

Monitoring and Eliminating Risks of Corrosion and Stress Corrosion Cracking in Kraft Pulp Digesters

Laurila, T., Savcor Oy, Finland

Niemeläinen, P., Savcor Consulting Inc., Canada

Pulliainen, M., Savcor Oy, Finland

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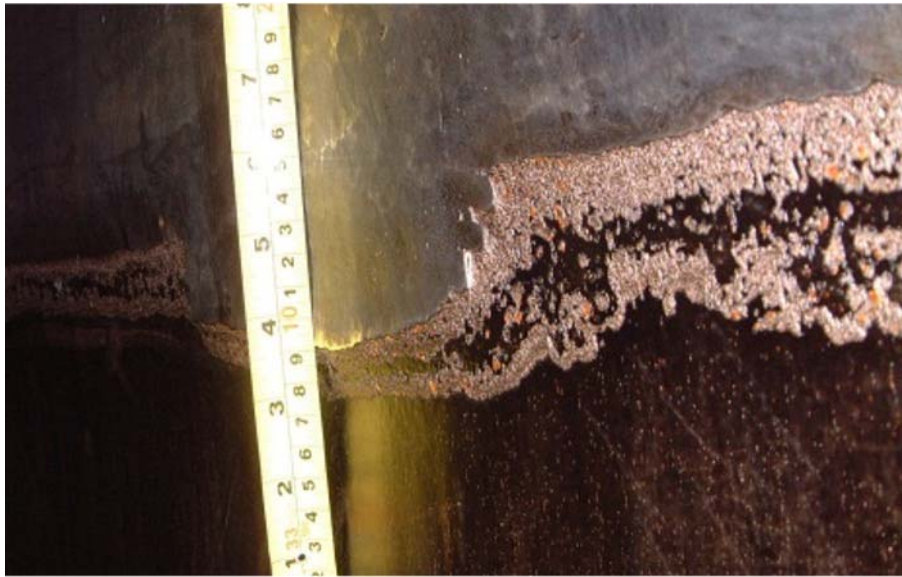
Agenda

1. Common types of corrosion
2. Corrosion management
3. Methodology
4. Case studies
5. On-line corrosion monitoring
6. Discussion
7. Conclusions



Common types of corrosion

General



Thinning

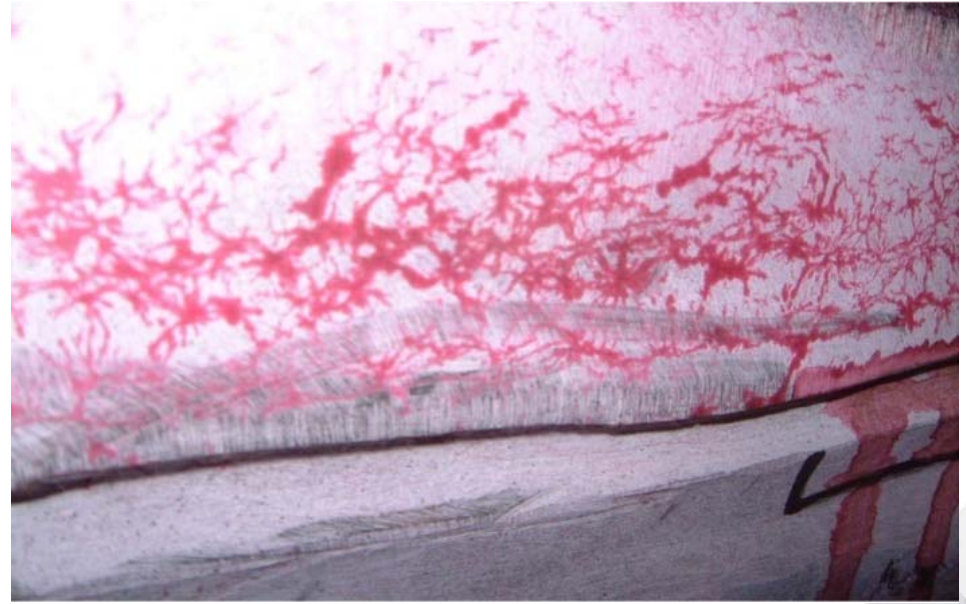


Common types of corrosion

Pitting



Stress Corrosion Cracking (SCC)

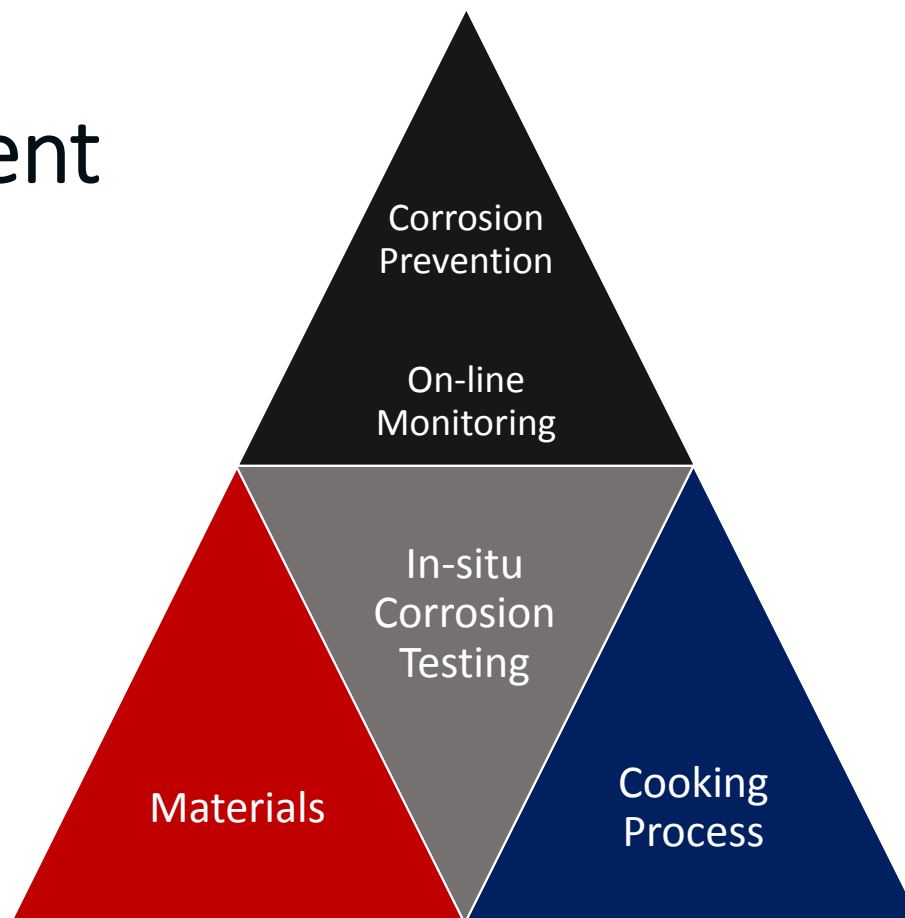


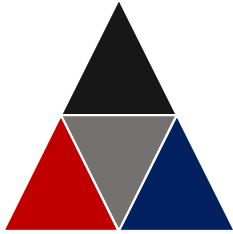
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Corrosion Management



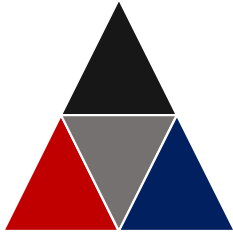


Materials

- Every digester and its construction and repair materials are different





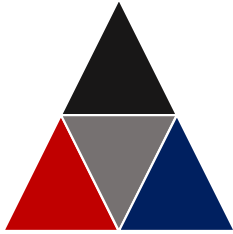


In-situ corrosion testing

Contact electric resistance (CER)

