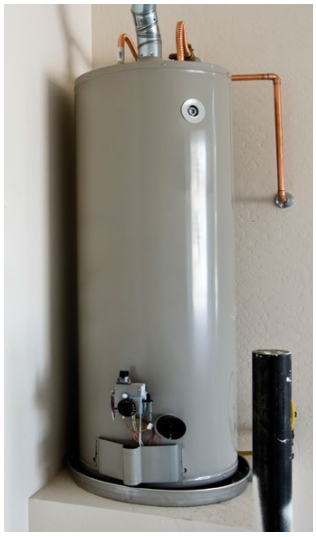
AK Steel
A CLEVELAND-CLIFFS COMPANY

ENAMELING
STEELS



Appliances

Barbecue Grills

Plumbingware

Architectural

AK Steel manufactures three enameled products to meet a variety of porcelain enameling and formability requirements: UNIVIT®, VIT-PLUS®, and I-F Enameling Steel. These products are manufactured specifically for use in appliances, plumbingware, barbecue grills, architectural panels, and other industries. They can be provided with different surface finishes depending on customer specifications or part requirements.

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ENAMELING STEELS

Product Description

PRODUCT FEATURES

ENAMELABILITY

Enameling Steels can be readily coated with porcelain enameling systems.

EXCELLENT SURFACE APPEARANCE

Enameling Steels have manufacturing controls in place to allow consistent surface quality, before and after porcelain enameling.

FORMABILITY

Enameling Steels can be used to produce parts containing simple bends to parts with extreme deep drawing requirements.

WELDABILITY

Enameling Steels can be joined using accepted welding practices suitable for porcelain enameling operations.

DESCRIPTION

Porcelain enameling characteristics, formability, and mechanical properties of AK Steel's Enameling Steels are developed by stringent controls of chemical composition, hot rolling parameters, cold reduction, annealing parameters, and temper rolling. AK Steel uses these control parameters to manufacture three uniquely different enameling steels: UNIVIT, VIT-PLUS, and I-F Enameling Steel. Each of these steels are manufactured from continuously cast slabs. I-F Enameling Steel is further processed at the melt stage to include vacuum degassing and the addition of titanium (Ti).

UNIVIT is a specialty enameling steel developed for applications where direct-on cover coat enameling is employed. It is equally well suited for those applications using ground coat, ground coat + cover coat, and two coat-one fire porcelain enameling systems. This product is free of porcelain enamel fishscale regardless of the enameling system employed. UNIVIT is described in ASTM A424 Type I.

VIT-PLUS is a controlled chemistry, nondecarburized steel. It has good strength-after-fire properties as shown in Figure 2. It is well suited for ground coat, ground coat + cover coat, and some two coat-one fire enameling systems. It is not recommended for direct-on cover coat porcelain enamel applications. Like the UNIVIT product, VIT-PLUS is free of porcelain enamel fishscale regardless of the enameling system employed. VIT-PLUS is described in ASTM A424 Type II.

I-F Enameling Steel is a vacuum degassed, titanium stabilized steel. I-F Enameling Steel can be used for ground coat, ground coat + cover coat, and two coat-one fire porcelain enameling systems. It is not recommended for use in direct-on, cover coat, enameling systems because the level of titanium in the base metal may interfere with the development of good porcelain-to-steel adherence. The porcelain enamel frit supplier should be made aware of the use of I-F Enameling Steel as minor formulation changes may be required depending on the particular enameling system. Fishscale will not be a hazard providing adequate porcelain enamel adherence and bubble structure are attained during the firing operation. Because of its excellent formability, it is most often used in the production of very difficult to form parts. I-F Enameling Steel can also be used where base metal sag during firing might be a problem (see Figure 1). I-F Enameling Steel is described in ASTM A424 Type III.

FIGURE 1 – BASE METAL SAG

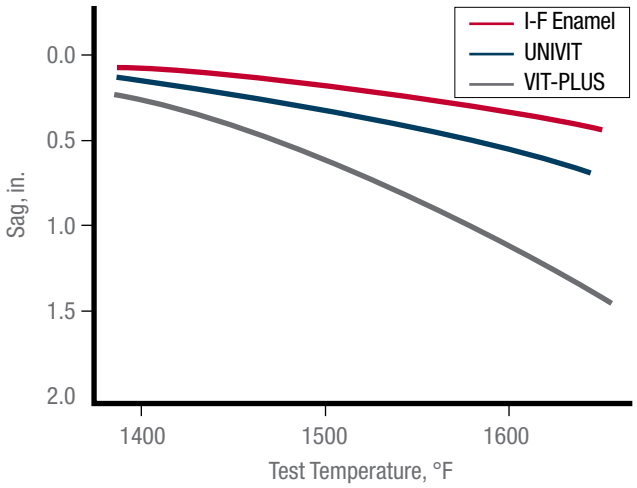
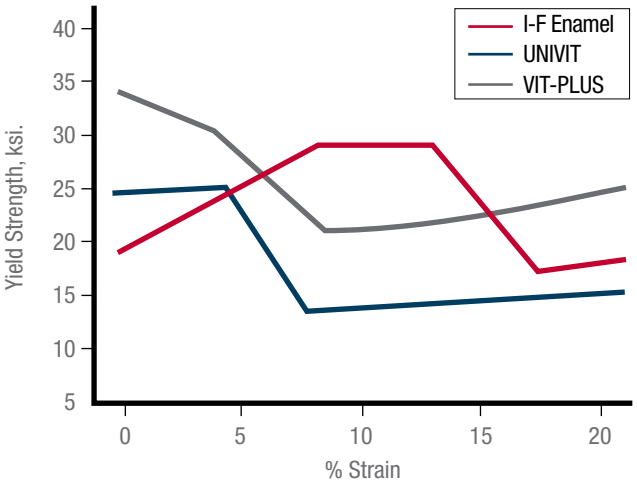


FIGURE 2 – STRENGTH AFTER STRAIN & FIRE



ENAMELING STEELS

Product Description

SURFACE FINISH

Enameling Steels are manufactured with matte finishes obtained by rolling with specially roughened rolls on the cold mill and the temper mill. Different finishes can be provided to maintain effective lubrication during metal forming or to satisfy specific part/customer specifications.

