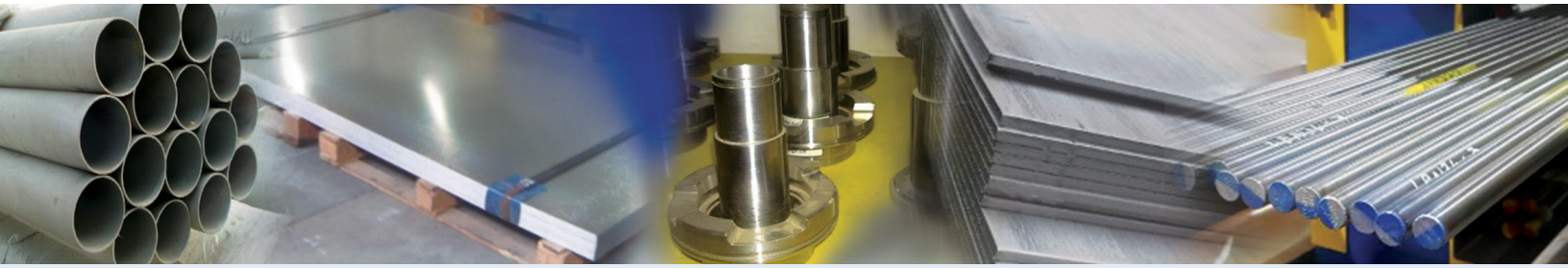
# HRP Training Aid: Metals and Alloys—Steels



## DESCRIPTION — ECCN

Maraging steel ..... 1C116, 1C216
Stainless steel plate, 304 and 316 ..... 1C999.b
Stainless steel plate, valves, piping, tanks, vessels ..... 2B999.g, 2B999.n
Titanium-stabilized duplex stainless steel (Ti-DSS) ..... 1C118

## DEFINITIONS

**Steel:** A predominantly iron alloy with added carbon to improve strength and fracture resistance compared with other forms of iron.

**Stainless steel:** A steel alloy containing a minimum of 10.5% chromium that makes the stainless steel highly resistant to corrosion and rust.

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# Categories

The 150+ different grades of stainless steel can be divided into the following categories:

## Austenitic (200–300 series)

- Makes up >70% of total stainless steel production; Type 304 and Type 316 are the two most common grades
- Contains appreciable amounts of chromium and nickel
- Nonmagnetic
- The type of stainless steel most frequently used in nuclear fuel cycle applications (e.g., in nitric acid–based processes used to process and purify uranium and plutonium solutions)

## Ferritic

- Generally exhibits better engineering properties than austenitic grades
- Reduced corrosion resistance due to lower chromium and nickel content
- Usually less expensive with good ductility
- Ferritic grades include 409, 430, 430LI, 434, 439, 442, 444, and 446

## Martensitic

- Can be high- or low-carbon steels; usually tempered and hardened
- Used largely for medical tools (scalpels, razors, and internal clamps)
- Maraging steel is a strong, tough, low-carbon martensitic steel
- Martensitic grades include 410, 420, and 440

## Duplex

- A mixed crystal structure of austenite and ferrite (i.e., duplex)
- High chromium (19%–32%), molybdenum (up to 5%), and lower nickel contents than austenitic stainless steels
- Magnetic
- Roughly twice the strength of austenitic stainless steels and improved resistance to localized corrosion and stress corrosion cracking
- Duplex grades include Duplex 2205 (22% chromium/5% nickel), which is most common; Duplex 2304; Duplex 2507; LDX 2101; and many other proprietary grades

# Maraging Steel
## 1C116, 1C216

### Controlled Items under ECCN 1C116

**Maraging steel having both of the following:**

- An ultimate tensile strength, measured at 20°C, equal to or greater than
  - 0.9 GPa in the solution annealed stage or
  - 1.5 GPa in the precipitation-hardened stage
- Any of the following forms:
  - Sheet, plate, or tubing with a wall or plate thickness ≤5.0 mm
  - Tubular forms with a wall thickness ≤50 mm and having an inner diameter ≥270 mm