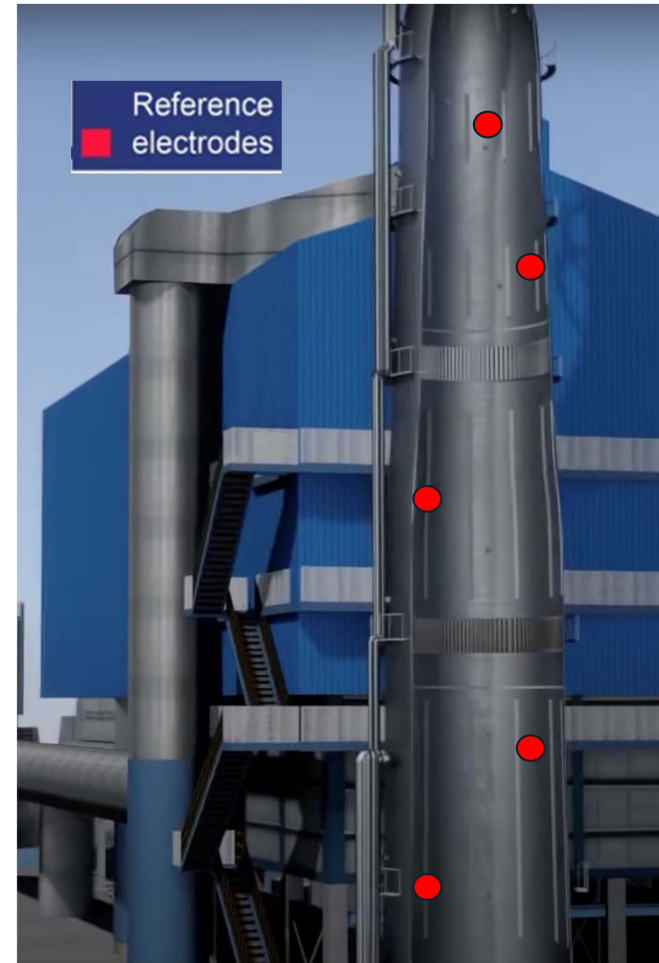
- Fresh liquor directly from the digester
- Temperature of the sample is kept in process temperature
- Close follow up of process conditions

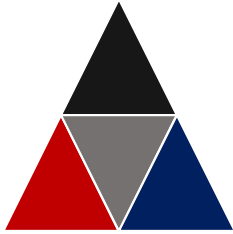




On-line monitoring

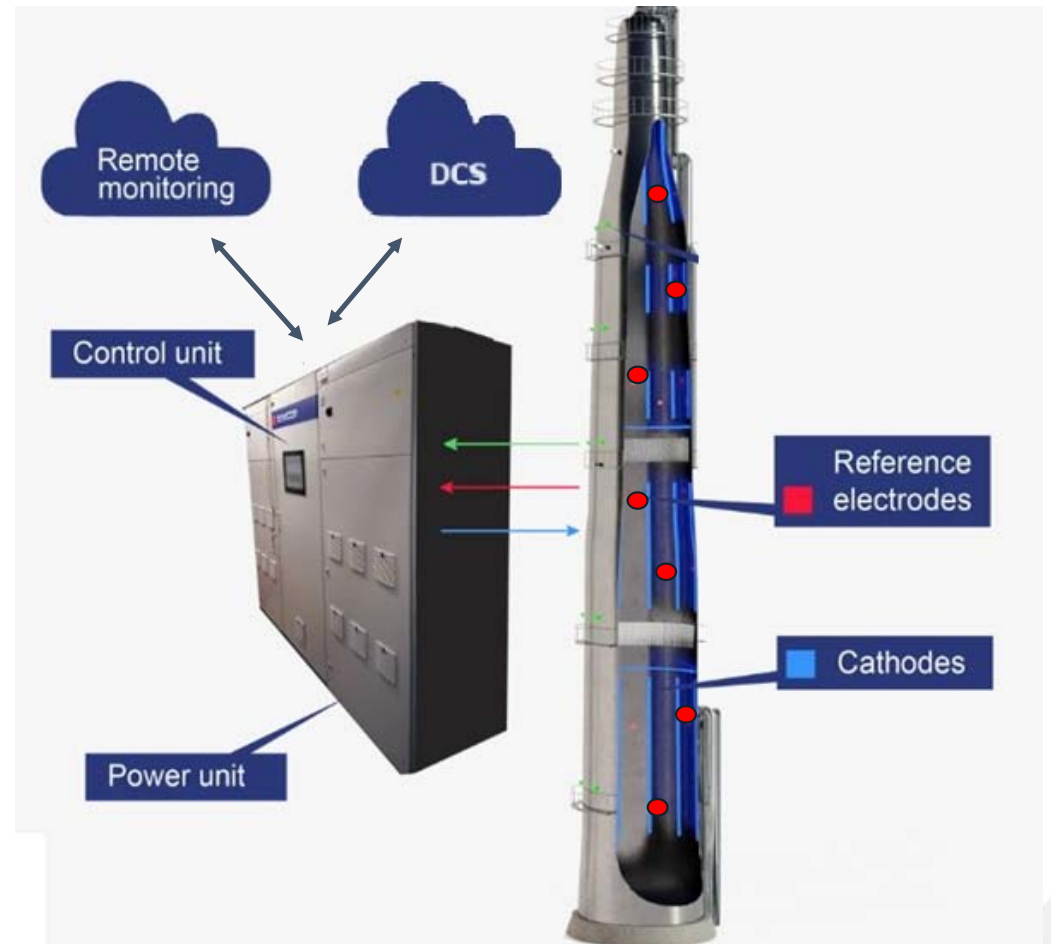
- Minimize corrosive runtime
- DCS connection
- Operator tool





Corrosion prevention

- Stops pitting and thinning
- Very effective in preventing stress corrosion cracking (SCC)



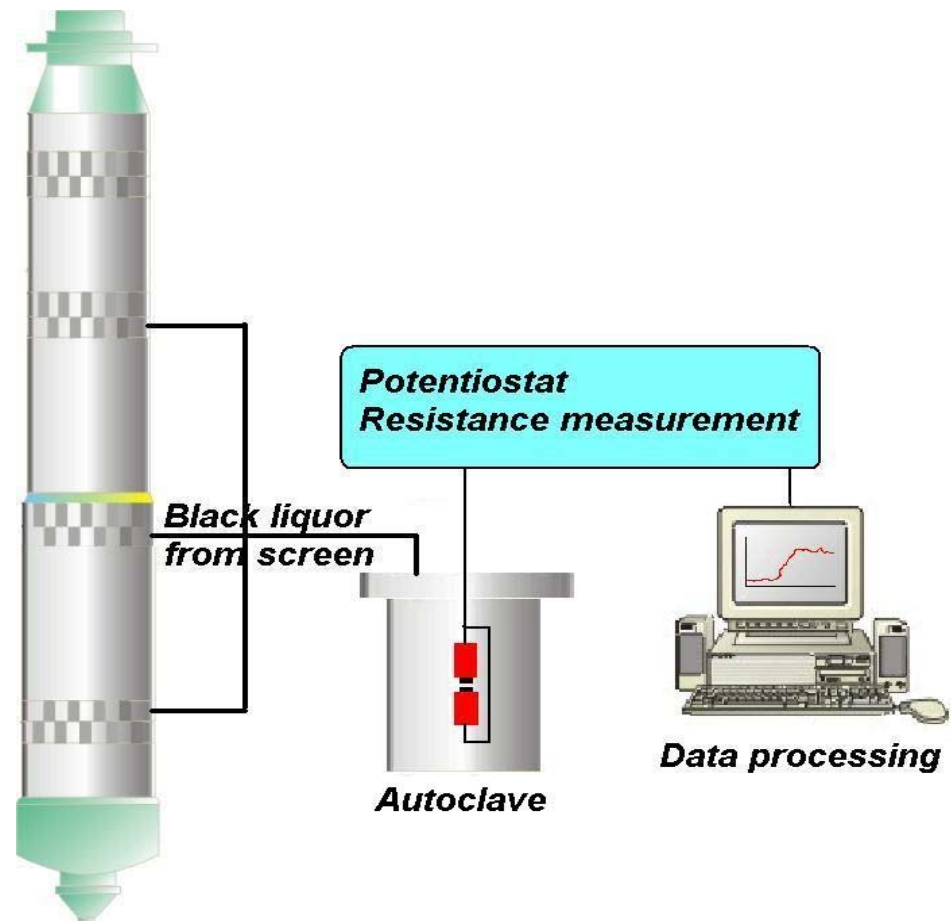
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Methodology

