

## Introduction

One of the most confusing topics related to coated-steel sheet products is the issue of coating weight designations and what they mean with respect to product performance. This discussion is intended to help clarify this issue.

## Coating Weight Measurement Systems

Each coated-steel sheet product has a coating weight designation system that is in common use today. The system for each type of coating is defined in the appropriate ASTM standard. For example, the most commonly used ASTM standard is A 653/A 653M which covers hot-dip galvanized products. The coating weight designation system is given in terms such as G60, G90, etc. These numbers refer to the weight (mass in SI units) of zinc on the surface of the steel sheet in Inch-Pound (English or Imperial) units of measurement. That is, for G90, the coating on one square foot of sheet (total coating, both sides of the sheet) weighs a minimum of 0.90 ounces. If equally applied to both sides of the sheet, there would be a minimum of 0.45 ounces on each surface.

The other measurement system in widespread use today is the SI (Metric) system. The conversion from the Inch-Pound weight in ounces per square foot ( $\text{oz}/\text{ft}^2$ ) to the SI mass in grams per square metre ( $\text{g}/\text{m}^2$ ) is:

$$1 \text{ oz}/\text{ft}^2 = 305.15 \text{ g}/\text{m}^2$$

**To convert from  $\text{oz}/\text{ft}^2$  to  $\text{g}/\text{m}^2$ , multiply by 305.15**

**Example: G90 (0.90  $\text{oz}/\text{ft}^2$ ) = Z275 (275  $\text{g}/\text{m}^2$ )**

Since what we are most interested in is the coating thickness, why don't the ASTM standards use thickness measurements? The answer is simply that it is difficult to directly measure the thickness accurately. For example, a G90 coating contributes about 1.6 mils (0.0016 inches) of thickness to the final coated sheet. For a coating equally applied to both sides of the sheet, this means there is about 0.0008 inches of zinc on each surface. Thus, to accurately determine the thickness of the coating, one needs to know the precise thickness of the steel and then use a thickness gauge capable of accurately reading to the nearest ten thousandth of an inch<sup>1</sup>. It is much easier, and more accurate, to use a "weigh-strip-weigh" procedure to determine the weight of coating. Weigh-strip-weigh refers to the technique of weighing a standard-sized sample of the product using a very accurate scale, then stripping the coating in a mild acid to remove only the coating, then reweighing the coupon to determine the weight loss. Hence, the origin of the term "weigh-strip-weigh". There are weigh-strip-weigh procedures that can be used for all zinc-based coatings in commercial production today. For the most common products, these procedures are defined in ASTM Standard A 90/A 90M, and cover galvanized and galvanized coated sheet, Galvalume<sup>®</sup> coated sheet, and Galfan<sup>®</sup> coated sheet. There are special procedures required for other types of alloy coatings such as zinc-nickel alloy electroplated sheet. These are covered by other ASTM standards.

<sup>®</sup>Galvalume is a registered trademark of BIEC International, Inc.

<sup>®</sup>Galfan is a registered trademark of the Galfan Technology Centre, Inc

<sup>1</sup> Today, there is a very precise on-line (on the coating line) technique being used by most producers to determine coating weight. This method could be used by the customer to determine coating thickness, but the equipment required is very expensive and it encompasses the use of sophisticated x-ray or radio-isotope fluorescence devices to measure the coating weight; equipment that is not easy for a user of the product to acquire or use. The devices, in fact, directly measure the actual coating thickness repeatedly, and then average and convert the readings to the more familiar coating weight units. Refer to ASTM Test Method A 754 for more information.

## Designation System for Galvanized and Galvannealed Coated Sheet Products

For galvanized sheet, the common Inch-Pound coating weight designations (ordered as A 653) are, in oz/ft<sup>2</sup>:

G30  
G40  
G60  
G90  
G115

There are other designations such as G165 and G210, but these products are used for very specialized applications.

In SI units (ordered as A 653M), the comparable coating mass designations for galvanized sheet are, in g/m<sup>2</sup>:

Z90  
Z120  
Z180  
Z275  
Z350

For galvanized coatings in most applications and environments, the corrosion performance is approximately linear as a function of coating weight (thickness). That is, a G60 coating has twice the thickness of a G30 coating, and the life of the product (defined, perhaps, as the time to 10% rust) in a given environment is approximately twice as long. Similarly, a G90 coating is approximately 50% thicker than a G60 coating, and thus would be expected to perform 50% better (in terms of time to 10% rust). Limits on maximum acceptable coating weights for an application are usually given by other factors such as cost or formability. For a more thorough discussion of this topic see GalvInfoNote #s 11 and 19.

