



# Stainless Steel & Specialty Steel Mill Products

**Classification and Technical Presentation** 





## STAINLESS STEEL: Overview and Technical Discussion







# BASICS







## STAINLESS STEELS IN THE ALLOY FAMILY HTS CHAPTER 72: IRON & STEEL







# EFFECT OF <u>CHROMIUM</u> ON ATMOSPHERIC CORROSION RESISTANCE

WHAT MAKES STEEL (IRON & CARBON) STAINLESS STEEL?

Stainless Steel: Predominately Iron 10.5% Min. Chrome / 1.2% Max. Carbon

> STAINLESS STEEL RANGE (HTS 7218 – 7223)

CHROMIUM Increase Chromium (Cr) = corrosion is REDUCED

**PER YEAR** MILS **CORROSION RATE** 





# WHY STAINLESS?







# WHY STAINLESS?

Corrosion Resistance
Mechanical Properties
Physical Properties
Ease of Fabrication
Appearance, Hygienic, Recyclable

Life cycle cost benefit...





### **Corrosion Resistance...**

# CHROMIUM OXIDE FILM STAINLESS STEEL BASE METAL WITH 10.5% MIN. CHROME

CHROMIUM OXIDE FILM PREVENTS FURTHER SPREADING OF OXYGEN

ON THE SURFACE >>> PROTECTING IRON FROM RUSTING.



Corrosion Resistance cont'd...

TOUGHNESS

# **STAINLESS ALLOYING ELEMENTS:**

MACHINABILITY

WEAR RESISTANCE

STRENGTH

DECREASE

BRITTLENESS

CHROMIUM	<ul><li>Corrosion resistance</li><li>Scaling resistance</li></ul>	DENSITY   WEIGHT
NICKEL	<ul><li>Acid corrosion resistance</li><li>Formability / Weldability</li></ul>	<ul> <li>Sulfur</li> <li>Manganese</li> <li>Aluminum</li> <li>Copper</li> </ul>
MOLYBDENUM	<ul><li>Pitting corrosion resistance</li><li>Strength</li></ul>	
NITROGEN	<ul><li>Crevice corrosion resistance</li><li>Strength</li></ul>	<ul> <li>Columbium</li> <li>Silicon</li> <li>Titanium</li> </ul>
CARBON	• <1.2% • Hardness	<ul><li>Calcium</li><li>Selenium</li></ul>













NOTE: AS STRENGTH INCREASES, DUCTILITY DECREASES







• Maximum stress that can be applied before mat'l begins to change shape – permanently.







- Maximum stress before mat'l breaks apart when stretched.
- Once a piece of steel is pulled past its tensile stress point, it will split apart.







# TENSILE TESTING ~ BAR ~

ULTIMATE TENSILE STRENGTH







# **TENSILE TESTING EQUIPMENT**









- Elongation is the percentage of stretch from the <u>original length</u> of the steel to the point of failure.
- Elongation: shows how ductile the steel is.
- More ductility = <u>More formability</u>







- 1. Mat'l is pulled to failure...
- 2. ...the diameter of the point at which the sample breaks is measured and compared to the original diameter.
- 3. The difference between the original sample and the broken piece is calculated and reported as the RA%.





# WHY STAINLESS

**Corrosion Resistance** 

**Mechanical Properties** 

**Physical Properties** 

**Ease of Fabrication** 

Appearance, Hygienic, Recyclable

Life cycle cost benefit...











## MAGNETIC PERMEABILITY:

## Ability to carry magnetism

Less, more, or no magnetism...

Varies: Alloys and heat treat practice







# THERMAL EXPANSION

Temperatures rise: length, width, area increases

#### **Examples:**

- Sag in electrical power lines

- Expansion Joints: railway lines / bridge decking

- Metal framed windows: need rubber spacers to avoid thermal expansion







## **HEAT CONDUCTIVITY**

How quickly material <u>absorbs</u> heat from area of <u>high</u> temperature and <u>moves it</u> toward areas of lower temperature

#### Examples:

- High Conductivity: promoting heat transfer cookware / heat exchanger

- Low Conductivity: preventing heat transfer Hot end jet engine

#### Metal rod (Good conductor)

#### Sist.

Heat is applied to one end of rod

#### 

Vibrating particles pumbing against each other

#### natenatenatenaten <mark>hannatenate</mark>









The density of a material is the mass contained in a unit volume

**Design considerations:** 

- Weight?
- Environment?
- Functionality?

