The Prediction of Long-term Coating Performance from Short-term Electrochemical Data, Part II. Comparison of Electrochemical Data to Field Exposure Results for Coatings on Steel

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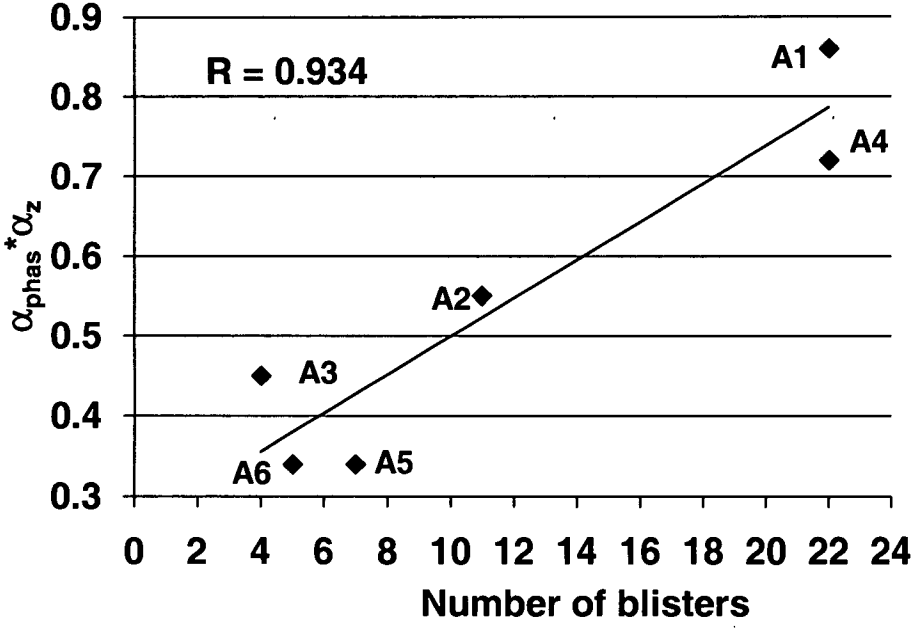
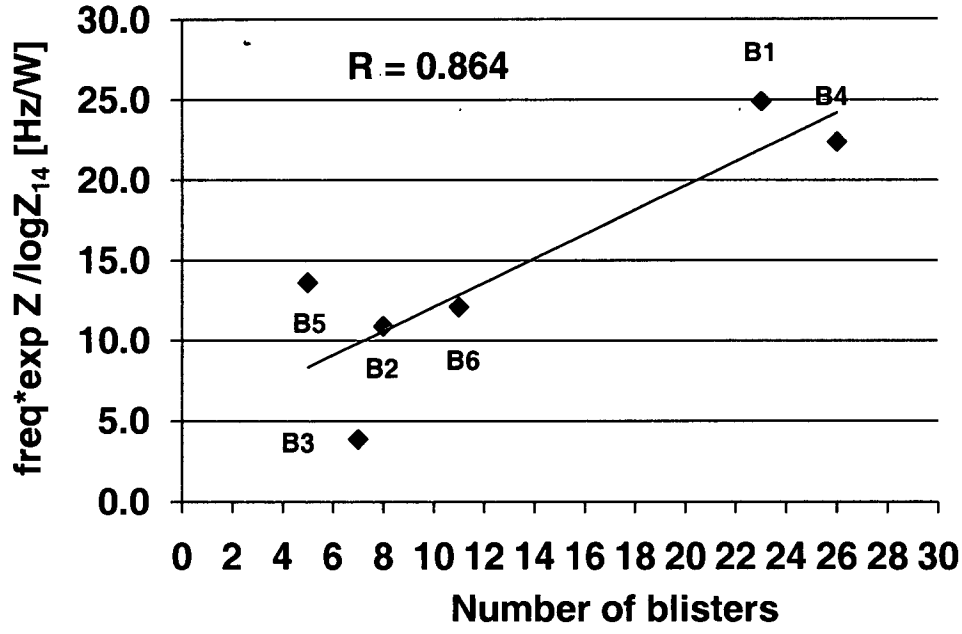
Correlation between the salt spray results and rapid electrochemical tests





