STAINLESS STEEL PRODUCTS
TECHNICAL SEMINAR

• Basics
• Manufacturing
• Family/Applications
BASICS
STAINLESS STEELS IN THE ALLOY FAMILY
(HTS CHAPTER 72 IRON & STEEL)

COST

CORROSION RESISTANCE

NICKEL BASE ALLOYS
(ALSO CHAPTER 75)

STAINLESS STEELS

ALLOY STEELS

CARBON STEELS
WHAT MAKES STEEL (IRON & CARBON) STAINLESS
(PREDOMINATELY IRON & CHROMIUM)

EFFECT OF CHROMIUM ON ATMOSPHERIC CORROSION RESISTANCE

STAINLESS STEEL RANGE
(HTS 7218 – 7223)

10.5 % CHROMIUM

CORROSION RATE MILS PER YEAR
CORROSION PROTECTION

THE CHROMIUM OXIDE FILM PREVENTS FURTHER DIFFUSION OF OXYGEN ON THE SURFACE, THUS PROTECTING IRON IN THE MATRIX FROM RUSTING.
ALLOYING ELEMENTS

CHROMIUM  CORROSION & SCALING RESISTANCE
NICKEL  ACID CORROSION RESISTANCE, FORMABILITY, AND WELDABILITY
MOLYBDENUM  PITTING CORROSION RESISTANCE AND STRENGTH
NITROGEN  CREVICE CORROSION RESISTANCE AND STRENGTH
CARBON (1.2% MAX)  HARDNESS

SULFUR  MANGANESE  ALUMINUM
COPPER  COLUMBIUM  SILICON
TITANIUM  CALCIUM  SELENIUM
WHY STAINLESS

• Corrosion Resistance

• Mechanical Properties
MECHANICAL PROPERTIES

STRENGTH

YIELD STRENGTH

ULTIMATE TENSILE STRENGTH

HARDNESS

NOTE: AS STRENGTH INCREASES, DUCTILITY DECREASES
TENSILE TESTING

TENSILE SPECIMENS
TENSILE TESTING EQUIPMENT
WHY STAINLESS

- Corrosion Resistance
- Mechanical Properties
- Physical Properties
PHYSICAL PROPERTIES

include .....  
MAGNETIC PERMEABILITY  
THERMAL EXPANSION  
HEAT CONDUCTIVITY  
DENSITY
WHY STAINLESS

• Corrosion Resistance
• Mechanical Properties
• Physical Properties
• Ease of Fabrication
• Appearance, Hygienic, and Recyclable
• Life Cycle Cost Benefit
LIFE CYCLE COST BENEFIT

TOTAL COST

SERVICE LIFE / REPLACEMENT COST

CARBON STEEL

STAINLESS STEEL
STAINLESS SEMI-FINISHED
HTS 7218

INDUSTRY TERMINOLOGY

INGOTS

BLOOMS

BILLETs

SLABS

HTS TERMINOLOGY

Ingots (Tapered Cast Blocks) (7218.10.00)

Generally Rectangles > 150mm Thick and Width < 4 x Thickness
Cross Section ≥ 232 cm²) = (7218.91.00.30)

Generally 100mm -600 mm Squares, or Rounds (7218.99.00)

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

Semi-finished Stainless Sold To Specs with Only Chemistry and Capability on Mill Test Reports – No Mech Props
STAINLESS PLATE
HTS 7219 & 7220 – FLAT ROLLED

- 4.75 mm Thick *Nominal*, Equal/Greater than 254 mm Wide
- Flat Plate Mill (Discrete), and *Continuous Mill Plate Coil*
- Annealed or Heat Treated, and Pickled/Descaled
- 600 mm and Wider - 7219, < 600 mm - 7220
- Not Further Worked Than Hot Rolled, Cold Rolled, or Other
- Smooth Flat Surface - Straight Square Edges
- Mill Test Report (Chemistry & Mechanical Properties)

*NOTE: Items in *italic* font are in scope definition for orders, but not HTS*
STAINLESS SHEET/STRIP
HTS 7219 & 7220 – FLAT ROLLED

- Under 4.75 mm Thick
- 600 mm and Wider (Sheet) - 7219
  - Greater Than 9.5 mm to 600 mm Wide (Strip) - 7220
  - Annealed or Heat Treated, and Pickled/Descaled
- Not Further Worked Than Hot Rolled, Cold Rolled, or Other
- **Coil** and Cut Length (Uncoiled)
- Mill Test Report (Chemistry & Mechanical Properties)

