Evaluation of the Proposed European Screening Test for Stainless Steel Rebar

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Evaluating and Ranking Corrosion Resistant Rebar

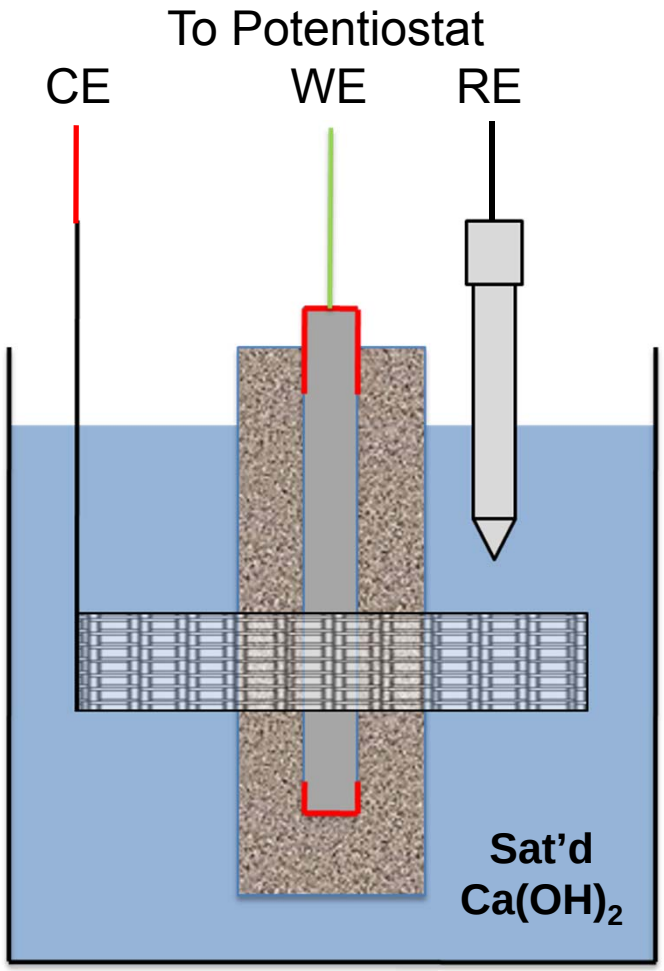
- Conventional testing of rebar embedded in concrete
  - ***Several years***
- Testing of rebar in synthetic pore solution with added chlorides
  - ***Several months***
- ASTM A955 Procedure A3: Cracked Beam Test
  - ***60 weeks***
- ASTM A955 Procedure A2 Rapid Macrocell Test
  - ***15 weeks***

Modification of EN 480-14:2006

Schönning & Randström, Eurocorr 2011 Paper 4903

- 10 replicates of each steel
- Stainless steel rebar cast in standardized mortar cylinders
- w/c = 0.50
- 4% Cl^- by mass of cement added as NaCl to mixing water
- After 24 hrs curing in mould, cylinders immersed in saturated $Ca(OH)_2$ solution
- Open circuit potential monitored for an additional 24 hrs
- Potential of +200 mV versus SCE applied for 1- 4 days
- Current monitored and, if greater than 0.025 mA/cm^2 for >2 hrs., active corrosion considered to have occurred

Experimental set-up



At least 25mm cover all around

Titanium mesh ring counter electrode

Rebar sealed at both ends using stop-off lacquer

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Questions

- Is +200 mV SCE appropriate?
- Is 4%Cl^- as NaCl appropriate?
- Is a corrosion limit of 0.025 mA/cm^2 (250 mA/m^2) appropriate as pass/fail?
- Does the concrete mix design influence the results?
- Do the rankings from this test correspond to those of long term tests without the applied potential?

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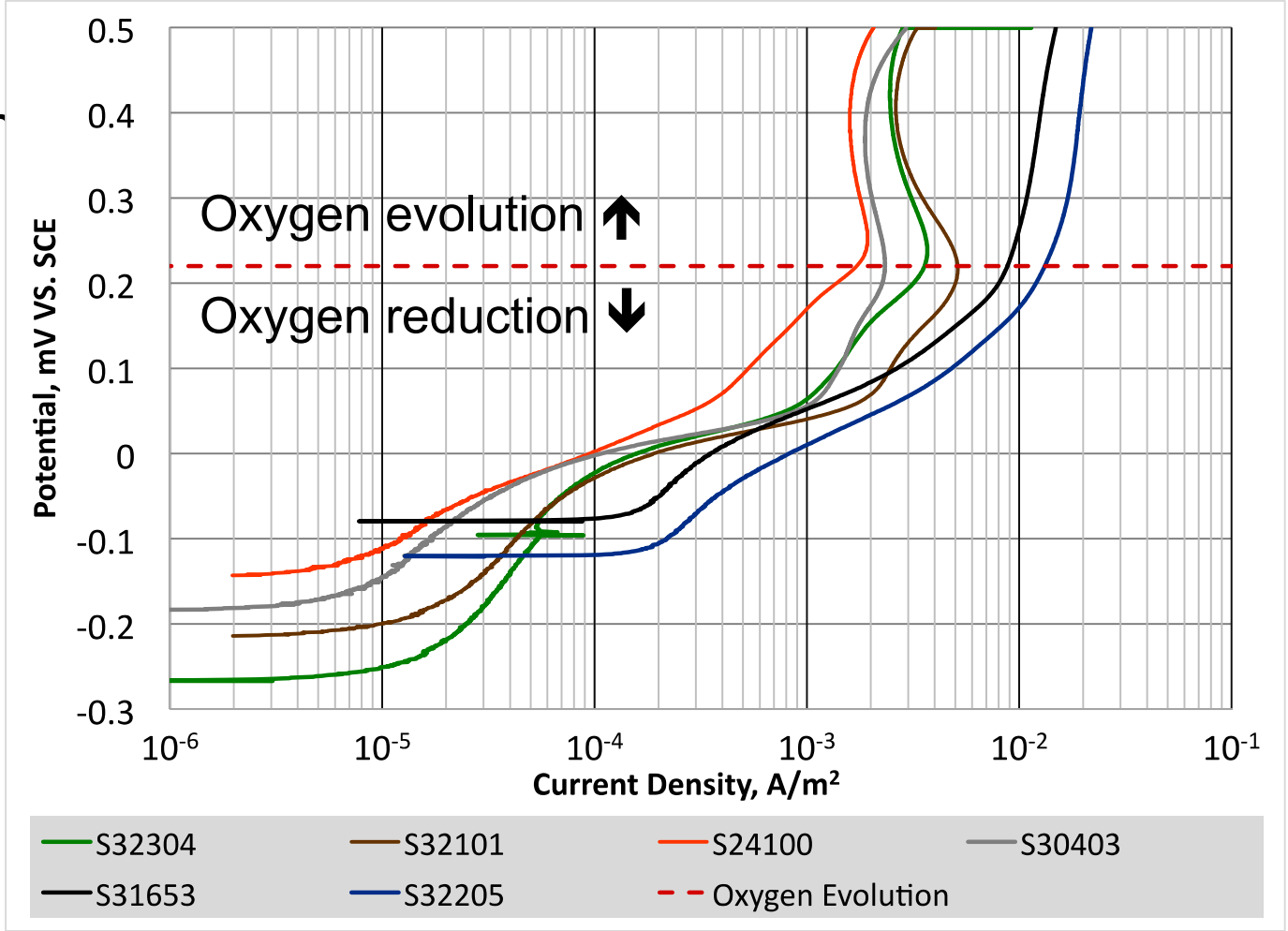
Is +200 mV SCE appropriate?

