WAGNERS COMPOSITE FIBRE TECHNOLOGIES

UTILITY POLES TECHNICAL GUIDE

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1 Scope

This document serves as the technical guide for utility poles manufactured by Wagners Composite Fibre Technologies (CFT). It covers key aspects such as material composition, manufacturing processes, mechanical performance, testing protocols, UV protection, and durability. Wagners Fibre Reinforced Polymer (FRP) utility poles are manufactured following American and international standards (ASTM, ANSI, ACMA) to meet anticipated pole operating and loading requirements. As FRP properties can differ based on resin selection, fibre architecture, and manufacturing techniques, the technical data in this document is specific to Wagners CFT utility poles.

2 Introduction

Fibre Reinforced Polymer poles represent a superior material in utility infrastructure. Fibre Reinforced Polymer poles are engineered using composite materials, primarily glass fibres bound with resin, resulting in poles that are exceptionally strong, lightweight, and resistant to environmental factors such as corrosion, chemical exposure, pests and UV radiation. Wagners CFT utility poles are manufactured using the pultrusion process as detailed in Section 4 and are designed to be durable, safe, and environmentally friendly. Wagners FRP utility poles are non-conductive, which significantly reduces the risk of electrical shock or electrocution, making them safer than traditional poles. They are also resistant to rust, rot, corrosion, termites, and acid sulphate soils, ensuring a longer lifespan even in harsh environments that are not offered in conventional poles.

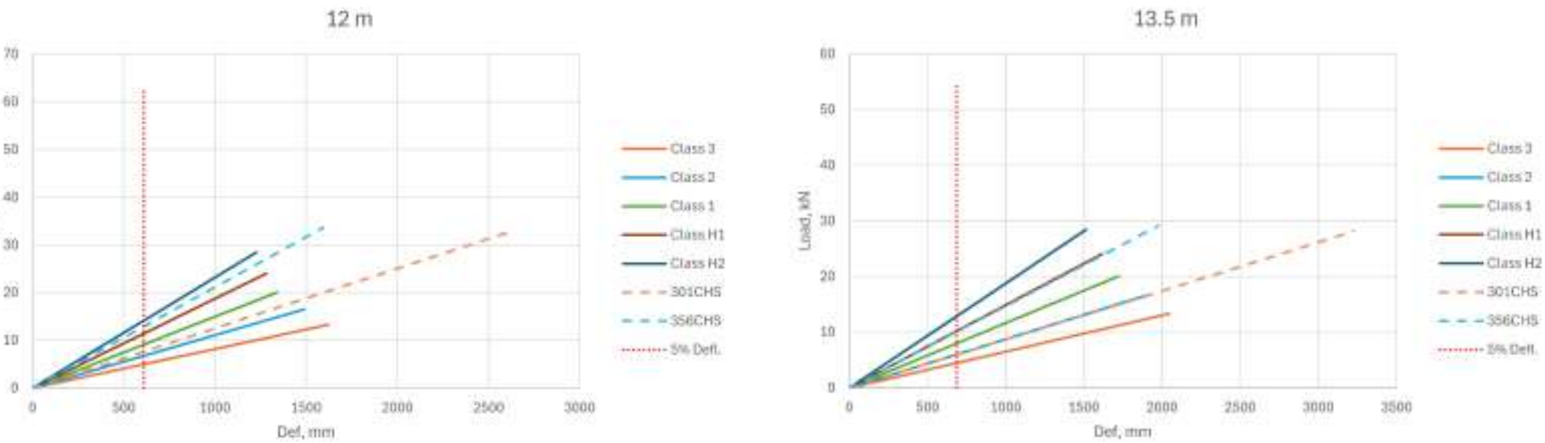
3 Performance Advantages of Wagners CFT Utility Poles

3.1 Resilience

With the advanced pull-winding pultrusion process used in Wagners CFT pole manufacturing, the poles are manufactured/ designed with a high Glass Transition Temperature (T_g) of 266°F (130°C) to perform reliably in a range of temperatures, varying from freezing winter conditions of 5°F (-15°C) to a condition of up to 122°F (50°C). This wide temperature tolerance ensures the poles remain structurally sound and functional in extreme temperature fluctuations. Owing to the inherent corrosion-resistance properties of vinyl ester resin in both acidic and alkaline environments, the Wagners CFT utility poles have demonstrated the capability to withstand harsh and extended environmental conditions such as hot weather, snow, humidity, rainfall, etc. Wagners CFT utility poles also remain impervious to termites, pests, woodpeckers and wildlife, resulting in a greater service life with minimal maintenance.

3.2 Superior Strength and Stiffness

Despite being lightweight, 25% of steel, Wagners CFT profiles have an elastic modulus of plus 5800 ksi (40GPa), ensuring a high strength-to-weight ratio, stiffness, and minimal deformation under load. Hence, Wagners CFT poles meet and exceed the strength limit of equivalent wood poles and exhibit higher ultimate tip horizontal load capacity compared to wood poles as per ANSI 05-2022 (Figure 1). Due to the elastic nature of the material until failure, the Wagners CFT utility pole exhibits a zero residual permanent deflection recorded upon releasing the load.



(a) 12-meter pole *(b) 13.5-meter pole*

Figure 1 –Timber pole vs Wagners CFT pole

3.3 High Durability

Fibre Reinforced Polymer products are well known for their excellent durability and performance. Wagners CFT utility poles are coated with a highly durable fluoropolymer coating system that provides supreme UV resistance, ensuring the long-lasting performance of the pole for its intended design life. The coated pultruded samples, based on ASTM G154, were exposed to a QUV-B weathering machine for more than 25000 hours, or approximately 129 years. Additionally, Wagners CFT poles are complemented by a polyester surface veil, which serves as a shield and outer layer during the manufacturing stage, acting as a secondary UV protection layer. Furthermore, all Wagners CFT poles exhibit an exceptionally low water absorption rate of only 0.2%, a benchmark considered remarkably minimal even among composite materials, which further enhances the durability of the Wagners CFT pole.

