Supporting presentation for lecturers of Architecture/Civil Engineering

Chapter 05:
Corrosion Resistance of Stainless Steels

Contents

1. Most materials decay over time

Most materials decay over time

Material	Wood	Steel	Concrete
			
Type of decay	Fungi Insects Sun+rain	Rust	Cracking/ Spalling
Mitigating actions	Chemicals Paint/varnish	Galvanising Painting	Corrosion resistant rebar

Most materials decay over time

Material	Stone	Glass	Polymers
			
Type of decay	Wear Damage by Pollution	Breaks	Become brittle under UV light
Mitigating actions	Usually none taken	Tempered glass	Improved polymer grades

Most materials decay over time

Material	Aluminum*	Copper	Stainless
			
Type of decay	Pitting over time, possible galvanic corrosion	Forms a green patina over time	No decay
Mitigating actions	Galvanic corrosion can be prevented	None	None required

* Aluminum forms a thin protective oxide just like stainless, but with a much lower corrosion resistance

Corrosion in concrete
(corrosion problems are not limited to outside surfaces !)

Stainless steel provides both strength and corrosion resistance inside the concrete, providing a long, maintenance-free service life of the structure.

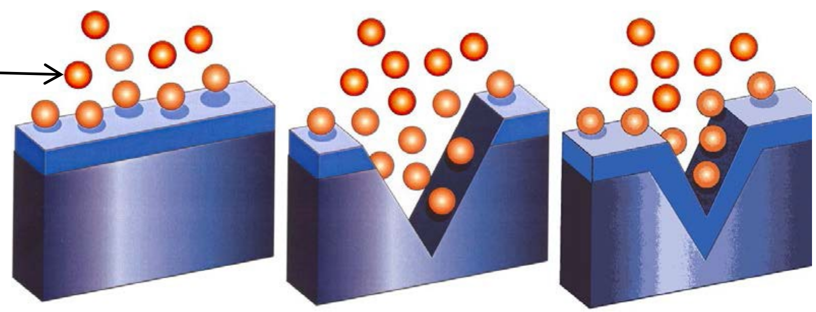
- Corrosion of unprotected carbon steel occurs even inside reinforced concrete structures as chlorides present in the environment (marine/deicing) diffuse through the concrete.
- Corrosion products (rust) have a higher volume than the metal, create internal tensions causing the concrete cover to spall.
- Mitigating the corrosion of steel reinforcing bar in concrete is a must.
- Various techniques are used: thicker concrete cover; cathodic protection; membranes, epoxy coating … **and stainless steel** rather than C-Steel.

2. Why does stainless steel resist corrosion

Passive Layer vs. Coatings

PASSIVE FILM on STAINLESS STEEL:
Oxy-hydroxides of Fe and Cr

Oxygen



2-3 nm thick
(0,002-0,003 µm)

Transparent
Adherent
Self repairing

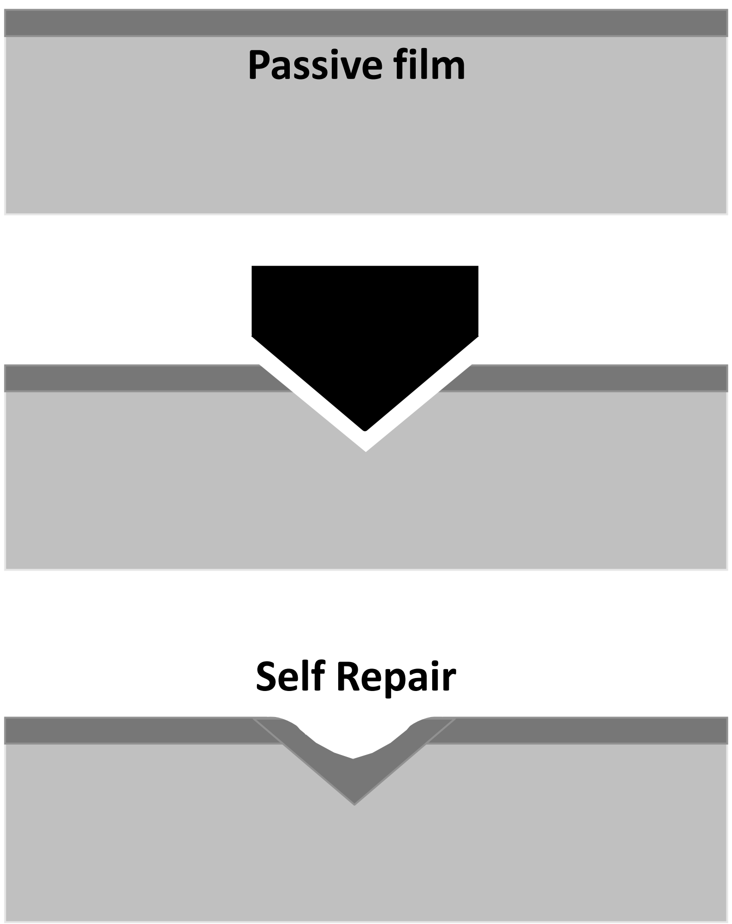
MULTI-LAYER COATINGS

Topcoat
Coat
Primer

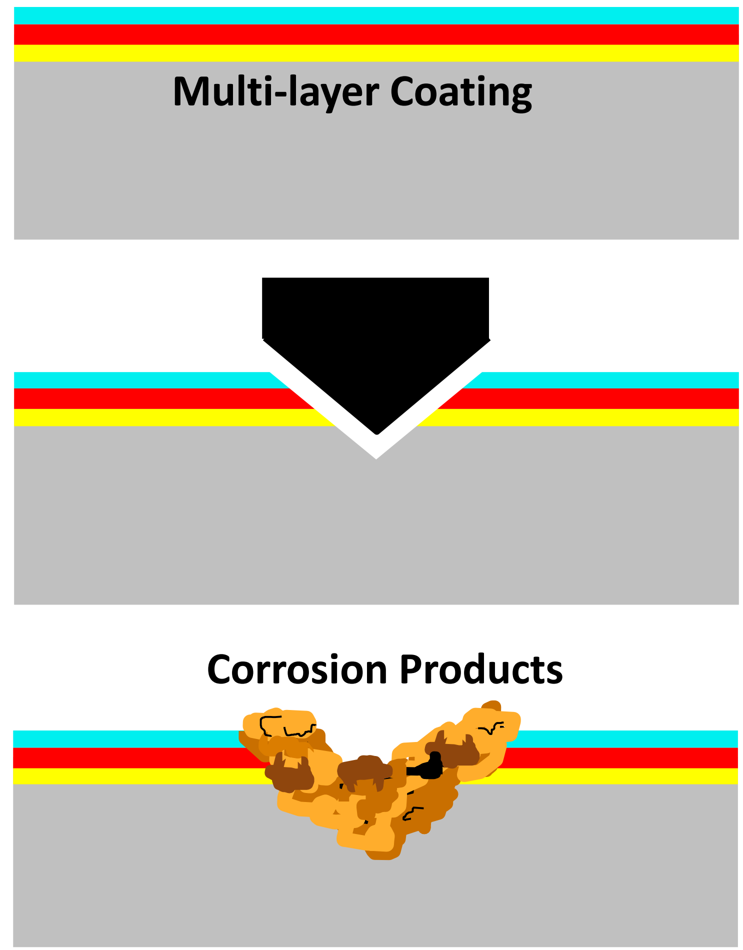
Typically
20-200 µm thick
May peel off
Not self-repairing

