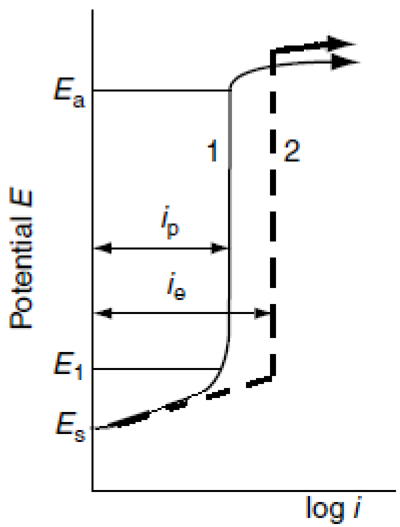
קורוזיה של פלדות פלב"מ וסגסוגות העמידות בפני קורוזיה בתוך שדה חשמלי המיוצר על ידי מערכות הגנה קתודית

Corrosion of stainless steels and of corrosion resistant alloys in the electric field induced by cathodic protection systems

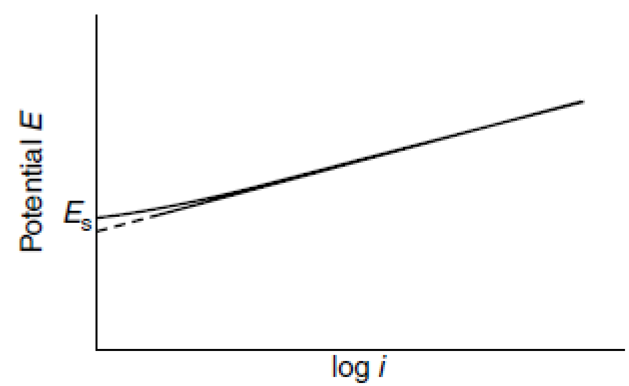
Local corrosion of passive metal under the attack of external anodic current

Objects of consideration are metallic parts and structures of stainless steels and of corrosion resistant alloys attacked by external current of anodic direction coming from cathodic protection systems.
Since the corrosion state of a metal depends on its potential value in the aggressive medium, analysis of the metal behavior is carried out with the help of polarization plots.
Interval $E_s – E_a$ is the area of the metal passive state.
Breakdown of the passive layer on the metal surface occurs above the potential E_a.
The attack of the external anodic current leads to local (pitting) corrosion development of the metal.



Anodic polarization plot of a passive metal

1 – potentiostatic; 2 – galvanostatic.
E_s – corrosion (stationary) potential,
E_a – activation (pitting) potential,
I_p – current density of the metal in a passive state,
I_e – external current density