3.4 Environmental Benefits

3.4.1 Non-leaching

Wagners CFT utility poles offer significant environmental benefits over traditional chemically treated timber poles. These benefits are particularly pronounced in their non-leaching characteristics, where, unlike treated wood, Wagners CFT utility poles do not release any hazardous chemicals. This is especially critical in environmentally sensitive locations such as wetlands, coastal areas and near water bodies, preventing them from being contaminated. The use of Wagners CFT utility poles in such locations ensures that environmental integrity and ecological health are maintained.

3.4.2 Inert

Unlike traditional poles, Wagners CFT utility poles are inherently resistant to corrosion and do not react chemically to most substances, including alkaline and acidic environments. This exceptional inert nature of Wagners CFT utility poles makes them an ideal choice for environments that are prone to moisture, salt water, and harsh chemical exposure. Due to their inert and non-leaching characteristics, Wagners CFT utility poles can be directly embedded in the ground without any special treatment or coating.

3.4.3 Environmental Product Declaration

Wagners' Environmental Product Declaration (EPD) provides a transparent overview of the environmental impact of Wagners CFT structural products throughout their cradle-to-grave life cycle. Wagners CFT utility poles have 39% less total global warming potential than galvanised steel poles across the full life cycle and over a 100-year service life. That means choosing FRP utility poles over galvanised steel will help reduce carbon emissions and cool the planet.* **These are the results of a Life Cycle Analysis comparing Wagners SHS 301 to a galvanised steel utility pole, which has been third-party reviewed and verified. Results could vary depending on the specific design of the poles being compared. Please note, no comparison to timber utility poles was available at the time of printing.*

3.5 Lightweight

Wagners CFT poles are substantially lighter in weight compared to steel, concrete and wood poles. One of the most immediate benefits of this reduced weight is the ease of transportation. Lighter poles mean that lighter equipment is needed for their transport, leading to a decrease in logistical costs. This is particularly beneficial in areas with challenging terrains, where the transportation of heavy poles can be both difficult and expensive. Also, when it comes to installation, the reduced weight of Wagners CFT poles allows for quicker and more efficient installation, saving both time and resources.

3.6 Fire Resistant

The Wagners CFT pole is classified as self-extinguishing as it will not fuel the fire once the source is removed. An internal test (following clause 8 of UL 94, ASTM E 84-05, and ASTM D 635:2003) simulating bush/wildfire test was undertaken where a full-scale pole was subjected to fire from a hay bale at the ground line. The flame lasted for 25 minutes with a maximum recorded surface temperature on the pole of 1652°F (900°C). Post-fire flexural tests were undertaken, and the results showed that the pole maintained its stiffness, with only a 35% reduction in ultimate strength compared to unexposed samples.

The engineering team at WCFT developed a new generation fire coating system named FireFix ®, which demonstrated excellent fire resistance. In cantilever testing after exposure to elevated temperature, based on the Ackerman fire testing setup, the coated utility pole, when exposed to 1100 °C for over one minute, was able to exceed its characteristic moment capacity.

3.7 Total Cost of Ownership

With a design life of up to 80years, Wagners CFT poles bring significant cost savings over the lifespan due to the reduced replacement cycles and minimal maintenance costs compared to traditional materials. Additionally, of the lightweight nature of Wagners CFT poles results in much easier and more cost-effective transportation and installation.

4 Manufacturing Process

To ensure consistent quality, Wagners CFT utility poles are manufactured by pultrusion. Pultrusion is an automated continuous manufacturing process, allowing for the efficient production of large quantities, at high and consistent quality composite profiles with a uniform cross-section, within tight tolerances, throughout the desired length.

4.1 Pull-Winding Pultrusion Technology

Wagners FRP composite poles are manufactured using methods that combine pultrusion with pull-wind technology, where only individual roving are used (no fibre matts) to provide strength/stiffness in both longitudinal and transverse directions. The continuous/individual glass fibres are wound and pulled over a central mandrel, with the resin being injected at the resin injection die, ensuring they are thoroughly impregnated with resin. The resin-impregnated fibres are then pulled through a heated die, shaping them in the desired cross-section. As the profile passes through the heating die, the heat initiates a chemical reaction (polymerisation), solidifying the structure. The solid profile eventually exits the die and is cooled before the cut-off saw cuts the profile into desired lengths.

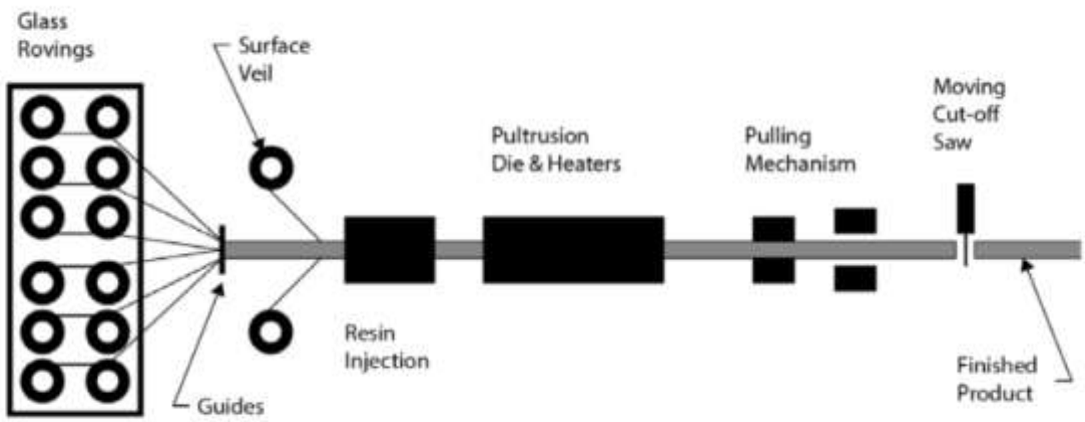


Figure 2 - Pultrusion process of Wagners FRP composite products.

