

# HOT-DIP GALVANNEALED STEEL



**Construction**

**Auto Body Panels**

**Electrical Enclosures**



**HOT-DIP GALVANNEALED STEEL** is continuously coated on both sides with a zinc-iron (Zn-Fe) alloy. Galvanized steel is a specialized variation of galvanized steel where induction heating is used to alloy the zinc coating with the steel to create a zinc-iron coating. The hot-dip process, pioneered by Cleveland-Cliffs, provides a tight metallurgical bond between the steel and coating. This process results in a material with the strength and formability of steel plus the corrosion protection of the zinc-iron coating. Zinc protects the base metal by providing a barrier to corrosive elements and also by the sacrificial nature of the coating.

Hot-Dip Galvanized steel is available with special surface finishes, tailored for specific applications, and in a variety of base metal grades and coating weights. Hot-Dip Galvanized steel is widely used in many applications in automotive and general manufacturing.

# HOT-DIP GALVANNEALED STEEL

## Product Features

### CORROSION RESISTANCE

The zinc coating protects the base metal by providing a barrier to corrosive elements and also by the sacrificial nature of the coating. Ultimate service life depends on coating thickness and the severity of the environment.

### EXCELLENT SURFACE APPEARANCE

Hot-Dip Galvanized steel is available as EXTRASMOOTH™ or ULTRASMOOTH® for the most demanding surface critical applications.

### FORMABILITY

Hot-Dip Galvanized steel can be used to produce parts containing simple bends to parts with deep drawing requirements.

### PAINTABILITY

Hot-Dip Galvanized steel is readily paintable provided proper pre-treatment is performed.

### WELDABILITY

Hot-Dip Galvanized steel can be joined using a variety of accepted welding practices. Its spot weldability is improved over free zinc coatings.

## Coating Characteristics

The hot-dip coating process assures a tightly adherent, uniform coating of zinc on both sides of the product. The strip passes through an induction furnace after the coating pot to allow the iron from the base metal to further diffuse into the zinc, creating a zinc-iron alloy layer. The coating is nominally 8 – 13% iron. Precise temperature control provides sufficient ductility in the coating to permit normal fabrication practices without incurring significant coating damage or powdering. Coating designation at A40 and higher may not be suitable for higher-forming applications due to the inherent attributes of the coating.

Hot-Dip Galvanized steel has a matte gray surface with no spangle which provides a good base for painting. For best results, the surface should be carefully cleaned with an alkaline cleaner, however in some cases, cleaning by a solvent may be acceptable. Cleaning should be followed by a pre-treatment prior to painting.

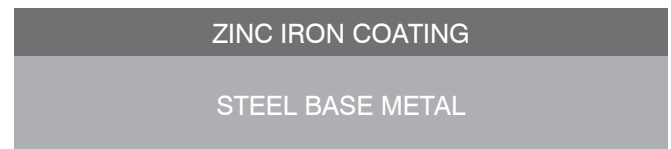
Hot-Dip Galvanized steel coatings are specified in several coating weight categories as shown in Table 1. The differences in designation are explained by the diagram in Figure 1. A schematic of the coating cross section is shown in Figure 2. For coating weights not listed, contact your Cleveland-Cliffs sales representative.

TABLE 1 – COATING WEIGHT

Coating Designation	Coating Weight Min.	
	oz./ft <sup>2</sup>	g/m <sup>2</sup>
<b>Triple Spot Designation (Total Both Sides)</b>		
A01	No Min.	No Min.
A20	0.20	61
A30	0.30	92
A40	0.40	122
A50	0.50	153
A60	0.60	183
<b>Single Spot Designation (Single Side)</b>		
45A/45A	0.15/0.15	45/45
60A/60A	0.20/0.20	60/60

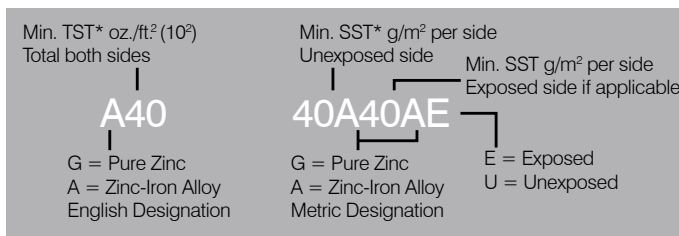
For other coating weights, please inquire.