Cyclic polarization of bars in non-cracked concrete exposed to 21% Cl^- brine



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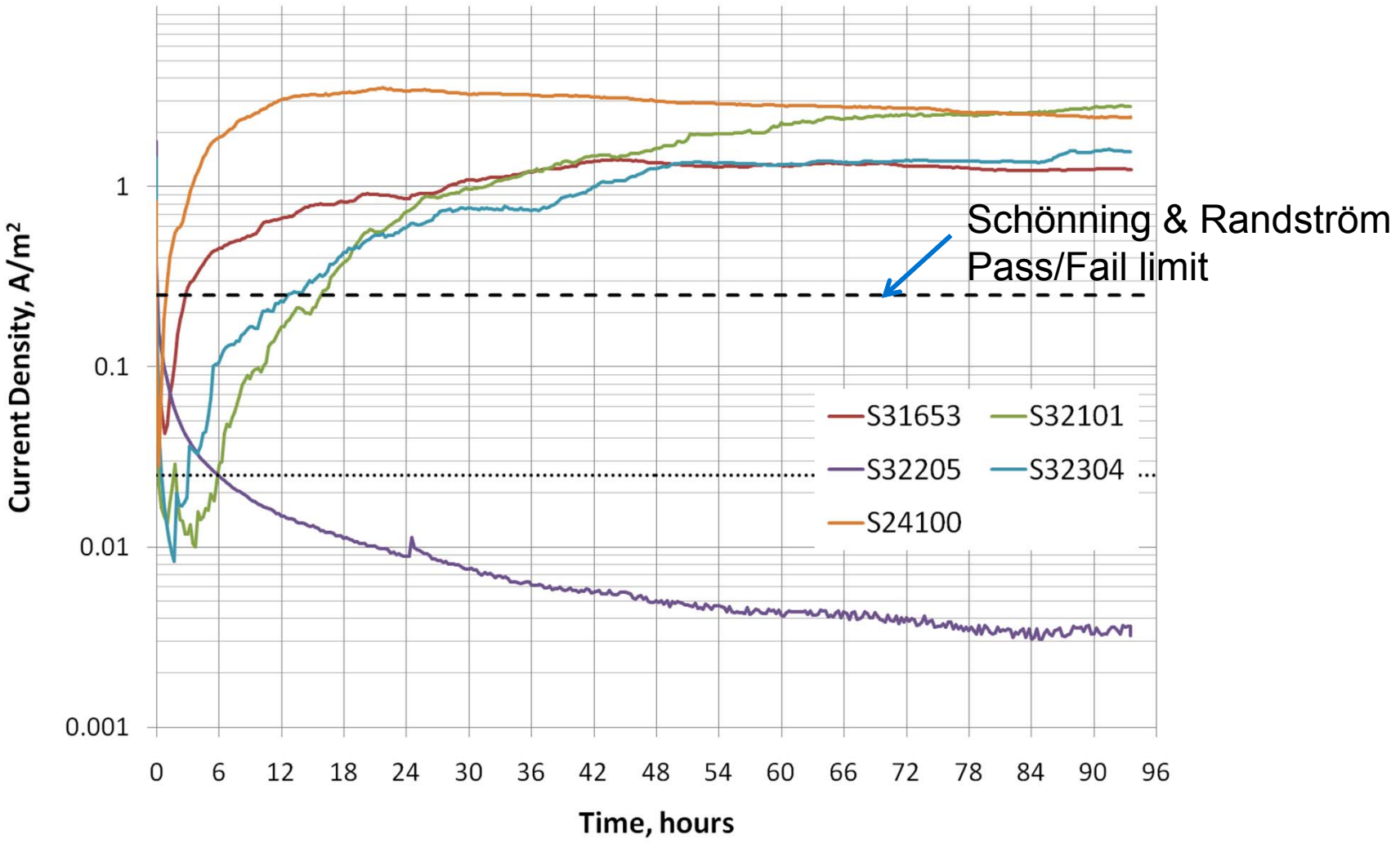
Our modifications of this procedure

- Only 3 replicates of each steel for each variable
- Typical highway concrete mixture
  - with 12.5 mm max coarse aggregate (instead of 19 mm)
  - w/cm = 0.40
- 3 different test variables

