, which is also a carcinogen and can cause eye, throat and respiratory irritation (14).

Influence on Small Bridges

Although bushfires typically have an assumed flame temperature of 1090K (817°C) per AS/NZS 3959 (3), the surface temperature of steel is unlikely to reach this value as heat can be reflected, radiated from the surface or conducted throughout the whole section. This has been shown during tests to examine the performance of steel when exposed to fires in buildings, based on the ISO 834 fire curve. Figure 2 shows the lower surface temperature result of a 100mm diameter, 200mm long steel rod in a furnace, despite the furnace failing to reach the desired temperature (15). The surface temperature and temperature profile of a steel cross-section will depend on the thickness of steel and its surface characteristics, with thicker steels able to absorb more heat and avoid the peak fire temperatures. The effect of steel thickness on the steel temperature can be seen in Figure 3 (16), which compares the temperature time curves of 10, 20 and 30mm galvanized steel plates.

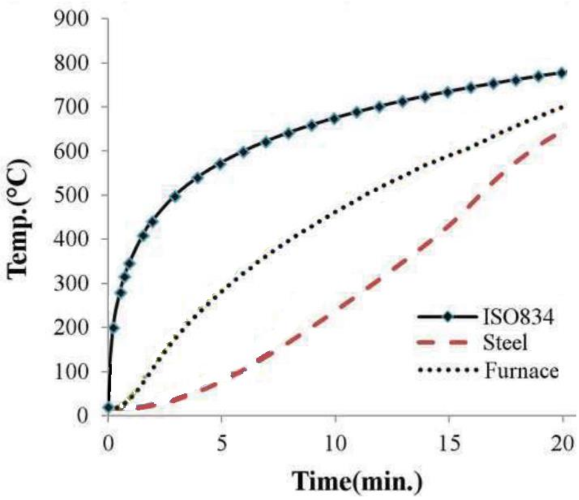

Figure 2. Temperature time curve for test furnace and 12mm diameter steel rod (15).

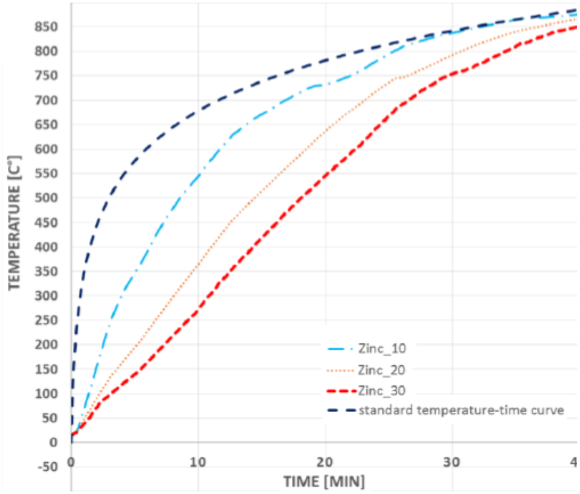

Figure 3. Temperature time curve for 10, 20 and 30mm galvanized plate (16).

Despite the lag in temperature which occurs when steel is subject to a bushfire, the steel can still reach temperatures which affect the yield strength and modulus of elasticity. A graph from Eurocode 3 for fire design (17) gives an overview of this phenomenon, which is shown in Figure 4, however it is only indicative in bushfire situation as it assumes a maximum heating rate of 50°C per minute in building fires.

