SGS REFRIGERATION

hot-dipped galvanized after fabrication insight

Introduction

Hot-dipped galvanized steel has been a staple material of construction in the industrial refrigeration industry. This material is typically used on condenser coils and, recently, has been re-introduced into evaporative condenser casing material. Hot-dipped galvanized after fabrication (HDGAF) steel provides significant advantages over typical mill galvanized steel which include, but are not limited to, longer service life, ease of inspection and an all-over complete protection.

Benefits of Galvanized Steel

In order for steel to last it needs additional protection against its worst enemy: corrosion. One effective way to guard steel is by galvanizing, a process that gives steel a zinc-coating and provides three levels of corrosion resistance:

- Barrier protection: zinc creates a physical barrier that separates the steel surface from the environment. Steel that has a protective zinc barrier will oxidize at 1/30th the rate of unprotected steel.

Before

After

- Cathode protection: zinc present on the steel sacrifices itself to environmental factors to protect the steel beneath and nearby. The sacrificial zinc can protect against scrapes in the coating up to 1/4".
- Zinc patina: zinc oxidizes and forms a patina – a natural by-product from zinc interacting with water and air. The patina is a hard, protective layer making zinc less penetrable by environmental factors.

Methods of Galvanization

Mill Galvanization Before Fabrication:

Mill galvanization is commonly referred to by its zinc weight per square foot. G90 or G235 has 90 grams or 235 grams of zinc per square foot. This process is also known as pre-galvanization, and it involves applying a zinc coating to the steel before it is fabricated into its final shape. The process can be summarized into five main steps:

- Surface preparation
- Fluxing
- Galvanizing bath
- Removal of excess zinc*
- Cooling

Consider This:

*Additional zinc provides more barrier and cathodic protection. The only reason to remove it is to lower cost while meeting the minimum specification.

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Hot-Dipped Galvanized After Fabrication:

The process of hot-dipped galvanization after fabrication involves immersing the fabricated steel structure or component(s) into a bath of molten zinc to apply a protective zinc coating. American Society for Testing and Materials (ASTM) requires at least 45% more zinc per square foot than G235 (below for reference). The process can be summarized into the six steps below:

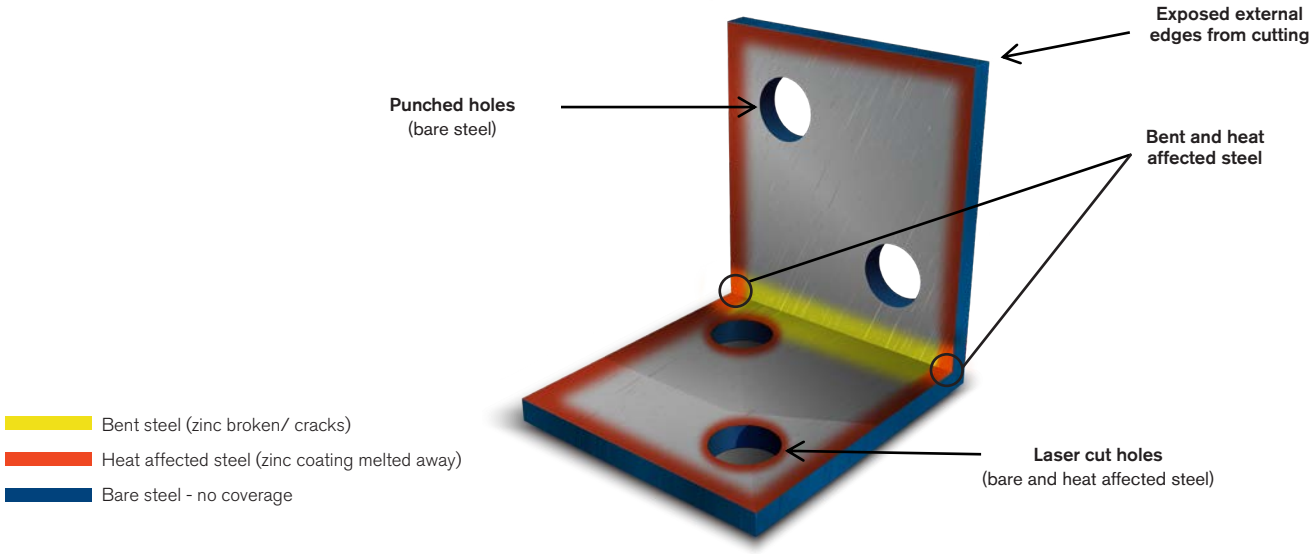
- Surface preparation
- Fluxing
- Dipped in 830° F molten zinc
- Cooling
- Coating thickness verification*
- Inspection and finishing

Consider This:

*HDGAF provides more zinc than specified every time and SGS does not remove extra zinc providing extra protection. SGS has never sent a HDGAF part back for having too much (or excess) zinc.

HDGAF vs Mill Galvanization

When both mill galvanized steel and unprotected (hot rolled) steel arrive at a manufacturing facility, they are bent, punched and/or laser cut to produce structures or components to be assembled into final products. The production processes takes a toll on the mill galvanized steel creating an uneven coating at bends or holes and heat-affected areas at welds. The major issue with this is that zinc is not structurally sufficient for welding or bending, and any fabrication done to pre-galvanized steel will expose the raw steel underneath. When examined, these weakened or bare points are the places where corrosion starts.