Variables tested

- Potentials:
  - +200 mV SCE
  - +100 mV SCE
- Chloride content by weight of cementitious materials:
  - 5% (*max. content reported in field in Canada*)
  - 3%
- Concrete mix:
  - 75% GU (Type 1) + 25% Slag
  - 100% GU

OPC with 25% slag, 5% Cl-, +200 mV SCE



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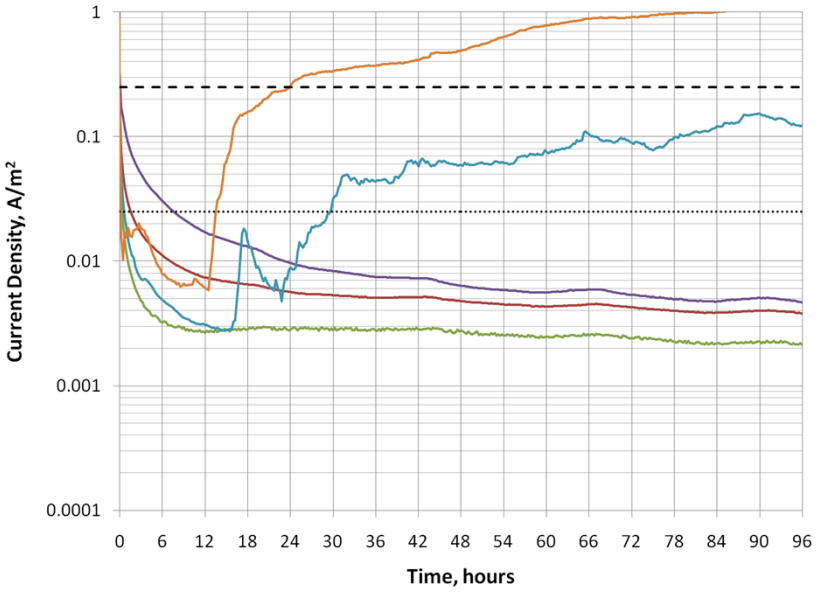
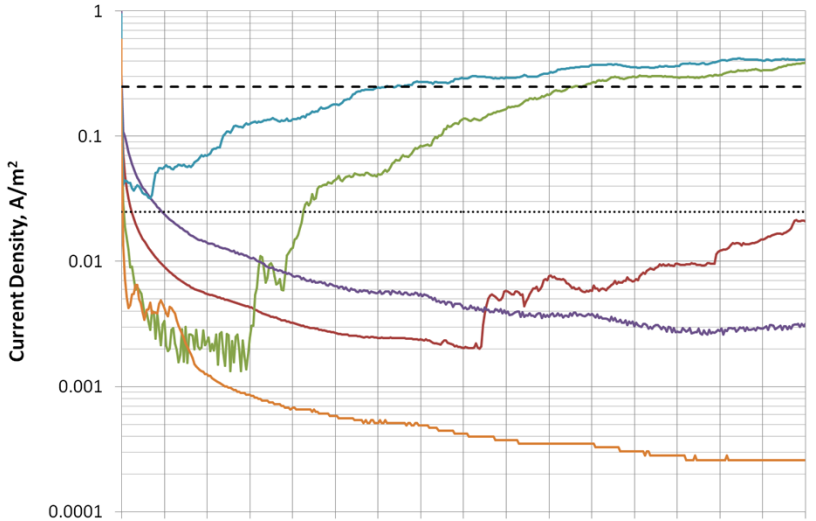
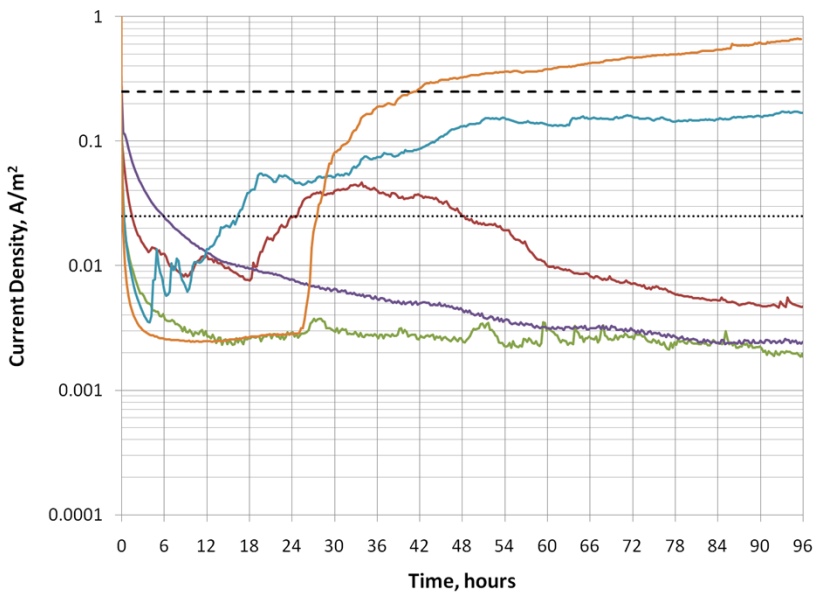
OPC with 25% slag, 3% Cl-, +200 mV SCE