4.1.1 Glass Fibres

Wagners CFT utility poles use boron-free, electric-grade E-CR (electrical-corrosion resistant) glass fibres as their primary reinforcement. E-CR glass fibres serve as a load-carrying component, providing impressive strength and stiffness.

4.1.2 Polymer Resin

Wagners CFT profiles utilise thermoset vinyl ester resin due to their excellent mechanical toughness and corrosion resistance. Inherent corrosion resistance allows vinyl ester resins to perform exceptionally well in both acidic and alkaline environments. In addition to their inherent properties, Wagners CFT resins have further additives injected at the time of pultrusion to improve the flame retardancy (when specified/required) of the finished profiles.

4.2 Identification

Wagners CFT utility poles can be equipped with a permanent branded nameplate or ID tag containing the pole identification information as per each end user. Figure 3 shows an example of what is currently been used for an Australian client.

Figure 3 - ID plate information.

5 Pole Structural Tests & Capacities

To guarantee that each utility pole of Wagners CFT meets the expected standards of performance, rigorous structural analysis is supported by a comprehensive testing regime following the recognised international industry standards/procedures. The testing takes place mainly at the Wagners CFT industry-standard in-house testing facility, and some universities and other approved, accredited labs. Through these rigorous tests, Wagners CFT ensures that every utility pole produced is safe and reliable to meet its intended design. The physical (Table 1) and mechanical (Table 2) properties of the typical utility poles manufactured by Wagners CFT are demonstrated.

Table 1. Physical properties

Physical Properties	**Units**	***301CHS***	***356CHS***
Outer Diameter	**mm**	301	356
Inner Diameter	**mm**	274	329
Thickness	**mm**	13.5	13.5
Cross-Sectional Area	**mm^2**	12193	14526
External Surface Area	**m^2/m**	0.95	1.12
Mass	**kg/m**	24.6	29.5
Second Moment of Inertia	**10^6 mm^4**	126.26	213.33
Section Modulus	**10^3 mm^3**	838.9	1198.5
Radius of Gyration	**mm**	101.8	121.2
Torsion Constant	**10^6 mm^4**	252.52	426.66
Torsion Modulus	**10^3 mm^3**	1677.9	2397

Table 2. Mechanical properties

Mechanical Properties	Units	301CHS	356CHS
Tensile Strength	**MPa**	635	635
Compressive Strength	**MPa**	395	395
In-Plane Shear Strength	**MPa**	93	93
Modulus of Elasticity (Tensile)	**GPa**	40	40
Modulus of Elasticity (Compressive)	**GPa**	41.2	41.2
Bending Stiffness (EI)	**10^{12} N.mm^2**	5.1	8.5
Ultimate Moment Capacity	**kN-m**	375.4	445.6
Characteristic Moment Capacity	**kN-m**	332.2	394.3

5.1 Full-scale Cantilever Pole Flexural Test

Full-scale cantilever flexural tests were undertaken on the FRP composite pole per the modified ASTM D1036 test procedure and AS/NZS 7000 (Figure 4, full-scale flexural test conducted until failure). The full-scale flexural test demonstrates and assists in establishing the structural capacity of the utility poles under serviceability and strength limit state cases. Wagners CFT poles surpass the strength limit of poles made of various strengths of timber as classified by AS/NZS 2878:2000. The full member capacities are detailed in Table 2. The characteristic moment capacity is calculated based on the *Kt* factor of 1.13 per AS/NZS 1170.0 (2002).

Figure 4 – Testing of the cantilever full-scale flexural test.

5.2 Four-point Bending Test

The four-point bending test is an approved ASTM D6109-19 test that is widely adopted in the industry to gather critical data on the flexural strength and stiffness of structural members (Figure 5). By applying downward force at the midspan of utility pole specimens, the ability of Wagners CFT utility poles can be determined to resist bending and deformation. This information assists in calculating the elastic modulus and ultimate bending moment capacities of Wagners CFT utility poles. Samples predominantly failed due to compression buckling at mid-span, indicating localised instability under bending. The testing of five 356 CHS and 301 CHS poles showed ultimate bending capacities of 509.1 kN-m and 359.45 kN-m, respectively.

Figure 5 - Four-point bend test setup

5.3 Crush Strength Test

To guarantee the resilience of Wagners CFT utility poles, they are subjected to a crush strength test (Figure 6a). This test measures the pole's ability to withstand compressive forces, ensuring it can endure high-impact events without compromising its structural integrity.