For other metallic-coated sheet products, the life versus coating thickness is not typically linear; thus, determining the coating weight (mass) to use is not as simple as it is for galvanized coatings. Also, when these products are painted, the behaviour is even more complex. The subject of painted hot-dip products is addressed in GalvInfoNote #s 8 and 20.

The common Inch-Pound coating weight designations (ordered as A 653) for galvannealed product are, in oz/ft<sup>2</sup>:

A25  
A40  
A60

As with the galvanized product designators, A40 for example requires a minimum coating weight of 0.40 oz/ft<sup>2</sup>. Because the coating contains approximately 8 to 10% iron, the density is slightly different than the density of zinc and the coating thickness is not quite the same as for a G40 galvanized coating, although the difference is too small to be of concern. The effect of density will be discussed later in this GalvInfoNote. Also, see GalvInfoNote #5 for a full explanation of hot-dip galvannealed coatings.

The SI equivalent coating mass designations (ordered as A 653M) for galvannealed sheet are, in g/m<sup>2</sup>:

ZF75  
ZF120  
ZF180

For galvanized and galvannealed coated sheet, the relationship between coating weight (mass) and thickness is as follows:

$$1 \text{ oz/ft}^2 = 0.0017 \text{ in} = 305.15 \text{ g/m}^2 = 0.0427 \text{ mm} \quad (1)$$

## Designation System for Electrogalvanized Coated Sheet Products

For electroplated coatings (pure zinc and all the alloy coatings), the most common designator unit in use today is the SI system ( $\text{g}/\text{m}^2$ ). Refer to ASTM Standard A 879/A 879M, which until 2004 did not even include the Inch-Pound ( $\text{oz}/\text{ft}^2$ ) designator system. The stimulus for this common use of the SI designators is that most electroplated products<sup>2</sup> are used for automotive applications and the automotive companies, who implemented worldwide specifications some time ago, adopted the use of SI units.

More recently, as hot-dip galvanized and galvanized coatings have seen increasing use by the automotive industry, it became the practice to manufacture these products to conform to  $\text{g}/\text{m}^2$  requirements instead of  $\text{oz}/\text{ft}^2$ ; hence automotive specifications for hot dip coated sheet contain only SI designators.

This use of both dimensional units has led to considerable confusion in the marketplace. What adds to this confusion is that for ASTM electrogalvanize products, and for all automotive specifications covering EG and hot-dip, the use of the letter "G" means it is a SI coating. Conversely, use of the letter "G" in the coating designator of ASTM hot-dip products means it is an Inch-Pound coating. For example, the designator 40G40G (sometimes referred to loosely as G40/40) in A 879/A 879M ( $\text{g}/\text{m}^2$ ), is easy to confuse with A 653/A 653M G40 ( $\text{oz}/\text{ft}^2$ ), especially since both hot-dip galvanize and electrogalvanize can be referred to (incorrectly) by the G40/40 term. Also, almost all automotive specifications require designation of the coating mass on each side of the sheet, e.g., 40G40G, requires  $40 \text{ g}/\text{m}^2$  on each side. The Inch-Pound term G40, a designator used only for hot-dip galvanized sheet, is defined by A 653/A 653M as total coating weight, both sides. It has approximately  $0.23 \text{ oz}/\text{ft}^2$  ( $70 \text{ g}/\text{m}^2$ ) of coating on each side of the strip, if the coating is equally divided. This issue is further confused by the adoption of unclear language in the trade. As mentioned, some people might refer loosely to 40G40G as G40/40 or even G40. If the steel producer made the product to meet automotive 40G40G ( $40 \text{ g}/\text{m}^2$  minimum on each side), the coating is not as thick as if the producer had made the product to meet a G40 coating weight ( $\text{oz}/\text{ft}^2$ ). Similar confusion is introduced by intermixing use of G60 per ASTM A 653/A 653M and G60/60 (correctly 60G60G) per A 879/A 879M (or per an automotive company's 60G60G, SI designation).

It is not easy to keep the terminology straight, but users should be aware that both units are in common use today, and are advised to pay close attention when ordering and know precisely what is meant by the terminology being used. See the Table 3 at the end of this article, which summarizes all of the designations and may be useful in keeping confusion to a minimum.

GalvInfoNote #3 explains the electrogalvanizing process.