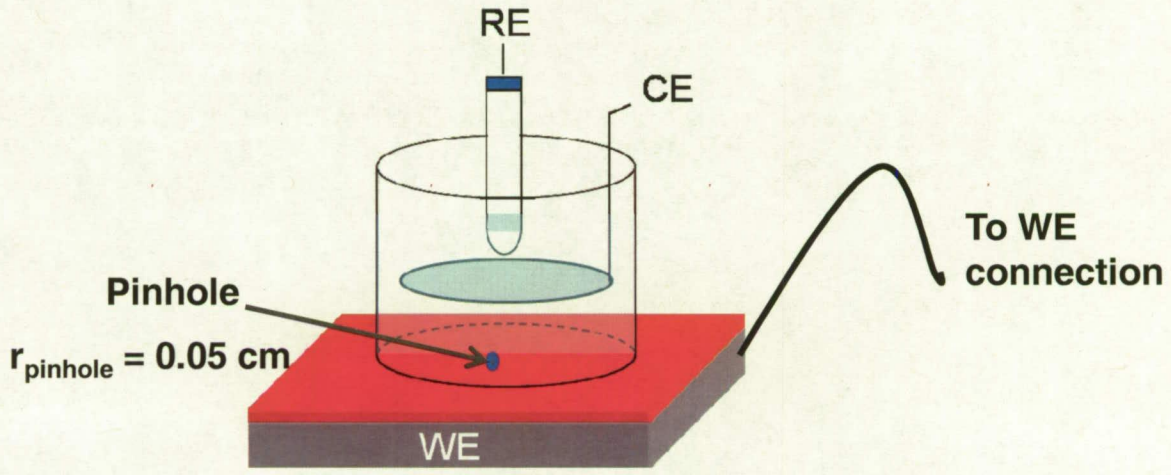
ASTM D 610-01 Rating Scale at 18 months

Rating	Description
10	No rusting or less than 0.01% of surface rusted
9	Minute rusting, less than 0.03% of surface rusted.
8	Few isolated rust spots, less than 0.1% of surface rusted
7	Less than 0.3% of surface rusted
6	Extensive rust spots, but less than 1% of surface rusted
5	Rusting to the extent of 3% of surface rusted
4	Rusting to the extent of 10% of surface rusted
3	Approximately 1/6 of the surface rusted
2	Approximately 1/3 of the surface rusted
1	Approximately 1/2 of surface rusted
0	Approximately 100% of surface rusted

Experimental

19 different coating systems on 1008 steel substrates were evaluated in 0.5 M NaCl at room temperature and with potentials referenced to SCE

Barnacle-type cell



First round of experiments

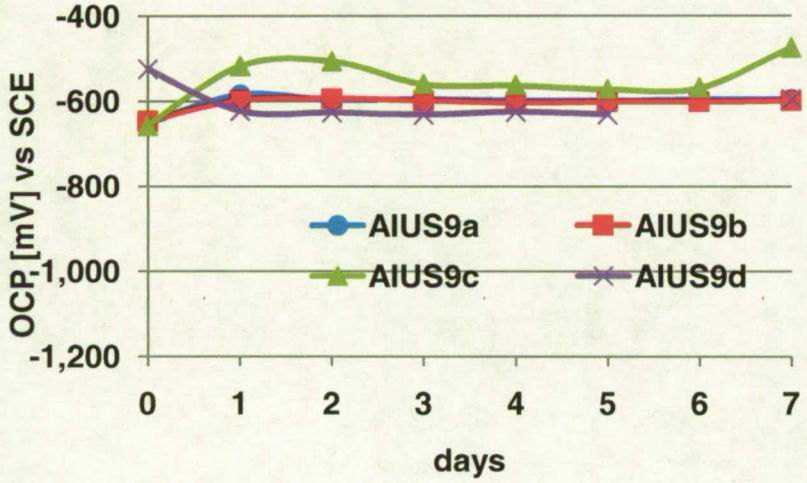
1)The panels were immersed in 0.5 M NaCl and an impedance spectra was collected