Damage to protective layer

Stainless Steel

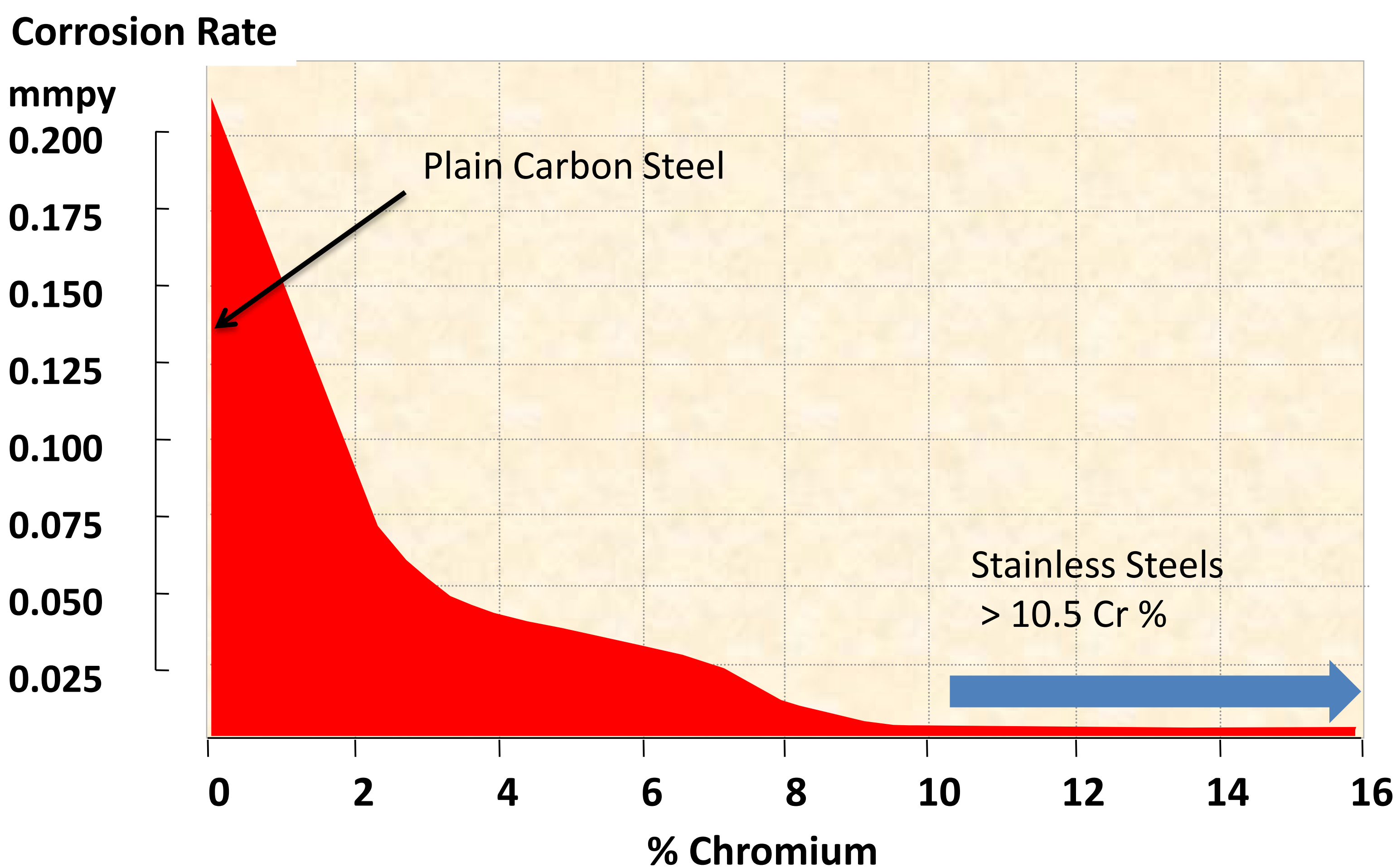


Mild Steel



3. Types of corrosion of stainless steels

Effect of Chromium Content on Atmospheric Corrosion Resistance (uniform corrosion)



When the selection of the stainless steel grade has not been properly made, corrosion may occur

…no material is perfect!

think of it as selecting the right vehicle for the intended use

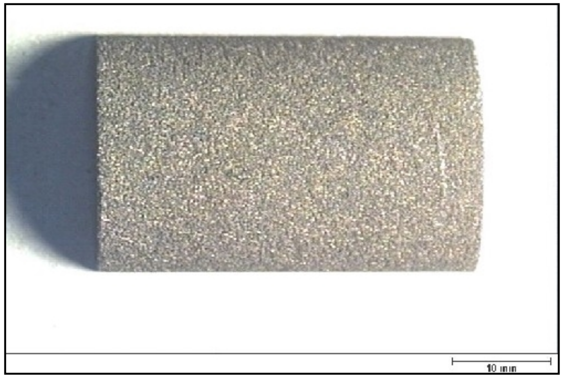
Types of corrosion on stainless steels

a) Uniform
b) Pitting
c) Crevice
d) Galvanic
e) Intergranular
f) Stress corrosion cracking

See Reference 1

a) What is uniform corrosion?

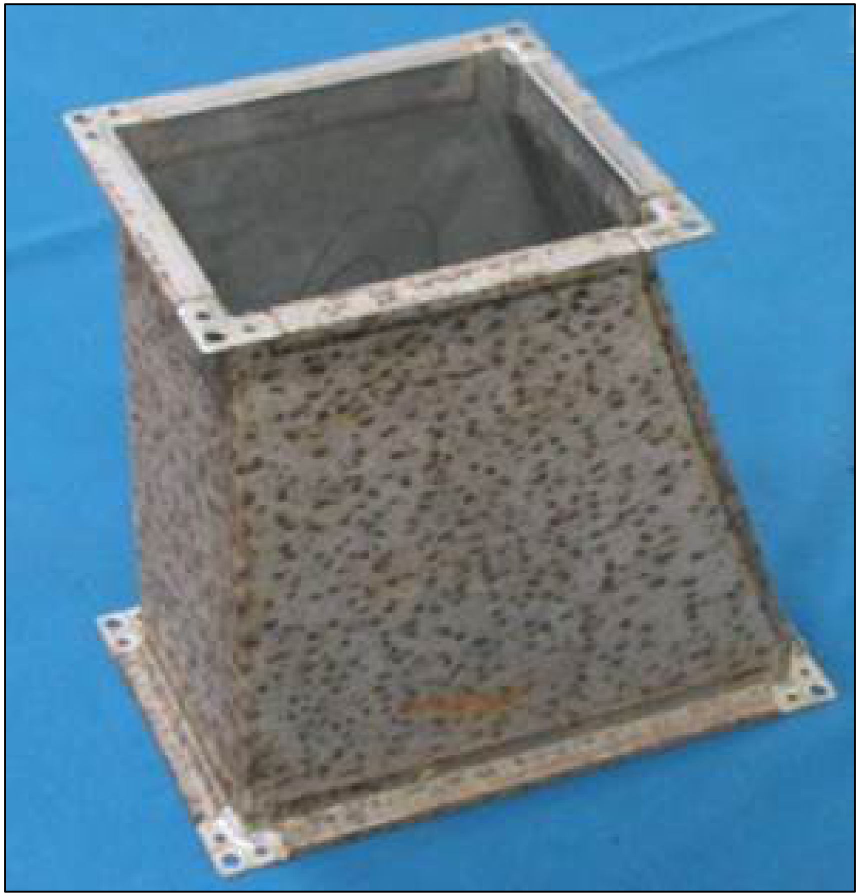
- When the passive film is destroyed by the aggressive environment, the whole surface corrodes uniformly and metal loss can be expressed as µm/year
- This is typical of unprotected Carbon steels.
- This does not occur on stainless steels in the building industry, as the corrosion conditions are never that aggressive (it requires typically immersion in acids)



b) What is pitting corrosion[1,2,3,7]?

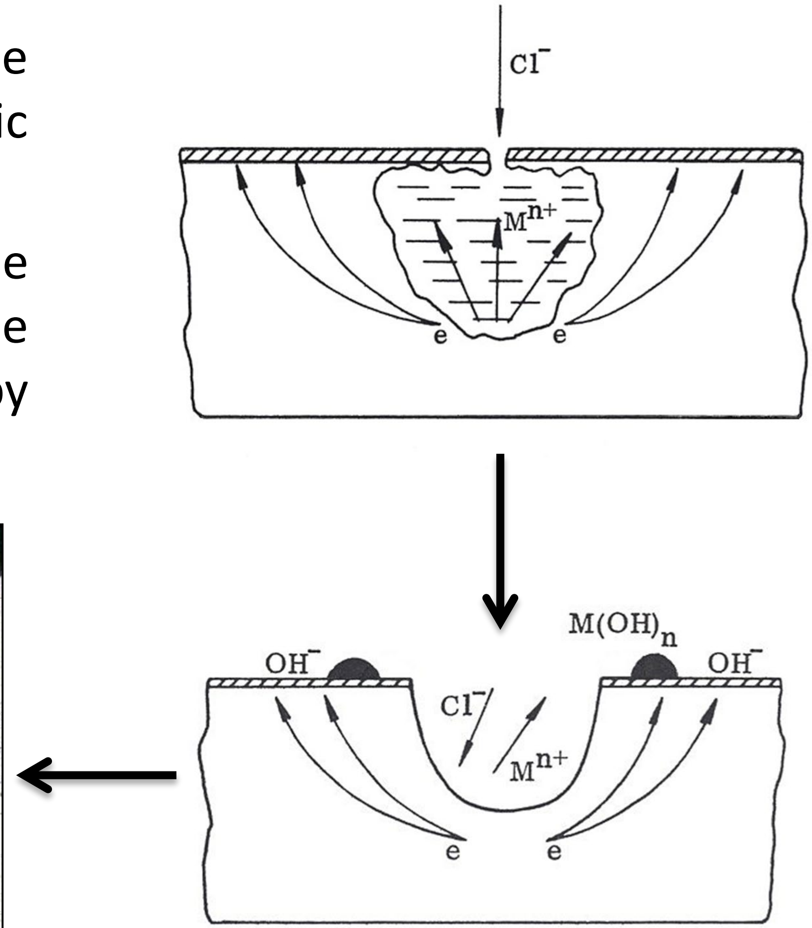
Pitting corrosion, or pitting, is a form of extremely localized corrosion that leads to the creation of small holes in the metal.

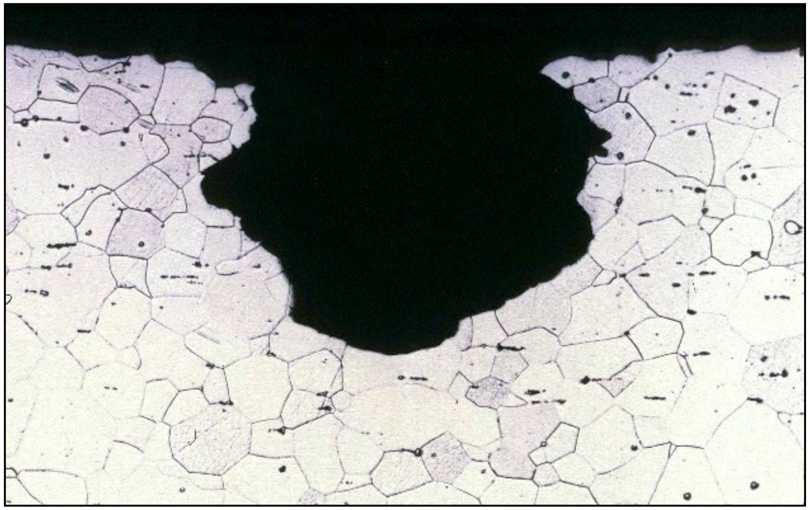
This picture shows pitting of stainless steel EN1.4310 (AISI 301) resulting from insufficient corrosion resistance in a very aggressive chlorinated environment.



