AMERICAN FITTINGS Corporation
Technical Paper Galvanized Fitting for RGS Conduit

Overview

AMERICAN FITTINGS Corporation (AMFICO) fittings are manufactured from solid alloy steel bar stock. Chemical and physical properties for the Alloy Steel Used vs. Malleable Iron (MI) and Zinc Die Cast (ZDC) are outlined on Pages 4 and 5. Since Alloy Steel has a far greater tolerance for corrosion resistance over both MI and ZDC the utilization for hot dipped is not necessary. MI REQUIRES hot dipped galvanized due to its inherent physical and chemical issues. MI fittings are normally twice the weight and mass of Alloy Steel fittings with far greater susceptibility for corrosion, flaking, and cracking. All AMFICO fittings are manufactured in the USA from domestic steel.

The following details the differences between Hot Dipped Galvanizing and Mechanical Plating.

Mechanical Plating for AMERICAN FITTINGS products are fully in accordance with ASTM B695 Class 12 (12 µm = .0005 in). The zinc coatings are classified according to thickness and identified into two types as coated without supplementary treatments or with colored chromate conversion treatment. The thickest coating classes are usually referred to as "mechanically galvanized". All deposited coatings will have a bright uniform silvery appearance, and a matte to medium-bright luster. Fittings are QC tested for adhesion, salt-spray corrosion resistance, appearance, thickness, and absence of hydrogen embrittlement. All tests results comply with the ASTM B695 requirements.

As noted below AMFICO plated Fittings are RoHS compliant, while Zinc Hot Dipped Galvanized are not. Nor will the process for Hot Dipped Galvanize meet RoHS compliance.

Mechanical Plating vs. Electroplating

Electroplating is a process in which electric current is used to deposit metal onto a workpiece. In the process, the workpiece to be plated is the cathode of the circuit and the metal to be plated on the workpiece is the cathode. Both are submerged in an electrolytic solution that permits the flow of electricity. Direct current is applied to the anode, which oxidizes the metal atoms, which allows them to be dissolved in the solution. These dissolved atoms are then deposited on the cathode (workpiece) which forms the plated surface.

Electroplating Causes Hydrogen Embrittlement

Hydrogen embrittlement is a phenomenon in which a material experiences a significant reduction in ductility and tensile strength when atomic hydrogen diffuses into the material.

Prior to electroplating, workpieces must go through an acid pickling process to clean the surface of the workpiece. This process produces hydrogen, which then diffuses into the workpiece causing it to become brittle. Hydrogen is also produced during the electroplating process further embrittling the workpiece. In order to remove the hydrogen after plating the workpiece must go through a baking process at 400-800°F (204-426°C) for 2-8 hours depending on the thickness of the workpiece.

Hydrogen in its atomic form diffuses interstitially through the crystal lattice, and concentrations as low as several parts per million can lead to catastrophic brittle failure in normally ductile material. Martensitic steels are especially vulnerable to hydrogen embrittlement.

Electroplating is one of the few process that induce hydrogen embrittlement. This makes it necessary to add a post-plating baking process to drive out any dissolved hydrogen.

Mechanical plating eliminates the risk of hydrogen embrittlement and eliminates the need for any post-plating risk reduction processes.

Mechanical Galvanizing vs. Hot Dip Galvanizing Process

Hot dip galvanizing is the process of coating parts with molten zinc by immersing them in a bath of molten zinc at a temperature around 840°F (449°C). This results in a zinc coating of 0.002" or greater, which prevents corrosion.

Mechanical Plating is Lead-free; <u>Prime Western Zinc used in hot dip contains lead and is not RoHS compliant</u>

Advantages of Mechanical Plating over Hot-Dip

- ASTM B695 Testing and Conformance
    - ASTM B695 Has Salt Spray Testing Requirements, Hot Dip Galvanizing Does Not

- Better Sacrificial Protection, No Hydrogen Embrittlement
    - Sacrificial metal coating is applied with coverage to all surfaces of the part to the corners recesses, threaded areas as well as to the flat, more exposed regions. Threaded peaks especially show no build-up plating thickness. They or other sharp points have uniform thickness you want in plating. Because mechanical plating is so uniform, you can save money by coating at lower average thickness. Parts weighing up to three pound and measuring with a longest dimension up to eighteen inches can be handled, including some that are usually rack excessive build-up on plating or protruding points of the part and leave other areas with thinner spot more vulnerable to corrosion.

- *Excellent Adhesion and Controlled Uniformity of Coating Thickness:*
    - Sacrificial metal coating is applied with coverage to all surfaces of the part to the corners recesses, threaded areas as well as to the flat, more exposed regions. Threaded peaks especially show no build-up plating thickness. They or other sharp points have uniform thickness you want in plating. Because mechanical plating is so uniform, you can save money by coating at lower average thickness. Parts weighing up to three pound and measuring with a longest dimension up to eighteen inches can be handled, including some that are usually rack excessive build-up on plating or protruding points of the part and leave other areas with thinner spot more vulnerable to corrosion.
    - If an application requires torqueing, exposure to vibration or any handling that could rupture a finish, mechanical plating provides durable metal coating with excellent adhesion. Even if the mechanical plating finish is scratched, there is still galvanic protection for the base metal. The base metal is less chemically active so that the coating corrodes first

- Room temperature process, no detempering
    - Mechanical Galvanizing is a room temperature process that does not detemper heat-treated parts. Mechanical Galvanizing does not fill valleys of threaded fasteners and their parts mate quickly and easily.

- Integrity and Uniformity of Threaded Connection
    - In hot-dip galvanizing, threads must be cut or chased after galvanizing, robbing them of protection and requiring extra expense. Mechanical Galvanizing produces parts that are ready to use without any further processing steps.