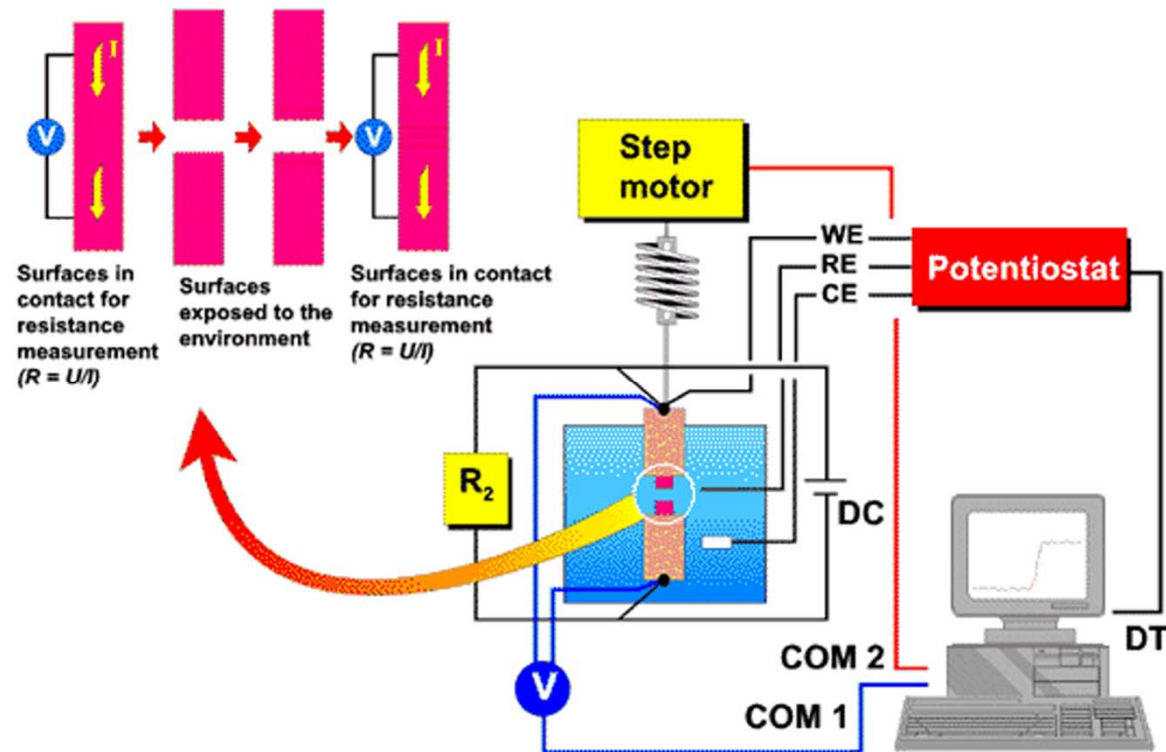
- Contact electric resistance (CER)
- Free potential measurements
- Polarization scans
- Step response
- Sweep