S31653
S32101
S32205
S32304
S24100

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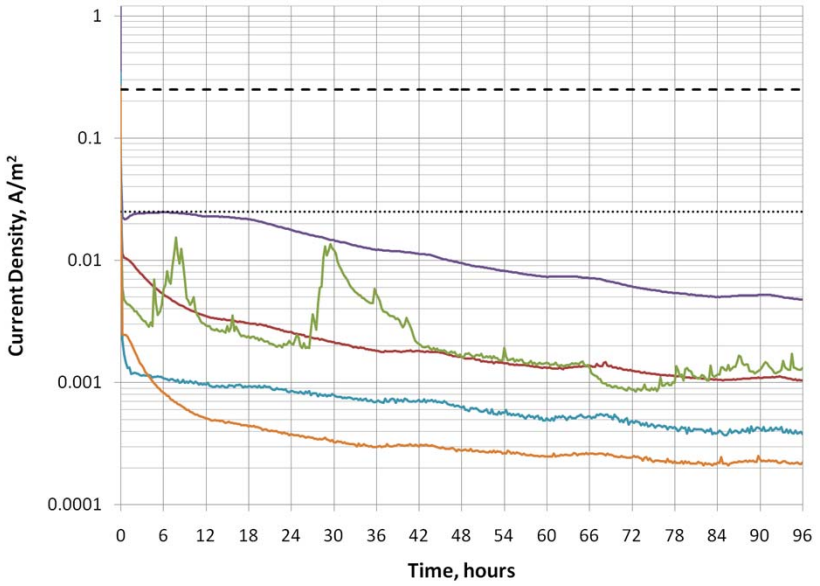
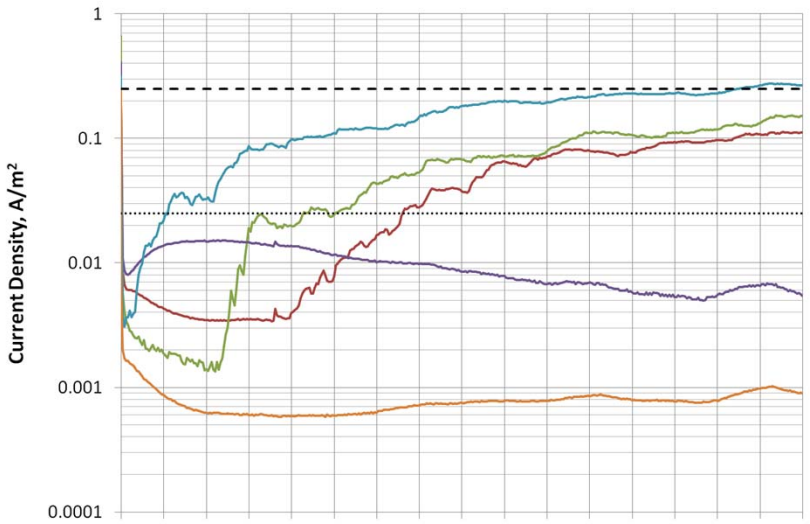
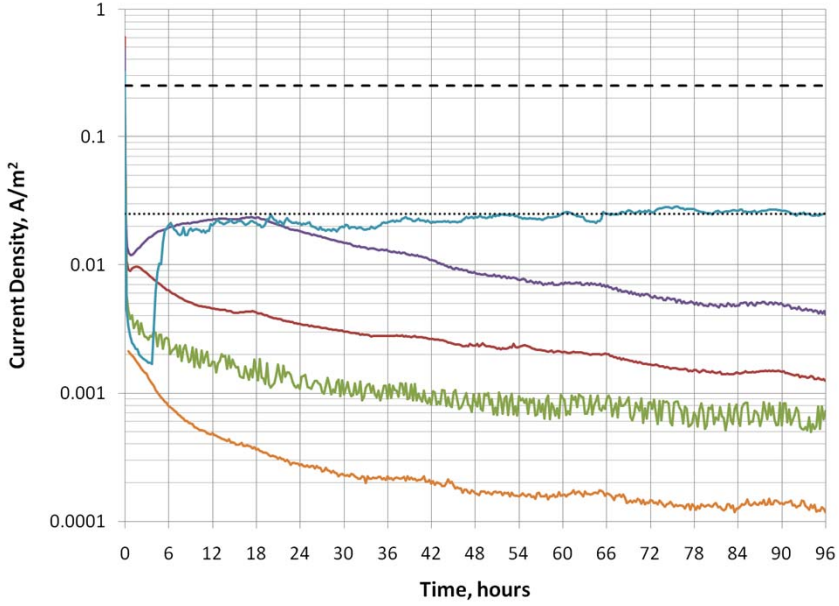
OPC with 25% slag, 3% Cl-, +100 mV SCE