## Designation System for Galvalume<sup>®</sup> Coated Steel Sheet

Galvalume<sup>®</sup> Steel Sheet is in common use today throughout the construction and other industries. It, too, has very specific coating designators. Fortunately, there are only a few designators, but that doesn't mean there is no confusion about the meaning. The designation system for coating weight (mass) is given in ASTM Standard A 792/A 792M. The three Inch-Pound coating weight designations (ordered as A 792) are, in  $\text{oz}/\text{ft}^2$ :

AZ50  
AZ55  
AZ60

These designators are comparable to those used for galvanized in that the dimensions are  $\text{oz}/\text{ft}^2$ . But, one has to be aware that the designation AZ60 is not equivalent to a G60 coating with respect to the thickness of the coating. Here is where the issue of density comes into play. The coating on Galvalume<sup>®</sup> has about 55% aluminum and 45% zinc. Actually, the coating has a small addition of silicon, but for purposes of this discussion the silicon is not important. Since aluminum is less dense than zinc (a given volume weighs less than the same

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<sup>2</sup>There is an electrogalvanized product that is most often used for relatively low corrosivity applications such as indoor wall panels, lighting fixtures, etc. This product is defined in ASTM Specification A 591/A 591M. For this product, there are both Inch-Pound and SI designators.

volume of zinc), an AZ60 coating is thicker than a G60 galvanized coating. See the section on theoretical weight (mass) later in this article to understand how differences in coating density affect the coated sheet.

Because Galvalume<sup>®</sup> and galvanize coatings behave quite differently with respect to corrosion rate, it is not possible to try to draw a performance equivalency curve. That is, there is no need to ask the question as to what Galvalume<sup>®</sup> coating is equivalent in performance to a G90 coating. The major use of Galvalume<sup>®</sup> is for construction industry building panels, and for this application the most common coating weights are AZ50 and AZ55. The differences in performance between these two designators are subtle; ask your supplier which coating thickness he recommends for your application.

For Galvalume<sup>®</sup>, there is also a SI coating mass designator system (ordered as A 792M). The SI equivalents to AZ50, AZ55 and AZ60 are, in g/m<sup>2</sup>:

AZM150  
AZM165  
AZM180

Galvalume<sup>®</sup> is produced only by hot-dip coating, so there is no confusing terminology related to the manufacture of an electroplated product as there is for galvanize (recall the G40/40 versus G40 terminology).

For Galvalume<sup>®</sup> coated sheet, the relationship between coating weight (mass) and thickness is as follows:

$$1 \text{ oz/ft}^2 = 0.0032 \text{ in} = 305.15 \text{ g/m}^2 = 0.0813 \text{ mm} \quad (2)$$

See GalvInfoNote #12 for a complete description of Galvalume<sup>®</sup>.

## Designation System for Galfan<sup>®</sup> Coated Sheet

A third type of zinc-based coating that has not seen much use for sheet products in the United States, but is recognized by ASTM, is Galfan<sup>®</sup> coated sheet. Galfan<sup>®</sup> has a coating that consists of 95% zinc and 5% aluminum. The designation system for coating weight (mass) is given in ASTM Standard A 875/A 875M. The common Inch-Pound coating weight designations (ordered as A 875) are, in oz /ft<sup>2</sup>:

GF30  
GF45  
GF60  
GF75  
GF90

For Galfan<sup>®</sup>, since the coating contains about 95% zinc and thus has approximately the same density as zinc, the GF90 designator refers to a coating approximately equivalent in thickness to a G90 galvanized coating.

The equivalent SI coating mass designations (ordered as A 875M) are, in g/m<sup>2</sup>:

ZGF90  
ZGF135  
ZGF180  
ZGF225  
ZGF275

As with Galvalume<sup>®</sup>, Galfan<sup>®</sup> is made only by the hot-dip process so there are no confusing designator systems that involve per side terminology.

For Galfan<sup>®</sup> coated sheet, the relationship between coating weight (mass) and thickness is as follows:

$$1 \text{ oz/ft}^2 = 0.00175 \text{ in} = 305.15 \text{ g/m}^2 = 0.0446 \text{ mm} \quad (3)$$

## Theoretical Weight (Mass) per Unit Area

Because the densities of zinc-based hot-dip coatings are lower than the density of steel, the weight per unit area of coated sheet is less than uncoated sheet of the same thickness. This small difference can be of importance when large volumes of coated sheet are being consumed. The adjustment in weight (mass) varies as a function of the coating type and thickness. Using the density of the various coatings, and the actual typical thickness when applied, a "coating factor" can be calculated for each coating type and designation. To arrive at the theoretical weight (mass) per unit area of sheet, the coating factor is subtracted from the weight (mass) of uncoated sheet of the same thickness. The coating factor is actually the difference in weight (mass) between the coating metal and steel of the same thickness as the coating.