Figure 6 – Crush strength test

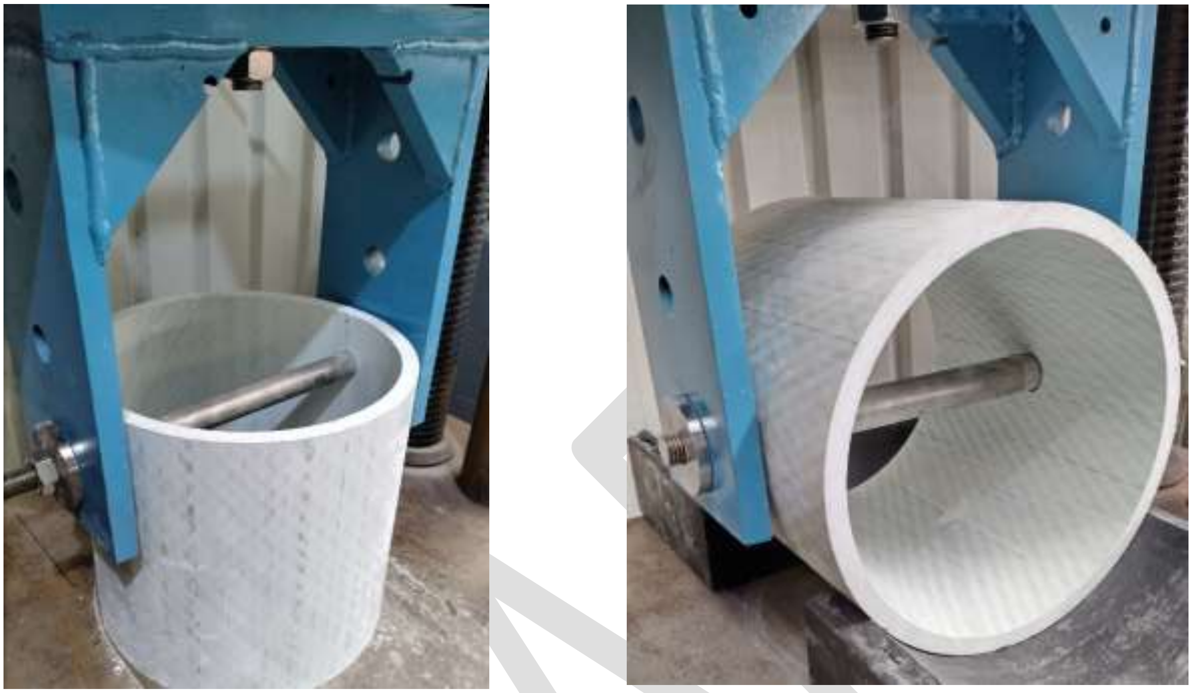
The crush strength testing of the 301 CHS and 356 CHS profiles was undertaken by applying a point load using a 230mm wide steel plate, and the design strength was established using ASCE Pre-Standard (2010). The ultimate crush strength of the CHS poles under a 230mm wide load plate is 84 kN. In addition to the mechanical tests, Wagners CFT conducts a series of tests focusing on the conditions a utility pole could be exposed to during its service.

6 Connections

The connection capacities of Wagners CFT poles at different configurations were characterised per ASCE 74-23 ‘Load and Resistance Factor Design (LRFD) for Pultruded Fibre Reinforced Polymer (FRP) Structures’ as AS/NZS1170:0:2002 ‘Structural Design Actions – Part 0: General Principles’.

6.1 Bolted Connection Test

The bolted connection test evaluates the shear strength of bolted connections in Wagners CFT poles using industry-standard-sized bolts (Figure 7). The test is conducted in the longitudinal and transverse orientations to evaluate the bolted shear strength in both directions. Tests were conducted on the 356 CHS to evaluate its bolted connection capacities in both longitudinal and transverse orientations using M20 and M24 bolts. Characteristic values for the bolted connection capacities were established using ASCE 7-23 ‘LRFD for Pultruded FRP Structures’ for longitudinal direction using M24 bolts (139.9 kN), transverse direction using M24 (139.0 kN) and M20 bolts (113.4 kN). The transverse bolted connection testing of Wagners CFT 301 CHS was also undertaken by applying a compressive load onto the M24 and M20 threaded bolts through a stainless-steel sleeve, and the average failure loads were 124.91 kN and 120.4 kN, respectively.



(a) Longitudinal (b) Transverse

Figure 7 - Bolted connection test setup

In a case where the stainless-steel sleeve is not implemented in the connection, the following values, Table 4, can be used for the design as a characteristic capacity:

Table 3. Connection capacities without using a sleeve

Profile	Bolt Size	Orientation	Chara. Capacity (kN)
356 & 301 CHS	M16	Long.	83.5
		Trans.	73.2
	M20	Long.	110.9
		Trans.	75.4
	M24	Long.	117.4
		Trans.	77.5

6.2 Bolt Torque Test

A proper bolt torque test is essential for the hollow FRP poles to determine their capacity. The bolt torque test involves applying torque to bolts to establish the relevant design values, ensuring that safety standards are met (Figure 8). The washer size and thickness play a critical role in the bolt torque capacity. In the testing conducted, the M24 bolt and a square 152x9.5 mm stainless steel washer were used. All bolts in both 356 CHS and 301 CHS specimens exhibited no signs of cracks or any noise up to 800 N-m of torque.

Figure 8 - Bolt torque test setup

In a case of not using any washer, and according to ASCE No. 104, an applied torque of 55 ft-lbs (75 N-m) is designated as the required threshold at which no significant deformation of the cross-section should occur. In contrast, the Wagners CFT pole sustained an applied torque of 147.5 lb-ft (200 N-m) without any crack initiation, indicating superior mechanical resilience and durability under extreme loading conditions.

6.3 Bolt Pull-Through Test

The bolt pull-through test assesses and determines the design capacity of Wagners CFT utility poles under forces exerted by fasteners, where the force is going through the pole rather than along its length, i.e. push-pull on bolts (Figure 9). Washer pull-through capacity value depends on the bolt size and the washer. Table 5 demonstrates the characteristic value strength of the washer pull-through for both 301 and 356 CHS profiles with different bolts and washers.

Figure 9 - Bolt pull-through test setup

Table 4. Washer pull-through capacities

Bolt	Washer	Characteristic pull-through capacity (kN)	
		356 CHS	**301 CHS**
M16	Std flat washer	34.2	37.4
M16	Sq. 50 x 4.5 mm	37.1	41.2
M16	Sq. 150 x 9.5 mm	65.7	63.6
M20	Std flat washer	39.1	44.3
M20	Sq. 50 x 4.5 mm	42.4	48.8
M20	Sq. 150 x 9.5 mm	75.1	75.4
M24	Std flat washer	42.6	47.3
M24	Sq. 50 x 4.5 mm	46.2	52.1
M24	Sq. 150 x 9.5 mm	81.8	80.5

6.4 Pole Step Test

The pole steps are experimentally tested to determine their capacity and confirm their compliance with AS 1657-2013. This test verifies that the poles can support the steps used by workers to climb and perform maintenance tasks, ensuring the safety of utility workers and the structural integrity of the poles (Figure 10a). The capacity can also vary with the size and length of the step itself. The ultimate load of 10.8 kN measured on the pole step, considering a 20mm diameter and 150mm long pole step (Figure 10b). It needs to be mentioned, the ultimate load was governed by the yielding of the step while the FRP pole was intact.