NOTE: Items in *italic* font are in scope definition for orders, but not HTS
STAINLESS BAR/ANGLE
HTS 7222

• **Straight Lengths** = Scope Definition - Bars & Rods = HTS Definition
• 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)

**NOTE:** Items in *italic font* are in scope definition for orders, but not HTS
STAINLESS ROD
HTS 7221

- 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)

NOTE: Items in *italic font* are in scope definition for orders, but not HTS
STAINLESS WIRE
HTS 7223

- Tightly Wound Coils
- Cold Drawn Or Cold Rolled 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
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<tbody>
<tr>
<td><strong>AISI Designation</strong></td>
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<td><strong>Mill Test Report</strong></td>
<td>19 CFR 141.89 with CBP CF 7501</td>
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</table>
MANUFACTURING
MAKING A STAINLESS PLATE

4.75 mm Thick & Larger
- HTS 7219 ≥ 600mm
- HTS 7220 < 600mm

STAINLESS SCRAP + RAW MATERIALS ADDED TO EAF

Melt + AOD + CASTING = CAST SLAB

CAST SLAB

ANNEAL

PICKLE

DISCRETE PLATES
(7219.21, .22 & 7220.11)

ANNEAL

PICKLE

(7219.11, .12 & 7220.11)

COILED PLATES

NOTE: AOD = ARGON OXYGEN DECARBORIZATION

HOT ROLLING (Not Further Worked Than Hot Rolled)
STAINLESS HOT ROLLED SHEET

Less Than 4.75 mm Thick (HTS 7219.13, .14, .23, .24)
Not Further Worked Than Hot Rolled

NOTE: AOD = ARGON OXYGEN DECARBORIZAION
STAINLESS COLD ROLLED SHEET/STRIP
Less Than 4.75 mm Thick (HTS 7219 & 7220)
Not Further Worked Than Cold Rolled or Other

COLD ROLLED 2D SHEET

HOT ROLLED SHEET
COLD ROLLING

ANNEAL
PICKLE

SENDZIMIR MILL

2B SHEET
≥600 MM WIDE
(7219.32, .33, .34, .35, .90)

CUT
POLISH
SLIT

STRIP
< 600 MM WIDE
(7220.20, .90)
MAKING A STAINLESS BILLET
HTS 7218.99.00

**ELECTRIC ARC FURNACE**

STAINLESS SCRAP + RAW MATERIALS

Melt + AOD = INGOT + CASTING

Melt + AOD = INGOT + REMELT

Melt + VAR or ESR = REMELT + CAST BILLET

CAST BILLET = ROLLED BILLET = VAR OR ESR BILLET

NOTE: VAR = VACUUM ARC REMELT
ESR = ELECTROSLAG REMELT
FORGED ROUND BAR

Generally 152.4 mm and Larger, Not Further Worked Than Hot Worked (HTS 7222.11.00.82 & .84)

STAINLESS SCRAP
+ RAW MATERIALS
ADDED TO EAF

MELT

AOD

INGOT

FORGE

ANNEAL

STRAIGHTEN

HOT FORGED

NOTE: AOD = ARGON OXYGEN DECARBORIZATION
ROLLED ROUND BAR

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

BILLET/BLOOM + HOT ROLL + ANNEAL

STRAIGHTEN = HOT ROLLED
STAINLESS COLD FINISHED ROUNDS

Industry Standards ≥ 18 mm HTS 7222.20.00.62, .64, .67, & .69
Not Further Worked Than Cold Formed/Finished

Forged Annealed

- As Turned
- Rough Grind
- Burnish
- Polish
- CG
- CG & Belt
- Cold Drawn

Rolled Annealed

- Peel
- Rough Grind
- Burnish
- Polish
- CG
- CG & Belt
- Draw

Forging Quality

- Rough Turned
- 125 RMS
- Hot Finished Tolerances

- Forging Quality
- 100 RMS

Cold Finished Tolerances

- Smooth Turned
- 50 RMS

- CGE
- 50 ≤ 38mm
- 70 > 38mm

- Centerless Ground
- 50 ≤ 38mm
- 70 > 38mm

- CG & Polish
- 32 RMS

- Cold Drawn
- RMS N/A
COIL TO COLD FINISHED BAR
Industry Standards < 18 mm
HTS 7222.20.00.41 & .43
Not Further Worked Than Cold Formed/Finished