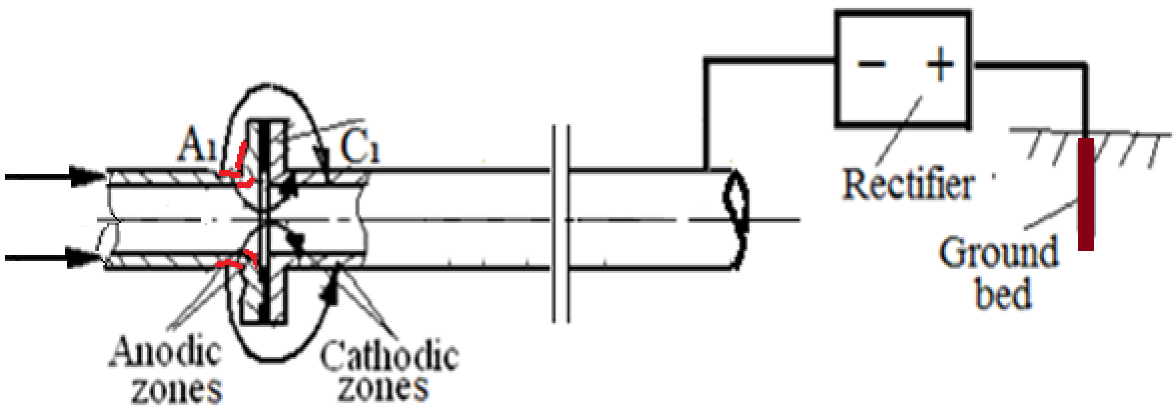


Anodic polarization plot of an active metal

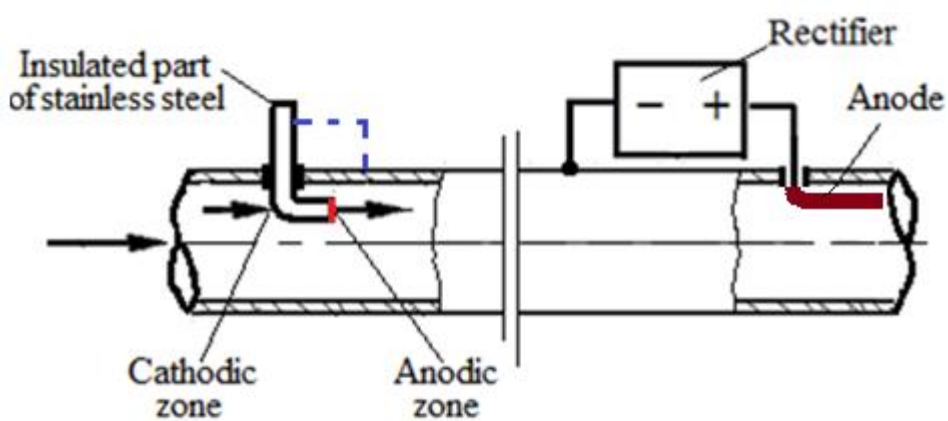
Corrosion damage of insulated parts of a pipeline by external current from cathodic protection systems

Attack by external anodic current becomes possible when the parts of stainless steel of the metallic structure are insulated from the cathodically protected structure

Current flow (shown by arrows) and consequent corrosion damages occurring at insulated flanges of cathodically protected pipeline



Attack of an insulated metallic part by current (shown be arrows) coming from cathodic protection system of the internal tube surface



Corrosion by stray current corrosion of discontinuous cathodically protected rebar of stainless steel

Disconnection of the rebar inside the cathodically protected concrete structures leads to rebar corrosion at the anodic areas of the disconnected rebar.