2) A pinhole was created manually using a TiN scribe

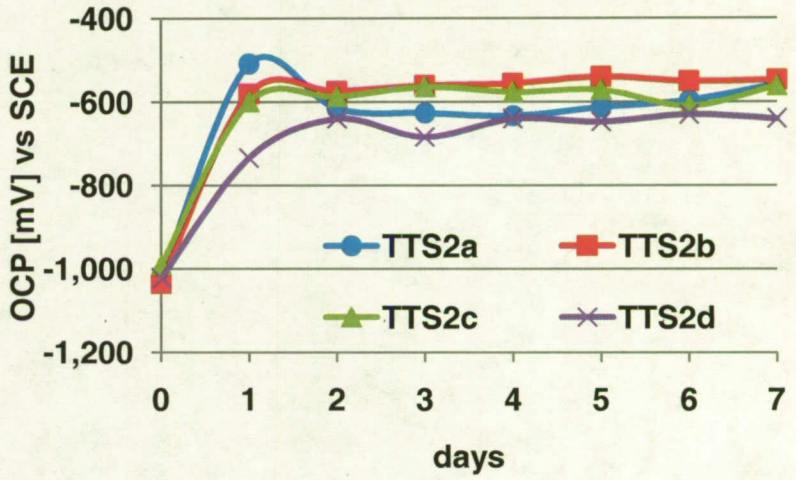
3) OCP monitored for 30 mniutes and then EIS spectra collected every 24 hours for 7 days

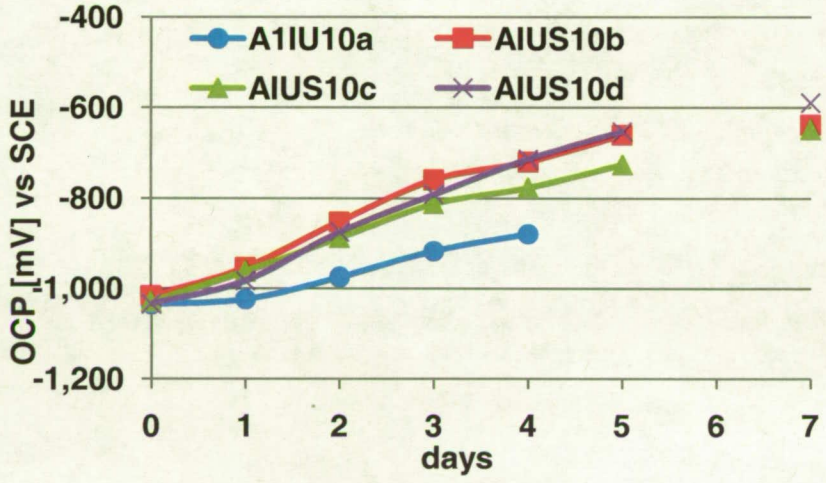
4 distinct OCP behaviors were observed during the first series of tests