### Controlled Items under ECCN 1C216

**Maraging steel, other than that controlled by 1C116:**

- Capable of an ultimate tensile strength ≥1,950 MPa at 20°C before or after heat treatment
- ECCN 1C216 does not control forms in which all linear dimensions are ≤3 in. (75 mm)

### KEY POINTS

- Considered a specialty steel (iron and nickel) with very low carbon content
- Known for its superior strength, machinability, and corrosion resistance
- Closely resembles stainless steel: lustrous gray color when clean and freshly prepared
- Differs from stainless steels (look for the following):
  - Dark oxide layer (tarnish) on the surface is common after heat treatment
  - Magnetic
- Must consult technical data sheets for strength and form specifications
- Most maraging steel meets the strength requirements of ECCN 1C116 or ECCN 1C216
- Focus on the form and dimensions in determining control:
  - Sheet, plate, or tubing ≤0.2 in. (5 mm) thickness or
  - Tubes ≤2.0 in. (50 mm) wall thickness and having an inner diameter ≥10.6 in. (270 mm)
  - Forms in which all linear dimensions are ≤3 in. (75 mm) are not controlled
- The number in the grade is the ultimate tensile strength in kilopounds per square inch (ksi):
  - Grade 150 → UTS 150 ksi = 1,034 MPa (not controlled)
  - Grade 200 → UTS 200 ksi = 1,379 MPa (not controlled)

- Grade 250 → UTS 250 ksi = 1,724 MPa (meets ECCN 1C116)
- Grade 300 → UTS 300 ksi = 2,068 MPa (meets ECCN 1C116 and ECCN 1C216)
- Grade 350 → UTS 350 ksi = 2,413 MPa (meets ECCN 1C116 and ECCN 1C216)
- Grade 400 → UTS 400 ksi = 2,760 MPa (meets ECCN 1C116 and ECCN 1C216)

- Grades 250, 300, 350, and 400 often labeled "18Ni" (nickel content ~18%)
- Look for the following on documentation or technical data sheets:
  - Common trade names: VascoMax®, NiMark®, Marvac®
  - References to grades (M400, M350, C-300, C-250)
  - Any metal labeled "18Ni"
  - Major manufacturers: Carpenter Technology Corp., Allvac, Latrobe Specialty Steel Co., Magellan Metals

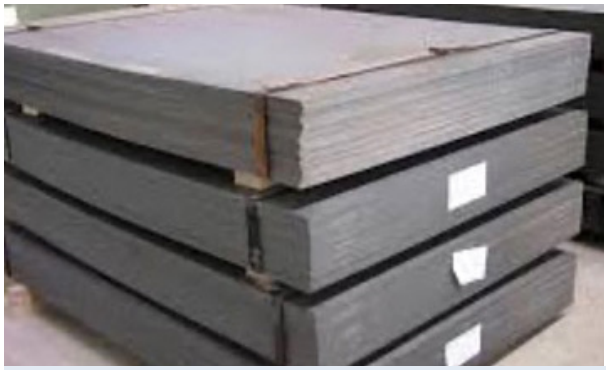
**Maraging steel closely resembles stainless steel when newly produced but quickly develops a dark oxide layer**

