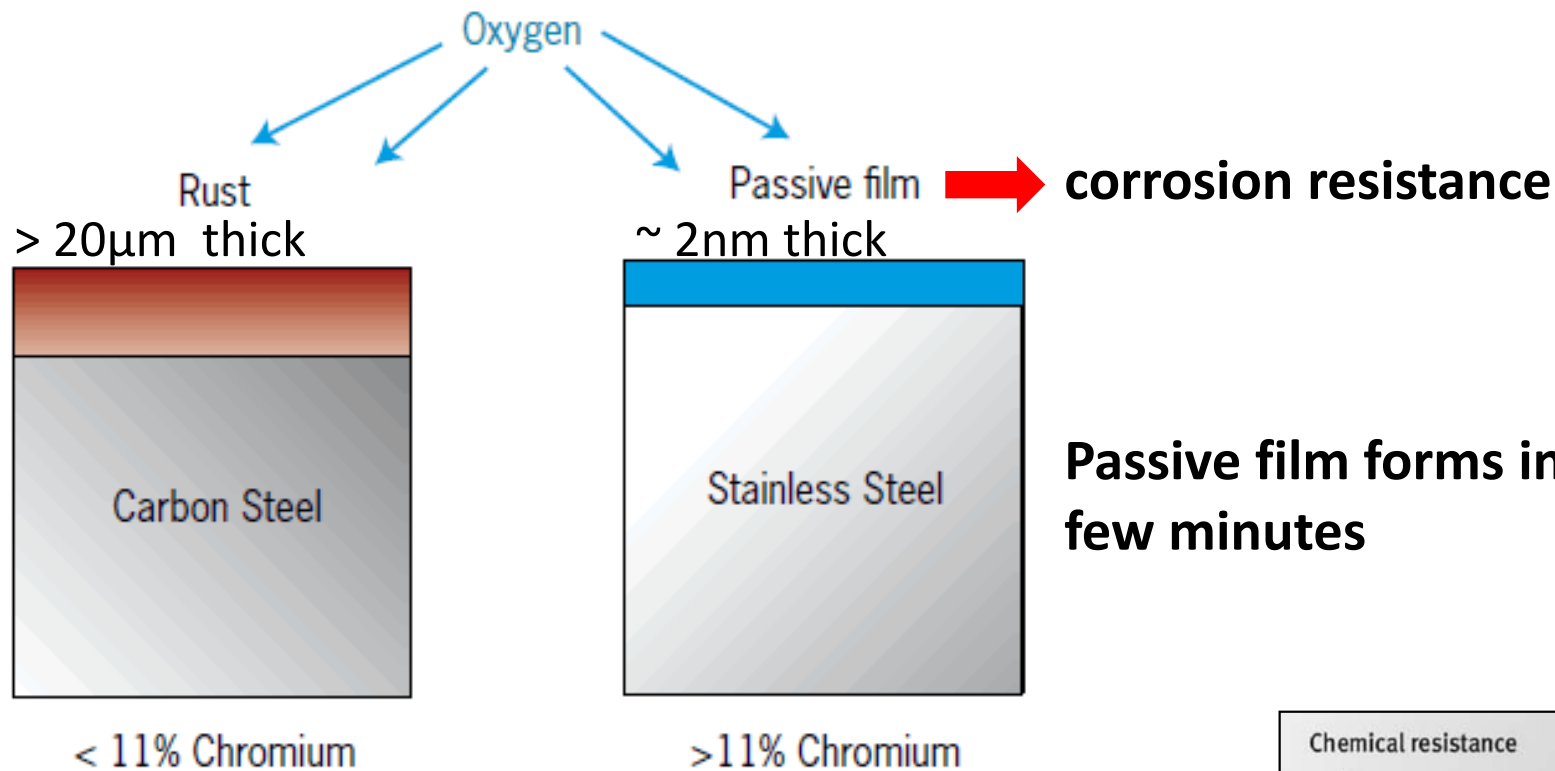
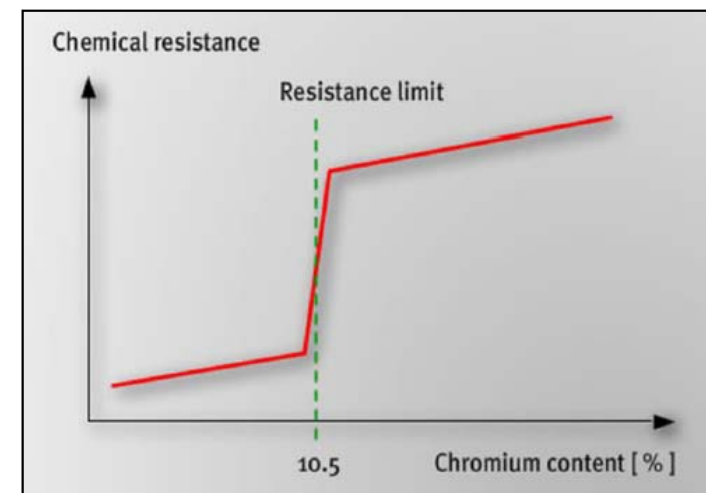