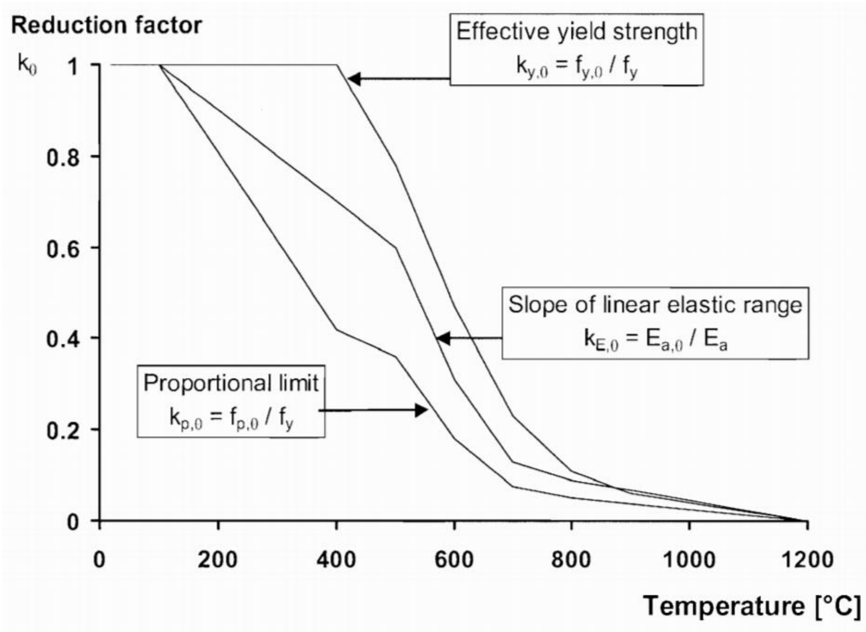

Figure 4. The reduction factor in yield strength and modulus of elasticity for steel at elevated temperatures (17).

When direct flame impingement occurs on a small bridge, the AS/NZS 1530.8.2 (5) bushfire simulation says the fire front is expected to last less than two minutes, but nominates a 30-minute exposure period for potentially higher transient temperatures and potential presence of adjacent large burning items. In the small bridges context, this could include things like timber slats burning on top of steel members which can cause localised damage to the coating in these areas. The final condition of a steel small bridge after a bushfire depends greatly on the properties of the bushfire, thickness of the steel, and whether steel is in contact with combustible materials. Oftentimes the steel in small bridges retains its structural integrity both during and after the bushfire event.

PERFORMANCE OF PROTECTIVE COATINGS IN BUSHFIRES

Galvanized Coatings

The pure zinc in a galvanized coating has a melting point of 420°C and the alloy layers of the coating have a much higher melting point of 650°C. The galvanized coating behaves differently depending on its chemical composition when approaching its melting point (18). For some zinc coatings, a solid-state reaction occurs, and the pure zinc diffuses into the alloy layers, converting to zinc-iron alloy. In some zinc coatings the diffusion of zinc into the alloy layers is blocked by other elements and the pure zinc will run off the surface when it reaches 450°C. The alloy layers will remain intact up to temperatures of 650° and given zinc has a boiling point of 907°C, a galvanized coating is unlikely to vaporise.

The performance of hot dip galvanized utility poles was tested in 2006 using a grid of liquid propane burners (seen in Figure 5 (19)) to recreate actual bushfire flame characteristics of radiant heat and flame immersion (19). The maximum heat flux achieved during testing was 180 kW/m^2 at the end of 30 seconds of flame immersion, which is relatively large compared to the highest bushfire attack level (flame zone) heat flux of >40 kw/m^2 in AS 3959 (3). A maximum air temperature of 675°C was recorded and the maximum surface temperature measured was 520°C. The galvanized coating was found to remain intact even at the highest temperatures, although some surface staining was observed (Figure 6) after flame immersion which could be due to burning the propane, or the polymer sleeves and bituminous wraps applied to the bottom of the pole for extra protection when embedded in soil or concrete.

Figure 5. Set up of flame immersion testing of hot dip galvanized members (19).

Figure 6. Appearance of galvanized coating after flame immersion testing with radiant burners still on (19).

Paint Coatings

The temperature tolerance of paints varies based on their type and steel coated with a paint system may have difficulty conducting the fire's heat to the underlying steel. Many manufacturers list the elevated temperature limit on their product's technical data sheet, but the performance when in direct contact with flames is rarely reported. When exposed to temperatures higher than recommended many failure modes are possible, including peeling or crazing of the paint, ignition and burning, or melting. Particular care should be taken if any of the paints in the system are combustible at the temperature of the bushfire, as having a fuel source in contact with the steel can cause increased temperatures and damage.