**Maraging steel crank shaft**

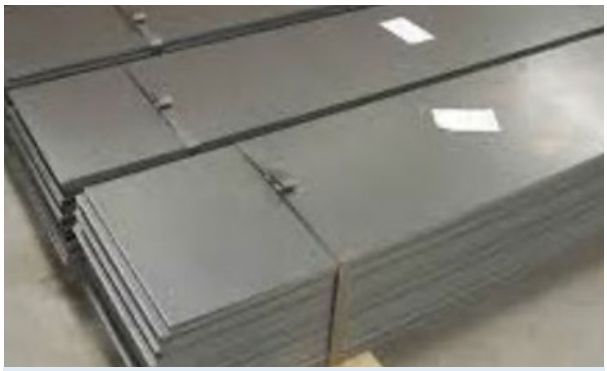
**Maraging 350/VascoMax® 350**

**Industrial die constructed of maraging steel**

**250 grade maraging steel/Marvac® seamless tube and pipes**



**Maraging 350/VascoMax® 350 plates**



**Maraging 350/VascoMax® 350 sheet**

**NOTE:**

The difference between metal **sheet** and metal **plate** is defined by thickness, which is typically measured in inches. If the thickness of the metal is 1/4 in. (6 mm) or more, then it is considered plate. If the thickness is <1/4 in. (6 mm), then it is considered sheet.

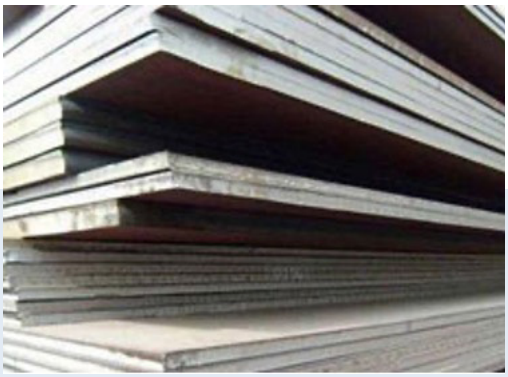
# Stainless Steel Plate, 304 and 316
## ECCN 1C999.b

**This ECCN controls exports to North Korea for antiterrorism reasons and to Iraq for regional stability reasons specific materials (including Item b. below) not elsewhere specified in the Commerce Control List.**

b. 304 and 316 stainless steel plate

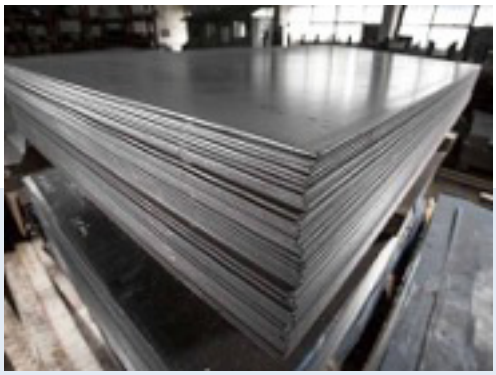
### KEY POINTS

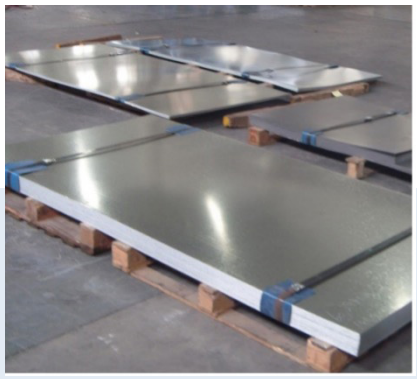
- 304 and 316 are the two most widely used stainless steels globally; austenitic stainless steels containing 16%–20% chromium and 8%–14% nickel; both are nonmagnetic
- Aesthetically, 304 and 316 appear the same; the only way to differentiate between them is chemical testing
- Price of 316 stainless steel is ~40% higher than the price of 304 stainless steel
- 304L and 316L are low-carbon versions of 304 and 316, which improves weldability
- Typical plate dimensions:
  - Thickness: 1/4–1 1/2 in.
  - Width: 1–4 ft
  - Length: 2–10 ft



**Type 304 stainless steel plate**

- Most versatile and widely used stainless steel due to its corrosion resistance and value
- Also known as "18/8" stainless (18% chromium and 8% nickel)
- Well suited to applications in harsh environments and frequently used in the food and beverage industry
- Applications include storage tanks, fasteners and finishing hardware, heat exchangers, and piping





**Type 316 stainless steel plate**

- Better corrosion resistance than Type 304 due to the addition of molybdenum plus a higher nickel content
- Most suitable stainless steel for marine environments
- Other applications include chemical processing and storage equipment, refinery equipment, and medical devices