Billet + Rod Coil Rolling + Anneal or Anneal Pickle

Draw + Straighten & Cut

Peel + Straighten & Cut

Cold Drawn
Burnish
RMS N/A
Cold Drawn
Burnish & Polish
RMS N/A
Centerless Ground
CG
50 RMS
CG & Polish
32 RMS
Belt Finish
CGE
50 RMS
STAINLESS FAMILY
STAINLESS STEEL CLASSES

Class 1 - Martensitic
Class 2 - Ferritic
Class 3 - Austenitic
Class 4 - PH (Precipitation Hardened)
Class 5 - Duplex
CLASS 1  MARTENSITIC

• Chromium With Carbon Generally $\geq 0.08\%$
• Heat Treatable For Hardness/Strength
• Tempered to Improve Ductility
• Minimum Corrosion Resistance
• Magnetic
• Part of 400 Series Grades
CLASS 1  MARTENSITIC GRADES

GUN BARREL
T-416R

KNIFE BLADE
T-410

PUMP CAP SCREW
T-410

DENTAL INSTRUMENTS
T-440C

STEAM TURBINE BLADE
T-410Cb ESR
## MOST POPULAR ALLOYS
### CLASS 1  MARTENSITIC

<table>
<thead>
<tr>
<th>AISI Grade</th>
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<tr>
<td>410</td>
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<td>416</td>
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<td>420F</td>
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<td>440C</td>
<td>S44004</td>
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CLASS 2  FERRITIC

- Chromium With Carbon ≤ .06%
- Not Hardenable Except By Cold Working
- Improved Corrosion Resistance
- Not Susceptible to Stress Corrosion Cracking
- Magnetic
- Remainder of 400 Series Grades
CLASS 2  FERRITIC

409Cb
11Cr  Ti

ECONOMICS

439
17Cr  Ti

WELDABILITY

430
17Cr .05C

MACHINABILITY

430F
.35 Sul

SOLENOID QUALITY

444
2 Mo

CORROSION RESISTANCE

446
25 Cr

OXIDATION RESISTANCE
CLASS 2  FERRITIC GRADES
MUFFLER
FERRITIC STAINLESS GRADE 409
ASTM A 240
# MOST POPULAR ALLOYS

## CLASS 2  FERRITIC

### CONTAINING < 15% CHROMIUM

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>409</td>
<td>S40900</td>
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<td>409Cb</td>
<td>S40940</td>
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### CONTAINING ≥ 15% CHROMIUM

<table>
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<tr>
<td>430</td>
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<tr>
<td>430F</td>
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<td>434</td>
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</table>
CLASS 3 AUSTENITIC

- Chrome – Nickel - Manganese
- Not Hardenable Except By Cold Working
- Best Corrosion Resistance
- Non Magnetic
- Excellent Formability and Weldability
- 200 & 300 Series Grades
CLASSES 3 AUSTENITIC

304
18CR8NI
.08 Max C

WELDING
347
321
Ti 8xC

HI TEMP
SERVICE
310
309
25CR 12 Ni

SCALING
RESISTANCE
302
301
17Cr 7Ni

WORK HARDENING
201

316L
16Cr 10Ni 2Mo

316
317L

304H

CHLORIDE CORROSION
RESISTANCE

304L
.03Max C

303
303Se

MACHINABILITY
303
35Sul
303Se

XM28
.30N
316N
.15N
XM19
.30N

X28N
.15N
304N
.15N

STRENGTH

305
18Cr 11Ni

302HQ

HIGH

LOW

301
17Cr 7Ni

302

302HQ

305
18Cr 11Ni

XM28
.30N
316N
.15N
XM19
.30N
CLASS 3  AUSTENITIC GRADES
SKYSCRAPER ROOF
AUSTENITIC STAINLESS GRADE 304
ASTM A 240
PAVILION
AUSTENITIC STAINLESS GRADE 304
ASTM A 240
KITCHEN APPLIANCES
AUSTENITIC STAINLESS GRADE 304
ASTM A 240
COOKING UTENSILS
AUSTENITIC STAINLESS GRADE 304
ASTM A 240
WINEMAKING VESSELS
AUSTENITIC STAINLESS GRADE 304
ASTM A 240
STAINLESS SOLAR COLLECTORS

Austenitic Grade 304 ASTM A 240 parabolic mirrors concentrate solar heat to drive a Stirling engine and generator to produce electricity.
CONSTRUCTION

Maine, USA
Private house clad in
304 ASTM A 240 – 18 gauge
sheet with a brushed finish