S31653 S32101

S32205 S32304

S24100

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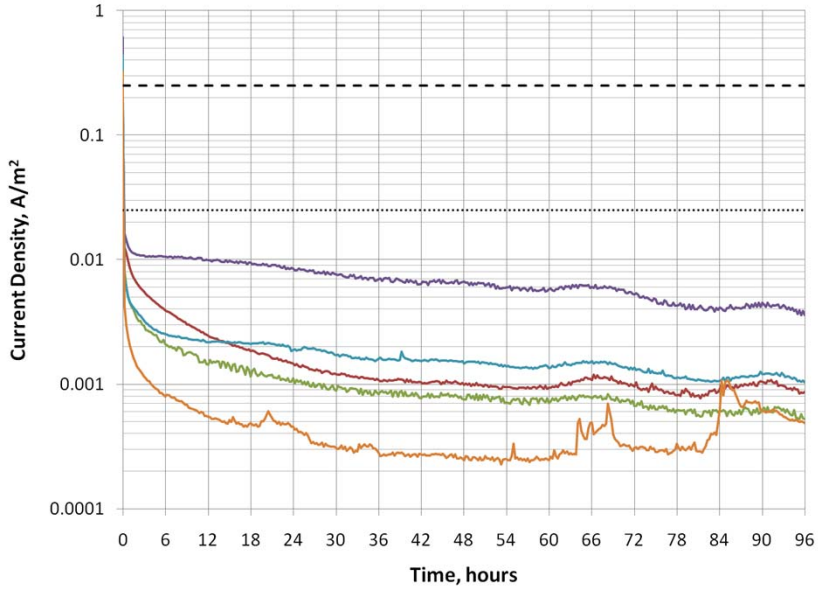
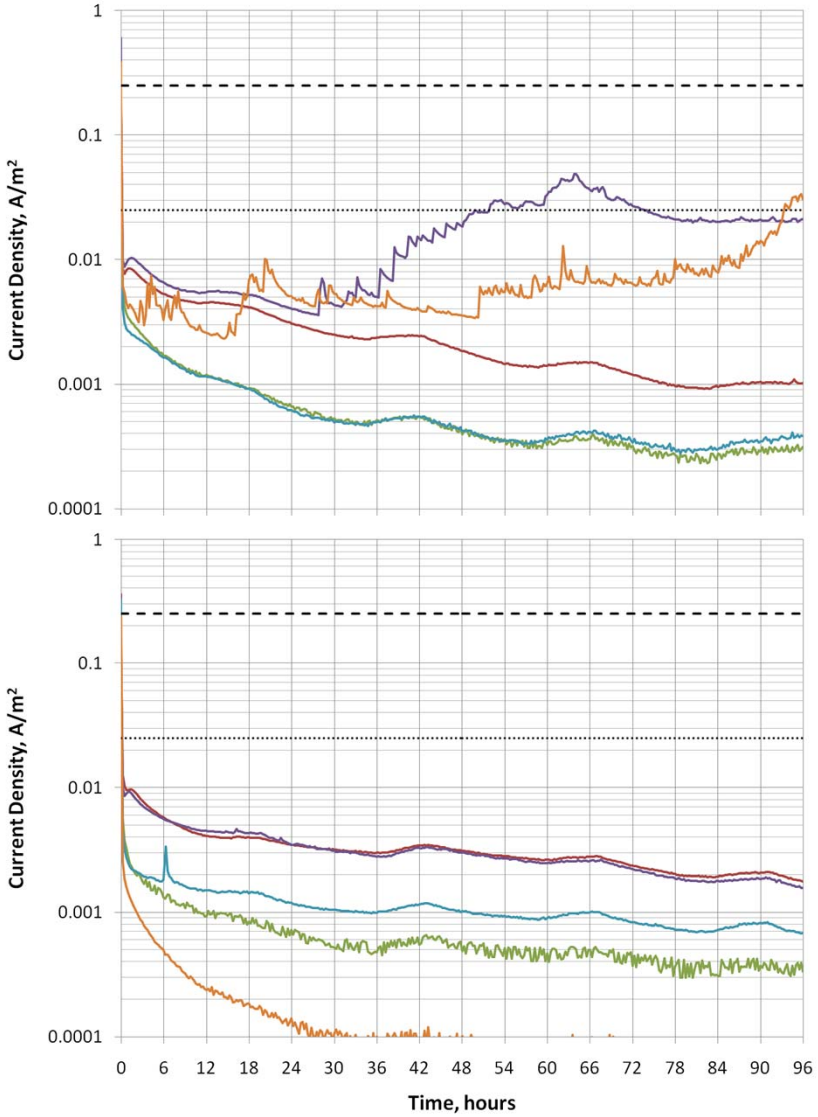
OPC, 3% Cl-, +100 mV SCE





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S32101
S32205
S32304
S24100

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No corrosion

Little corrosion

Extensive corrosion

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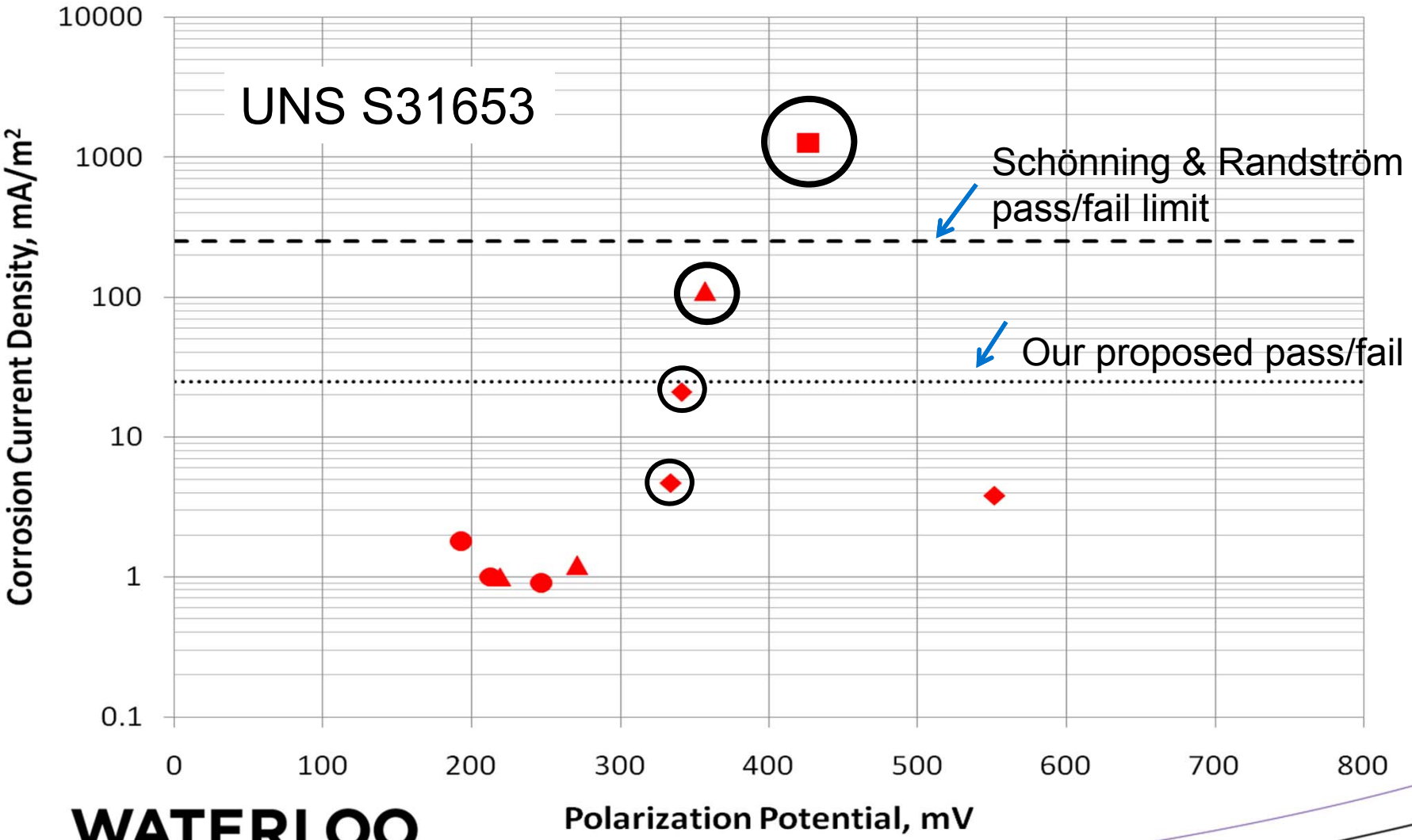
■ OPC w. 25% slag, 5% Cl-, +200 mV SCE