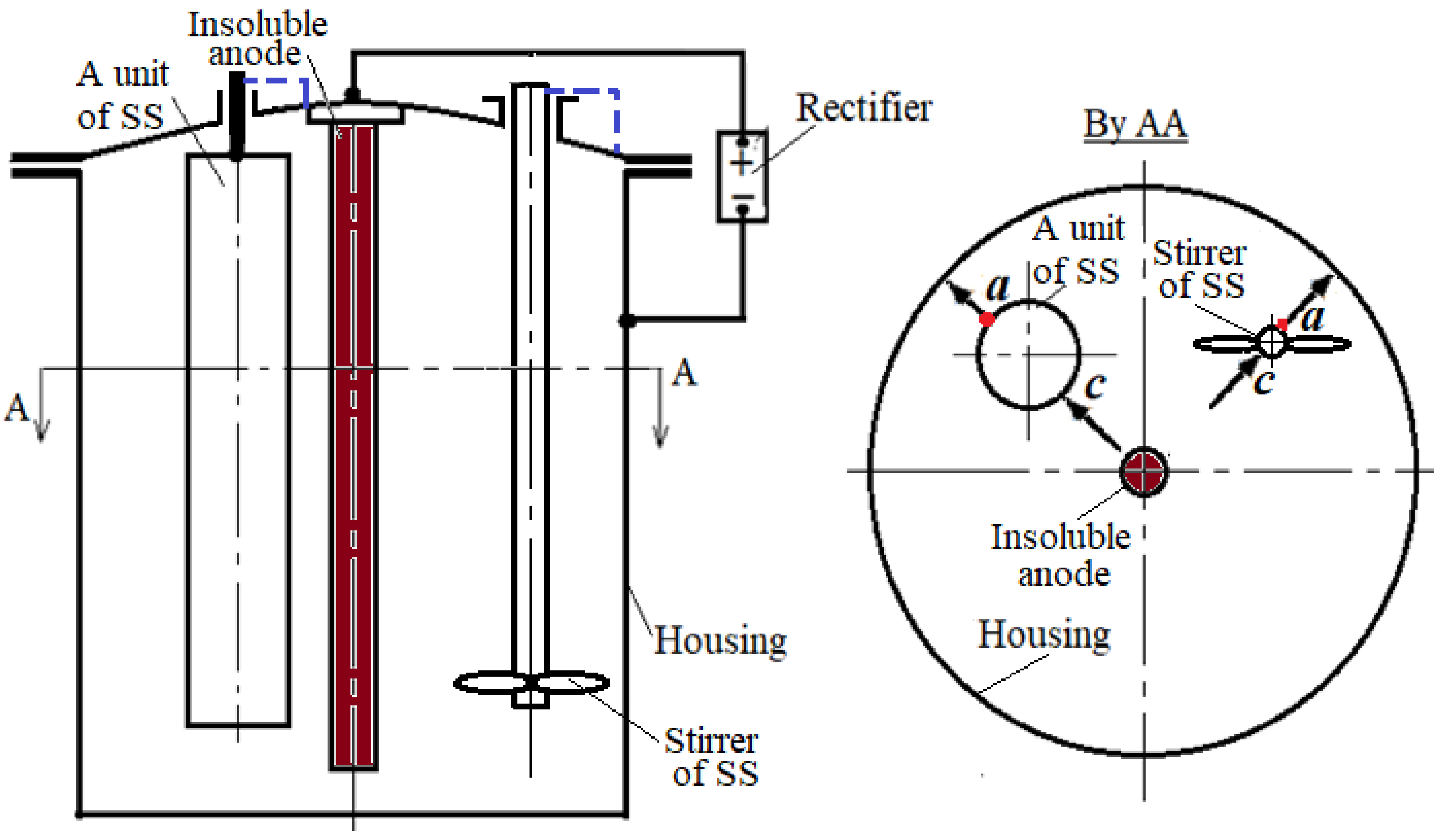
a

b

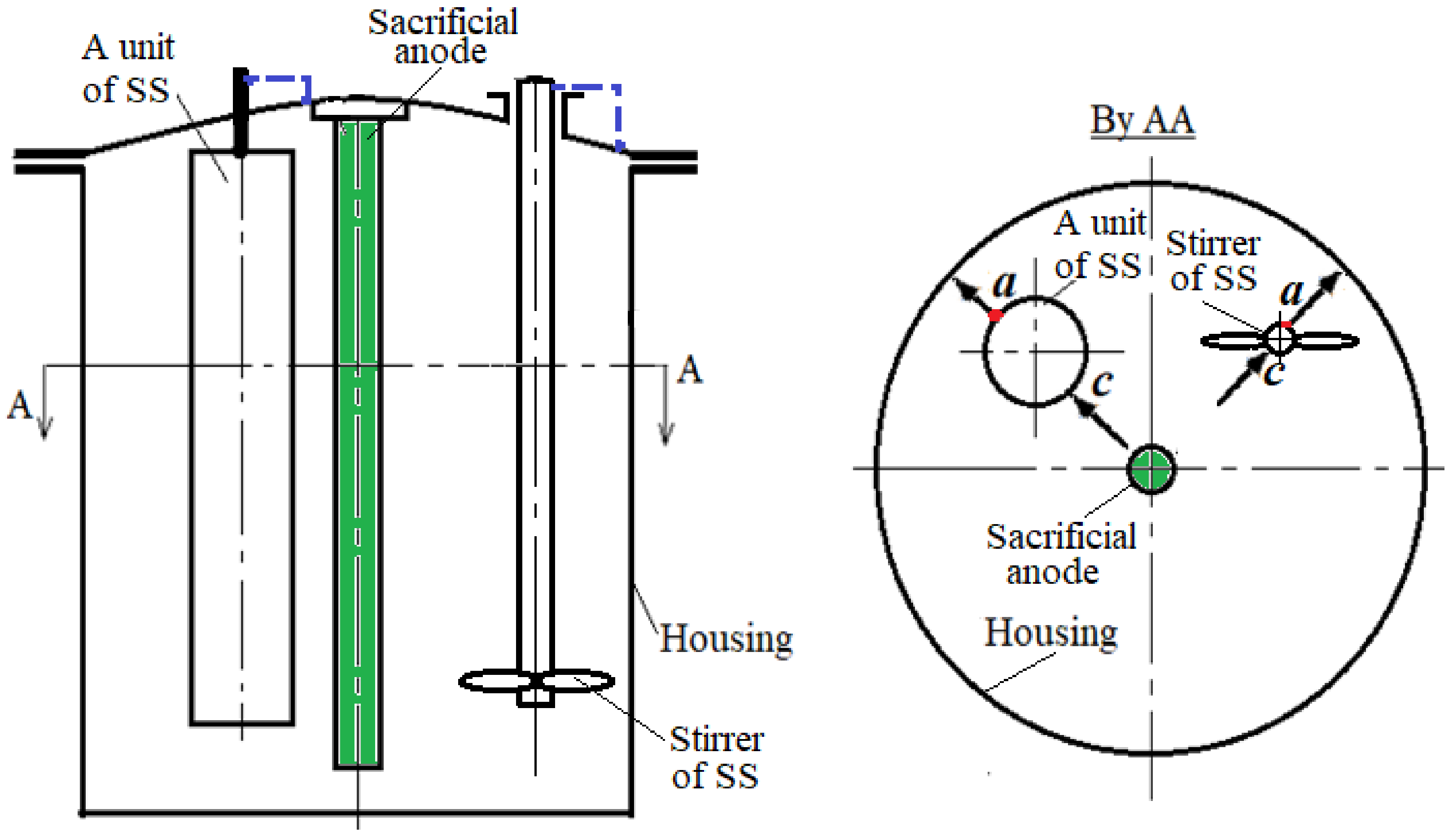
a - Continuous (left) and discontinuous reinforcing bars;
***b* -** cracked specimen with discontinuous reinforcing bar after 2-month test at current density less than 1 A/m^2