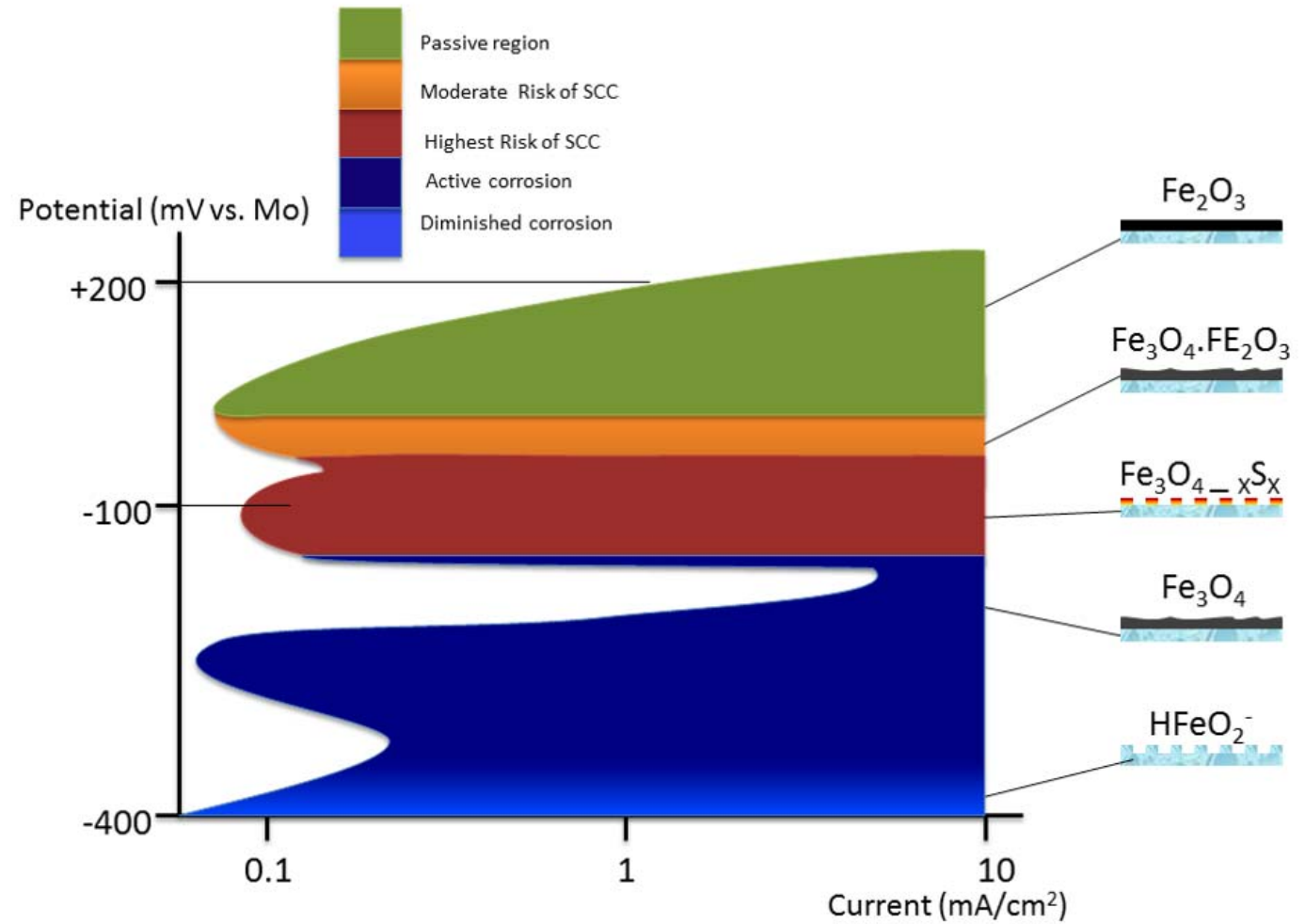
Methodology



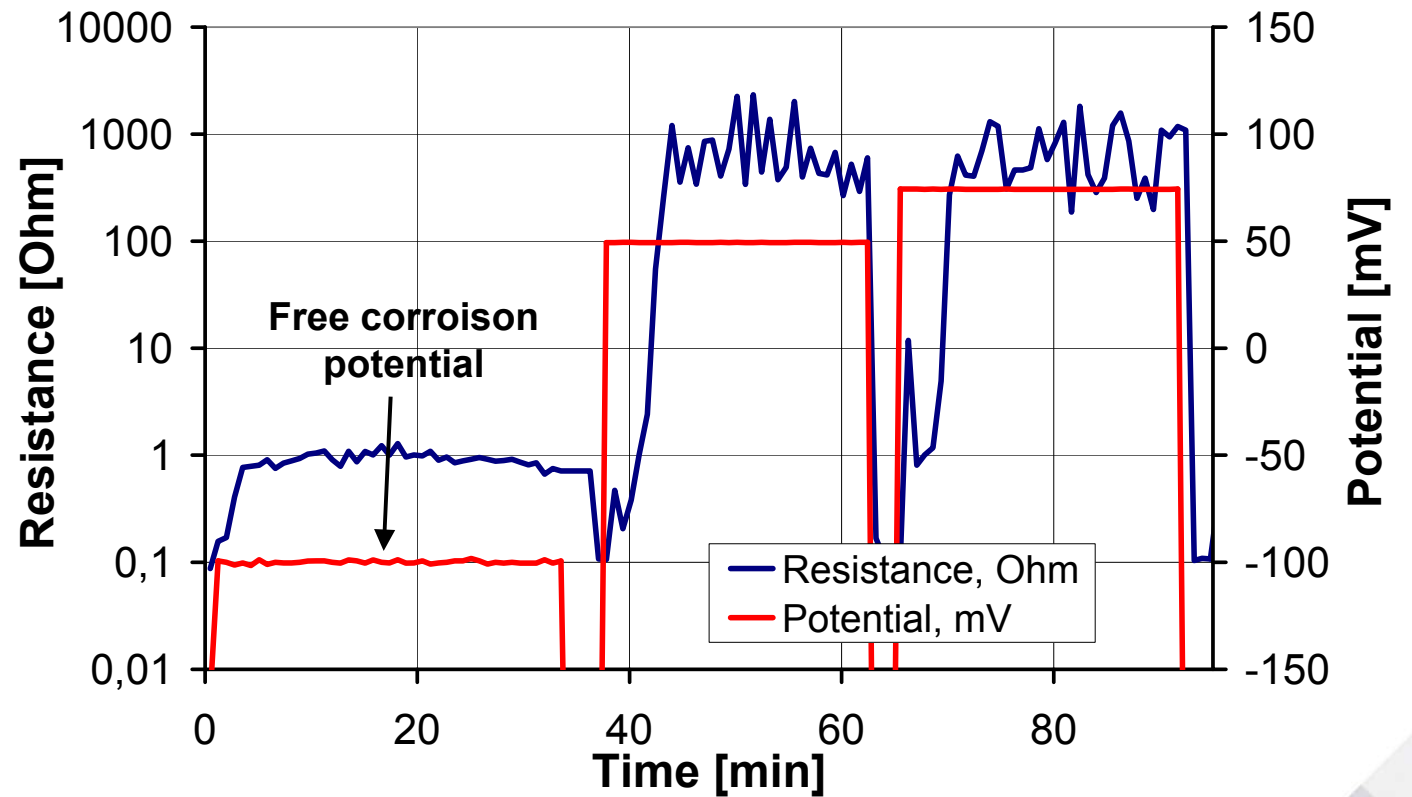
Methodology



Methodology



Methodology



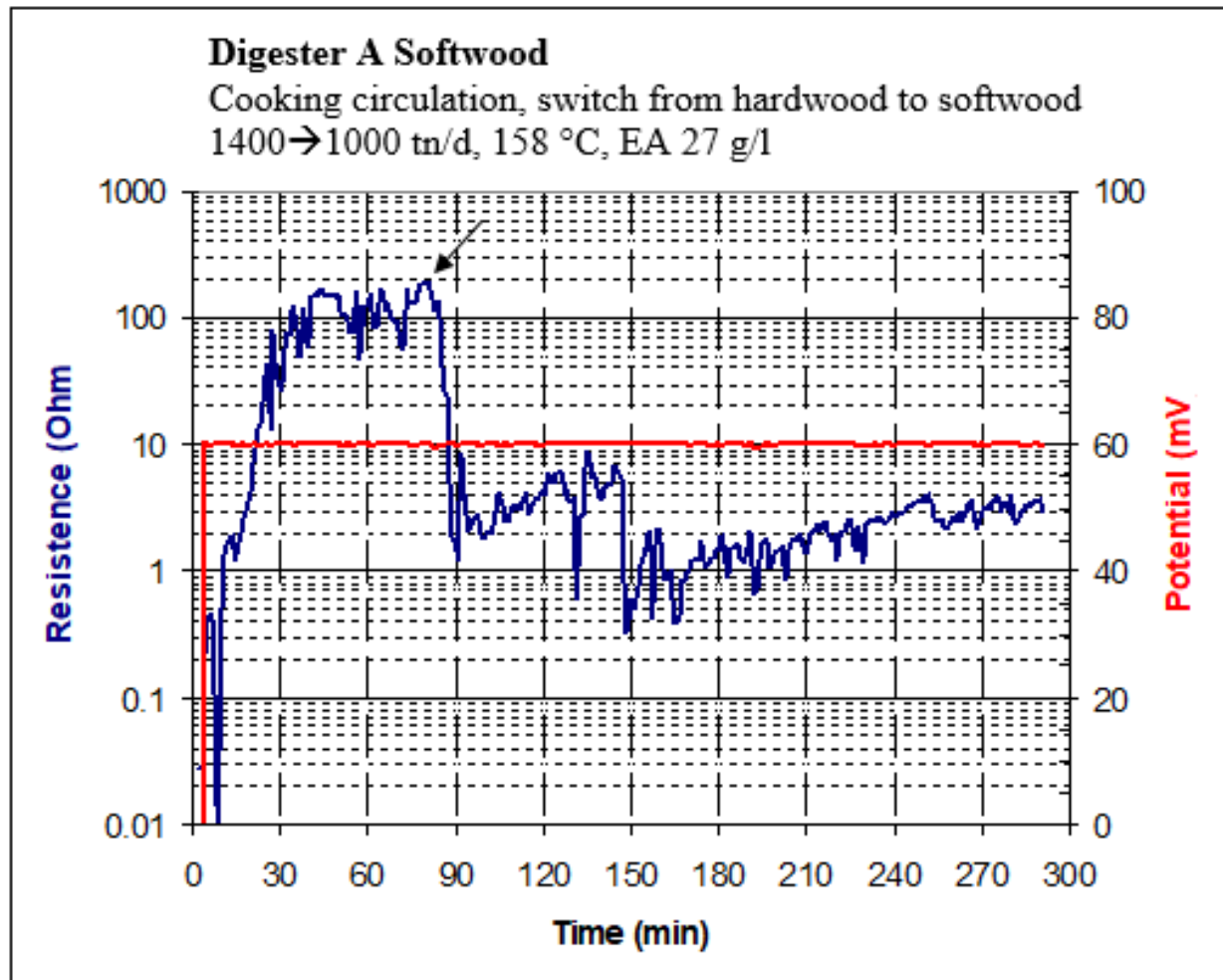
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Wood species

- Switch from hardwood to softwood, cooking circulation, potential constant at +60 mV
- Passivation collapses when switched to softwood
- Softwood is typically more aggressive in terms of corrosion
- Passive range is different for softwood, often higher than for hardwood