Pitting corrosion mechanisms

1. Initiation on a very small surface irregularities or non-metallic inclusions
2. Propagation as the electrochemical reactions in the pit cavity are not prevented by re-passivation

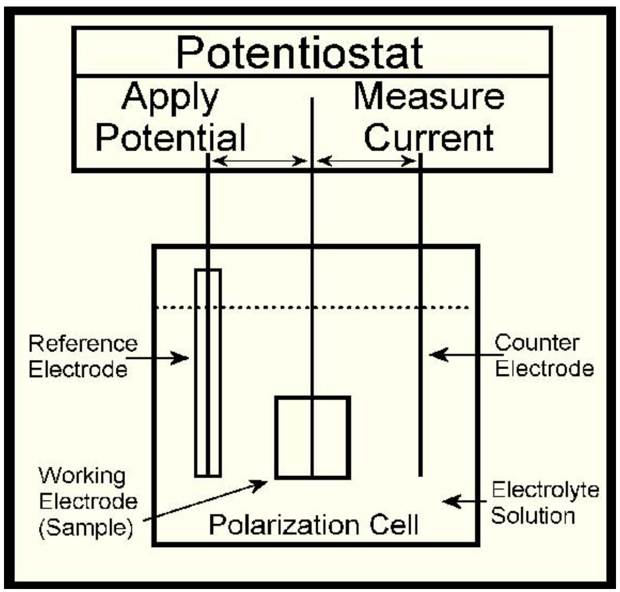




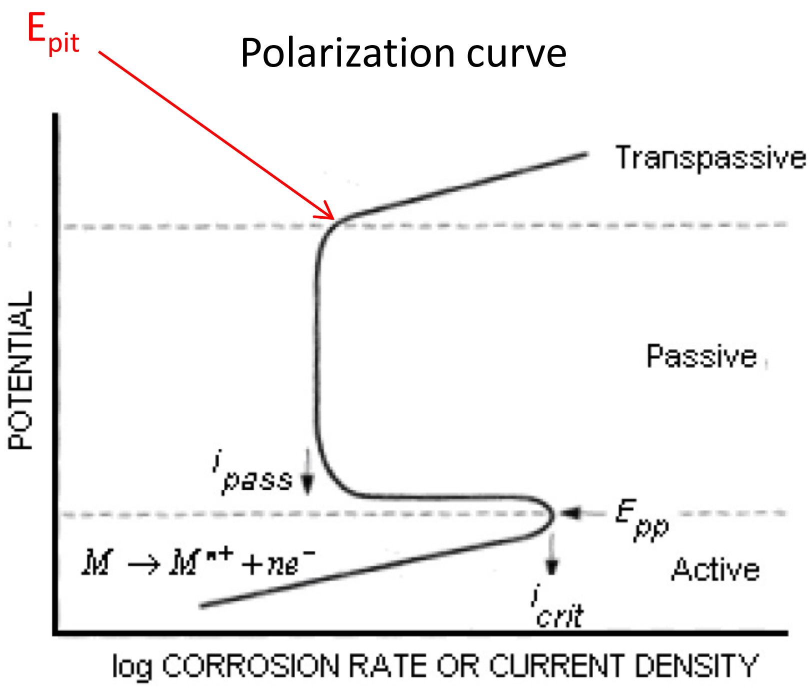
Pitting can be reproduced in an electrochemical cell[4]

- Corrosion involves the dissolution of metal, i.e. an electrochemical process with
  a) electrochemical reactions at the surface of the metal and
  b) a current between the corroding metal (anode) and a cathodic part
- These processes can be simulated in an electrochemical cell, a device that allows the study of corrosion processes

Electrochemical cell



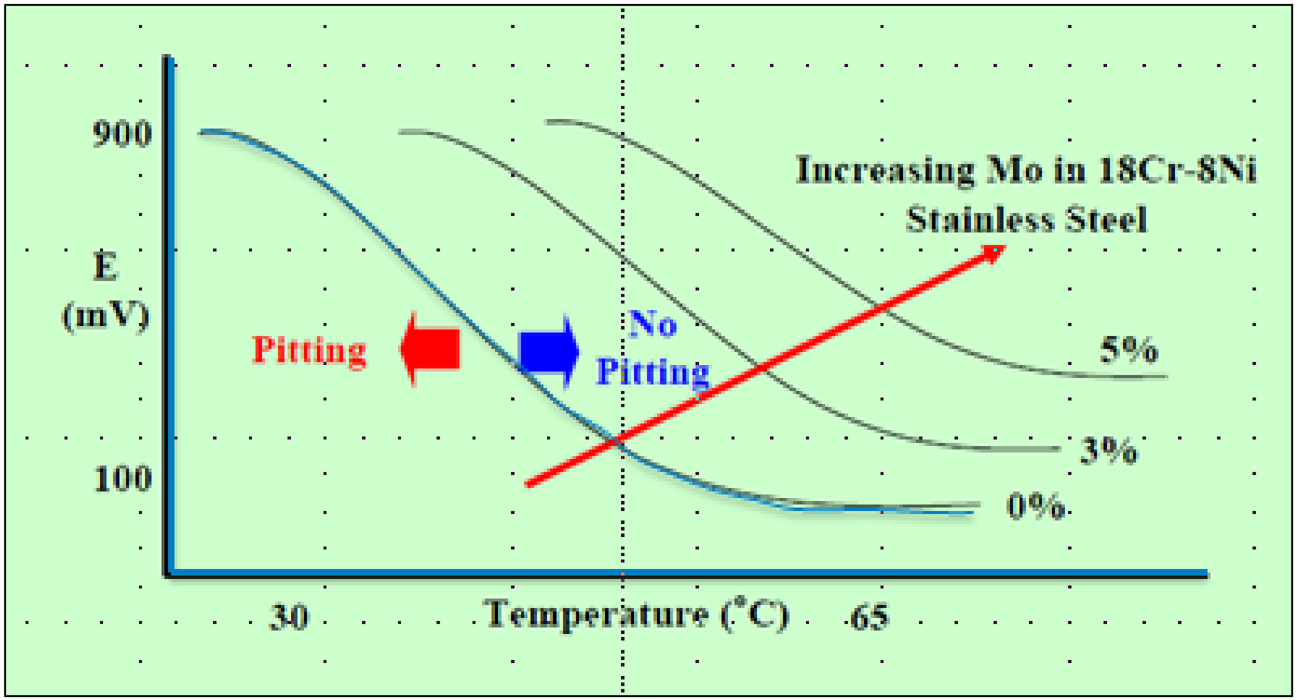
Polarization curve



Major factors that influence pitting corrosion[1]

(the pitting potential E_{pit} is generally used as the criterion for pitting)

1. Temperature



Increasing the temperature reduces drastically the resistance to pitting.

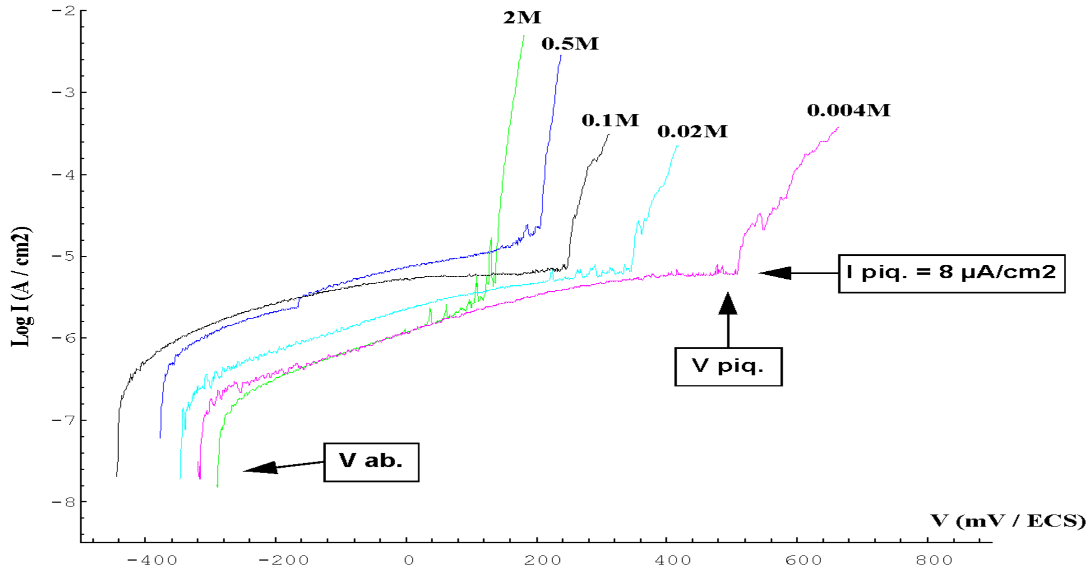
Major factors that influence pitting corrosion[5]

(the pitting potential E_{pit} is generally used as the criterion for pitting)