▲OPC w. 25% slag, 3% Cl-, +100 mV SCE

♦OPC w. 25% slag, 3% Cl-, +200 mV SCE

● OPC, 3% Cl-, +100 mV SCE



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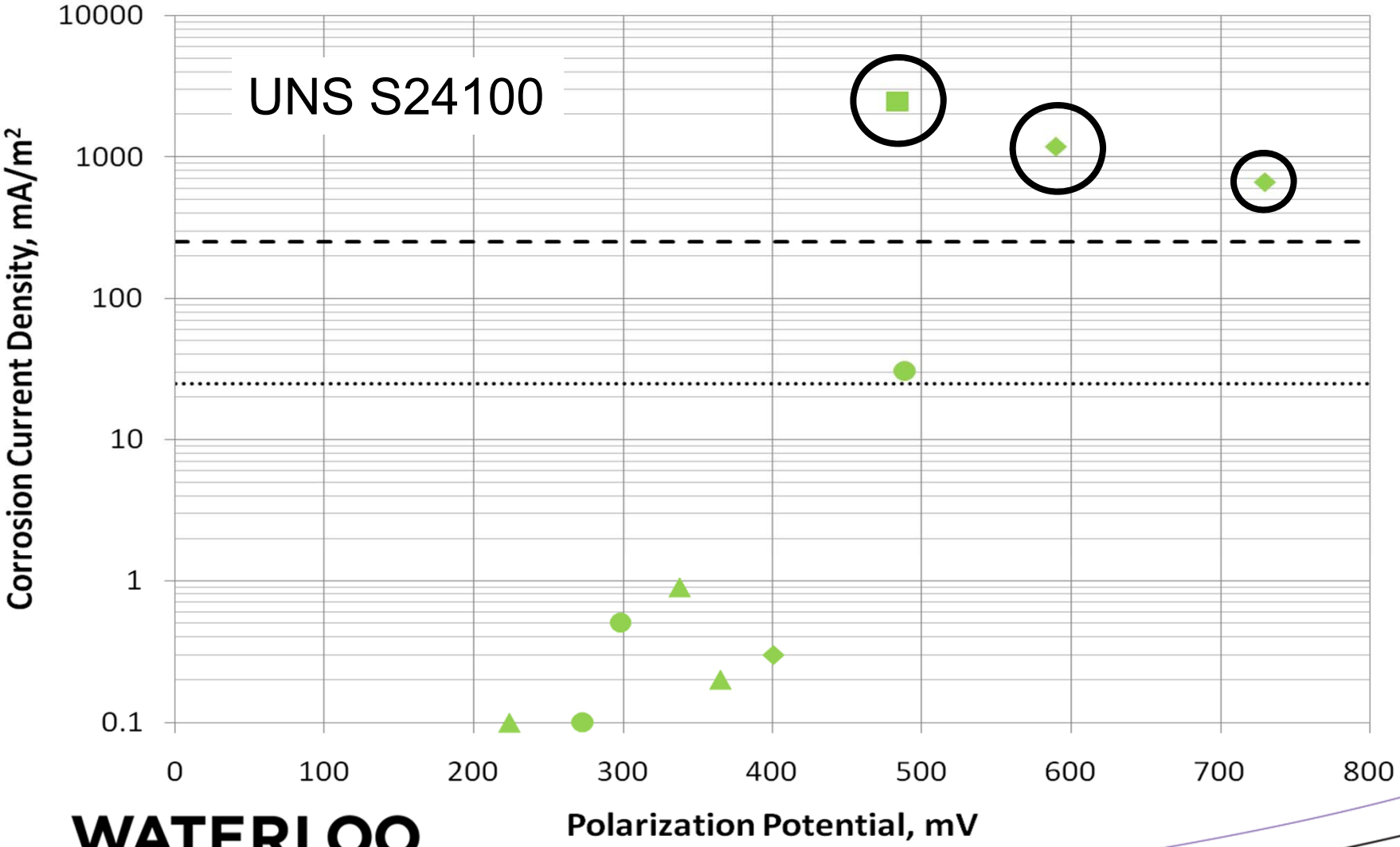