Pictures of crazing of powder coating after bushfires resemble the crazing of paint coatings. An example of powder coating over a continuously coated sheet can be seen in Figure 7 (14) and shows "extensive damage to the surface coatings" after bushfire exposure. Figure 8 (19) shows powder coating over hot dip galvanizing after flame exposure in which members were "severely scorched and crazed".

Figure 7. Appearance of sheeting consisting of powder coating over continuously coated sheet after being exposed to high temperatures (14).

Figure 8. Appearance of powder coating over hot dip galvanizing after exposure to flames (19).

The highest temperatures recommended by paint manufacturers for different paint types can be seen in Table 4, with multiple technical data sheets examined for inorganic zinc silicate. Note that the temperatures given are for dry heat and no information was present on the data sheets for flame exposure. The temperatures given by most of the paint companies relate to retention of protective properties, with the note that aesthetic properties might suffer at the given temperatures.

Table 4. Temperature limits of commonly used paints.

Paint Type	Zinc rich epoxy	Inorganic Zinc Silicate	Epoxy	Acrylic	Polyurethane
Temperature	120°C (20)	Up to 400°C (21) (22) (23) (24)	120°C (25)	120°C (26)	120°C (27)

INSPECTION AND REPAIR OF COATINGS AFTER BUSHFIRES

General Inspection

When inspecting a small bridge after a bushfire the structural integrity of the bridge should be confirmed before assessing the corrosion protection, as replacement of some members or the whole bridge might be required.

In many cases corrosion protection can be intact despite staining or other aesthetic impact to the coating. During bushfires a layer of soot may become deposited on the surface, which should be cleaned using a dry sponge, with remaining residue removed using a degreaser solution and sponge if required. If residue remains it can be cleaned using a weak acid or base cleaning solution and scrubbing with a non-metal bristle brush. It is important to thoroughly rinse the surface with water after cleaning to remove any remaining acid or base which could damage the remaining protective coating or steel. The steel should be visually inspected to determine whether the coating has been destroyed and whether bare steel has been exposed. Inspection of paint coatings and galvanizing should be carried out with the recommended advice below, with red rust stains typically indicating the base steel has been exposed. In some cases, timber preservatives or treatments may have the appearance of rust or rust staining can occur from other sources. This makes the cleaning stage important to determine the condition of the coating.

If the coating passes a visual inspection, the remaining thickness of the coating should be determined. Devices such as the Elcometer 456 and Positector 6000 use a magnetic method to measure the distance between the instrument's probe tip and underlying ferrous steel, allowing the thickness of any galvanizing or paint to be tested. If calibrated correctly the device will return a value of roughly zero if placed on bare steel or rust, indicating that no protective coating remains. After measuring the remain coating thickness the recommendations below can be followed.

Galvanized Coatings

If the galvanized coating has adequate thickness, the remaining durability can be estimated from

Table 2 using the details of the environment in Table 1. This approach can be taken as the durability of galvanized coatings is determined by the corrosion of the zinc over time. If the coating is continuous and adequately thick the bridge can be returned to service. If any staining remains and is an aesthetic issue, a suitable paint system from AS/NZS 2312.2 can be chosen to restore the aesthetics of the bridge.

If the galvanized coating is not continuous, has a low calculated remaining durability or has been destroyed by the fire, the entire coating or local areas should be repaired according to the appropriate Standard.

Paint Coatings

When performing visual inspection of paint coatings, close examination of areas showing peeling, blisters or bare spots are recommended as these are likely to require repair. Given the variation in paint formulations between paint manufacturers, the manufacturer should be consulted for advice following a fire, with adhesion or holiday testing potentially required. If the coating isn't damaged and the corrosion protection is deemed adequate the bridge should be able to be returned to service. If aesthetic issues such as crazing, or staining require repair the paint manufacturer should be consulted to determine whether remaining paint can be coated over or requires full refurbishment.