- What do we need 'it' to do?







# WHY STAINLESS?

	Corrosion Resistance
	Mechanical Properties
	Physical Properties
/	Ease of Fabrication
/	Appearance Clean Hygienic

Life cycle cost benefit...





### **Ease of Fabrication**



Metallurgical properties allow most sizes and shapes fabricated with ease.







### Appearance... Clean... Hygienic





- Architecture / Art
- Demanding environments
  - No pores, cracks for bacteria to hide







# Life cycle cost benefit... Steel production Pre-consumer steel scrap Manufacturing Post-consumer steel Steel's life cycle Steel recycling Reuse and remanufacturing Use





### Life cycle cost benefit, cont'd...



## **SERVICE LIFE / REPLACEMENT COST**







# **STAINLESS STEEL**





# WHY STAINLESS?

## Stainless Steel: Various product forms...





**SLAB** 



# STAINLESS SEMI-FINISHED HTS 7218





## **HTS TERMINOLOGY**

Ingots >Tapered Cast Blocks) (7218.10.00)

**Generally Rectangles** > 150mm thick and width < 4 x Thickness Cross Section <u>></u> 232 cm<sup>2</sup>) = (7218.91.00.30)

Generally Billets > 100mm - 600mm Squares or Rounds (7218.99.00)

Generally Slab ≥150mm Thick x 900mm Wide and Width ≥ 4 x Thickness (7218.91.00.60)





# STAINLESS PLATE HTS 7219 & 7220 – FLAT ROLLED





- Flat Mill Plate (discrete) and Continuous Mill Plate (coil)
- 4.75mm nominal thickness // ≥ than 254mm wide
- <u>600mm and wider = HTS 7219 // < 600mm in width = HTS 7220</u>
- Annealed or Heat Treated and Pickled or Descaled
- Not further worked than Hot Rolled, Cold Rolled, or other
- Smooth Flat Surface Straight Square Edges
- Mill Test Report (Chemistry & Mechanical Properties)





# STAINLESS SHEET/STRIP HTS 7219 & 7220 – FLAT ROLLED



- Under 4.75mm thick
- <u>SHEET</u>: 600mm and wider = HTS 7219
- <u>STRIP</u>: Greater than 9.5mm to 600mm Wide = HTS 7220
- Annealed or heat treated and pickled or descaled
- Not Further Worked Than Hot Rolled, Cold Rolled, or Other
- Coil and Cut Length (Uncoiled)
- Mill Test Report (Chemistry & Mechanical Properties)



# STAINLESS BAR/ANGLE HTS 7222



- SCOPE DEFINITION: <u>Straight Lengths</u> // HTS DEFINITION: <u>Bars & Rods</u>
- Not Further Worked Than Hot Rolled or Cold Finished = Same Product
- Rounds, Hexagons, Squares, Flats, Shapes = 7222.11, .19, .20, and .30
- Angles & Structural Shapes = 7222.40
- Rebar Scope Definition not in HTS (Logical 7222.11.00.57/59)
- Specified Uniform Dimensional Tolerances
- Mill Test Report (Chemistry & Mechanical Properties)







- Irregularly Wound Hot Rolled Coils
- Hot Rolled Annealed and/or Pickled/Descaled
- Rounds or Shapes Generally 5.0mm 32mm
- Mill Test Report (Chemistry & Mechanical Properties)



# STAINLESS WIRE HTS 7223





- Tightly Wound Coils
- Cold <u>Drawn</u> or Cold <u>Rolled</u> from Rod
  - Rounds (7223.00.10)
  - Flats (7223.00.50)
  - Shapes (7223.00.90)
- Specified Uniform Dimensional Tolerances
- Mill Test Report (Chemistry & Mechanical Properties)