### Theoretical Weight

The formula for calculating the theoretical weight of galvanized sheet in lb/ft<sup>2</sup> is:

$$TW = t \times 40.833 - CF \quad (4)$$

Where: TW = Theoretical Weight in lb/ft<sup>2</sup>  
 t = actual sheet thickness in inches  
 CF = Coating Factor in lb/ft<sup>2</sup>

For example; galvanized sheet 0.020 inches thick with a G90 coating has a coating factor of 0.006 lb/ft<sup>2</sup>, based on the relationship in (1) and a typical actual G90 coating weight of 0.96 oz/ft<sup>2</sup>. Therefore:

$$TW = 0.020 \times 40.833 - 0.006 = 0.8107 \text{ lb/ft}^2$$

### Theoretical Mass

The formula for calculating the theoretical mass of galvanized sheet in kg/m<sup>2</sup> is:

$$TM = t \times 7.85 - CF \quad (5)$$

Where: TM = Theoretical Mass in kg/m<sup>2</sup>  
 t = actual sheet thickness in millimetres  
 CF = Coating Factor in kg/m<sup>2</sup>

For example; galvanized sheet 0.50 mm thick with a Z275 coating has a coating factor of 0.029 kg/m<sup>2</sup>, based on the relationship in (1) and a typical actual Z275 coating mass of 293 g/m<sup>2</sup>. Therefore:

$$TM = 0.50 \times 7.85 - 0.029 = 3.896 \text{ kg/m}^2$$

Using the above relationships, theoretical weight (mass) can be calculated for all combinations of sheet thicknesses and coating types/thicknesses. For quick reference, producers of coated sheet usually have tables available for their customers showing this information for the products and thicknesses they sell. The above formulas can be used to interpolate between the thicknesses shown in these tables.

If you do not have access to such information, Tables 1 & 2 below show the coating factors for the more commonly ordered coating designations for galvanize, Galvalume<sup>®</sup> and Galfan<sup>®</sup>.

**Table 1 Some Inch-Pound Coating Factors for Zinc-Based Coated Sheet**

<b>Product</b>	<b>Coating Designation</b>	<b>Coating Factor (lb/ft<sup>2</sup>)</b>
<b>Galvanize</b>	A25	0.0022
	G60	0.0043
	G90	0.0060
<b>Galvalume®</b>	AZ50	0.0383
	AZ55	0.0426
	AZ60	0.0447
<b>Galfan®</b>	GF45	0.0059
	GF75	0.0091
	GF90	0.0111

**Table 2 Some SI Coating Factors for Zinc-Based Coated Sheet**

<b>Product</b>	<b>Coating Designation</b>	<b>Coating Factor (kg/m<sup>2</sup>)</b>
<b>Galvanize</b>	ZF075	0.011
	Z180	0.021
	Z275	0.029
<b>Galvalume®</b>	AZM150	0.187
	AZM165	0.208
	AZM180	0.218
<b>Galfan®</b>	ZGF135	0.029
	ZGF225	0.044
	ZGF275	0.054

## Summary

This article explains why the coating designation systems in use today are so confusing, and hopefully, to help you better understand that it is important to be sure that you and your supplier are speaking the same language. Shown below is a table giving examples of all the designators discussed above. Give us some feedback. Was this GalvInfoNote helpful? Did it confuse you further? Are there still issues that need better clarification? See GalvInfoNote #16 for a further explanation of ASTM specifications for coated steel sheet products.

### Table 3 Designators for Zinc-Based Coatings on Steel Sheet - SUMMARY

Product	Example of a Common Coating Designation		Minimum Coating Weight (Mass) (Total both surfaces, except as shown)	
	Inch-Pound	SI	Inch-Pound oz/ft <sup>2</sup>	SI g/m <sup>2</sup>
ASTM A 653/A 653M Galvanize	G90	Z275	0.90	275
ASTM A 653/A 653M Galvanneal	A40	ZF120	0.40	120
ASTM A 591/A 591M Electrogalvanize	40Z	12G	0.04 per surface	12 per surface
ASTM A 879/A 879M Electrogalvanize	13Z13Z	40G40G	0.13 per surface	40 per surface
Automotive Galvanize	N/A*	90G90G	N/A*	90 per surface
Automotive Galvanneal	N/A*	45A45A	N/A*	45 per surface
ASTM A 792/A 792M Galvalume <sup>®</sup>	AZ55	AZM165	0.55	165
ASTM A 875/A 875M Galfan <sup>®</sup>	GF75	ZGF225	0.75	225

\*Not Applicable

See GalvInfoNote #s 4 and 16 for a more in-depth explanation of the above ASTM standards for coated sheet products.

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