Since paint coatings don't corrode naturally their thickness remains almost uniform over time, with their durability largely dependent on the adhesion and porosity of the paint film. If the remaining coating thickness is significantly different than the original specification estimating the remaining durability is difficult and repairing the paint is recommended.

Repair

When it is determined that the steel's protective coating requires repair after a fire, the repair procedure used will depend on the extent of damage and whether steelwork can be taken off site for processing.

When damage is localised and repairs are only required for small areas, taking the steel off site is unlikely to be economical. In these cases, repairing with paint is recommended, using a system which will achieve roughly equivalent durability to the remaining undamaged coating. The surface should be prepared according to the paint manufacturer's instructions, with some products such as epoxy mastics typically being more tolerant to lower grades of surface preparation (for example power tool cleaning instead of abrasive blasting), which might play a factor in paint selection. Performing an expensive local repair that achieves a high durability is unlikely to be economical if the entire remaining coating system will require maintenance beforehand. Conversely, if the estimated life of the coating is high (for example, a thick galvanized coating remains) and local repair is required, thermal zinc spraying could be considered in the damaged areas to achieve the equivalent life to the remaining coating.

If the entire protective coating requires repair, multiple repair methods can be considered. For galvanized steel, if it can be removed from site and taken to a galvanizer's plant it can be re-galvanized, with the chemical pre-treatment process at the plant generally used to prepare the steel for recoating. If the steelwork was initially painted it can be repaired by galvanizing if permitted by the design, with the galvanizer consulted to determine its suitability. The durability of the new galvanized coating can be determined per

Table 2. Alternatively, a paint repair can be applied on site and abrasive blasting after the fire would likely be required to achieve the manufacturer's recommended surface cleanliness. A paint system from Table 3 should be suitable and would have the estimated durability given in Table 3 before maintenance is required. A third option would be to use a thermal zinc spray for the entire repair, which is likely the costliest repair method (11) and would require blasting before thermal zinc spraying. Thick zinc coatings are possible with thermal spraying which offer long lives with low maintenance.

EXAMPLES FROM BUSHFIRES

It is not always possible to determine the initial coating system from the appearance after a bushfire event, making accurate record keeping of the specification and application particularly important.

Figure 9. Small bridge likely constructed using continuously galvanized sections with paint repair on welded areas.

Figure 9 shows a small bridge which was likely constructed using continuously galvanized hollow sections with paint repair on welded areas. The timber slats used as the walkway have been destroyed in areas the flame could access from below. The galvanized coating looks largely unaffected from this distance, with staining in some places potentially due to rust, a decorative top coat burning during the fire, or the timber and its preservatives burning or staining. In this case, cleaning the galvanizing and measuring the coating thickness is recommended as repair of the galvanized coating might not be required. If the burning temperature of the wooden slats is known, it may be possible to deduce the heat of the fire, which may have been higher at the end above the burnt tree branch.

Figure 10. Small bridge likely manufactured from continuously galvanized hollow sections with paint used on weld repair.

Figure 10 shows a small bride which was likely manufactured from continuously galvanized hollow sections and fabricated after galvanizing, with the welds repaired using paint. The paint repair is thick and peeling due to the heat. The paint used was likely to be a zinc rich epoxy as it is commonly used to repair galvanizing after welding. The marks which resemble rust on the section in the foreground may have been caused by a timber preservative or treatment, given the marks are most pronounced around the bolts.

Figure 11. A low reading of 3.1 microns on an area of damaged coating.

When coating readings are very low, such as in Figure 11, the coating is unlikely to provide acceptable durability and repair is usually required. The surrounding areas should also be measured to determine how far along the member the repair is required.

Figure 12. A reading of 12.8 microns taken on a member after a fire.

If the surface of the steel member has a colour similar to rust, it should be cleaned to ensure coating thickness measurements aren't compromised. A reading of 12.8 microns was obtained in Figure 12, which may have originally been Z275 or Z350 in-line galvanized tubing to AS 1397 (8). It is unclear whether the member has been cleaned after the fire and a repair may be required if a lower reading is obtained after cleaning.