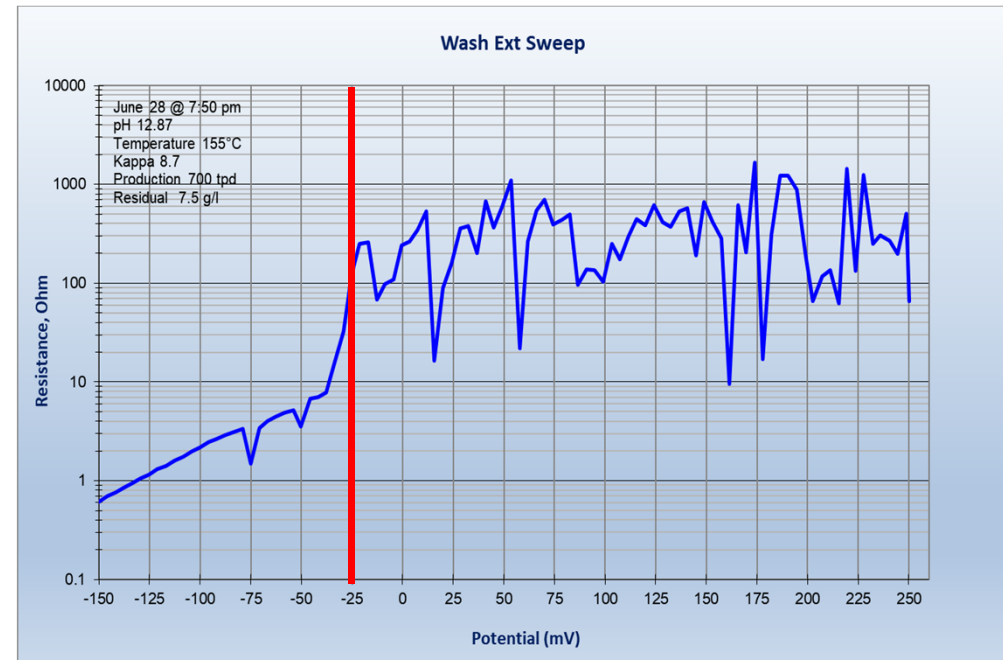
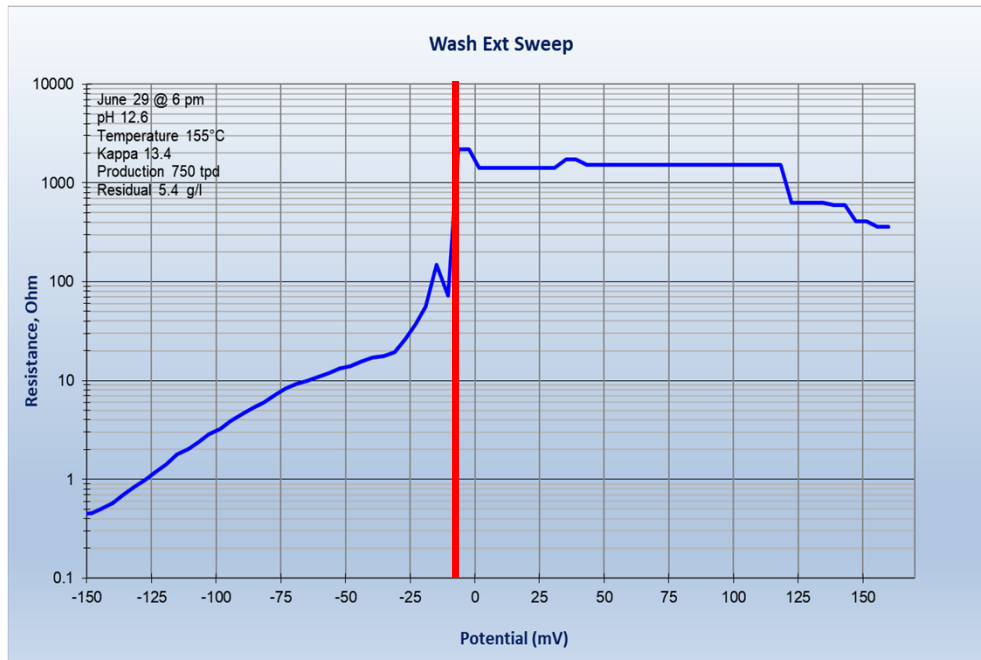
Production rate

- Hardwood
- 1200 – 1550 t/d
- Easy passivation at 1200 t/d
- 1550 t/d with higher temperature requires higher potential for passivation

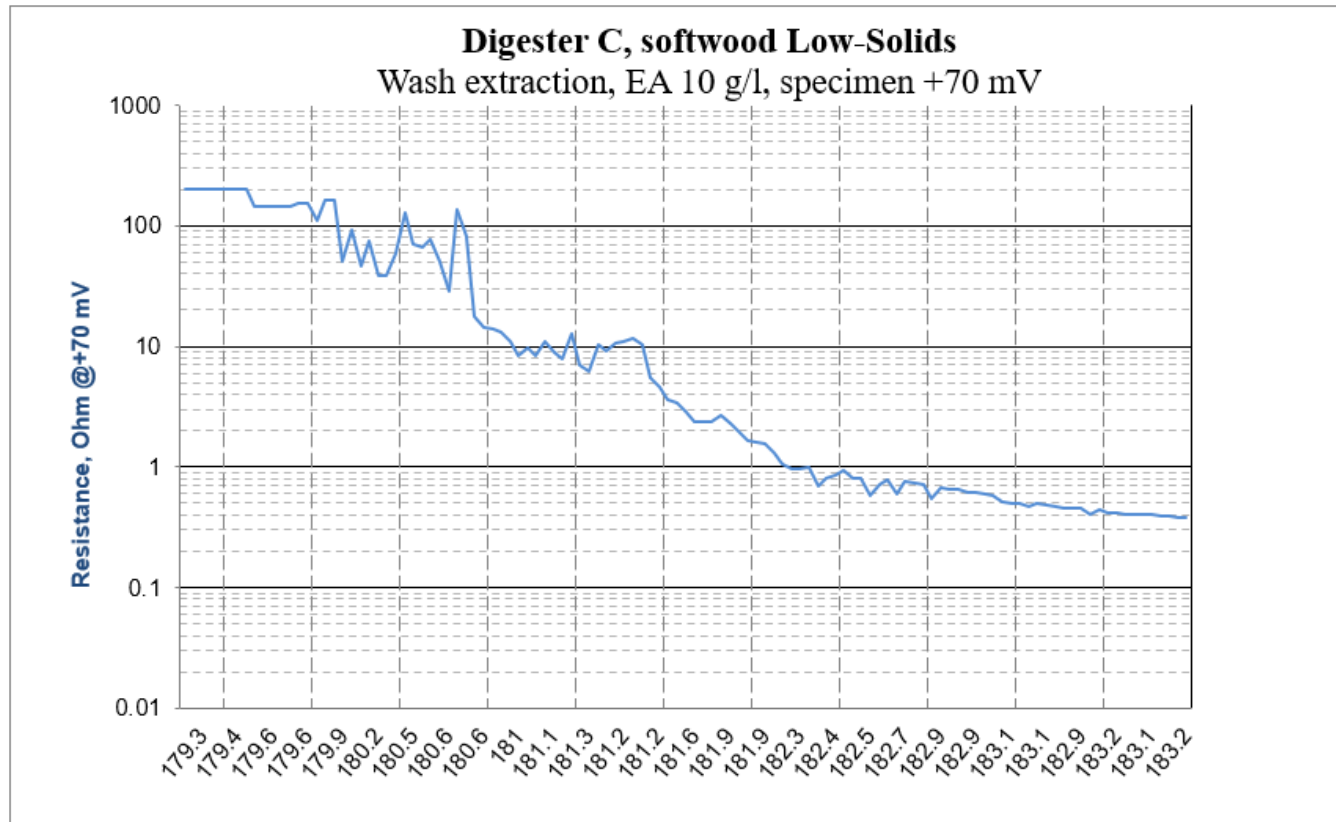
Digester A		
Cooking circulation		
Potential:	Hardwood 1200 tn/d, 151°C EA 27 g/l	Hardwood 1550 tn/d, 155°C EA 26 g/l
-60 mV		
-50 mV	Passivating	Weak passivation
-40 mV		
-25 mV	Passivating	Weak passivation
-20 mV		
+0 mV	Passivating	Porous passivation
+20 mV		
+25 mV	Passivating	
+40 mV		Passivating
+50 mV	Passivating	
+60 mV		Passivating
+75 mV	Passivating	
+80 mV		Passivating
+100 mV		