1) The potential remained around -0.6 V throughout the 7 days of exposure time

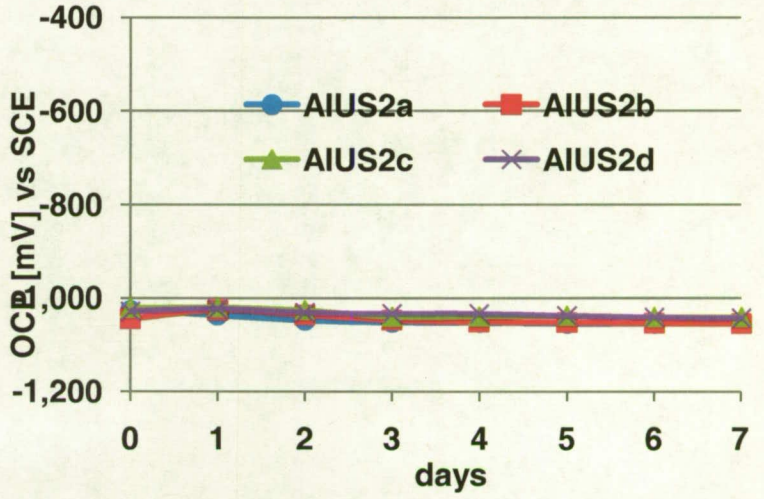


2) The potential rapidely increased from around -1 V to -0.6 V



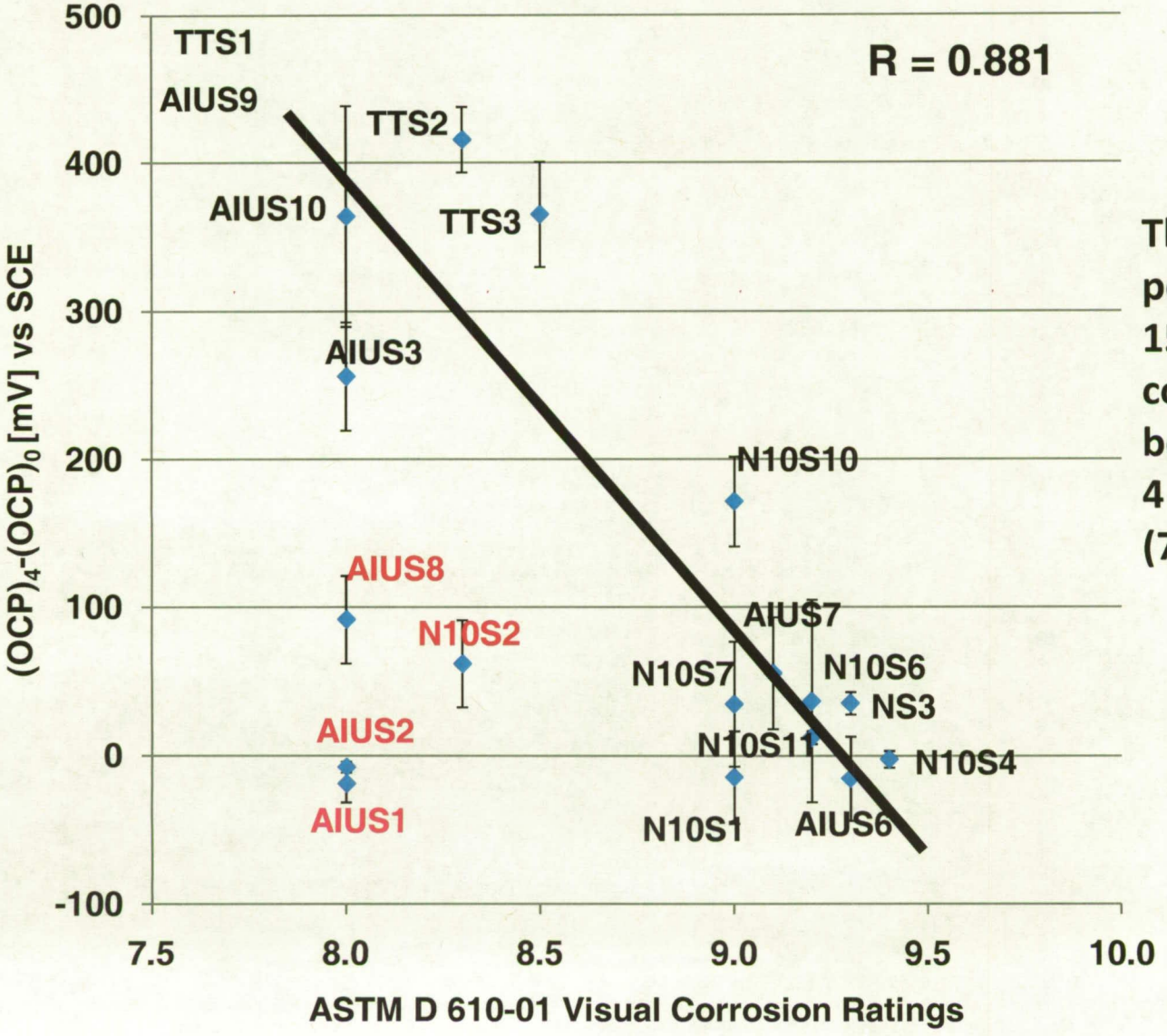


3) The potential gradually creased from around -1 V to -0.6 V



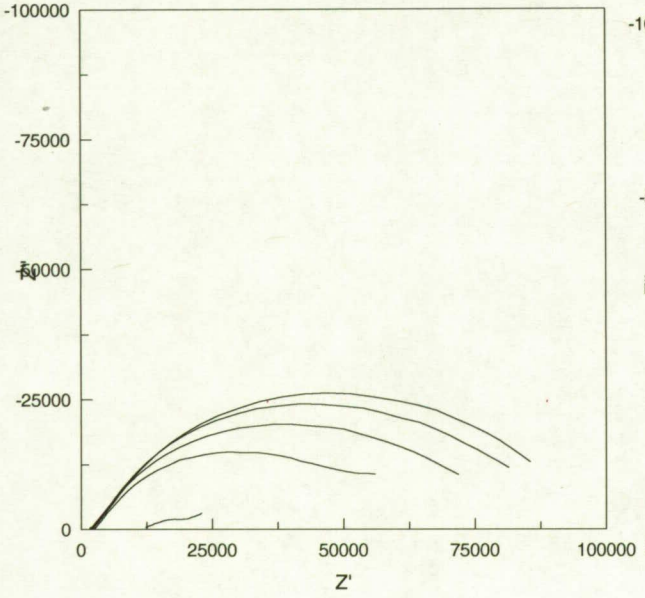
4) The potential remained below or at around -1 V