SURFACE PROTECTION AND LUBRICATION

To prevent staining in transit, it is recommended that Enameling Steel be supplied with a rust preventative oil.

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, AK Steel can directly affect the mechanical properties of the steel.

UNIVIT and VIT-PLUS steels are produced to provide maximum formability and can be supplied as Commercial Steel (CS) for moderate forming or bending applications. For more stringent forming applications, Drawing Steel (DS), should be ordered. I-F Enameling Steel should be ordered for the most difficult to form parts.

Typical mechanical properties are shown in Table 1.

Spin forming and related fabrication techniques may affect the void structure of the enameling steel product which could compromise the fishscale resistance. This should be considered when evaluating this fabrication technique.

JOINING SYSTEMS

Porcelain Enameling Steels can be readily joined using a variety of joining processes, such as resistance welding, low heat input arc welding, laser welding, and mechanical fastening. Resistance spot, seam, and projection welding are commonly used for joining Enameling Steels due to the high production rate and low per weld cost characteristics of this group of processes. The effects of each of these on subsequent porcelain enameling operations must be thoroughly evaluated by the end user for each specific application. A material's physical and electrical properties directly affect welding processes. Therefore, welding parameters may need adjustment when changing grade of Enameling Steel, surface finish, or lubricant/oil.

APPLICATIONS

Enameling Steels are used for various applications requiring cleanability, thermal shock capability, chemical resistance, corrosion protection, weather resistance, certain mechanical or electrical properties, and where color or appearance is important. Some common applications include ranges, washers and dryers, barbecue grills, water heater tanks, plumbingware, cookware, chemical processing tanks, agricultural storage tanks, architectural panels, signs, and tanning beds.

SPECIFICATIONS

Enameling Steels are produced in conformance to the following specifications:

ASTM A424	Steel sheet for porcelain enameling
ASTM A568	General requirements

For any specification not listed here, contact your AK Steel sales representative.

OUTSIDE PROCESSING

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

TECHNICAL ASSISTANCE

AK Steel's technical representatives can provide you with more detailed information concerning this product. They also are available to assist in reviewing any welding, forming, porcelain enameling, or other material selection issues.

MILL LIMITS

Enameling Steels are available in thicknesses from 0.019 – 0.085 in. (0.48 – 2.16 mm), and widths up to 80 in. (2032 mm) depending on dimension and product quality. For sizes outside these limits, please contact your AK Steel sales representative.

The standard coil inner diameter is 24 in. (609 mm). Thickness, width, and flatness tolerances are covered in ASTM A568.

ENAMELING STEELS

Tables

TABLE 1 – TYPICAL MECHANICAL PROPERTIES – STANDARD GRADES

Grade	YS		UTS		Elong. %	n-Value	r_m
	ksi.	MPa	ksi.	MPa			
UNIVIT Drawing Steel (DS)	25	165	43	165	44	0.22	< 1.3
I-F Enamel	20	140	44	300	46	0.24	1.7
VIT-PLUS DS	26	180	44	300	42	0.22	< 1.3

Typical properties produced by AK Steel for these grades.
All properties are tested per ASTM A370.

TABLE 2 – TYPICAL CHEMISTRIES

Grade	C	Mn	P	S	Si	Cu	Al	Ti
UNIVIT*	0.003	0.21	0.01	0.01	0.01	0.02	0.05	–
I-F Enamel	0.005	0.20	0.01	0.01	0.01	0.02	0.05	0.13
VIT-PLUS	0.04	0.21	0.01	0.01	0.01	0.02	0.05	–

**Chemistry listed is the typical product chemistry after mill processing. The carbon level is higher on heat analysis.*

TABLE 3 – ENGINEERING PROPERTIES

Young's Modulus of Elasticity	200 x 10^3 MPa at 20 °C
Density	7.87 g/cm^3 at 20 °C
Coefficient of Thermal Expansion	UNIVIT: 11.9 µm/m/°C in 20 – 100 °C range I-F Enamel: 12.9 µm/m/°C in 20 – 100 °C range Vit-Plus: 12.4 µm/m/°C in 20 – 100 °C range
Thermal Conductivity	UNIVIT: 90 W/m°C at 20 °C I-F Enamel: 93 W/m°C at 20 °C Vit-Plus: 89 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

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Founded in 1847, Cleveland-Cliffs is among the largest vertically integrated producers of differentiated iron ore and steel in North America. With an emphasis on non-commoditized products, the Company is uniquely positioned to supply both customized iron ore pellets and steel solutions to a quality-focused customer base. AK Steel, a wholly-owned subsidiary of Cleveland-Cliffs, is a leading producer of flat-rolled carbon, stainless and electrical steel products. The AK Tube and Precision Partners businesses provide customer solutions with carbon and stainless steel tubing products, die design and tooling, and hot- and cold-stamped components. In 2020, Cliffs also expects to be the sole producer of hot briquetted iron (HBI) in the Great Lakes region. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs approximately 11,000 people across mining and steel manufacturing operations in the United States and Canada.

Additional information about AK Steel is available at www.aksteel.com.

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