# WHAT'S IN A NAME?







# WHAT'S IN A NAME?

<b>AISI</b> Designation	• Type 304/L	
UNS Number	• S30403	
Composition	• 18-8	
Trade Names	Project 70	
Applications	<ul> <li>Machining / Forging / Redraw</li> </ul>	
Specification	• AMS-5639, ASTM-A-479	
Mill Test Report (MTR)	• 19 CFR 141.89 with CBP CF 7501	





# MANUFACTURING





# Steel Production: Basic Process Path







# 4.75 mm thick and up: - HTS 7219 > 600mm wide



- HTS 7220 < 600mm wide



HTS 7219.11 and .12 // 7220.11











### STAINLESS COLD ROLLED SHEET/STRIP

<4.75mm thick – HTS 7219 & 7220</p>
Not Further Worked Than Cold Rolled or Other





### MAKING A STAINLESS BILLET HTS 7218.99.00















Generally 18mm to 152.4mm Diameter – HTS 7222.11.00.57 & .59 Not Further Worked Than Hot Rolled





STAINLESS COLD FINISHED ROUNDS

Industry Standards 218mm – HTS 7222.20.00.62, .64, .67, & .69 Not Further Worked Than Cold Formed/Finished







### Industry Standards <18mm HTS 7222.20.00.41 & .43

#### Not Further Worked Than Cold Formed/Finished







# STAINLESS FAMILY







# **STAINLESS STEEL CLASSES**

CLASS 1	Martensitic	
CLASS 2	• Ferritic	
CLASS 3	Austenitic	
CLASS 4	Ph (Precipitation Hardened)	
CLASS 5	• Duplex	



All about MICROSTRUCTURE...



# STAINLESS STEEL CLASSES







# What is 'microstructure'?

# All metals and metal alloys have a crystalline structure...







# CLASS 1 MARTENSITIC

Chromium with Carbon Generally > .08%

**HARD** > Heat Treatable For Hardness/Strength

Heat to 1330° austenite phase... Quench fast... Martensite.

**Good Formability / Ductility** 

**Minimum Corrosion Resistance** 

Part of 400 Series Grades

Magnetic





# CLASS 1 MARTENSITIC







### CLASS 1 MARTENSITIC GRADES







# **MOST POPULAR ALLOYS** CLASS 1 MARTENSITIC

#### **CONTAINING < 15% CHROMIUM**

AISI Grade	UNS Number
410	<b>S41000</b>
416	<b>S41600</b>
420	<b>S42000</b>
<b>420F</b>	<b>S42020</b>

#### **CONTAINING > 15% CHROMIUM**

AISI Grade 440C

UNS Number S44004







# **CLASS 2 FERRITIC**



**Good formability / ductility.** 

Improved corrosion resistance

Not susceptible to stress corrosion cracking

**Remainder of 400 Series Grades** 

Magnetic











### CLASS 2 FERRITIC GRADES







### MUFFLER FERRITIC STAINLESS GRADE 409 ASTM A 240







# **MOST POPULAR ALLOYS CLASS 2 FERRITIC CONTAINING** > 15% CHROMIUM

**CONTAINING < 15% CHROMIUM** 

AISI Grade	<u>UNS Number</u>
409	<b>S40900</b>
<b>409Cb</b>	<b>S40940</b>



AISI Grade	<u>UNS Number</u>
430	<b>S43000</b>
<b>430F</b>	<b>S43020</b>
<b>430FR</b>	-
434	<b>S43400</b>