Correlation between the ASTM D 610-01 corrosion ranking at 18 months and the difference between the OCP at day 4 and day 0



The 18 months field perfomance of 15 out 19 samples correlates with the ocp behavior observed over 4 days (79% of samples)

N10S11a



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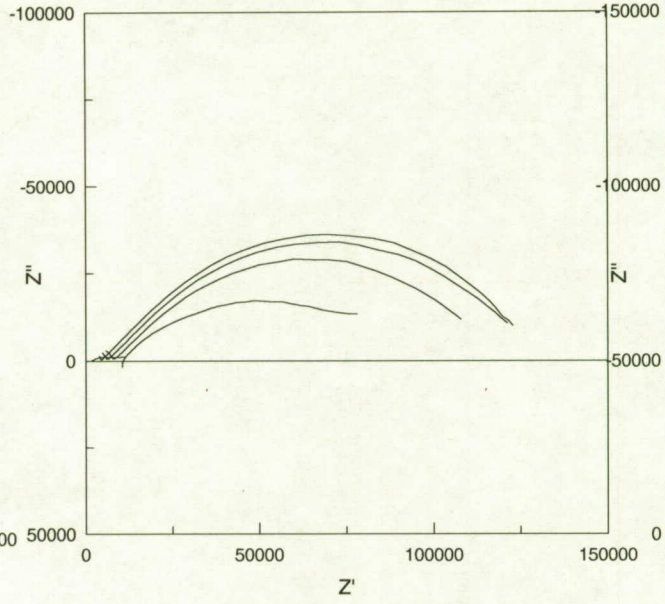

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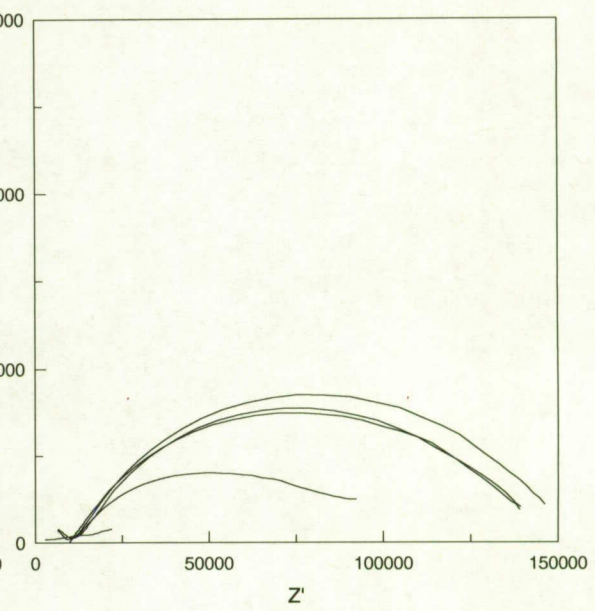