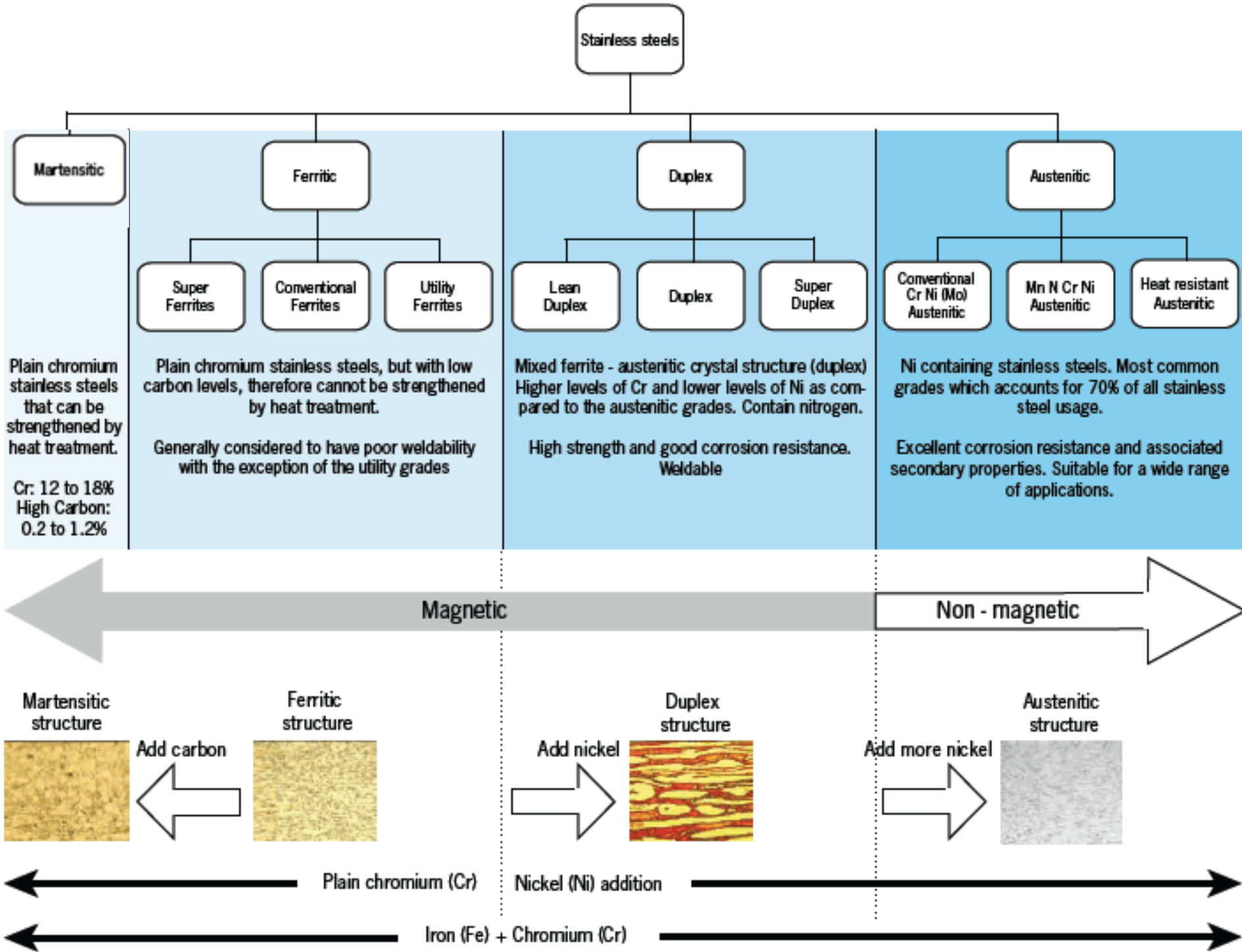