For HDGAF units, the bare metal is run through the same production processes as pre-galvanized parts but then it is fully submerged and coated in a zinc protective barrier. This eliminates the weaknesses that are apparent in mill (pre galv) galvanized steel and gives the components and full units the barrier, cathode and, after time, the patina protection. Often times, the coating from HDGAF is thicker than ASTM's spec requires, interior angles have a thicker coating, and all edges and holes are completely coated and protected. It should be noted that ASTM A123 specification states, "once a product has been hot-dipped galvanized, any further fabrication […] may have negative effects on the corrosion protection of the coating." This means that

Table 1: Zinc Coating Thickness Comparison

Gauge (GA)	Thickness (in)	A653-G235	ASTM A123	Ratio
14	0.0747	2.0	2.5	1.25
12	0.1046	2.0	2.5	1.25
10	0.1345	2.0	2.9	1.45
7	0.1793	2.0	2.9	1.45

the zinc coating process needs to be the last step in the component or structure's manufacturing process. Additionally, as referenced in Table 1: Zinc Coating Thickness Comparison, the specification requires a higher minimum coating thickness for steel ranging from 7-14 gauge (25% to 45% minimum thicker coating for HDGAF).

SGS Test Results

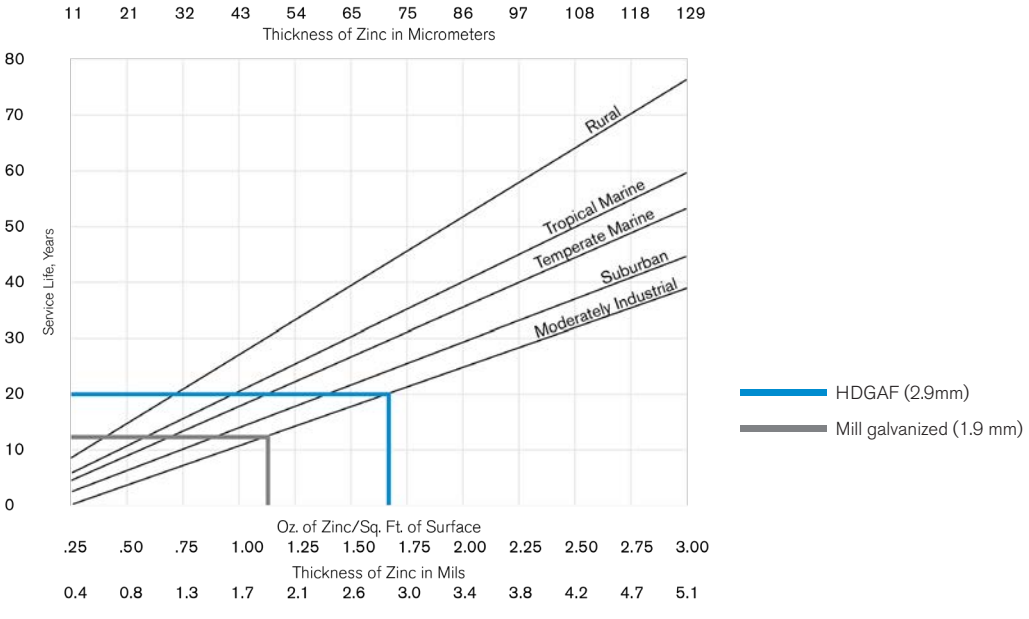
SGS testing is 50%-75% thicker than standard. SGS measures the last-in/first-out corner, which has the thinnest application of galvanization compared to the rest of the manufactured piece, meaning every HDGAF component from SGS is coated beyond standard requirements.

The service life of both mill galvanized steel and HDGAF steel can be compared. Both materials hold up to the environmental conditions differently. mill galvanized steel offers a service life of 10-15 years depending on a number of variables, but as shown in Table 2: Service Life vs. Thickness of Zinc, service life is directly proportional to the thickness of the zinc coating. A653 dictates a minimum thickness of G235 mill galvanized steel at 2.0mm while ASTM A123 requires a minimum thickness for hot-dipped galvanized steel at 2.5-2.9mm. While G235 mill galvanized steel is projected to have a service life of 10-15 years, hot-dipped galvanized after fabrication steel is projected to last up to 45% longer based on the minimum thicknesses required.

Another difference between mill galvanized steel and HDGAF steel is the bonding between the zinc coating and the steel surface is stronger in HDGAF. This improved adhesion adds resistance to peeling, chipping or cracking of the protective layer, even under mechanical stress or thermal expansion and contraction.

Table 2

Service Life* vs. Service Thickness



*Service Life is defined as the time to 5% rusting of the steel surface

Benefits of HDGAF

- Lower long term cost: More protection = less maintenance due to thicker coating
- 45% longer life span: Thicker coating than G235 – more zinc, larger protection barrier
- Low maintenance: Self maintaining for longer, less maintenance required
- Reliability: Minimum coating thickness needs to be achieved to meet spec, leads to predicted and reliable service
- Tougher: They form a metallurgical bond which is stronger than any other steel coating
- Automatic protection for any damaged areas: Galvanized zinc is self-repairing while other coatings need to be touched up if damage occurs
- All over, complete protection: Coating is applied after the parts have been bent, cut, or punched leading to a full coverage coating that encompasses the edges of these processes
- Ease of inspection: Visual inspection is only needed due to the nature of the adhesion process of the coating

Conclusion

In conclusion both mill galvanized steel and hot-dipped galvanized after fabrication steel offer protection against corrosion, but **HDGAF ensures equipment and component longevity over typical G90 or G235**. With 100% coating coverage and no fabrication damage, HDGAF steel provides a thicker minimum standard coating for commonly used gauge material. These are the predominate reasons why hot-dipped galvanized after fabrication steel is better suited for industrial applications over similar mill galvanized steel where zinc is thinner, damaged or missing after welding, cutting and bending fabrications.

Sources

[1]Zinc Coating Thickness Reference / Coroborating Material: https://www.colmaccoil.com/media/191331/g235-coating-final.pdf

https://galvanizeit.org/duplex-systems-galvanize-it-seminar/hot-dip-galvanizing-process/hdg-benefits

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