Sometimes a part of reinforcing bars (at the areas contacting with aggressive environment) is made of stainless steels 304 and 316. A direct contact between stainless steel and carbon steel bars is excluded in these structures, in order to prevent galvanic effect. However, the structure with discontinuous rebar is susceptible to stray current attack. Reinforcing bars of stainless steel undergo cracking even earlier than the specimens reinforced with bars of carbon steel. So, when hazard of stray current attack exist, such combination of rebar cannot be used.

Schematic of an apparatus provided with cathodic protection by impressed current



Schematic of an apparatus provided with cathodic protection by sacrificial anode



Potentials of different metals in chloride containing aggressive environments

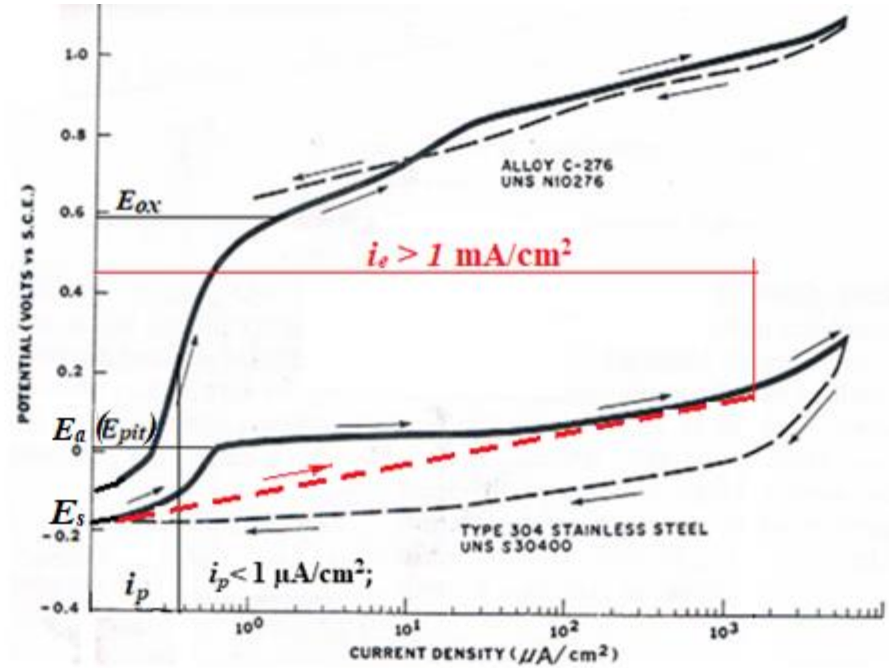
Corrosion potential of stainless steels in seawater(temperature 25°C, flow velocity 4m/sec) (M. Schumacher, Seawater Corrosion handbook)