Stainless steels are: Iron-base alloys containing at least 10.5% chromium



Increasing Cr content increases the effectiveness of the passive film... but there are other important factors that influence the corrosion resistance (see Chapter 3)





Cr-Ni (Mo)Austenitics

Material	Thermal expansion coefficient , $10^{-6} \text{ }^\circ\text{K}^{-1}$	Thermal conductivity, $\text{W }^\circ\text{m}^{-1} \text{ }^\circ\text{K}^{-1}$
Austenitics	18	15
Ferritics	10	25
Duplex	14	15
Martensitics	8	24
Carbon steel	12	18
Aluminum	22	230
Copper	17	380
Concrete	10	1

Common Properties:

- Non Magnetic
- High expansion coefficient (compared to C-Steels)
- Low heat conductivity
- Very good corrosion resistance, increases with alloy content
- ...but can be susceptible to SCC in hot chloride environments (e.g. swimming pools)
- High ductility and impact resistance at all (including very low) temperatures
- Strength can be increased by cold working (but not by heat treatment)
- Very good fire resistance
- Very good cold and hot forming properties (ductility, elongation)
- Easy to weld (TIG, MIG)

Sub-groups:

- Cr-Ni (Typically 304 /4301)
- Cr – Ni – Mo (Typically 316/4401)

Color code:

- Physical properties
- Corrosion resistance
- Mechanical properties
- Fabrication

The best known and still the most used today

Cr-Mn Austenitics

Main differences with Cr-Ni austenitics

- Fair corrosion resistance
- ...but far more susceptible to SCC and to pitting, particularly at low Ni and Cr levels
- Higher strength
- Poor cold forming properties due to high work-hardening
- Poor machinability
- More difficult to weld
- Cost less

Material	Thermal expansion coefficient , $10^{-6} \text{ } ^\circ\text{K}^{-1}$	Thermal conductivity, $\text{W } ^\circ\text{m}^{-1} \text{ } ^\circ\text{K}^{-1}$
Austenitics	18	15
Ferritics	10	25
Duplex	14	15
Martensitics	8	24
Carbon steel	12	18
Aluminum	22	230
Copper	17	380
Concrete	10	1

Used mostly in India and China

Ferritics

Common Properties:

- Magnetic
- Low thermal Expansion coefficient close to that of C-Steels
- Good Heat conductivity
- Insensitive to Stress Corrosion Cracking
- Good ductility (lower than austenitic grades, though)
- Not suitable for use at very low temperatures
- Strength can be somewhat increased by cold working (but not by heat treatment)
- Very Good cold forming properties: (less springback, lower tool wear but lower elongation requires a different deep drawing process compared to austenitics)
- Stabilized grades (ie with Nb and/or Ti) are easy to weld (TIG, MIG)

Sub-groups:

- Cr (Typically 430 /4016)
- Cr – Mo (Typically 444/4539)

<u>Material</u>	Thermal expansion coefficient , $10^{-6} \text{ }^{\circ}\text{K}^{-1}$	Thermal conductivity, $\text{W }^{\circ}\text{m}^{-1} \text{ }^{\circ}\text{K}^{-1}$
<u>Austenitics</u>	18	15
<u>Ferritics</u>	10	25
<u>Duplex</u>	14	15
<u>Martensitics</u>	8	24
<u>Carbon steel</u>	12	18
<u>Aluminum</u>	22	230
<u>Copper</u>	17	380
<u>Concrete</u>	10	1

Offer a an optimum performance /cost for many applications and are increasingly used

Duplex (also called Austenitic-Ferritic)

Common Properties:

- Magnetic
- Expansion coefficient intermediate between ferritic and austenitics)
- Low heat conductivity
- Excellent corrosion resistance, increases with alloy content
- Insensitive to Stress Corrosion Cracking
- High strength, Good ductility
- Strength can be increased by cold working (but not by heat treatment)
- Good cold and hot forming properties (ductility, elongation)
- Weldable (TIG, MIG)

Sub-groups:

- Cr-Ni (Typically /4362)
- Cr – Ni – Mo (Typically /4462)

Material	Thermal expansion coefficient , $10^{-6} \text{ } ^\circ\text{K}^{-1}$	Thermal conductivity, $\text{W } ^\circ\text{m}^{-1} \text{ } ^\circ\text{K}^{-1}$
Austenitics	18	15
Ferritics	10	25
Duplex	14	15
Martensitics	8	24
Carbon steel	12	18
Aluminum	22	230
Copper	17	380
Concrete	10	1

Offer the best combination of corrosion resistance and mechanical properties

Martensitics

Common Properties:

- Magnetic
- Low thermal expansion coefficient
- Good heat conductivity
- Fair to good corrosion resistance, increases with alloy content
- High strength obtained by heat treatment (not by cold work).
Limited elongation
- Not suitable for use at very low temperatures
- Not suitable for forming, often processed by machining
- Can be welded (TIG, MIG) , but require usually post-weld heat treatment