Effective alkali (5.4 → 7.5 g/l)



Temperature (179 → 181 C) (354 → 358 F)



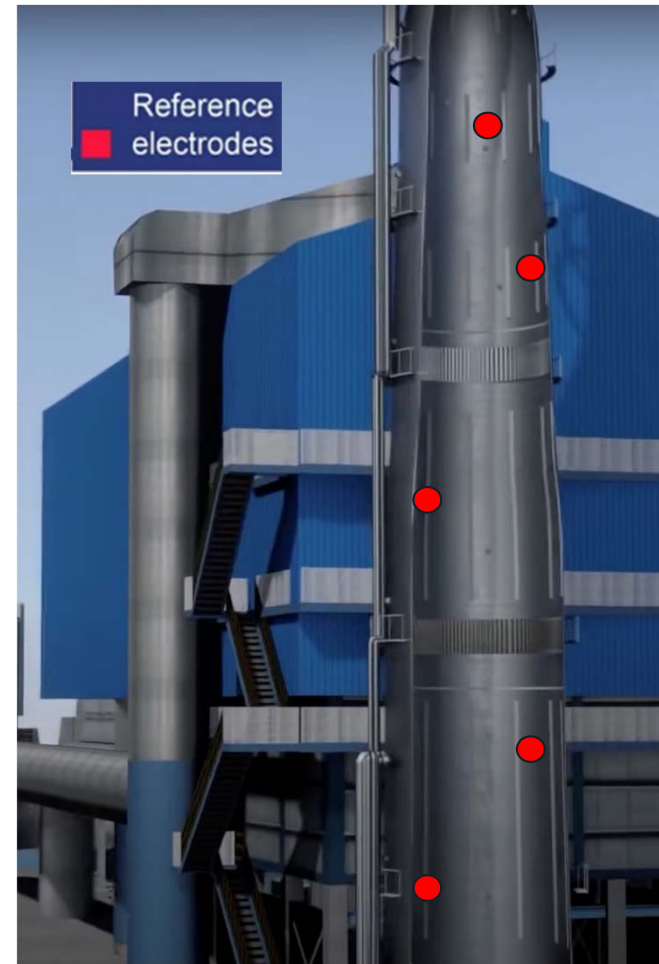
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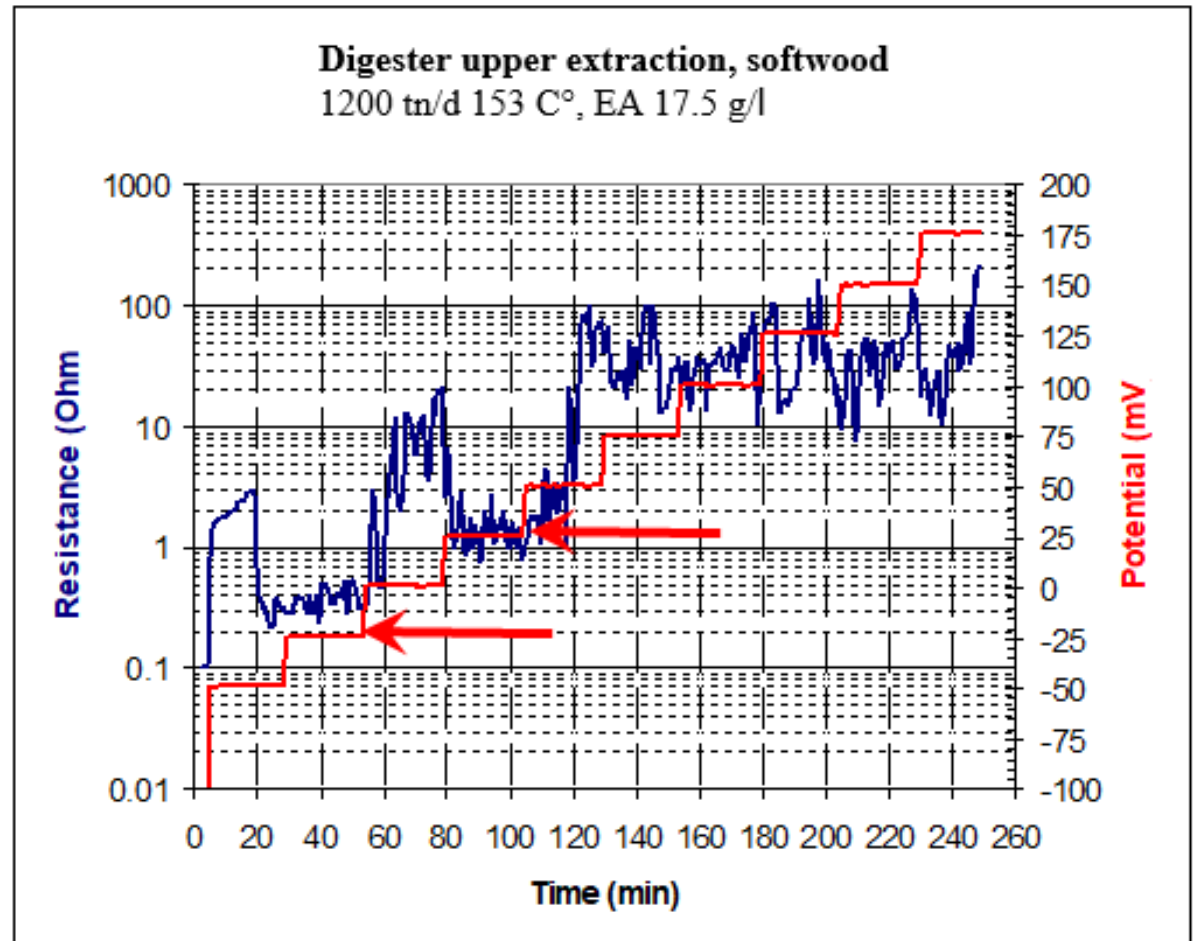
On-line corrosion monitoring

- CER defines corrosion risk potential ranges
- Target potentials for corrosion prevention range
- Key for monitoring and avoiding corrosion, operator tool