Figure 10 - Pole step test setup

7 Durability Performance

Wagners CFT utility poles exhibit high durability and excellent resistance to aggressive environments. Wagners FRP sections have been thoroughly tested/evaluated for durability in accelerated weathering conditions and actual case studies and have demonstrated great corrosion resistance in both acidic and alkaline environments. The durability report can be made available per request.

7.1.1 Water Absorption

The Wagners CFT pole demonstrates excellent performance in high-humidity and moisture environments. It exhibits significant resistance to moisture absorption. Tests conducted at 23°C for 24 hours according to ISO 62 (ASTM D570 equivalent) have yielded a remarkably low moisture absorption rate of less than 0.2%. These strong results are attributed to the unique pultrusion process used in manufacturing Wagners CFT poles, which assures high glass content and effective stacking to minimise air voids, thereby reducing the likelihood of water ingress. The low moisture absorption contributes to the durability of Wagners CFT poles, as the deterioration of FRP materials typically occurs when moisture enters through air voids in exposed composites. Low temperatures can lead to freeze-thaw cycles, as water expands by 9% when frozen, exerting internal stresses. However, due to the notably low water absorption of Wagners CFT poles, they are highly effective in withstanding the impacts of freeze-thaw cycles.

7.1.2 Weathering and UV Protection

In FRP pole applications, surface finishes play a crucial role in providing UV protection, ensuring long-term appearance, enhancing performance, and extending service life. Wagners CFT utility poles are manufactured using vinyl ester resin, which is superior to polyester resin, and coated with a specifically formulated fluoropolymer paint system offering excellent UV resistance. It prevents UV degradation such as fibre blooming, flaking, blistering, and cracking, and provides an aesthetically pleasing finish uniform along the entire pole length. The paint system is thoroughly tested in a QUV machine for up to 25,000 plus hours under accelerated weathering conditions and has been proven in many case studies around the world. UV and weathering tests were undertaken on Wagners CFT composite materials as per ASTM G154. The samples were tested using Type 1 lamps (UVB-313) with a cycle time of eight hours UV at 140°F (60°C), followed by four hours of condensation at 122°F (50°C), with no indication of fibre blooming nor any structural damage. In addition to the simulated exposure, Wagners CFT has conducted mechanical coupon testing on a decade-old pultrusion in service. The testing validated the long-term protection provided by the Wagner coating system under harsh UV conditions and conformed to the simulated testing.

8 Environmental Performance

Wagners CFT utility poles are sustainable and environmentally conscious and have achieved a cradle-to-grave Environmental Product Declaration (EPD) from EPD Australasia as per ISO 14025:2006 and EN 15804:2019. Environmental Product Declarations are based on Life Cycle Assessments (LCA) and communicate independently verified data about the environmental performance of products and services. Having an EPD shows that Wagners CFT is an early mover in the market and demonstrates the businesses genuine commitment to environmental responsibility and transparency. The full EPD can be accessed via the Wagners CFT website.

9 Electrical Performance

Wagners CFT poles are widely used for low-voltage and high-voltage grid lines. Wagners CFT has completed extensive electrical testing on its FRP composite material as per AS 4435.1-1996 and AS/NZS 2947.1: 1999. Wagners CFT coated members can withstand lightning impulse voltage tests at 210 kV over a distance of 310mm, equivalent to 17 kV per 25mm.

10 Fire Performance

The Wagners CFT pole is classified as self-extinguishing as it will not fuel the fire once the source is removed, unlike timber. The Wagners CFT pole is also able to achieve a V0 rating/classification as per UL94, clause 8. Wagners CFT poles have a Flame Spread Index of 25, which qualifies them for a Class A rating as per ASTM E84. Regarding the Bushfire Attack Level (BAL-40), a fire test was undertaken under AS1530.8.1:2018 to validate the performance/compliance of Wagners CFT poles in such extreme conditions. The utilisation of sacrificial intumescent coating protected the FRP poles by creating an insulation char layer between the fire and the utility pole. Once the fire protection coating was removed, some browning of the pole surface was apparent, likely due to the effects of smoke/temperature (Figure 11). Moreover, an internal test simulating a bush/wildfire test was undertaken where a full-scale pole was subjected to fire from a hay bale at ground line. The flame lasted for 25 minutes with a maximum recorded surface temperature on the pole of 1652°F (900°C). Post-fire flexural tests were undertaken, and the results showed that the pole maintained its stiffness, with only a 35% reduction in ultimate strength

(Figure 12). Furthermore, in a fire test, Wagners CFT poles and CCA-treated timber were tested against intense direct flame, radiant heat and wind exposure to stimulate Australian bushfires. While CCA-treated timber poles continued to burn and smoulder over several hours and were deemed structurally destroyed, Wagners CFT poles exhibited sufficient residual strength to allow for powerline assessment and repair or planned replacement.

The field of fire protection of FRP poles is still a developing subject in the FRP industry, Wagners CFT leading the forefront and developing an in-house protective coating that can meet the harshest industry-approved bushfire simulation test.

a) Test setup as per AS1530.8.1 *b) Test setup as per AS1530.8.1*

Figure 11 – Bushfire test

a) Bush/ wildfire test *b) Post-fire flexural test*

Figure 12 - Full-scale fire bush/wildfire test.