2. Chloride concentration

The pitting resistance decreases a the Cl^- concentration increases (the log of the Cl^- concentration)

$$E_{pit} = A \log [Cl^-] + B$$

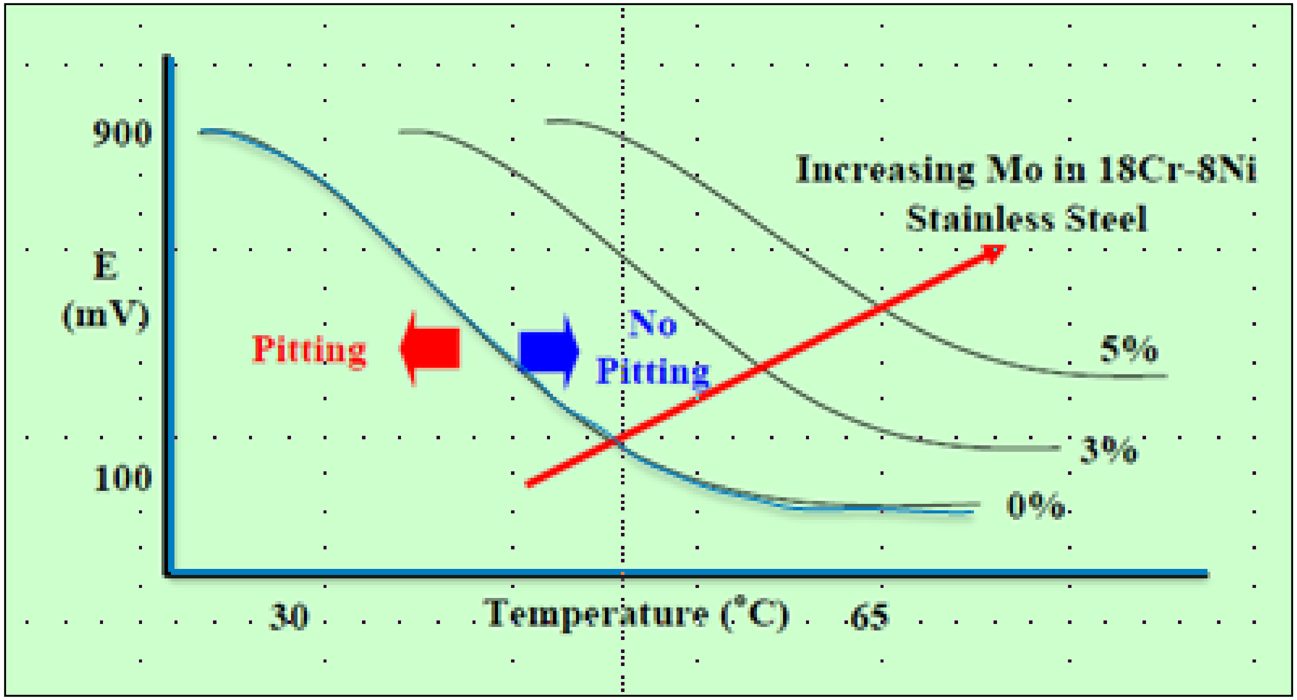


Major factors that influence pitting corrosion[1]

(the pitting potential E_{pit} is generally used as the criterion for pitting)

3. Stainless steel analysis

The pitting resistance increases strongly with some alloying elements: N, Mo, Cr



The role of the alloying elements is described by the PREN (Pitting Resistance Equivalent Number)

Updated!

Pitting Resistance Equivalent Number (PREN)[6]

- By calculating the PREN it is possible to compare stainless steel grades resistance against pitting. The higher the number the better the resistance.
- Obviously the PREN alone cannot be used to predict whether a particular grade will be suitable for a given application

PREN = Cr + 3.3Mo + 16N, where

Cr = Chromium content

Mo = Molybdenum content

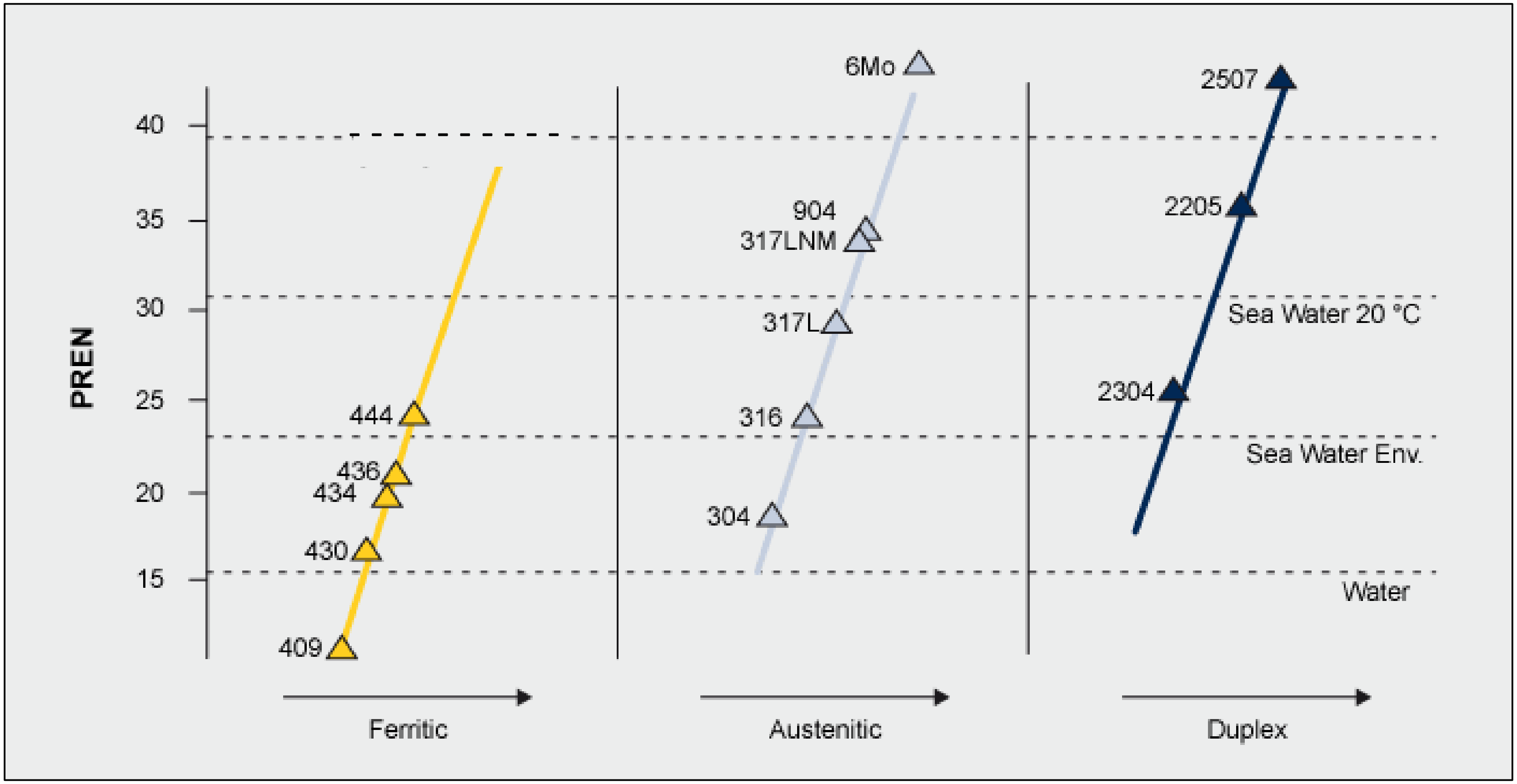
N = Nitrogen content

EN	AISI	PREN
1.4003	-	10.5 - 12.5
1.4016	430	16.0 - 18.0
1.4301	304	17.5 - 20.8
1.4311	304LN	19.4 – 23.0
1.4401/4	316/L	23.1 – 28.5
1.4406	316LN	25.0 – 30.3
1.4439	317L	31.6 – 38.5
1.4539	-	32.2 – 39.9
1.4362	-	23.1 – 29.2
1.4462	-	30.8 – 38.1
1.4410	-	40
1.4501	-	40

Please note that the PREN does not involve Ni.
The resistance to pitting corrosion does not depend upon the Ni content of the stainless steel. See next slide

PREN of some common grades[9]

Updated!



Ferritic stainless steels can match 304 and 316 austenitic stainless steels in pitting corrosion resistance.

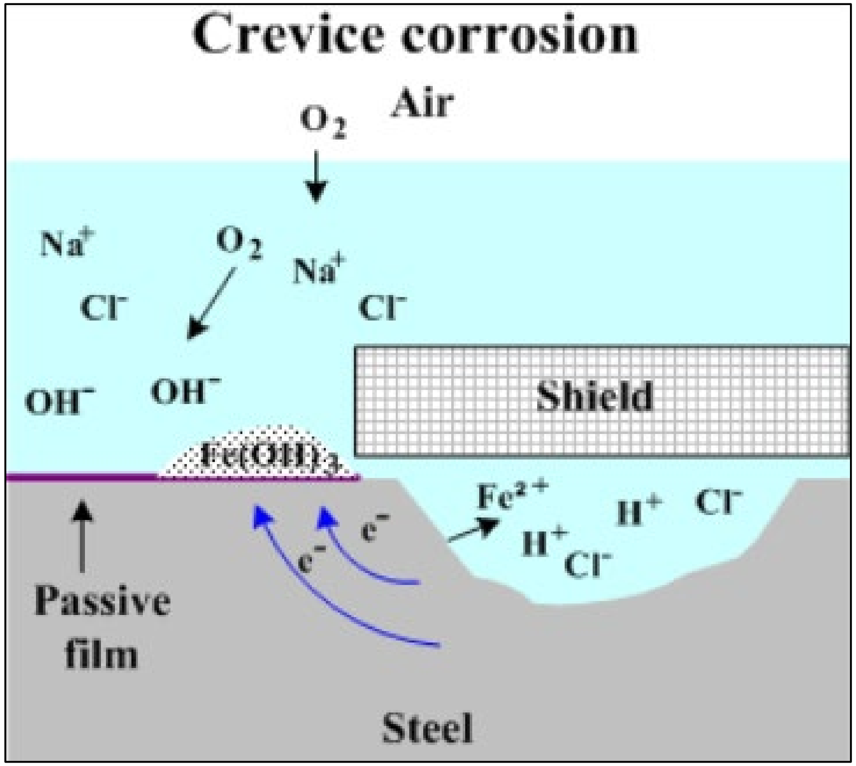
Note: Please see Appendix for EN standards designations

c) What is Crevice Corrosion[1]?

Crevice corrosion refers to corrosion occurring in confined spaces to which the access of the working fluid from the environment is limited. These spaces are generally called crevices. Examples of crevices are gaps and contact areas between parts, under gaskets or seals, inside cracks and seams, spaces filled with deposits and under sludge piles.