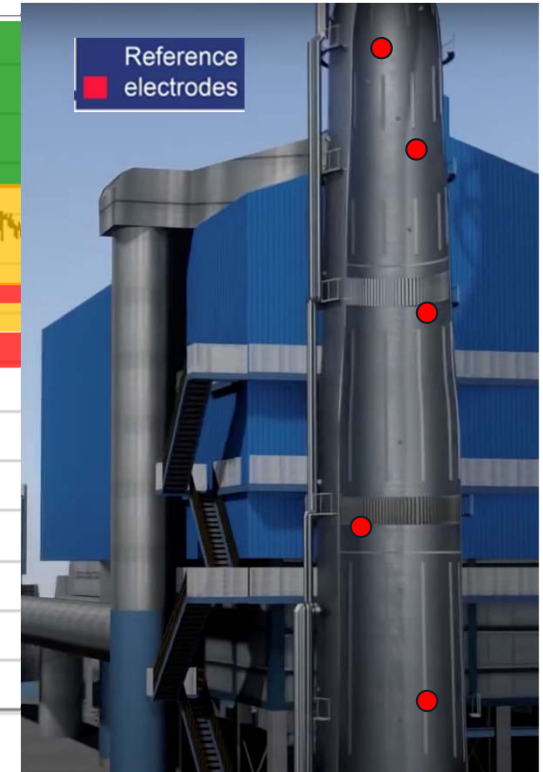
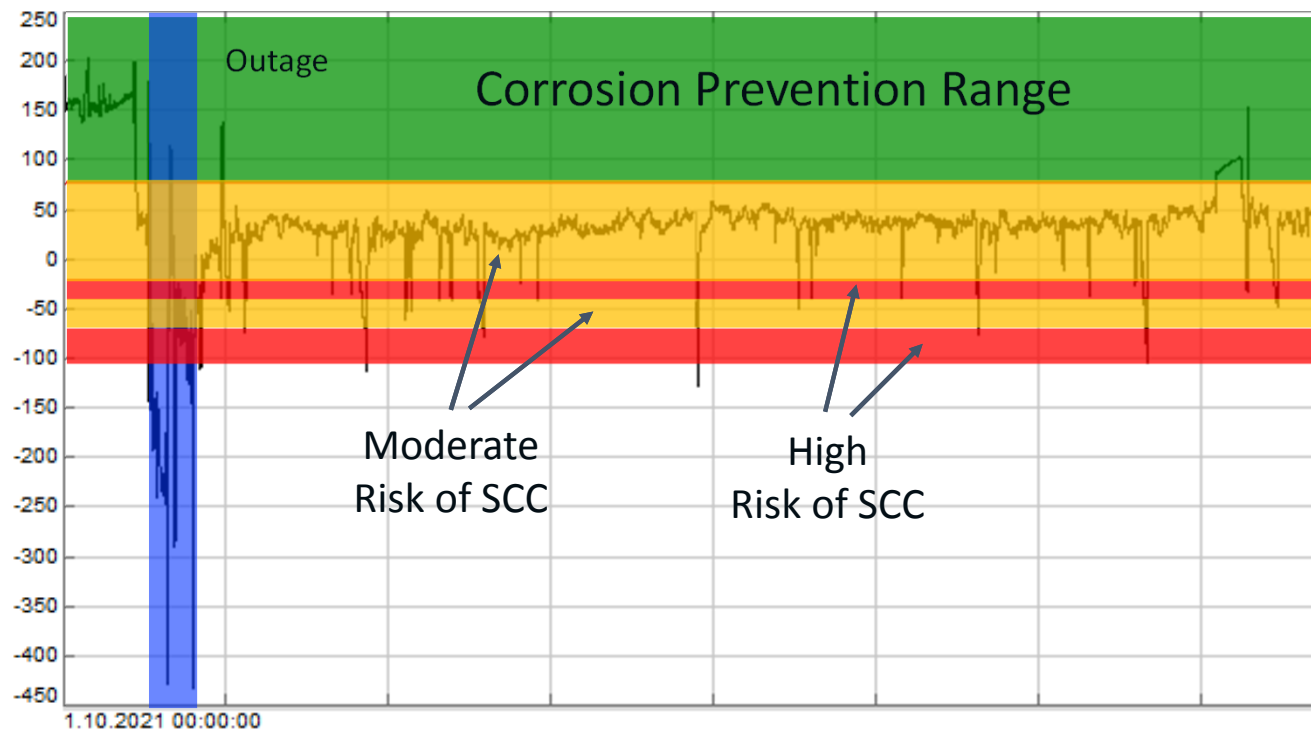