11 Serviceability Considerations

Wagners CFT composite poles, while exceptionally strong, have a lower stiffness compared to materials like steel due to their lower modulus of elasticity. The lower stiffness translates into comparatively higher deflections and, as such, the design of composite profiles is generally deflection-controlled (e.g., 5% of the pole length under service loads, per ASCE 104). The FRP poles are carefully designed, tested, and analysed at the Wagners CFT facility to meet the client's serviceability criteria and do not exceed specified deflection limits under service loads.

12 Poles Hardware & Accessories

Wagners CFT poles are compatible with most of the commercially available hardware for FRP poles, and other hardware connections can still be accommodated if needed. However, it is recommended to engage/communicate with the Wagners CFT engineering team for sanity checks to ensure the structural integrity of the system/components working together properly and efficiently.

12.1 Crossarms Mounting Brackets

Crossarms can be mounted onto Wagners CFT utility poles using a gain block/kingbolt connection to provide the transition between the circular pole to the square/rectangular crossarms. Standard two fixing points mounting brackets can also be adopted if that is the preferred connection method.

(a) Bearing capacity of the crossarm at the gain block　　*(b) Mounting bracket*

Figure 13 – Crossarm – to – Wagners CFT pole connections

12.2 Top and Bottom Caps

Wagners CFT poles are supplied with a flat top and bottom plastic cap mechanically fixed to the side of the pole with rivets or screws to prevent easy removal. A hole in the bottom cap can be/is generally provided for water drainage as shown in Figure 14.

a) Top Cap *b) Bottom Cap*

Figure 14 – Wagners CFT utility pole caps

12.3 Poles Steps

Wagners CFT poles are pre-drilled to accommodate pole steps and other utility hardware as required by the asset owner. Hole size and location will be as per client specifications (e.g., AS 1657-2013 for pole steps), which could vary from one utility to another.

12.4 Small Fixings

Small brackets, clips, saddles, or identification markers can be fixed to the pole before or post installation through screwing, strapping, or gluing. This type of fixing might leave marks on the poles. Also, it is suggested to check with a professional if this type of fixing becomes outside the norm.

12.5 Hole Plugs

Predrilled and unused holes on the body of the pole can be closed with hole plugs that meet the specifications and requirements of the end-user.

12.6 Surface Logs

Wagners CFT offers FRP surface logs, which can be utilised in the foundation of the utility poles to increase the bearing area of the soil when required (Figure 15). The Wagners CFT surface logs are similar in dimensions to the timber logs and provide exceptionally higher strength. Additionally, due to the inert nature of FRP, Wagners CFT surface logs are immune to rotting, insect damage, and moisture absorption, making them more durable and long-lasting than traditional timber logs.

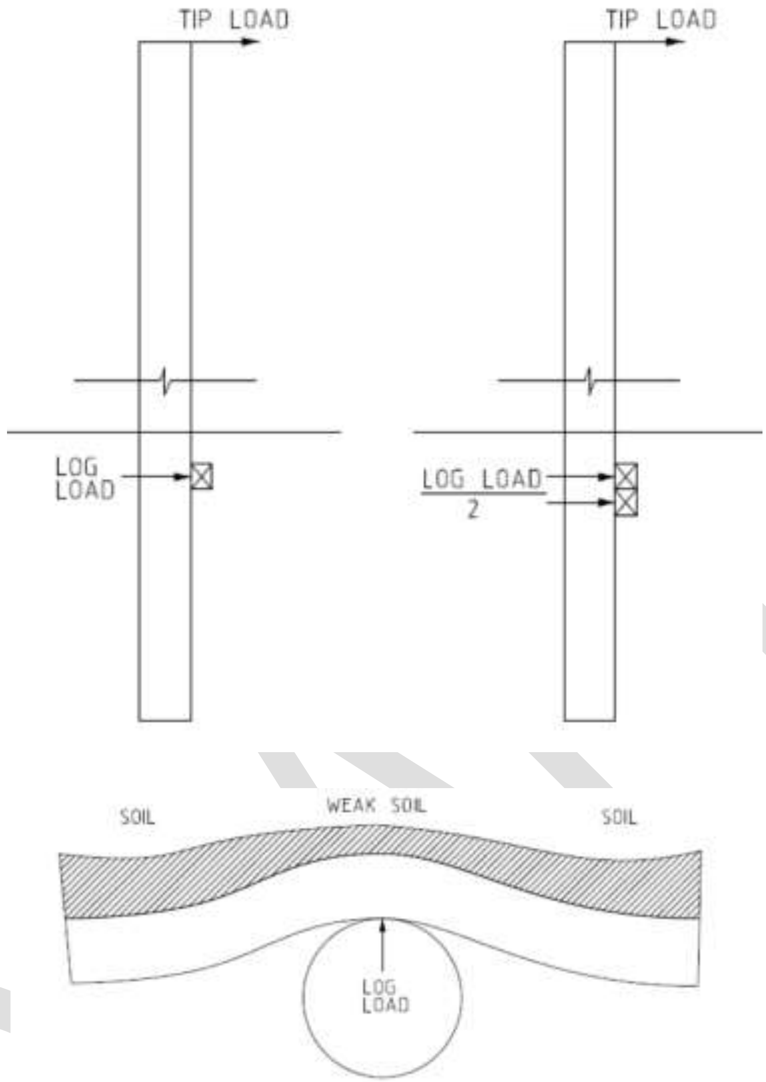


Figure 15 - FRP surface logs attached to utility poles in the foundation

13 Transport and Installation

13.1 Packaging and Shipping

The general specifications/guidelines for the transportation, loading, unloading, storage, and lifting of Wagners FRP poles are presented below. Ensuring the correct packaging of dispatched items with a recommended cribbing material (e.g., rubber-lined wooden supports) is crucial for Wagners CFT to fulfil their Chain of Responsibility (COR) obligations. The packaging must adhere to the following criteria:

a) Withstand road transport over long distances and rough terrain.

b) Be safely lifted on and off relevant transport vehicles.

c) Minimise the risk of injury to those involved in freight loading and unloading.

d) Minimise the risk of damage to the item.

e) Minimise the risk to the environment.

f) Minimise the risk to other freight, road users, and the public.