# **CLASS 3 AUSTENITIC**

70% of stainless grades are austenitic

Best Corrosion Resistance / higher temp. applications

**Excellent Formability and Weldability** 

200 & 300 Series Grades

**Non-Magnetic** 









### **CLASS 3 AUSTENITIC GRADES**





#### Laser Cut from Stainless Plate

### AUSTENITIC STAINLESS

**GRADE 304 / ASTM A 240** 









### VENTILATION EXHAUST

### AUSTENITIC STAINLESS

GRADE 304 / ASTM A 240









### Museum of Pop Culture

### 3,000 panels

### AUSTENITIC STAINLESS

**GRADE 304 / ASTM A 240** 





#### SKYSCRAPER ROOF AUSTENITIC STAINLESS GRADE 304 ASTM A 240







### Industrial Kitchen AUSTENITIC STAINLESS GRADE 304 // ASTM A240







## WINEMAKING VESSELS AUSTENITIC STAINLESS GRADE 304 ASTM A 240





## CONSTRUCTION





#### **Chesapeake Bay, USA**

316 ASTM A240 stainless steel is used for the roof and walls.

#### Maine, USA Private house clad in 304 ASTM A240 – 18 gauge sheet with a brushed finish







## Walt Disney Concert Hall AUSTENITIC STAINLESS GRADE 304 / ASTM A240






## **STAINLESS STEEL**

### 1967 Lincoln Continental 1936 Ford Tudor Sedan 1960 Ford Thunderbird





## MOST POPULAR ALLOY CLASS 3 AUSTENITIC

**CONTAINING**  $\geq$  8% - < 24% Nickel

CONTAINING <u>> 8%</u> - < 24% Nickel & > 1 1/2% - < 5% Molybdenum

AISI Grade	<u>UNS Number</u>
301	<b>S30100</b>
302	<b>S30200</b>
<b>302HQ</b>	<b>S30430</b>
303	<b>S30300</b>
304	<b>S30400</b>
<b>304L</b>	<b>S30403</b>
305	<b>S30500</b>
<b>308L</b>	<b>S30803</b>
321	<b>S32100</b>
347	<b>S34700</b>

<u>UNS Number</u>
<b>S31600</b>
<b>S31603</b>
<b>S20910</b>







# **CLASS 4 PH GRADES**

**Combination of High Strength and Good Corrosion Resistance** 

**Precipitation Hardening:** 

heat treat > increase yield strength

**Easy Heat Treatment With No Distortion** 

**Tradenames** 

**Aerospace driven** 









## **CLASS 4 PH GRADES**







## GOLF CLUB IRONS PH STAINLESS GRADE 17-4 (630) // ASTM A564







## MOST POPULAR ALLOYS CLASS 4 // PH GRADES

**CONTAINING** > 1/2% - < 24% Nickel

CONTAINING ≥ 24% Nickel & > 1/2% - < 5% Molybdenum

AISI Grade	<b>UNS Number</b>
630 (17-4 PH)	<b>S17400</b>
(15-5 PH)	<b>S15500</b>
631 (17-7 PH)	<b>S17700</b>









# **CLASS 5 DUPLEX ALLOYS**

**Chromium - Nickel - Moly** 

50% Austenite - 50% Ferrite

**Excellent Stress Corrosion Cracking Resistance** 

**Annealed Strength > 300 Series** 

**Good Fatigue Strength** 





# **CLASS 5 DUPLEX ALLOYS**

#### CONTAINING > 0.5% NICKEL & > 1/2% - < 5% MOLYBDENUM







## DEEP WELL DRILLING DUPLEX STAINLESS GRADE 2205 // ASTM A276







## REBAR FOR BRIDGE DECK DUPLEX STAINLESS GRADE 2205 // ASTM A955





# STAINLESS SUMMARY



- Why SS?
  - corrosion resistance / physical and mechanical properties
  - ease of fabrication / hygienic / recyclable
- Production Process 'Similar' to Carbon Steel
- Five stainless classes all unique based on microstructure
- 8 and 10 Digit HTS Category Based Upon Chemistry
  - Chrome, Nickel, Moly Content
  - Whether Hot Rolled or Cold Rolled/Finished







# **Additional Information:**

#### **SSINA**

- www.ssina.com
- Education, training, and this presentation available

#### **Nickel Institute**

www.nickelinstitute.org

#### **International Stainless Steel Forum**

www.worldstainless.org

	TIELP
SUPPOR	TAN
-	CSISTANCE
GUIDANC	E ASSIC
and	The second