On-line corrosion monitoring

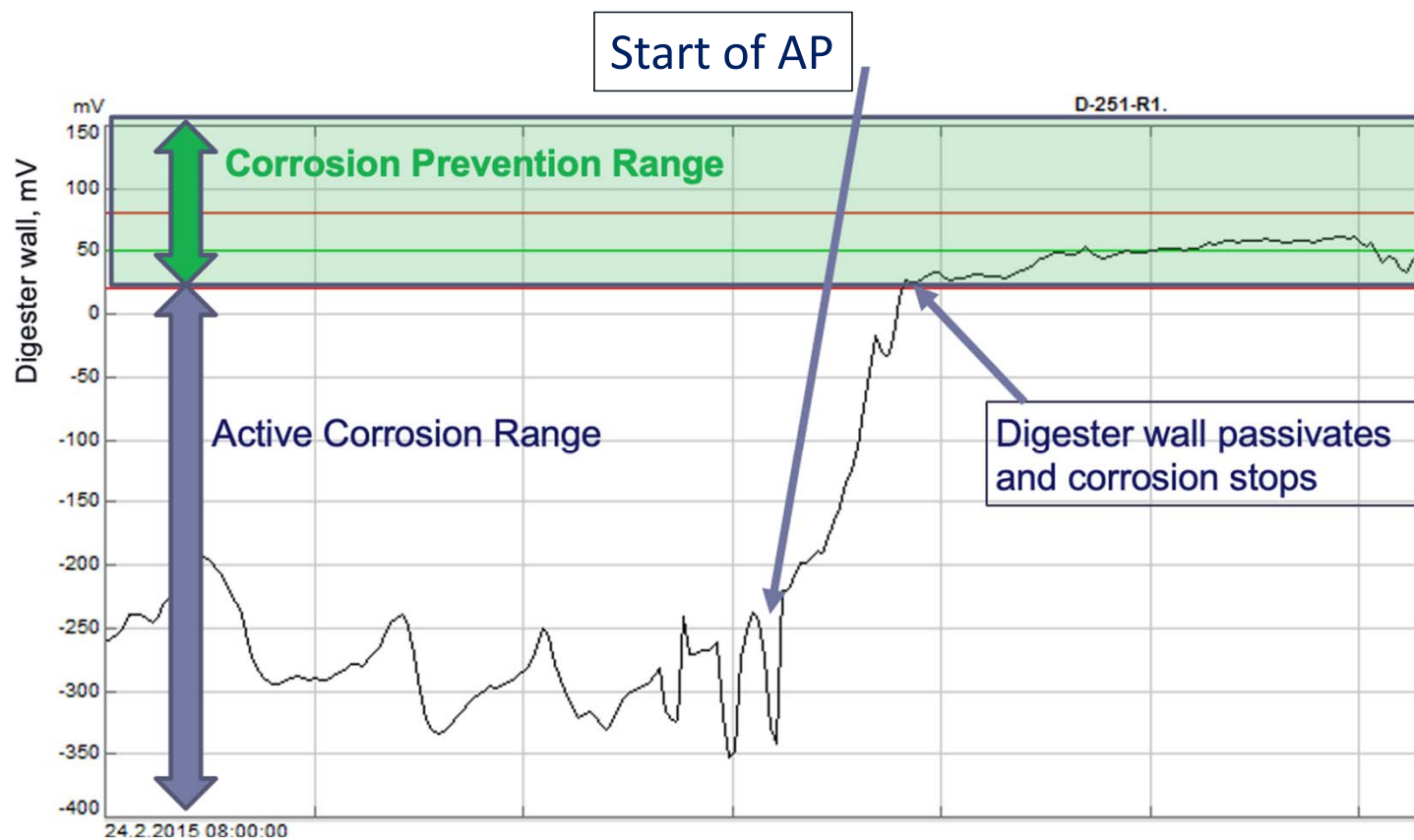
- CER safe ranges to be followed



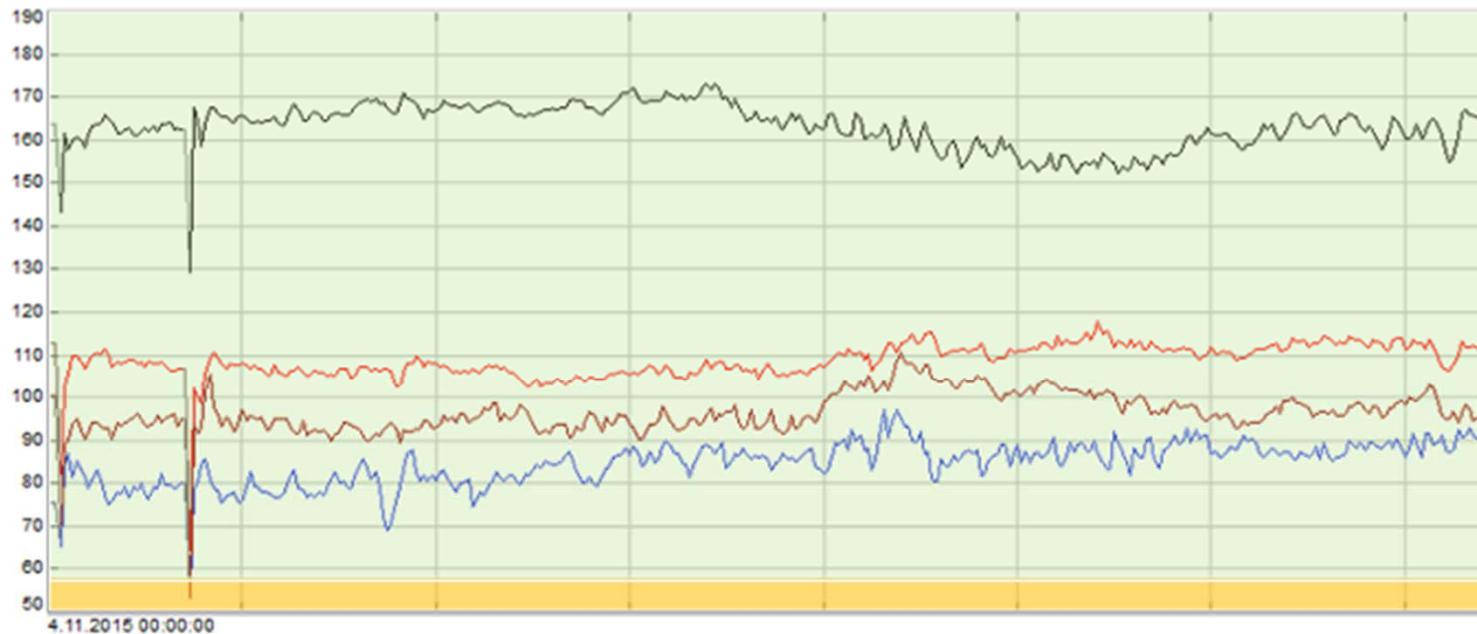
On-line corrosion monitoring (no AP applied)



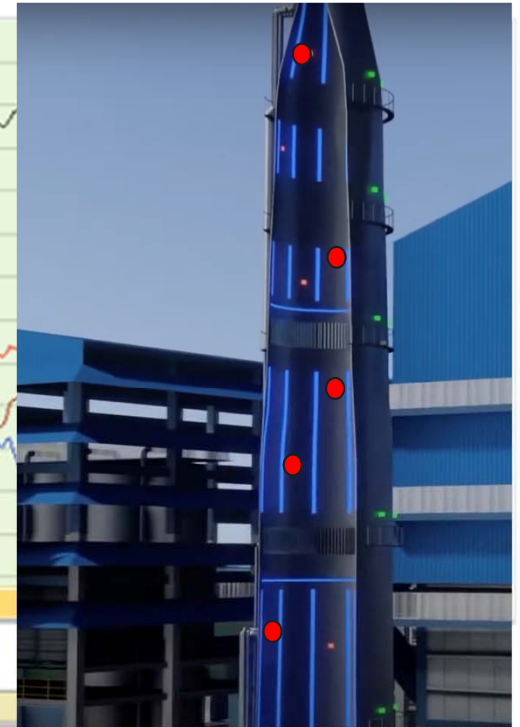
Anodic Protection



Anodic Protection



Left axis		Left axis	
■ Upper cooking, R8 reference (mV)	53.5 - 97.07	■ Upper cooking, MR3 reference (mV)	64.1 - 125
■ Upper cooking, R6 reference (mV)	53.2 - 110.6	■ Upper cooking, R7 reference (mV)	129 - 182.4



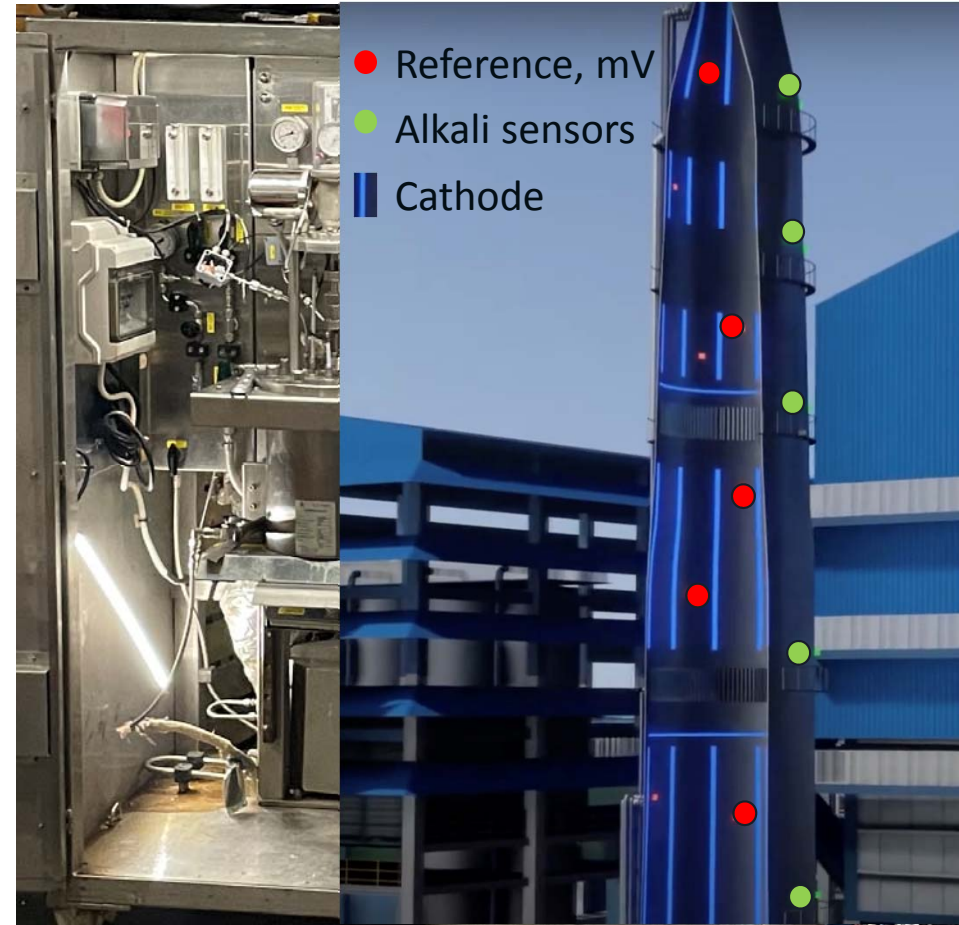
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Discussion

- CER measurements have been routinely conducted for over 20 years
- High resolution of CER enables the chemical variations on the liquor and temperature changes and their influence on passivation to be seen
- Effect of wood species, vessel zones and different types of pulping modifications can be investigated
- On-line monitoring of corrosion potential is key in effective anodic protection control
- New method for EA measurement installed directly to vessel wall helps finetune protection



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Conclusions

- Cooking conditions affect electrochemical potentials, passivation region, and consequently the corrosion behavior of continuous digesters
- Every digester and cooking process is unique and requires individual assessment of corrosion risks
- On-line corrosion monitoring together with safe potential ranges defined by CER is an effective tool in order to continuously monitor corrosion risks
- Key variables are wood species, process temperature and effective alkali level