Mechanism of Crevice Corrosion

- Initially, no difference between the cavity and the whole surface
- Then things change when the cavity becomes depleted in oxygen
- A set of electrochemical reactions occurs in the crevice, with the result of increasing Cl- concentration and decreasing the local pH, to the extent that passivation cannot occur
- Then the metal in the crevice undergoes uniform corrosion



Critical Pitting Resistance Temperature (CPT)
Critical Crevice Corrosion Temperature (CCT)
of various austenitic & duplex grades[8]

Note: The higher the Temperature, the better the corrosion resistance

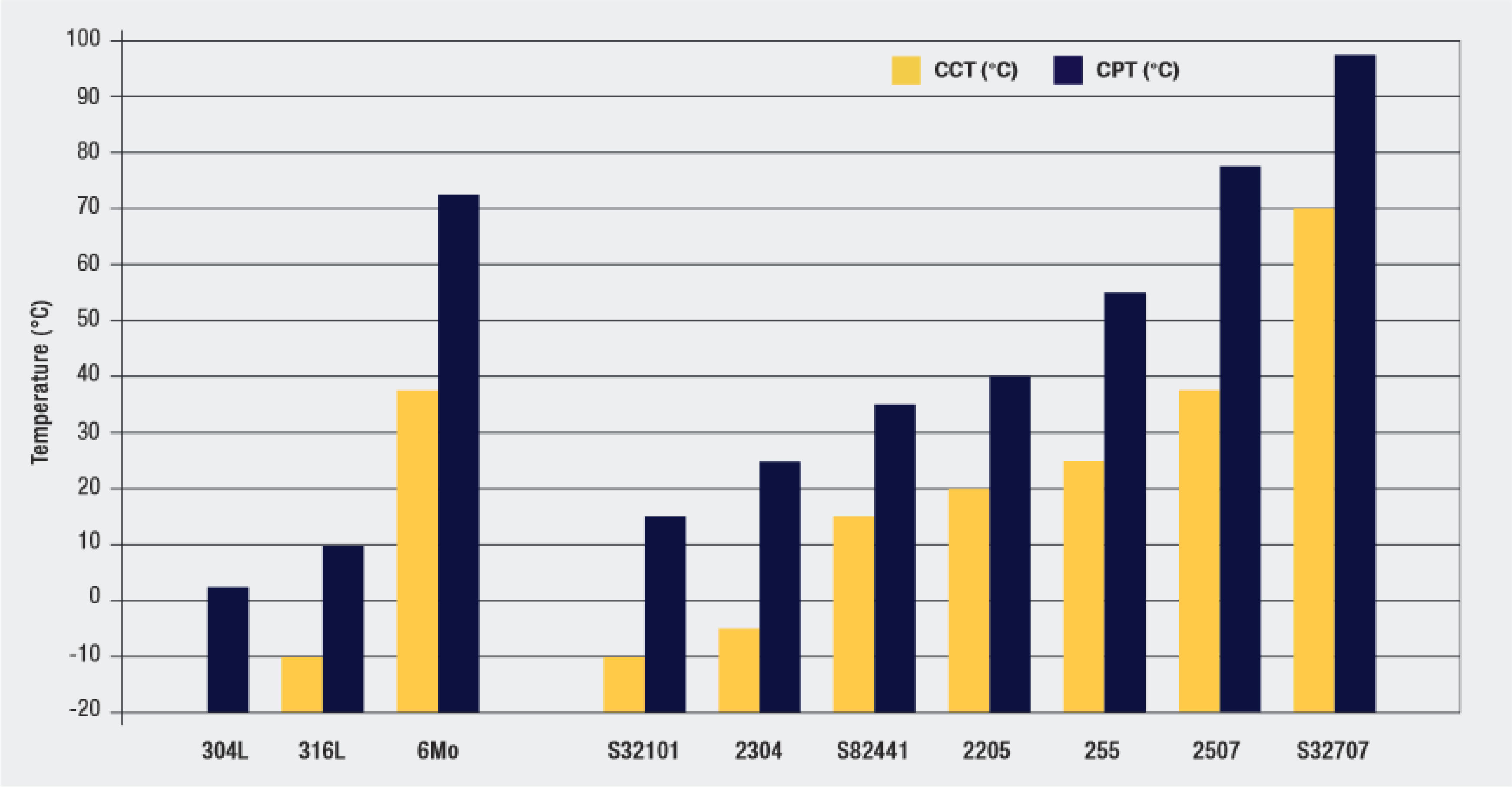


Figure 9: Critical pitting and crevice corrosion temperatures for unwelded austenitic stainless steels (left side) and duplex stainless steels (right side) in the solution annealed condition (evaluated in 6% ferric chloride by ASTM G 48).

Note: Please see Appendix for EN standards designations

How to avoid crevice corrosion

1. Optimize design:
   a) Use welded parts.
   b) Design vessels for complete drainage.
2. Clean to remove deposits (whenever possible)
3. Select a suitably corrosion resistant stainless steel (see part 4 of this chapter)

d) What is Galvanic Corrosion[1]? (also known as bimetallic corrosion)

Corrosion that can occur when 2 metals with very different galvanic potentials are in contact.

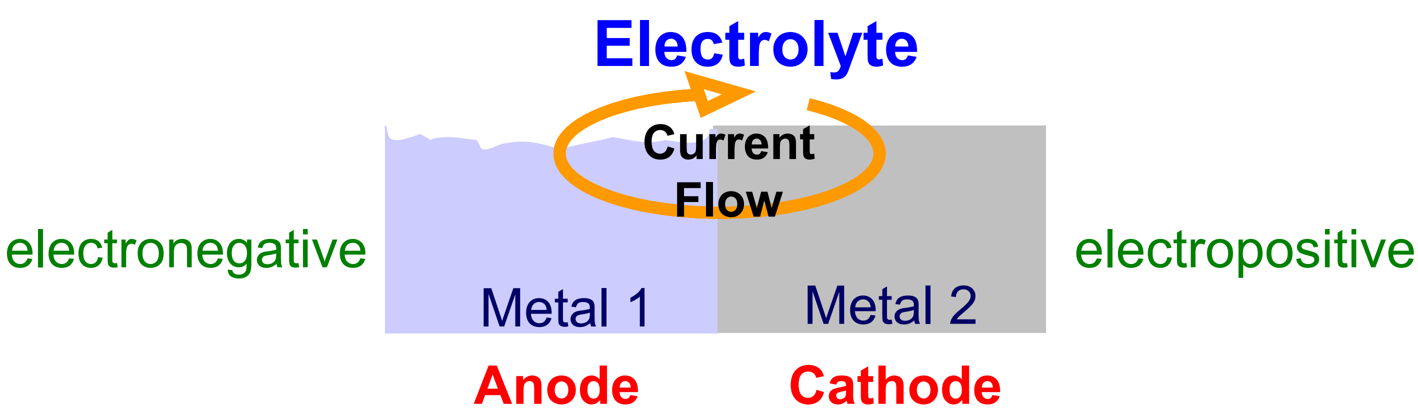
The most anodic metal is attacked

Example on the picture on the left: The stainless steel plate was secured to a stainless steel vessel, using mild steel bolts – resulting in galvanic corrosion of the bolts in presence of humidity, (=electrolyte)

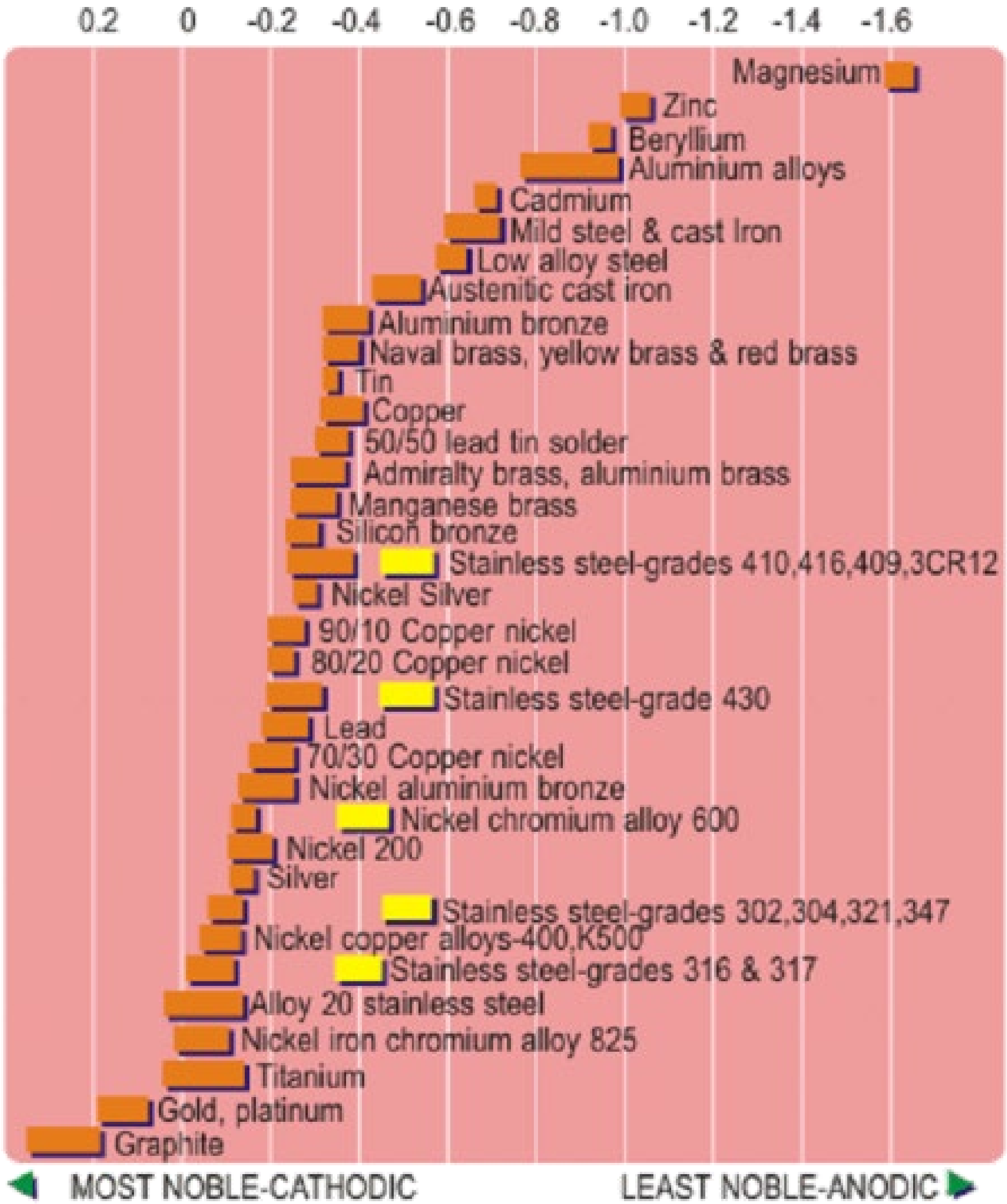
See Reference 11

Mechanism of galvanic corrosion

- Each metal has a characteristic potential when immersed in an electrolyte (measured against a reference electrode.)
- When 2 metals are connected with a conducting liquid (humidity is enough):
- And when the 2 metals have very different potentials
- A current will flow from the most electronegative (anode) to the most electropositive (cathode).
- If the anode area is small it will show dissolution of the metal