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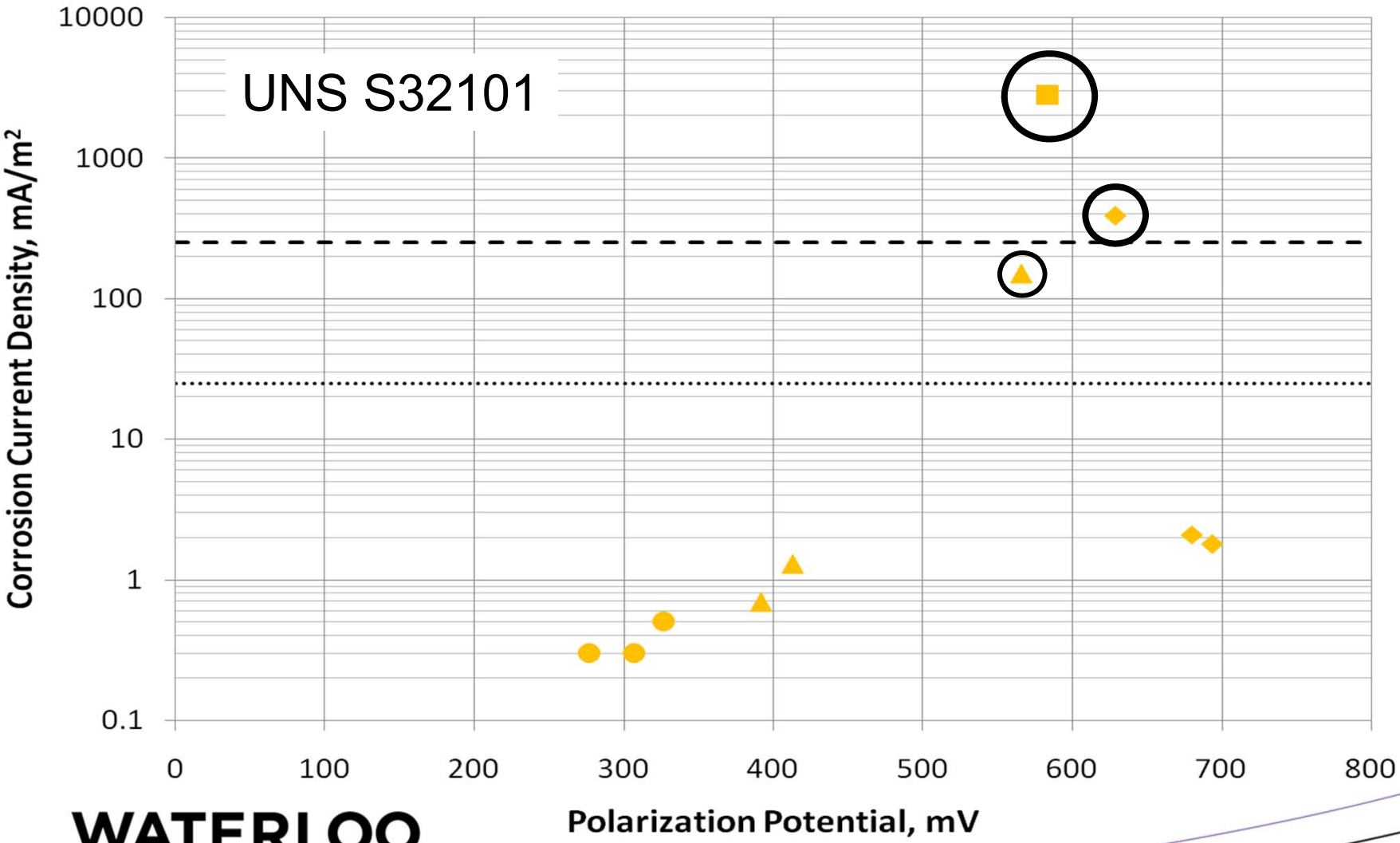

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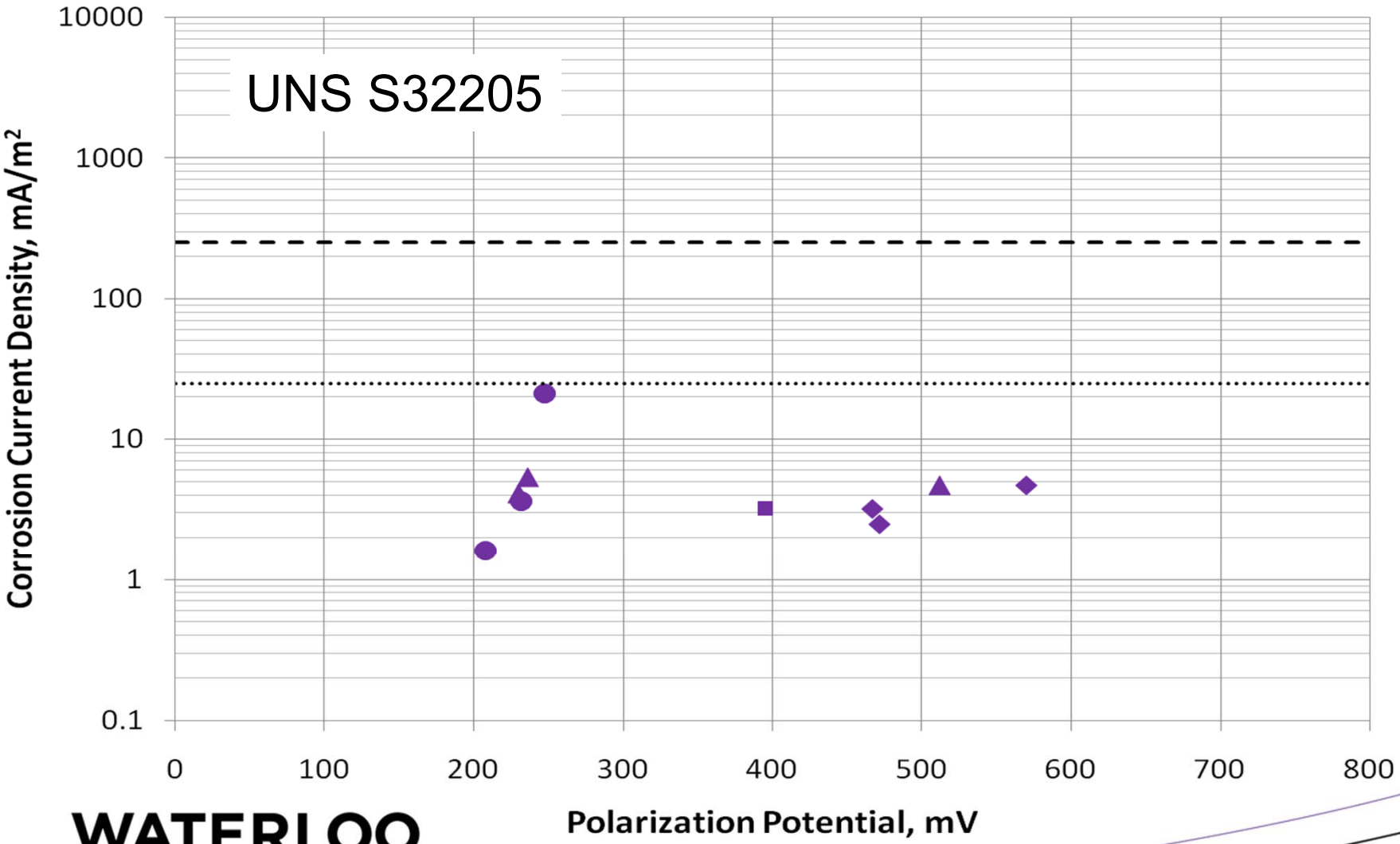