FIGURE 2 – COATING CROSS SECTION



Layers not shown to scale.

FIGURE 1 – COATING DESIGNATION



\*TST/SST = Triple Spot Test/Single Spot Test as defined by ASTM A924.

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## Surface Protection and Lubrication

To prevent staining in transit and storage, Hot-Dip Galvannealed steel should be coated with a protective oil. The mill can apply a mineral oil with a rust preventative combination, a pre-applied, press-forming lubricant, a mill-applied phosphate coating or a chemical treatment (with or without oil). A chemical treatment is not recommended if the product will be painted, unless proper surface preparations are taken. Specific chemical treatment requirements, such as RoHS, must be clearly indicated and reviewed.

## Formability and Mechanical Properties

The formability of all steel products is a result of the interaction of many variables. These variables include: the mechanical properties of the steel, the forming system (tooling) used to manufacture parts and the lubrication used during forming. Of these three, Cleveland-Cliffs can directly affect the mechanical properties of the steel having tight control over chemical composition, hot rolling parameters, the amount of cold reduction, in-line annealing time and temperature, and the amount of additional processing will allow the production of high quality Hot-Dip Galvannealed steel to meet customers' requirements.

### COMMERCIAL STEEL (CS)

Commercial Steel Type B (CS Type B) and Forming Steel Type B (FS Type B) should be used for moderate forming or bending applications. These products are produced from aluminum-killed continuously cast slabs and, unless otherwise specified, have a carbon content of 0.02 – 0.15%C and 0.02 – 0.10%C respectively. To prevent the occurrence of fluting or stretcher strains during forming or processing, both products must be ordered as EXTRASMOOTH. These products are subject to aging and the temper rolling effect is temporary.

### DEEP DRAWING STEEL (DDS)

For more stringent forming applications, Deep Drawing Steel should be ordered. DDS has a controlled carbon content less than 0.06%C. Interstitial Free (I-F) steel may be supplied at the manufacturer's discretion unless low carbon is specifically requested at the time of purchase.

### EXTRA DEEP DRAWING STEEL (EDDS)

Extra Deep Drawing Steel or Extra Deep Drawing Steel Plus (EDDS+) should be ordered for the most demanding forming applications. These steels, also known as Interstitial-Free (I-F) steel, are produced from vacuum-degassed less than 0.010%C, stabilized grades. EDDS+ has the lowest carbon content available and has been specially formulated to be Cleveland-Cliffs' most ductile product.

For high-strength applications, Hot-Dip Galvannealed steel is available as Structural Steel (SS) or High Strength Low Alloy Steel (HSLAS). Bake Hardenable (BH), Dent Resistant (DR) and Dual Phase (DP) Steels are also available.

Typical mechanical properties are shown in Table 2, page 4.

# HOT-DIP GALVANNEALED STEEL

## SPECIFICATIONS

Hot-Dip Galvanized steel is produced in conformance to the following specifications:

ASTM A653	Base metal chemistry, grades and coatings
ASTM A924	General requirements and tolerances

For any specifications not listed here, contact your Cleveland-Cliffs sales representative.

## OUTSIDE PROCESSING

Tailored blanks, tension leveling, re-squaring, slitting, cut-to-length and coil coating are just some of the services Cleveland-Cliffs can provide through arrangements with outside processors.

## TECHNICAL ASSISTANCE

Cleveland-Cliffs' technical representatives can provide you with more detailed information concerning this product. They also are available to assist you in reviewing any welding, forming, painting or other material selection issue.