Tom Selleck home by an
architect Chesapeake Bay,
USA

316 ASTM A 240 stainless
steel is used for the roof
and walls
KITCHEN SINK
AUSTENITIC STAINLESS GRADE 301
ASTM A 240
SUBWAY & LIGHT RAIL CARS
AUSTENITIC STAINLESS GRADE 201
ASTM A 240
STRUCTURE – BOTANICAL GARDEN
AUSTENITIC STAINLESS GRADE 304
ASTM A 276 & A 240
POULTRY PROCESSING
AUSTENITIC STAINLESS GRADE 304L
ASTM A 276
1981 DELOREAN
AUSTENITIC STAINLES GRADE 304
ASTM A 240
1936 STAINLESS STEEL FORD
AUSTENITIC STAINLESS GRADE 304
ASTM A 240
MEMORIAL STRUCTURE
AUSTENITIC STAINLESS GRADE 304
ASTM A 240
## MOST POPULAR ALLOYS
### CLASS 3  AUSTENITIC

<table>
<thead>
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<th>UNS Number</th>
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<td>347</td>
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CONTAINING ≥ 8% - < 24% Nickel & > 1 1/2% - < 5% Molybdenum
CLASS 4 PH GRADES

• Combination of High Strength and Good Corrosion Resistance
• Precipitation Hardening
• Easy Heat Treatment With No Distortion
• Tradenames
CLASS 4 PH GRADERS

- **MARTENSITE to MARTENSITE**
  - 17-4PH (630)
  - 17Cr 4Ni 3Cu
  - Custom 450
  - 15-5PH
  - 15Cr 5Ni 3Cu

- **AUSTENITE to MARTENSITE**
  - 17-PH (631)
  - 17Cr 7Ni 1Al
  - PH 15-7Mo

- **AUSTENITE to AUSTENITE**
  - A-286
  - 15Cr 25Ni 2Ti

**FORMABILITY**

**HIGH TEMP PROPERTIES**

**TRANSVERSE PROPERTIES**

- PH138- Mo
  - 13Cr 8Ni 2Mo 1Al

**HIGHER STRENGTH & TOUGHNESS**

Most grades are registered trade names

**NOTE:** Elements in ITALICS form the precipitate when combined with Ni
CLASS 4 PH GRADES

JET ENGINE SEAL
T-630 (17-4)

HARLEY-DAVIDSON WHEEL AXLE
T-630 (17-4)
GOLF CLUB IRONS
PH STAINLESS GRADE 17-4 (630)
ASTM A 564
MOST POPULAR ALLOYS
CLASS 4 PH GRADES

CONTAINING > 1/2% - < 24% Nickel

<table>
<thead>
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<th>AISI Grade</th>
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<tbody>
<tr>
<td>630 (17-4 PH)</td>
<td>S17400</td>
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<tr>
<td>(15-5 PH)</td>
<td>S15500</td>
</tr>
<tr>
<td>631 (17-7 PH)</td>
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CONTAINING ≥ 24% Nickel & > 1/2% - < 5% Molybdenum

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<th>AISI Grade</th>
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<tr>
<td>(A-286)</td>
<td>S66286</td>
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</tbody>
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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

2205  
(UNS S31803) 
22Cr 5Ni 3Mo

OTHER SIGNIFICANT GRADES  
2304  Ferralium 255  2507  
(S32304)  (S32550)  (S32750)
DEEP WELL DRILLING
DUPLEX STAINLESS GRADE 2205
ASTM A 276
REBAR FOR BRIDGE DECK
DUPLEX STAINLESS GRADE 2205
ASTM A 955
STAINLESS SUMMARY

• Predominately Iron with 10.5% Min. Chrome, 1.2% Max. Carbon
• Trade Case Scope Definition not Same as HTS
• Mill Test Report Chemistry Only - Semi Finished HTS 7218
  - Manufacturer + Country of Origin
• Mill Test Report Sheet/Strip, Plate, Bar, Rod/Wire
  - Required by 19 CFR 141.89 with Submission of CBP CF 7501
  - Manufacturer + Country of Origin
• Production Process Similar to Carbon Steel
• Grade Name Has no Number Significance
• 8 & 10 Digit HTS Category Based Upon Chemistry (Chrome, Nickel & Moly Content), and whether Hot Rolled or Cold Rolled/Finished
CONTACTS

- www.ssina.com (Education – Training Section for Downloading Copy of This Presentation)
- www.nidi.org
- www.worldstainless.org
- ED BLOT & ASSOCIATES, INC. eblot@aol.com