Figure 16 – Wagners CFT utility poles ready for transport

13.2 Storage

Considering the high durability of Wagners FRP poles, they can practically be stored indoors or in open-air yards, depending on the site logistics/requirements. Cribbing/dunnage is used for storage and transport, which elevates the poles off the ground and facilitates the easy strapping of nylon lifting straps underneath. Also, ASCE 104 recommends placing support every 10ft to prevent sagging or bowing under self-weight, which could vary upon further structural checks, i.e. pole size, weight, stiffness and actual deflection/sagging.

13.3 Handling

Wagners CFT poles should be lifted rather than dragged on rough ground to prevent surface scratching and damage to the UV protective layer. If there was any excessive damage to the poles due to inappropriate handling, it should be discussed with the structural team of Wagners CFT to ensure the structural integrity of the poles is not compromised.

13.4 Holes Drilling in the Field

Wagners CFT poles will be pre-drilled to accommodate pole steps and other hardware as requested. Wagners CFT poles are compatible with most of the commercially available hardware for FRP poles. However, it is recommended to engage/communicate with the Wagners CFT engineering team for sanity checks to ensure the structural integrity of the system/components is working together properly and efficiently.

13.5 Lifting and Installation

Wagners CFT poles weigh approximately a third of traditional timber poles, making them significantly safer and easier to handle, transport, and install. Wagners CFT utility poles should be lifted using cranes or forklifts with rubber slings. For longer poles, spreader bars can be used to distribute the weight evenly. Fibre Reinforced Polymer poles can be installed similarly to poles made from other materials, but their lighter weight makes the process generally easier. Smaller and lighter equipment can be used, potentially lowering installation costs compared to poles of other types. Their high strength-to-weight ratio also makes FRP poles ideal for areas with restricted access, such as locations that require helicopter transport. Regarding Wagners CFT utility pole installation, the standard equipment and methods of traditional utility poles can be used based on the terrain and site conditions. Fibre Reinforced Polymer poles can be installed using a single pickup point. Rubber slings are typically used to secure and lift the pole without damaging the surface. Before lifting, ensure that all top caps, bearing plates, and joints are properly checked and secured. It is important to confirm that the lifting strap is tightly fastened and will not slip during the lift by using specially made straps or placing it below a temporary through-bolt or permanent hardware on the pole.

Figure 17 - Wagners CFT pole and crossarms are being installed into position

13.6 Direct Embedment

Wagners CFT utility poles are capable of being embedded directly into soil, concrete or structural foam without any detrimental effects on the pole due to the high durability of the FRP material. Well-designed and correctly installed foundations are crucial for the long-term stability of any pole material, including FRP poles. The foundation design must be adequate to resist the loads transferred by the pole to the ground. However, a general industry practice of the pole embedment depth is 10% of the pole length plus 800 mm, similar to other types of poles. However, in cases of poor soil conditions or higher load requirements, the embedment depth may vary. A geotechnical soil investigation is required to determine the soil holding capability and appropriate embedding burial depth.

14 Inspections and Maintenance

14.1 Field Inspections

Considering the high durability and long design life of Wagners FRP poles, regular inspections are not necessarily required, however, it is recommended after major loading events such as direct accidents and natural disasters.

14.1.1 Visual Inspections

Visual inspection is a very common and reliable technique for damage assessment at the surface level of FRP structures, however, it does not reveal much about underlying issues that might be within the wall of the hollow FRP pole. As per ASCE 104, the maintenance technician should visually inspect the FRP pole to identify the following:

- Tearing or other FRP damage at hardware/connections
- Vandalism damage
- Mechanical impact damage (typically near the ground line)
- Delamination
- Tracking on FRP surface
- Lightning damage
- Any surface damage or change in the surface conditions, including fibre blooming, cracking, crazing, charring, and discolouration

14.1.2 Tap Test

The tap test can be used as a routine test to further check for any suspected localised damage. The test requires an inspector to use a small hammer to tap all around the area of suspected damage. This is a fast, inexpensive, and easy way to roughly evaluate the condition of the FRP material and locate delamination, large voids, and cracks. A Tap Hammer or a coin can be used for this test. Inspection conducted with tools like a shifter/wrench should be avoided, as it can induce further damage to the composite.

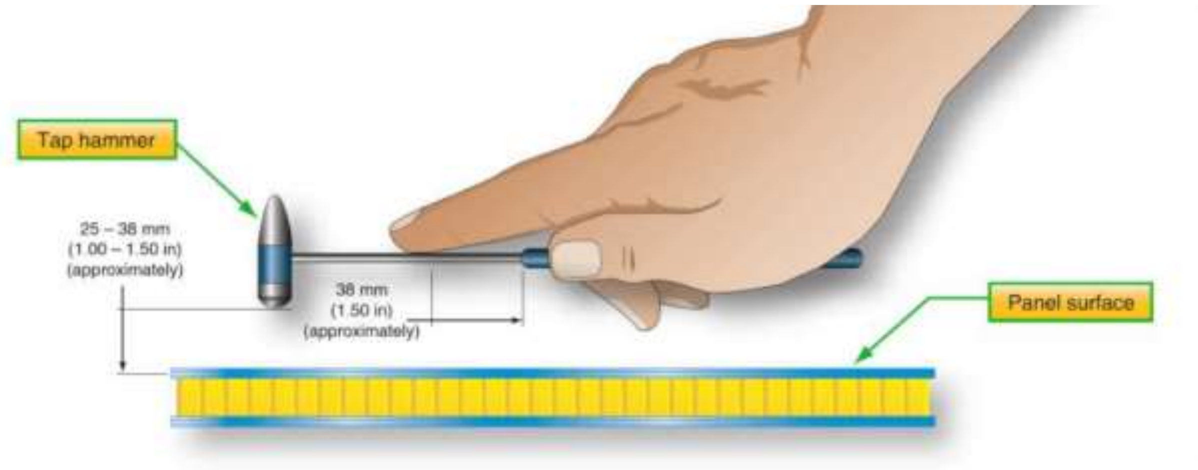


Figure 18 – Tap test (inspection of composites, aircraftsystemstech.com)

