Enameling STEELS

AK Steel

AK Steel manufactures three enameling 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 the appliance, plumbingware, and other industries. Enameling Steels provide the best enamelability, formability, surface finish, and gauge and flatness tolerances. They can be provided with different surface finishes depending on customer specification or part requirements. Oil-based or acrylic/polymer lubricants can be supplied to enhance formability and/or to avoid at-press lubrication.

PRODUCT FEATURES

- **Enamelability**

  Enameling Steels can be readily coated with porcelain enameling systems in use today.

- **Excellent Surface Appearance**

  Enameling Steels have manufacturing controls in place to insure consistent surface quality to satisfy customer requirements.

- **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 virtually any accepted welding practice suitable for porcelain enameling operations.

PRODUCT DESCRIPTIONS

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

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 A 424 Type 1.

VIT-PLUS is a controlled chemistry, nondecarburized steel designed to replace certain types of ingot products. 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 A 424 Type II.

I-F Enameling Steel is a vacuum degassed, titanium stabilized steel. This product is the result of continuing research for steels for the porcelain enameling industry. I-F Enameling Steel can be used for ground coat and two coat-one fire porcelain enameling systems. It is not recommended for use in direct-on cover coat enameling systems. Because of its excellent formability, it is most often used in the production of very difficult to form parts. I-F Enameling Steel should also be used where base metal sag during firing might be a problem (see Figure 1). I-F Enameling Steel is described in ASTM A 424 Type III.

I-F Enameling Steel is very well suited for ground coat enameling systems regardless of whether an acid pickling operation is used or not. It is not well suited for direct-on cover coat porcelain enamel applications because the level of titanium in the base metal interferes with the development of good porcelain-to-steel adherence in systems currently in use today. Your porcelain enamel frit supplier should be made aware of your use of I-F Enameling Steel as minor formulation changes may be required depending on your particular enameling system. Outgassing is not a hazard with I-F Enameling Steel as this product is degassed at the melt stage and any remaining carbon is combined with titanium as titanium-carbide. Titanium-carbide is stable at enamel firing temperatures. Likewise, enamel fishscale will not be a hazard providing adequate porcelain enamel adherence and bubble structure are attained during the firing operation.

FIGURE 1 – BASE METAL SAG

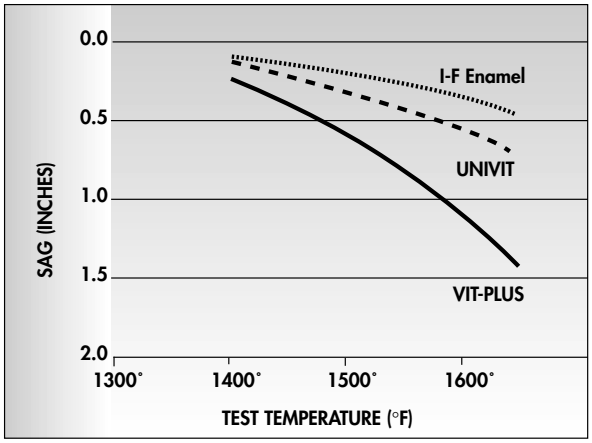
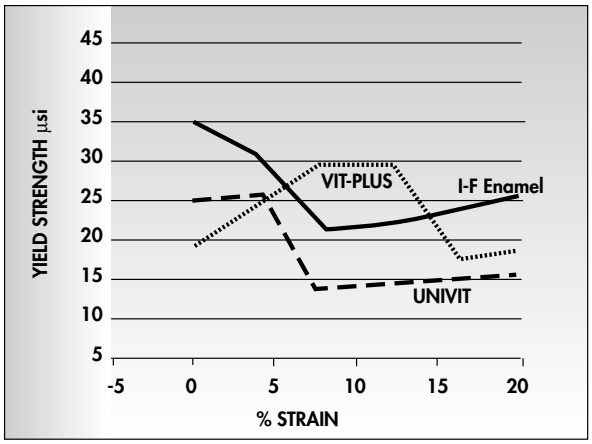


FIGURE 2 – STRENGTH AFTER STRAIN & FIRE



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 are provided to maintain effective lubrication during metal forming or to satisfy specific part/customer specifications.

SURFACE PROTECTION AND LUBRICATION

To prevent rusting in transit and storage, Enameling Steels should be coated with a rust protective oil. Rust preventative oil is a combination of a rust preventative and a mineral oil and is compatible with most petroleum-based and synthetic drawing lubricants. This rust preventative oil is very easily removed with a mild, warm alkaline cleaner.

FORMABILITY AND MECHANICAL PROPERTIES

The formability of all steel products is a result of the interaction of many variables, the main ones being 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 only directly affect the mechanical properties of the steel.

UNIVIT and VIT-PLUS steels are produced to provide maximum formability but can be supplied as Commercial Steel (CS) for moderate forming or bending applications. For more severe 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. The n-value, i.e. strain hardening exponent, has been shown to correlate with stretch forming behavior, while the r-value, r_m, is a measure of deep-drawing capability.

TABLE 1 – TYPICAL MECHANICAL PROPERTIES – STANDARD GRADES

Grade	YS ksi	YS MPa	TS ksi	TS MPa	% Elong. in 2"	"n"	"r_m"
UNIVIT DS	26	178	44	300	46	.23	1.2
I-F Enamel	23	159	45	313	44	.23	1.7
VIT-PLUS DS	29	198	45	311	43	.21	1.3

.0275 - .035 inches sheet thickness.
Typical properties produced by AK Steel for these grades.
All properties are tested per ASTM A 370.

TABLE 2 – TYPICAL CHEMISTRIES

Grade	C	Mn	P	S	Si	Cu	Al	Ti
UNIVIT	.003	.21	.01	.01	.01	.02	.05	–
I-F Enamel	.005	.20	.01	.01	.01	.02	.05	.13
VIT-PLUS	.04	.21	.01	.01	.01	.02	.05	–

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 are important.

Some common applications include major appliances such as 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 A 424	Steel sheet for porcelain enameling
ASTM A 568	General requirements

For any specification not listed here, please consult your AK Steel Sales or Technical Representative.

ENGINEERING PROPERTIES

TABLE 3

Young's Modulus of Elasticity	200 x 10^6 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°C to 100°C range I-F Enamel: 12.9 µm/m/°C in 20°C to 100°C range Vit-Plus: 12.4 µm/m/°C in 20°C to 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°C to 100°C range
Electrical Resistivity	0.142 µΩm at 20°C

OUTSIDE PROCESSING

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

MORE INFORMATION/TECHNICAL ASSISTANCE

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

MILL LIMITS

Enameling Steels are generally available in thicknesses from 0.019" (0.48 mm) to 0.085" (2.16 mm), and widths up to 80" (2032 mm) depending on thickness. For sizes outside these limits, please inquire.

The standard inner diameter of our coil is 24" (609 mm). Thickness, width, and flatness tolerances are covered in ASTM Specification A 568.

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