Stainless steel	Potential, V (SCE)	
	Passive state	Active state
410	-0.15	-0.52
430	-0.22	-0.57
304	-0.08	-053

Potential of carbon steel - 0.61 V

Potential of Hastelloy C - 0.08 V

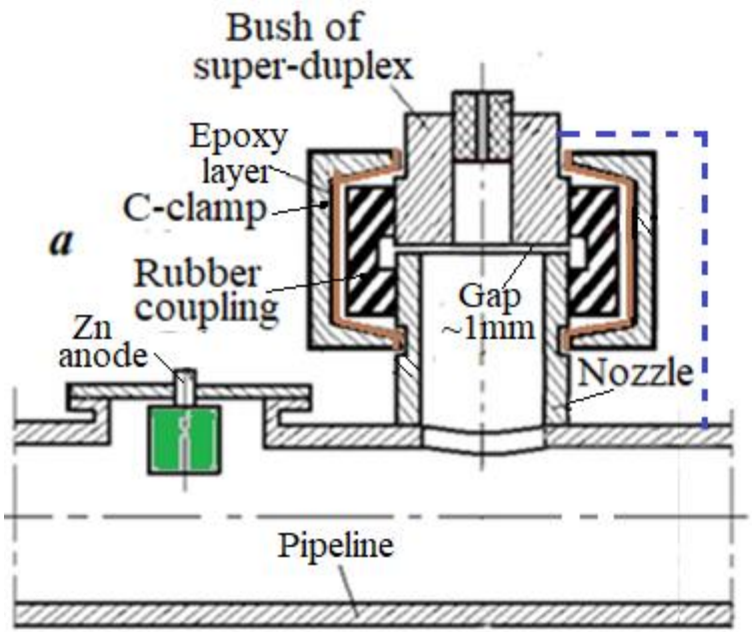
Cyclic potentiodynamic polarization curves on SS 304 and Hastelloy Alloy C-276 (Standard G-61- 86) in **3.56% NaCl solution at temperature 25°C** (representative)



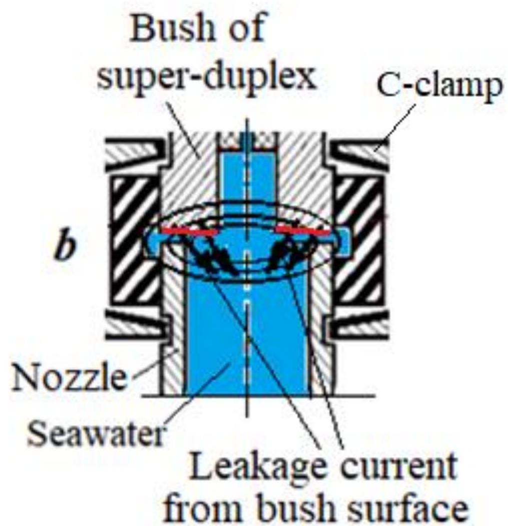
Factors shifting pitting potential to the negative: activators (Cl^-), temperature, surface defects (scratches), crevices, biofilm;

Factors shifting corrosion potential to the positive: stirring, oxidizers, contact with a more positive metal, **<u>external anodic current</u>**.

Corrosion by external current in seawater of a bush mounted at a sampler of a cathodically protected pipeline



a **- Sampler mounted at a cathodically protected pipeline**



b **- Electric field from the protected nozzle**

Stray current corrosion of bottom part of a bush made of super-duplex

Setting up electrical contact between the insulated and cathodically protected parts prevents corrosion by external current of the insulated part of metallic structure.

CONCLUSIONS

1. **Stainless steels and of other corrosion resistant alloys undergo local corrosion (pitting) as a result of attack by external anodic current, when external current density surpasses the metal's current density in passive state.**

2. **External current of anodic direction attacks some parts or units of a metallic structure, when they are insulated from the main cathodically protected structure.**

3 **Local corrosion by external anodic current at insulated parts of stainless steel occurs, when the main metallic structure of carbon steel is cathodically protected either by impressed current, or <u>by sacrificial anodes</u>.**

4. **The major method of prevention corrosion damage of the insulated parts of stainless steels and of corrosion resistant alloys consists in providing electric contact between these parts and the main cathodically protected metallic structure.**