Galvanic series for metals in flowing sea water.



Updated!

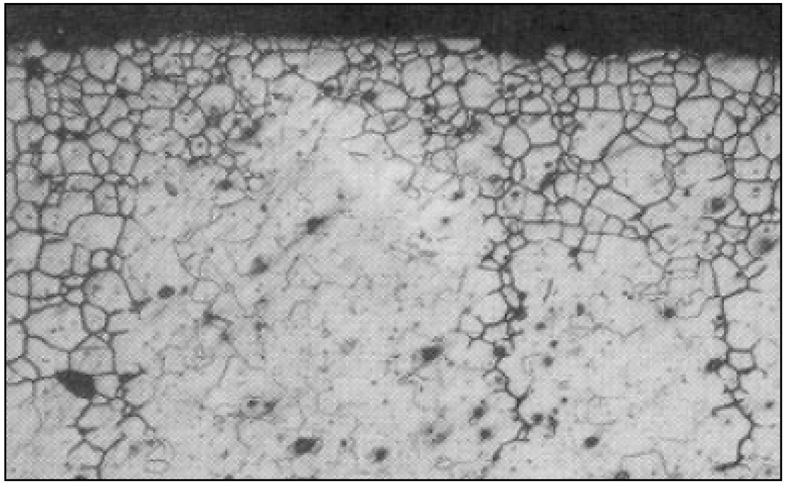
Basic rules on how to avoid galvanic corrosion

- Avoid situations of dissimilar metals
- When dissimilar metals are in contact make sure that the less noble metal (anode) has a much larger surface area than the more noble metal (cathode)
- Examples:
  - Use Stainless steel fasteners for Aluminum products (and never Aluminum fasteners for stainless)
  - Same between stainless steel and carbon steel

In concrete (high pH) contaminated with chlorides, stainless steel rebar DOES NOT INCREASE SIGNIFICANTLY the corrosion rates of carbon steel rebar by galvanic coupling
References are given in www.stainlesssteelrebar.org

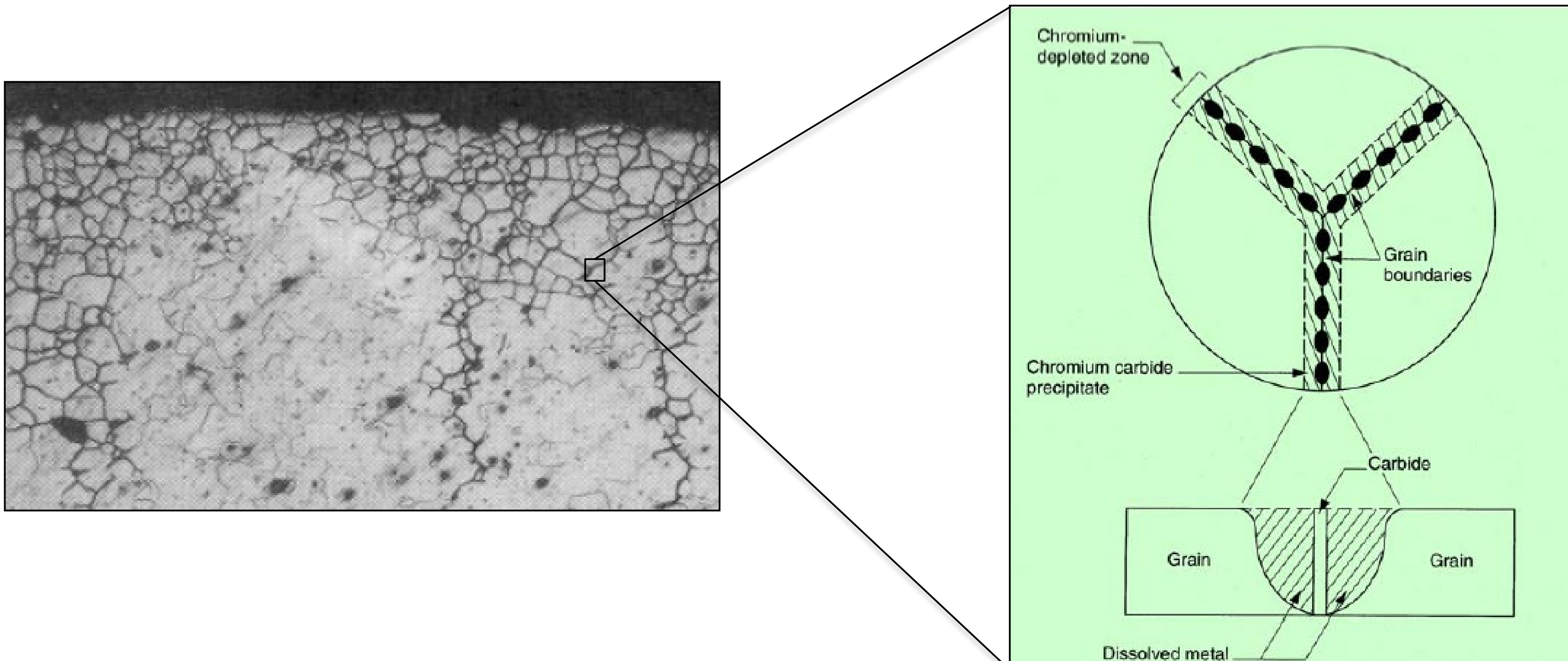
e) What is Intergranular Corrosion[1]?

Intergranular attack is caused by the formation of chromium carbides (Fe,Cr)23C6 at grain boundaries, reducing the chromium content and the stability of the passive layer.



In the above micrographs, stainless steels speciments were polished then etched with a stong acid medium. The network of black lines corresponds to a strong chemical attack of the grain boundaries which exhibit a much lower corrosion resistance than the grains themselves.

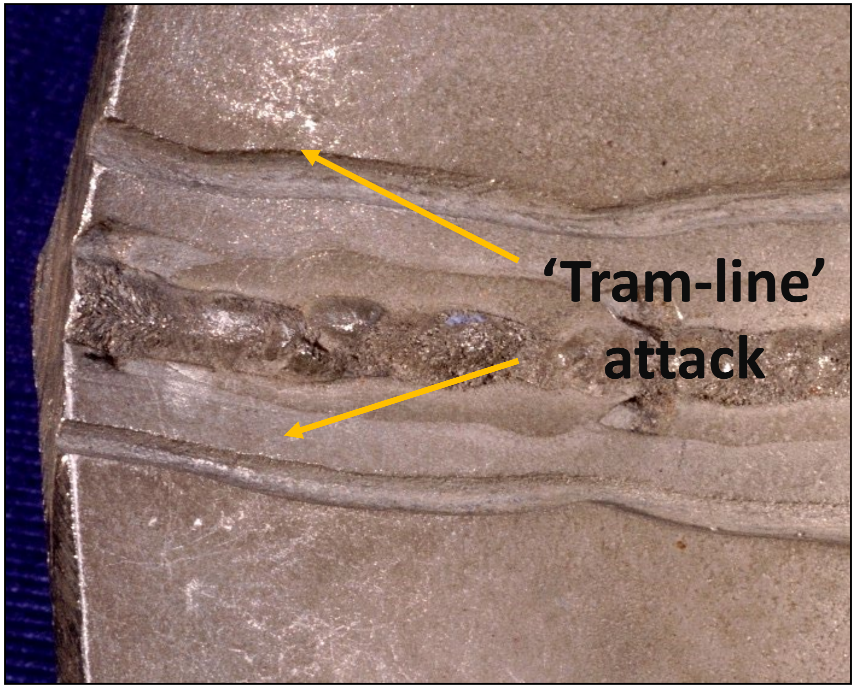
Schematic view of Cr depletion at grain boundaries



When does Intergranular Corrosion occur?