## MILL LIMITS

Hot-Dip Galvanized steel is available in thicknesses from 0.018 – 0.100 in. (0.46 – 2.54 mm), and widths up to 80 in. (2032 mm) depending on dimensions and product quality. For sizes outside of these limits, please contact your Cleveland-Cliffs sales representative.

The standard coil inner diameter is 24 in. (609 mm).

*\*Please inquire for Hot-Rolled substrate capability.*



# HOT-DIP GALVANNEALED STEEL

## Tables

**TABLE 2 – TYPICAL MECHANICAL PROPERTIES – STANDARD GRADES**

Quality Designation	Description	YS		UTS		Min. Elong. %	n-Value	r <sub>m</sub>
		ksi.	MPa	ksi.	MPa			
Commercial Steel (CS Type B)	May be moderately formed. A specimen cut in any direction can be bent flat on itself without cracking.	38	265	50	345	37	–	–
Deep Drawing Steel (DDS)	DDS may be used in drawing applications.	26	179	46	317	40	0.23	1.5
Extra Deep Drawing Steel (EDDS)	Interstitial Free (I-F) steels are made by adding titanium and/or niobium to the molten steel after degassing and offer excellent drawability.	24	165	45	310	43	0.23	1.6
Extra Deep Drawing Steel Plus (EDDS+)		22	152	44	301	48	0.24	1.6

*Typical properties produced by Cleveland-Cliffs for these grades.*

*Commercial Steel, Deep Drawing Steel, and Extra Deep Drawing Steel are designations described in the ASTM specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process A653/A653M. Each of these steel designations is associated with unique requirements for chemical composition and with non-mandatory, typical mechanical properties. All properties are tested per ASTM A370.*

**TABLE 3 – ASTM SPECIFIED PROPERTIES – HIGHER STRENGTH GRADE**

Quality Designation	Product Details	Min. YS		Min. UTS		Min. Elong. %
		ksi.	MPa	ksi.	MPa	
Structural Steel (SS)	33	33	230	45	310	20
	37	37	255	52	360	18
	40	40	275	55	380	16
	50 Class 1	50	340	65	450	12
High Strength Low Alloy Steel (HSLAS)	40	40	275	50	340	22
	50	50	340	60	410	20
	50 (HSLAS-F)	50	340	60	410	22
	55 Class 2	55	380	65	448	18
	60	60	420	70	482	16

*The following qualities are available to various customer or industrial requirements.*



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## Tables

**TABLE 4 – OTHER AVAILABLE GRADES**

Bake Hardenable (BH) grades offer good formability with increased strength from work hardening and subsequent paint/bake cycle.	Dent Resistant (DR) grades offer good formability with increased strength from a high work hardening rate.	Dual Phase (DP)
BH 180 BH 210 BH 220 BH 240 BH 250 BH 260	DR 180 DR 190 DR 210	DP 590 DP 600 DP 780 DP 800 DP 980 DP 1180

*For strength levels not listed, please inquire.*

**TABLE 5 – ENGINEERING PROPERTIES**

Young's Modulus of Elasticity	200 x 10 <sup>3</sup> MPa at 20 °C	
Density	7.87 g/cm <sup>3</sup> at 20 °C	
Coefficient of Thermal Expansion	Low-Carbon/HSLAS:	12.4 μm/m/°C in 20 – 100 °C range
	I-F Steel:	12.9 μm/m/°C in 20 – 100 °C range
Thermal Conductivity	Low-Carbon/HSLAS:	89 W/m°C at 20 °C
	I-F Steel:	93 W/m°C at 20 °C
Specific Heat	481 J/kg/°C in 50 – 100 °C range	
Electrical Resistivity	0.142 μΩ·m at 20 °C	

### About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials, direct reduced iron, and ferrous scrap to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest supplier of steel to the automotive industry in North America. The Company is headquartered in Cleveland, Ohio with mining, steel and downstream manufacturing operations located across the United States and in Canada. For more information, visit [www.clevelandcliffs.com](http://www.clevelandcliffs.com).



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