Figure 13. A small bridge constructed of bolted continuously galvanized sections.

Figure 13 shows a bridge initially constructed using predominantly cold formed continuously galvanized sections, which is made evident by the small lip at the top and bottom of the “C” shape. The sections appear to have been joined by bolting and some distortion of the steel members seems to have occurred. This could be due to the thin sections losing strength in the fire from an understrength initial design or a variety of other fire related phenomena. The timber slats which sat on top of the steel were destroyed by the fire, however the galvanized coating looks largely intact despite some surface staining. In this case, it would be important for an engineer to determine the structural integrity of the bridge members to determine whether the steel will withstand the required loading and if replacing the bolts and tightening them would provide adequate capacity.

Figure 14. A high reading of 96 microns when measured on a charred surface.

Figure 14 shows a measurement being taken next to a bolt where a timber slat used to be. Since the measuring device uses a magnetic method to determine the distance between the probe and ferrous substrate, the charring on the surface is likely interfering with the measurement. Given the coating of the bolt and adjacent surfaces seem intact, the galvanized coating will likely have adequate thickness but lower than 96 microns when the charring is removed.

Figure 15. Reading of 12.9 microns on a continuously galvanized section.

Figure 15 shows a continuously galvanized section which is quite shiny in nature, suggesting the temperature didn't reach 450ºC to melt the free zinc or convert the free zinc into zinc-iron alloy. Despite this, the wooden slats on top of the member have burnt and the coating under the contact areas should be checked for damage. In a low corrosivity zone the remaining coating would be expected to last between 18 and 100 years based on the corrosion rates in AS/NZS 2312.2 (10).

Figure 16. Close-up of a batch hot dip galvanized corner post, beam and structural bolts.

Figure 16 Shows a close-up of a batch hot dip galvanized corner post, beam and structural bolts. The remaining galvanized coating looks sound, even on the bolts that were securing the timber slats which burnt during the fire. Some charring is evident on the section going into the ground, which are likely the remains of a paint or tape used to protect the galvanizing from corrosion in reactive soil.

Figure 17. More substantial small bridge made of after fabrication hot dip galvanized steel with a paint topcoat.

Figure 17 shows a bridge made of thick fabricated steel that was hot dip galvanized. Some of the timber slats have been damaged by fire, however the damage to the steelwork seems only cosmetic. The decorative paint top coat has been damaged, with crazing visible on some of the smaller uprights. The aesthetics of the bridge can be restored by repainting.

Figure 18. A hot dip galvanized coating which seems unaffected by the fire.

Figure 18 shows a coating thickness of 66.8 microns remains on the steel despite the bushfire exposure. In this case, the coating is likely adequate to be returned to service, with an expected life of at least 95 years in a low corrosivity zone based on AS/NZS 2312.2 (10) first year corrosion rates.

CONCLUSION

The location, access, cost and maintenance requirements are all important when specifying protective coatings in bushfire areas. The thermal characteristics of bushfires are vastly different to those of building fires, with an intense flame which typically moves quickly through the area. The thickness of the steel plays a large role in the temperature it will reach during the fire and the amount of damage caused to the structure and its coating. After a fire, cleaning any soot from the steel and performing a visual check for a continuous coating is recommended, followed by measuring the thickness of coating remaining using a device, such as a magnetic coating thickness gauge. Additional testing may be required for paint systems based on the recommendations of the paint manufacturer. While corrosion protection may still be adequate, restoration might be desired to reinstate the bridge's aesthetics. If the remaining coating isn't going to be durable it can be repaired by galvanizing if the steel can be removed from the location and the galvanizer believes the design is suitable for galvanizing. Coatings can also be repaired on site by preforming appropriate surface preparation followed by painting or metal spraying.

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ACKNOWLEDGEMENTS

The authors acknowledge the Western Australian Department of Parks and Wildlife (DPaW) for allowing the pictures to be included in the paper.

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