- Properly processed stainless steels are not prone to IC
- May occur in the Heat Affected Zone of a weld (either side of a weld bead) when
  - The Carbon content is high
  - and the steel is not stabilized (by Ti, Nb, Zr * which "trap" the carbon in the matrix, making it unavailable for grain boundary carbides)

* This is why there are grades containing Ti and/or Nb and/or Zr, grades qualified as "stabilized"



Weld Decay

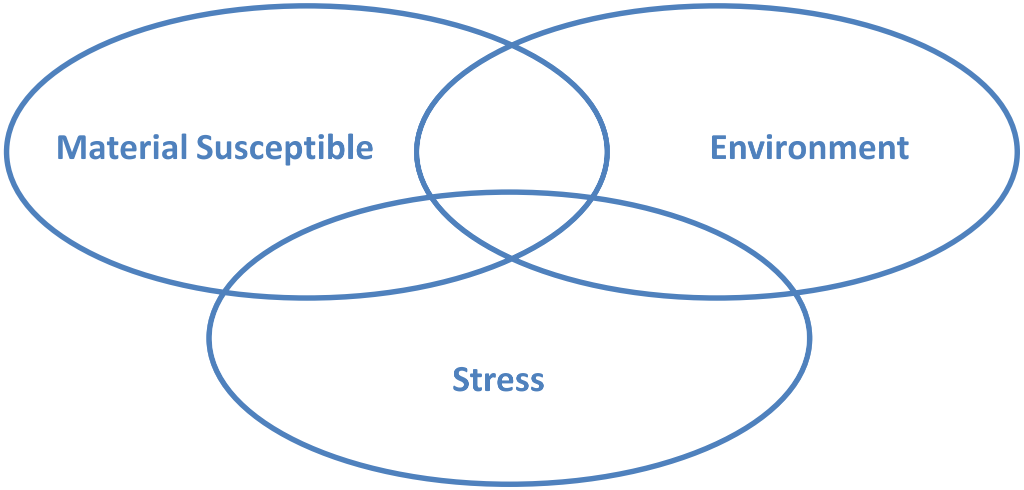
To find out more about welding and other joining methods, please go to Module 09

How to avoid Intergranular Corrosion

- Use low carbon grades, below 0,03% for austenitics
- Or use stabilized grades for ferritics and austenitics
- Or on austenitics, carry out a solution annealing treatment (at 1050°C all the carbides are dissolved) followed by quenching. (This is usually impractical, however).

f) What is Stress Corrosion Cracking[1] (SCC)?

- Sudden cracking and failure of a component without deformation.
- This may occur when
  - The part is stressed (by an applied load or by a residual stress)
  - The environment is aggressive (high chloride level, temperature above 50°C)
  - The stainless steel his not sufficiently SCC resistant

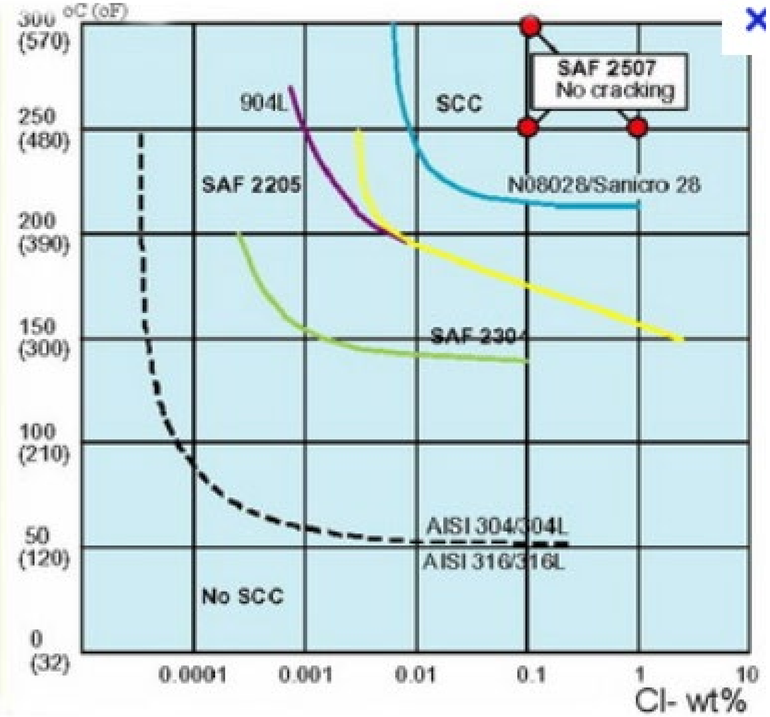


Ferritic and duplex (i.e. austenitic-ferritic) stainless steels are immune to SCC

Mechanism of Stress corrosion cracking (SCC)

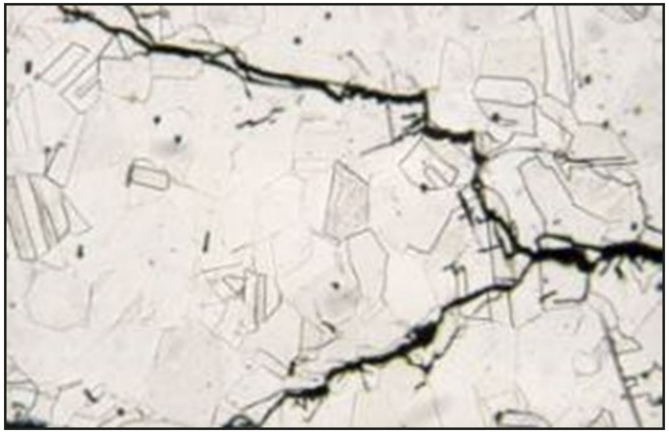
The combined action of environmental conditions (chlorides/elevated temperature) and stress - either applied, residual or both develop the following sequence of events:

1. Pitting occurs
2. Cracks start from a pit initiation site
3. Cracks then propagate through the metal in a transgranular or intergranular mode.
4. Failure occurs



Note: Please see Appendix for EN standards designations

Avoiding SCC – two choices



Chloride induced stress corrosion cracking in standard austenitic stainless steels, viz. 1.4301/ 304 or 1.4401 /316

+Ni
+Mo

1.4539
1.4547 (6Mo)

Select austenitic stainless steels with higher content of Ni and Mo (higher corrosion resistance)

+Cr

Select duplex grades, more price stable (less nickel)

1.4462
1.4410
1.4501

Ferritic and duplex stainless steels are immune to stress corrosion cracking (because the ferrite phase, unlike the austenite phase is not sensitive to this type of corrosion).

For more information on these grades, please go to Module 04

4. How to select the right stainless steel for adequate corrosion resistance

Two different situations:

1. Structural applications [10a]
2. Other applications [10b]

4 - 1 Structural Applications

Eurocode 1-4 provides a procedure for selecting an appropriate grade of stainless steel for the service environment of structural members. (Please note that at the present time – i.e. nov 2014 – the recommendations of the Evolution Group for EN 1993-1-4 have not been yet enforced)

This procedure is presented in the next slides

It is applicable to:

- Load bearing members
- Outdoor use
- Environments without frequent immersion in sea water
- pH between 4 and 10
- No exposure to chemical process flow stream

How the procedure works

1. The environment is assessed by a Corrosion Resistance Factor (CRF) made of 3 components (CRF= F1+F2+F3) where
   a) F1 rates the risk of exposure to chlorides from salt water or deicing salts
   b) F2 rates the risk of exposure to sulphur dioxide
   c) F3 rates the cleaning regime or exposure to washing by rain
2. A matching table indicates for a given CRF the corresponding CRC class
3. The stainless steel grades are placed in corrosion resistance classes (CRC) I to V according to the CRF value

The tables are shown in the next 4 slides

F_1 Risk of exposure to Cl (salt water or deicing salts)

Note: M is distance from the sea and S is distance from roads with deicing salts

1	**Internally controlled environment**	
0	**Low risk of exposure**	M > 10 km or S > 0.1 km
-3	**Medium risk of exposure**	1 km < M ≤ 10 km or 0.01 km < S ≤ 0.1 km
-7	**High risk of exposure**	0.25 km < M ≤ 1 km or S ≤ 0.01 km
-10	**Very high risk of exposure** Road tunnels where deicing salt is used or where vehicles might carry deicing salts into the tunnel	
-10	**Very high risk of exposure** North Sea coast of Germany All Baltic coastal areas	M ≤ 0.25 km
-15	**Very high risk of exposure** Atlantic coast line of Portugal, Spain, France Coastline of UK, France, Belgium, Netherlands, Southern Sweden All other coastal areas of UK, Norway, Denmark and Ireland Mediterranean Coast	M ≤ 0.25 km

F_2 Risk of exposure to sulphur dioxide

Note: for European coastal environments the sulphur dioxide value is usually low. For inland environments the sulphur dioxide value is either low or medium. The high classification is unusual and associated with particularly heavy industrial locations or specific environments such as road tunnels. Sulphur dioxide deposition may be evaluated according to the method in ISO 9225.

0	**Low risk of exposure**	(<10 µg/m³ average deposition)
-5	**Medium risk of exposure**	(10 – 90 µg/m³ average deposition)
-10	**High risk of exposure**	(90 – 250 µg/m³ average deposition)

F_3 Cleaning regime or exposure to washing by rain

(if $F_1 + F_2 = 0$, then $F_3 = 0$)

0	Fully exposed to washing by rain
-2	Specified cleaning regime
-7	No washing by rain or No specified cleaning

Matching Table

Table A.2: Determination of Corrosion Resistance Class CRC	
Corrosion Resistance Factor (CRF)	Corrosion Resistance Class (CRC)
CRF = 1	I
0 ≥ CRF > -7	II
-7 ≥ CRF > -15	III
-15 ≥ CRF ≥ -20	IV
CRF < -20	V

Corrosion resistance classes of stainless steels

Updated 2019

Table A.3: Grades in each Corrosion Resistance Class CRC				
	Corrosion resistance class CRC			
I	II	III	IV	V
1.4003	1.4301	1.4401	1.4439	1.4565
1.4016	1.4307	1.4404	1.4539	1.4529
1.4512	1.4311	1.4435	1.4462	1.4547
	1.4541	1.4571		1.4410
	1.4318	1.4429		1.4501
	1.4306	1.4432		1.4507
	1.4567	1.4578		
	1.4482	1.4662		
		1.4362		
		1.4062		
		1.4162		

Ferritics | Std Austenitics | Mo Austenitcs
Lean duplex | Super Austenitics | Duplex/super duplex