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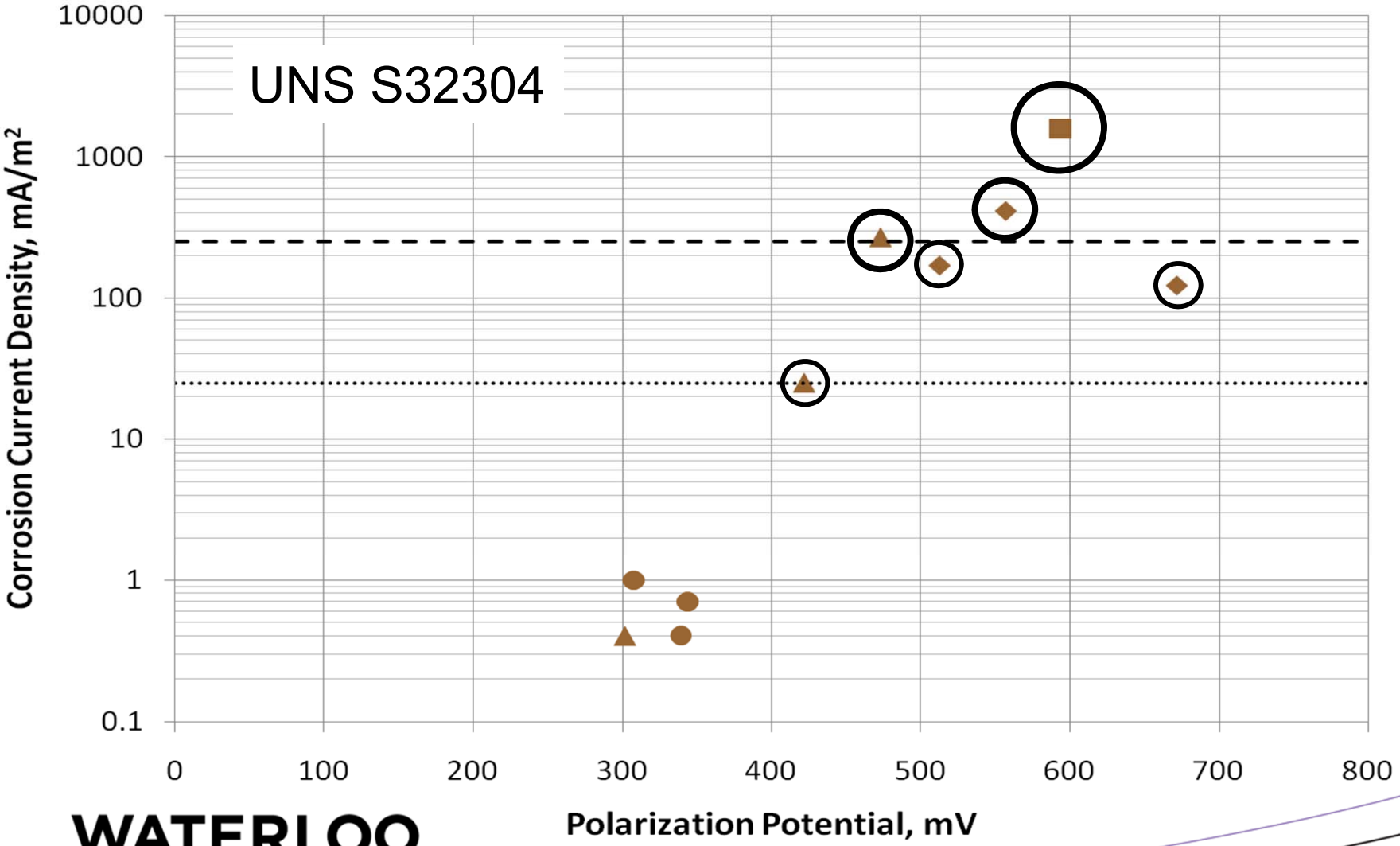

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Number of bars of the three replicates in concrete with 3% Cl^- with observed corrosion products after the 96 hrs at the potentials given (# bars with corrosion rate >0.025 mA/cm^2 for 2 hours)

Ranking	Grade	Concrete with slag @ 200mV	Concrete with slag @ 100mV	OPC concrete @100 mV
1	S32205	0 (0)	0 (0)	0 (0)
2	S32101	1 (1)	1 (0)	0 (0)
3	S31653	2 (0)	1 (0)	0 (0)
4	S24100	2 (2)	0 (0)	0 (0)
5	S32304	3 (1)	2 (1)	0 (0)

Comparative ranking on the basis of visual examination

	S32205	S31653	S32304	S32101	S24100
Current tests	1	3	5	2	4
Longitudinally cracked concrete	1	3	5	2	4
Transversely cracked concrete	2	3	4	1	5
Pore solution tests	1	3	2	4	5

Ranking from pore solution tests based on chloride threshold concentration, not visual observation

Conclusions

- + 200 mV SCE leads to instability of system;
- A fixed polarization with respect to the open circuit potential, might be a better measure;
- The pass/fail limit of 0.025 mA/cm^2 is too high and 0.0025 mA/cm^2 (25 mA/m^2) would be more appropriate;
- The different behaviour of the steels in the 2 concrete mixtures suggests use of an OPC mortar with w/c=0.50 may produce misleading results.

The Most Important Conclusion:

- The ranking of alloys on the basis of visual inspection of the corrosion after the tests agrees relatively well with that from longer term tests in cracked concrete