# Stainless Steel Plate, Valves, Piping, Tanks, Vessels

## ECCN 2B999.g, 2B999.n

**This ECCN controls exports to North Korea for antiterrorism reasons specific processing equipment (including Item g. 304 and 316 stainless steel valves, piping, tanks and vessels and Item n.) not elsewhere specified in the Commerce Control List.**

n. Austenitic stainless steel plate, valves, piping, tanks and vessels

### NOTES

- Popular grades of austenitic stainless steel include 303, 304, 310, 316, and 321
- Most popular grades of austenitic stainless steel plate are 303, 304, and 316
- Refer to ECCN 1C999.b of this training aid for discussion of 304 and 316 stainless steel plate

### 303 Stainless Steel Plate

- The unique chemical composition (higher levels of sulfur) of 303 stainless steel provides unique properties and important applications
- Possesses the highest machinability among the austenitic stainless steels but has reduced toughness and corrosion resistance compared with 304 and 316
- Used in applications requiring heavy machining to fabricate parts, such as nozzles, aircraft components, nuts and bolts, electrical components, gears, pump parts, shafts, valve components, and bushings
- Typical 303 stainless steel plate dimensions:
  - Thickness: 1/4–4 in.
  - Width: 4–8 ft
  - Length: 8–12 ft

**303 stainless steel plate**

## Notes regarding Valves, Piping, Tanks, Vessels under ECCN 2B999

- Austenitic stainless steel items under ECCN 2B999 provide significant corrosion resistance in harsh environments (e.g., nuclear fuel cycle activities, chemical processing)
- However, these items provide less corrosion resistance (lower nickel and chromium content) than similar items captured under other ECCNs for NP or CB reasons for control
- It is not the intent of 2B999.g and 2B999.n to capture all austenitic stainless steel items in any possible physical form or configuration
- For example, "vessels" would include those items similar in design features and application as vessels controlled under ECCN 2B350.a for CB reasons of control
- "Vessels" would not include a small stainless steel dewar or stainless steel box

# Titanium-Stabilized Duplex Stainless Steel (Ti-DSS) ECCN 1C118

## Controlled Items

**Having all of the following characteristics:**

- Containing 17.0%–23.0% by weight of chromium and 4.5%–7.0% by weight of nickel
- Having a titanium content >0.10% by weight
- Having a ferritic–austenitic microstructure of which at least 10% by volume is austenite
- Having any of the following forms:
  - Ingots or bars measuring 100 mm (4 in.) or more in each dimension
  - Sheets measuring ≥600 mm (24 in.) wide with a thickness ≤3 mm (1/8 in.)
  - Tubes with an outer diameter ≥600 mm (24 in.) and a wall thickness ≤3 mm (1/8 in.)

### KEY POINTS

- Ti-DSS is not a titanium alloy. It is a duplex (i.e., both ferric and austenitic crystal structure) stainless steel containing small amounts of titanium to stabilize and alter the properties of the stainless steel during heat treatment (slow cooling).
- The use of titanium enhances ease of welding and resistance to certain liquid rocket fuels (e.g., inhibited red fuming nitric acid, a common missile oxidizer).
- Typical formulations for controlled Ti-DSS range from 17% to 23% by weight of chromium and from 4.5% to 7.0% by weight of nickel. Most Ti-DSS will have >10% austenite crystal structure.
- Duplex stainless steel is much more expensive to make than other stainless steels.
- Duplex stainless steels stabilized with other elements such as nitrogen have many nonmissile/commercial applications. These types of duplex stainless steels are not controlled.
- Most duplex stainless steels that property managers encounter are nitrogen stabilized (i.e., not controlled).

**Note:** The microstructure and composition requirements can only be determined by paperwork, datasheets, or lab tests.

Ti-DSS tubes are almost identical to other stainless steels

Ti-DSS sheets and ingots or bars are often stacked and secured to a pallet

Ti-DSS components

## DOE/NNSA High Risk Property

https://hrp.doe.gov

https://ecap.doe.gov

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