14.2 Repair Methods

The appropriate repair method for Wagners FRP poles depends on the type of damage. ASCE 104 classify the FRP damage into three levels as listed below. Also, it is highly recommended that all repairs be assessed by Wagners CFT to ensure compliance with structural integrity standards.

- Level 1 – Minor repair, aesthetic, where no repair/minor touch-ups are required
- Level 2 – Moderate repair, outer and mid-thickness layers, where in-field repair is required
- Level 3 – Major repair of all layers of composites, where pole replacement is required

14.2.1 Level 1 - Minor repair

This repair level is intended for minimal surface damage only that could be caused due to the handling/installation or light environmental parameters such as small kinetic debris. Such surface/aesthetic damage can be repaired with a paint touch-up after preparing/cleaning the FRP surface. Table 5 below is the defect/activity matrix for Level 1 repair.

Table 5. Defect/activity matrix for Level 1 repair on WCFT poles

Defect/damage	Action
Chipping of the surface with exposed laminate, but no visible damage to the laminate	Touch up the surface with matching paint/coating.
Delamination of composites to a depth of up to 0.5mm and area not exceeding 50mm x 50mm or equivalent	Touch up the surface with matching paint/coating.
Minor impact damage, depth not exceeding 0.5mm and area not exceeding 50mm x 50mm square or equivalent, with damage restricted to the first layer of glass.	Touch up the surface with matching paint/coating.

14.2.2 Level 2 – Moderate repair

Level 2 repair is required for damage extended beyond the surface and going into the substrate fibre layers, such as deeper scratches and gouges, for example. This kind of damage is generally assessed on a case-by-case basis, where detailed information needs to be provided to assess:

- Extent of damage
- Structural utilisation of the pole
- Cost of the repair versus cost of replacement

This kind of repair generally involves sanding, cleaning, epoxy filling, sanding, and possibly hand layup laminating, then finishing/painting. Also, these repairs must be implemented by certified composite repair professionals to ensure the quality of the repair and the integrity of the repaired pole.

14.2.3 Level 3 – Major repair/replacement

Certain types of damage are irreparable, such as full flexural/shear failure through the whole wall, which requires the replacement of the damaged FRP pole.

15 Pole library

The Wagners CFT utility poles are/will be available in the overhead line design program available at the market.

16 Safety Information

Wagners CFT is committed to ensuring and complying with ISO 14001. Wagners FRP is classified as a non-hazardous material according to the Safe Work Australia criteria. A Safety Data Sheet (SDS) for Composite Fibre, Pultrusion can be downloaded from the resources page on the company website.

17 Quality Control

Wagners CFT incorporated a strict quality control procedure, including quality inspection requirements for the raw materials that have a direct impact on product quality for manufactured items, and stringent quality control measures on the manufactured product as per ISO9001. The following QA/QC testing info is fully detailed in the Wagners CFT quality control plan, and the Inspection Test Procedures (ITP) are available upon request.

- Testing frequency
- Determination of low and high confidence levels
- Pass/fail criteria
- Corrective action
- Test methods (work instructions)

- Test result records (forms)
- QC check responsibility

18 End-of-Life Recycling Options

Today, the end-of-life strategy for Wagners CFT utility poles island fill. Whilst this is not the preferred end-of-life strategy, it does not harm the environment as the product, once cured, is inert. However, the utility poles can be repurposed in various low-strength applications, fence posts, for example, or they can even be recycled. Fibre Reinforced Polymer waste management differs from conventional waste disposal. The recycling of thermoset composites remains an evolving research area, with emerging technologies such as pyrolysis and mechanical crushing showing promise. However, current limitations include high energy consumption and fibre degradation, which require further technological advancements. The recycling of FRP products is feasible where the glass can be retrieved and reused as reinforcements in several applications, while the resin parts can be crushed into fine sand and used as filler material in different proportions.

One of the emerging and commercially available technologies for recycling thermoset FRP is pyrolysis, which is defined as the thermal decomposition of the material at elevated/higher temperatures. Various research in the past has indicated that pyrolysis is a very effective and viable recycling technology for thermoset composites. Pyrolysis not only decomposes composite materials but also extracts valuable fibres and organic fuels for further application. Another recycling method is mechanical crushing, where the glass can be retrieved and reused as reinforcements in injection moulding applications, and the resin part can be crushed into fine sand and used as filler materials in cement production.

Wagners CFT is investing/participating in two major research hubs/projects focusing on FRP waste management to reuse and/or recycle FRP composite materials. The first research hub is led by RMIT University and titled Transformation of Reclaimed Waste Resources to Engineered Materials and Solutions for a Circular Economy (TREMS). TREMS focuses on reducing landfill waste and transforming reclaimed waste into new materials for use in construction and other manufacturing sectors. The second hub is led by Griffith University, and it is part of the National Environment Science Program 2 (NESP2) – Sustainable Communities Waste Hub (SCWH). NESP2 SCWH focuses on managing and reducing the impact of FRP composite waste on the environment by applying circular economy principles and innovative reuse approaches. At the end of these two major research projects, the developed technologies will minimise the environmental impact of FRP waste by value-adding and converting it into durable and sustainable construction/manufacturing materials through reuse and recycling.