- *No Galling:*
    - Because of the composite nature of mechanical coating, this naturally lubricated coating will not gall, producing more accurate torque-tension relationship.

- *Environmental Regulation and Considerations*
    - Mechanical Plating is Lead-free; *Prime Western Zinc used in hot dip contains lead and is not RoHS compliant*

AMFICO Compliances for Rigid Galvanized Steel Conduit Fittings ½" – 4"

- Certified Made in the USA
- UL 514B
- NEMA Standard FB1
- Certified for MIL-STD 810 Sinusoidal Vibrations
- Federal Standard A-A-50553
- UL Standards: 514B, 467
- CSA Standard: C22.2 No. 18F
- RoHS Compliant
- ANSI C 80.1 for Galvanized Rigid Conduit (GRC)
- ASTM B695

Chemical Composition of Fittings

Machined Alloy* Steel

Element	Chemical Composition %
Carbon	1.00
Manganese	***2.20***
Phosphorus	***2.25***
Sulphur	0.50
Lead	0.35
Silicon	na
Iron	Balance
Aluminum	na
Zinc	na
Tin	na
Cadmium	na
Cooper	na

Manganese provides degree of corrosion resistant in steel over iron.

*Alloy steels are made by combining carbon steel with one or several alloying elements, such as manganese, silicon, nickel, copper, chromium and aluminum. These metals are added to produce specific properties that are not found in regular carbon steel. The elements are added in varying proportions (or combinations) making the material take on different aspects such as increased hardness, increased corrosion resistance, and increased strength.

Cast Malleable Iron

Element	Chemical Composition %
Carbon	2.16-2.90
Manganese	0.15-1.25
Phosphorus	0.02-0.15
Sulphur	0.02-0.20
Lead	na
Silicon	0.90-1.90
Iron	Balance
Aluminum	na
Zinc	na
Tin	na
Cadmium	na
Cooper	na

Combine increase in carbon and lower amount of manganese, material is very susceptible to rust and corrosion.

Malleable cast iron is produced from white cast iron, which is made from hot liquid iron with certain chemical components. The white cast iron needs to be treated by malleablizing, such as graphitizing or oxidation and decarbonization, then its metallographic structures or chemical components will be changed, so can become into malleable cast iron.

Zinc Die Cast (Zamack # 3 -7)

Element	Chemical Composition %
Carbon	na
Manganese	0.02-0.06
Phosphorus	na
Sulphur	na
Lead	0.005
Silicon	na
Iron	na
Aluminum	3.70-4.30
Tin	0.002
Cadmium	0.004
Cooper	0.10
Zinc	Balance

Die casting entails forcing molten metal under high pressure into a mold cavity. The mold cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mold. Most die castings are made from non-ferrous metals, the most common being zinc, aluminum and magnesium.

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Physical Properties of Fittings – *See Definitions on Page 5*

Machined Alloy Steel	
ASTM Physical Test	Result
Tensile Strength (kpsi)	78
Yield Strength (kpsi)	70
Elongation (% in 2")	15
Brinell Hardness	163
Creep Concern *	No

Cast Malleable Iron (annealed)	
ASTM Physical Test	Result
Tensile Strength (kpsi)	52
Yield Strength (kpsi)	33
Elongation (% in 2")	10
Brinell Hardness	110-134
Creep Concern *	unknown

Zinc Die Cast (Zamack # 3 -7)	
Physical Test	Result
Tensile Strength (kpsi)	41
Yield Strength (kpsi)	NA
Elongation (% in 2")	13
Brinell Hardness	80
Creep Concern *	Yes

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Galvanized Products Available from AMFICO:

Rigid Conduit Couplings and Connectors including Rain Tight
Ground Bushings and Rigid Conduit Bushings
Watertight Hubs
Chase Nipples
Reducing Bushings
Rigid Conduit Enlargement Fittings
Seal Tight Fittings

Primary Definitions Used in Physical Characteristics Chart

Yield Strength

A yield strength or yield point is the material property defined as the stress at which a material begins to deform plastically. Prior to the yield point the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed, some fraction of the deformation will be permanent and non-reversible. The higher the yield point the more strength the material has and the longer the material can be stressed under load.

Brinell Hardness

Brinell hardness is determined by forcing a hard steel or carbide sphere of a specified diameter under a specified load into the surface of a material and measuring the diameter of the indentation left after the test. The Brinell hardness number, or simply the Brinell number, is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimeters. The result is a pressure measurement, but the units are rarely stated.

Tensile Strength

Tensile strength (TS) or *ultimate strength* is the capacity of a material or structure to withstand loads tending to elongate, as opposed to compressive strength, which withstands loads tending to reduce size. In other words, tensile strength resists tension (being pulled apart), whereas compressive strength resists compression (being pushed together). Ultimate tensile strength is measured by the maximum stress that a material can withstand while being stretched or pulled before breaking.

Elongation

Elongation is the amount of material strain a material can experience before failure in tensile testing.
* Creep (elongation under load) is the time-dependent strain on material that takes place under a given load.

Sources of Information

American Foundry Society	http://www.afsinc.org/
ASTM American Society of Testing Materials	http://www.astm.org/
DynaCast	https://www.dynacast.com/
MatWeb	http://www.matweb.com/index.aspx
Northwest Pipe Company	http://www.nwpipe.com/
Timken Steel Corporation	http://timkensteel.com/
Wikipedia	https://en.wikipedia.org/wiki/Alloy_steel
Wikipedia	https://en.wikipedia.org/wiki/Malleable_iron

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