Notes: Please see the appendix for EN standards designations
This does not apply to swimming pools

4 -2 Other applications

- No specific regulations are applicable
- Grade selection must be adequate for the expected performance
- Three ways to do this:
  - Ask an expert
  - Get help from stainless steel development associations
  - Find out successful cases with similar environments (usually available)

Grade Selection Guide for Architecture[10]

Caution: NOT applicable when

- Appearance does not matter
- Structural integrity is the primary concern (Then go to 4 – 1)

How the procedure works

- An evaluation score must be computed
- For each score a list of recommended stainless steel grades is provided

Criteria used in the evaluation score (see the next slides):

i. Environmental Pollution
ii. Coastal exposure or Deicing salts exosure
iii. Local weather pattern
iv. Design considerations
v. Maintenance schedule

i. Environmental pollution

Points	
	Rural
0	Very low or no pollution
	Urban pollution (Light industry, automotive exhaust)
0	Low
2	Moderate
3	High *
	Industrial pollution (Aggressive gases, iron oxides, chemicals, etc.)
3	Low or moderate
4	High *

* Potentially a highly corrosive location. Have a stainless steel expert evaluate the site.

ii. A) Coastal exposure

Points	
	Coastal or Marine Salt Exposure
1	Low (>1.6 to 16 km (1 to 10 miles) from salt water) **
3	Moderate (30m to 1.6 km (100 ft to 1 mile) from salt water)
4	High (<30m (100 ft) from salt water)
5	Marine (some salt spray or occasional splashing) *
8	Severe Marine (continuous splashing) *
10	Severe Marine (continuous immersion) *

* Potentially a highly corrosive location. Have a stainless steel corrosion expert evaluate the site.
** This range shows how far chlorides are typically found from large salt water bodies. Some locations of this type are exposed to chlorides but others are not.

ii. B) Deicing salts exposure

Points	
	Deicing Salt Exposure (Distance from road or ground)
0	No salt was detected on a sample from the site and no change in exposure conditions is expected.
0	Traffic and wind levels on nearby roads are too low to carry chlorides to the site and no deicing salt is used on sidewalks
1	Very low salt exposure (≥10 m to 1 km (33 to 3,280 ft) or 3 to 60 floors) **
2	Low salt exposure (< 10 to 500 m (33 to 1600 ft) or 2 to 34 floors) **
3	Moderate salt exposure (< 3 to 100 m (10 to 328 ft) or 1 to 22 floors) **
4	High salt exposure (<2 to 50 m (6.5 to 164 ft) or 1 to 3 floors) * **

* Potentially a highly corrosive location. Have a stainless steel corrosion expert evaluate the site.

** This range shows how far this chloride concentration has been found from small rural and large high traffic roads. Test surface chloride concentrations.

Note: if both coastal exposure and deicing salts are present, please ask an expert

iii. Local weather pattern

Points	
-1	Temperature or cold climates, regular heavy rain
-1	Hot or cold climates with typical humidity below 50%
0	Temperature or cold climate, occasional heavy rain
0	Tropical or subtropical, wet, regular or seasonal very heavy rain
1	Temperature climate, infrequent rain, humidity above 50%
1	Regular very light rain or frequent fog
2	Hot, humidity above 50%, very low or no rainfall ***

*** If there is also salt or pollution exposure, have a stainless steel corrosion expert evaluate the site.

iv. Design Considerations

Points	
0	Boldly exposed for easy rain cleaning
0	Vertical surfaces with a vertical or no finish grain
-2	Surface finish is pickled, electropolished, or roughness ≤ R_a 0.3 μm (12μin)
-1	Surface finish roughness R_a 0.3 μm (12μin) < X ≤ R_a 0.5 μm (20μin)
1	Surface finish roughness R_a 0.5 μm (20μin) < X ≤ R_a 1 μm (40μin)
2	Surface finish roughness > R_a 1 μm (40μin)
1	Sheltered location or unsealed crevices ***
1	Horizontal surfaces
1	Horizontal finish grain orientation

*** If there is also salt or pollution exposure, have a stainless steel corrosion expert evaluate the site.

About Ra: https://www.worldstainless.org/Files/issf/non-image-files/PDF/Euro_Inox/RoughnessMeasurement_EN.pdf

This table shows that corrosion resistance depends also on surface finish.
For more information on the available finishes, please go to Module 08

v. Maintenance schedule

Points	
0	Not washed
-1	Washed at least naturally
-2	Washed four or more times per year
-3	Washed at least monthly

Stainless Steel selection scoring system

Total score	Stainless Steel Selection
0 to 2	Type 304/304L is generally the most economical choice
3	Type 316/316L or 444 is generally the most economical choice
4	Type 317L or a more corrosion resistant stainless steel is suggested
≥ 5	A more corrosion resistant stainless steel such as 4462, 317LMN, 904L, super duplex, super ferritic or a 6% molybdenum super austenitic stainless steel may be needed
Note: please see the appendix for EN standard designations	

Proper selection of the stainless steel grades will lead to a long, maintenance-free, service life with a low life cycle cost and an excellent sustainability

For more information sustainability, please go to Module 11

Conclusion

- Proper selection of the right stainless steel grade for the application and the environment deserves attention.
- When this is done, stainless steel will provide unlimited service life without maintenance.

You will find in Module 2 a wide range of successful applications of stainless steels,
and in Module 1 timeless art, worldwide!

5. References

1. An excellent course on corrosion. Please look at chapters 7 (Galvanic Corrosion), 8 (intergranular corrosion), 11 (crevice corrosion) 12 (pitting) 14 (Stress corrosion cracking) and 15 (stress corrosion cracking of stainless steels) Original source: http://corrosion.kaist.ac.kr Dowloads available from: https://www.worldstainless.org/Files/issf/Education_references/Zrefs_on_corrosion.zip
2. Some basics on corrosion from NACE http://corrosion-doctors.org/Corrosion-History/Course.htm#Scope
3. An online course on corrosion http://www.corrosionclinic.com/corrosion_online_lectures/ME303L10.HTM#top
4. Information on electrochemical testing http://mee-inc.com/esca.html
5. Ugitech: private communication
6. BSSA (British Stainless Steel Association) website " Calculation of pitting resistance equivalent numbers (PREN)" http://www.bssa.org.uk/topics.php?article=111
7. On Pitting corrosion https://kb.osu.edu/dspace/bitstream/handle/1811/45442/FrankelG_JournalElectrochemicalSociety_1998_v145n6_p2186-2198.pdf?sequence=1
8. http://www.imoa.info/download_files/stainless-steel/Duplex_Stainless_Steel_3rd_Edition.pdf
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11. http://en.wikipedia.org/wiki/Galvanic_corrosion
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14. http://www.outokumpu.com/en/stainless-steel/grades/duplex/Pages/default.aspx
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16. http://www.bssa.org.uk/topics.php?article=606
17. a) 通用不锈钢板材EN 10088-2的化学组成: http://www.bssa.org.uk/topics.php?article=44 b) 通用不锈钢长材EN 10088-3的化学成分: http://www.bssa.org.uk/topics.php?article=46

Appendix: Designations[17]

EN Designation		Alternative Designations			
Steel name	Steel number	AISI	UNS	Other US	Generic/ Brand
Ferritic stainless steels - standard grades					
X2CrNi12	1.4003		S40977		3CR12
X2CrTi12	1.4512	409	S40900		
X6CrNiTi12	1.4516				
X6Cr13	1.4000	410S	S41008		
X6CrAl13	1.4002	405	S40500		
X6Cr17	1.4016	430	S43000		
X3CrTi17	1.4510	439	S43035		
X3CrNb17	1.4511	430N			
X6CrMo17-1	1.4113	434	S43400		
X2CrMoTi18-2	1.4521	444	S44400		
Martensitic stainless steels - standard grades					
X12Cr13	1.4006	410	S41000		
X20Cr13	1.4021	420	S42000		
X30Cr13	1.4028	420	S42000		
X3CrNiMo13-4	1.4313		S41500	F6NM	
X4CrNiMo16-5-1	1.4418				248 SV
Martensitic and precipitation-hardening steels - special grades					
X5CrNiCuNb16-4	1.4542		S17400		17-4 PH

EN Designation		Alternative Designations			
Steel name	Steel number	AISI	UNS	Other US	Generic/ Brand
Austenitic stainless steels - standard grades					
X10CrNi18-8	1.4310	301	S30100		
X2CrNi18-9	1.4307	304L	S30403		
X2CrNi19-11	1.4306	304L	S30403		
X2CrNiN18-10	1.4311	304LN	S30453		
X5CrNi18-10	1.4301	304	S30400		
X6CrNiTi18-10	1.4541	321	S32100		
X4CrNi18-12	1.4303	305	S30500		
X2CrNiMo17-12-2	1.4404	316L	S31603		
X2CrNiMoN17-11-2	1.4406	316LN	S31653		
X5CrNiMo17-12-2	1.4401	316	S31600		
X6CrNiMoTi17-12-2	1.4571	316Ti	S31635		
X2CrNiMo17-12-3	1.4432	316L	S31603		
X2CrNiMo18-14-3	1.4435	316L	S31603		
X2CrNiMoN17-13-5	1.4439	317L			
X1NiCrMoCu25-20-5	1.4539		N08904		904L
Austenitic-ferritic stainless steels-standard grades					
X2CrNiN22-2	1.4062		S32202		DX 2202
X2CrMnNiMoN21-5-3	1.4482		S32001		
X2CrMnNiN21-5-1	1.4162		S32101		2101 LDX
X2CrNiN23-4	1.4362		S32304		2304
X2CrNiMoN12-5-3	1.4462		S31803/ S32205	F51	2205

Note: This is a simplified table. For special grades, please look at reference 17.

Thank you

Test your knowledge of stainless steel here:

https://www.surveymonkey.com/r/3BVK2X6