Sub-groups:

- C- Cr (Typically 420/4028)
- C-Cr-Ni (Typically /4313)
- Precipitation Hardening (17/4 PH/4542)

Material	Thermal expansion coefficient , $10^{-6} \text{ }^\circ\text{K}^{-1}$	Thermal conductivity, $\text{W }^\circ\text{m}^{-1} \text{ }^\circ\text{K}^{-1}$
Austenitics	18	15
Ferritics	10	25
Duplex	14	15
Martensitics	8	24
Carbon steel	12	18
Aluminum	22	230
Copper	17	380
Concrete	10	1

Are used as engineering steels with corrosion resistance

Chemical Composition of Stainless Steels

Main World Standards:

ISO



EN



ASTM/AISI



UNS



JIS



Notes:

Most countries refer to the above standards, which are widely accepted.

A lot of the grades are very similar in all of the above standards.

Correspondance tables are available:

[http://www.worldstainless.org/what is stainless steel/standards](http://www.worldstainless.org/what_is_stainless_steel/standards)

Main grades in ABC: EN 10088-4 (for sheet/plate/strip)

Grade	ASTM UNS	C Wt%	Cr Wt%	Ni Wt%	Mo Wt%	Other Wt%	Typical use ^{3,4}
4003	S40977	0,02	11,5	0,5	-	-	heated and unheated interiors
4016	430	0,04	16,5	-	-	-	decorative interior cladding
4509	S43932	0,02	18	-	-	Nb Ti	inland roofing and rainwater goods - often Tin-coated for patina
4510	439	0,02	17	-	-	Ti	
4521	444	0,02	17,8	-	2,1	Ti	domestic plumbing market
4301	304	0,04	18,1	8,1	-	-	building interiors and exteriors in normal industrial atmospheres away from the coast
4307	304L	0,02	18,1	8,1	-	-	
4306	304L	0,02	18,2	10,1	-	-	
4401	316	0,04	17,2	10,1	2,1	-	permanently wet applications, locations in a coastal atmosphere, polluted industrial atmospheres or near roads where de-icing salts can be an issue
4404	316L	0,02	17,2	10,1	2,1	-	
4571	316Ti	0,04	16,8	10,9	2,1	Ti	
4529	N08926	0,01	20,5	24,8	6,5	N, Cu	road tunnels and indoor swimming pools
4547		0,01	20,0	18,0	6,1	N, Cu	
	S31254						

ABC = Architecture, Building and Construction

Main grades in ABC: EN 10088-5(for bars/wires/sections)

Grade	ASTM UNS	C Wt%	Cr Wt%	Ni Wt%	Mo Wt%	Other Wt%	Typical use ⁶
4003	S40977	0,02	11,5	0,5	-	-	
4016	430	0,04	16,5	-	-	-	Slate hooks
4542	630	0,04	16,0	4,0		Cu,Nb	Tie bars
4301	304	0,04	18,11	8,1	-	-	Rebar A2 fasteners
4307	304L	0,02	8,118	8,1	-	-	
4311	304N	0,02	,1	8,6	-	N	
4567	304Cu	0,02	17,1	8,6	-	Cu	
4401	316	0,05	16,6	10,1	2,1	-	Building interiors and exteriors in normal industrial atmospheres away from the coast, Rebar
4404	316L	0,02	16,6	10,1	2,1	-	
4429	« 316LN »	0,02	16,6	11,1	2,6	N	
4529	« 926 »	0,01	20,5	24,8	6,5	N, Cu	Road tunnels and indoor swimming pools
4547	S31254	0,01	20,0	18,0	6,1	N, Cu	
4362	S32304	0,02	22,5	3,6	0,3	N, Cu	Rebar and mechanical components
4462	S32205	0,02	21,5	4,6	2,8	N	Rebar and mechanical components

References

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2. Chemical composition of stainless steel long products for general purposes to EN 10088-3: <http://www.bssa.org.uk/topics.php?article=46>
3. EN 10088-4:2009 Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
4. EN 10088-5: 2009 Stainless steels. Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes.
5. Stainless steel flat products for building – the grades in EN 10088-4 explained: http://www.euro-inox.org/pdf/build/EN10088-4_EN.pdf
6. http://www.worldstainless.org/Files/issf/non-image-files/PDF/ISSF_The_Ferritic_Solution_English.pdf
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8. http://www.worldstainless.org/Files/issf/non-image-files/PDF/Practical_Guidelines_for_the_Fabrication_of_Duplex_Stainless_Steels.pdf