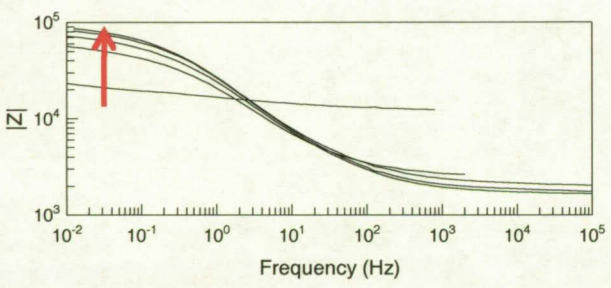

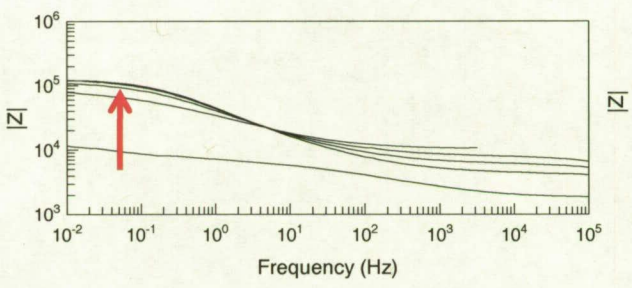

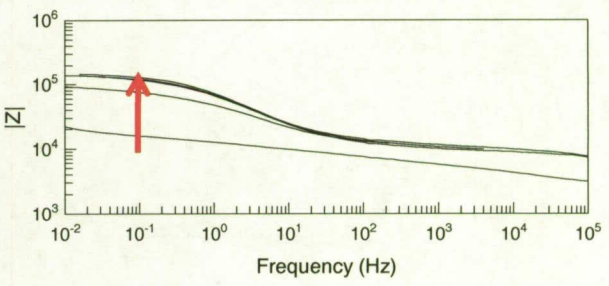

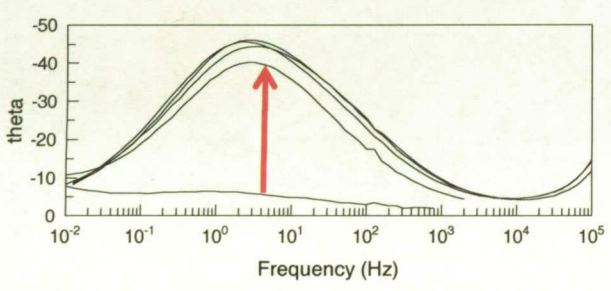

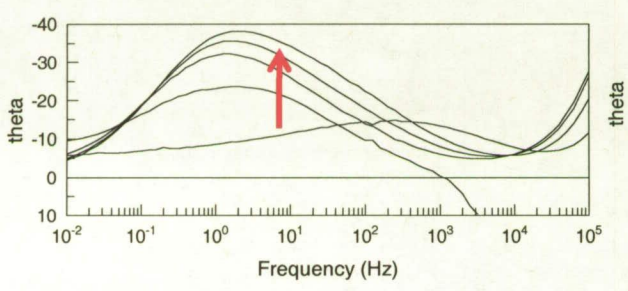

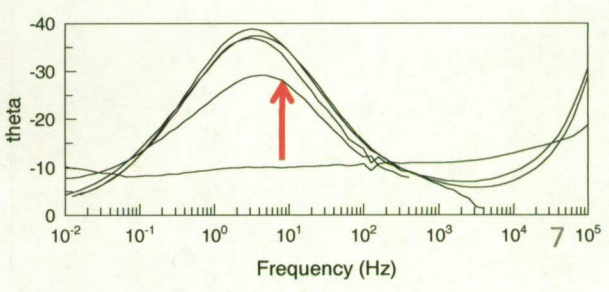

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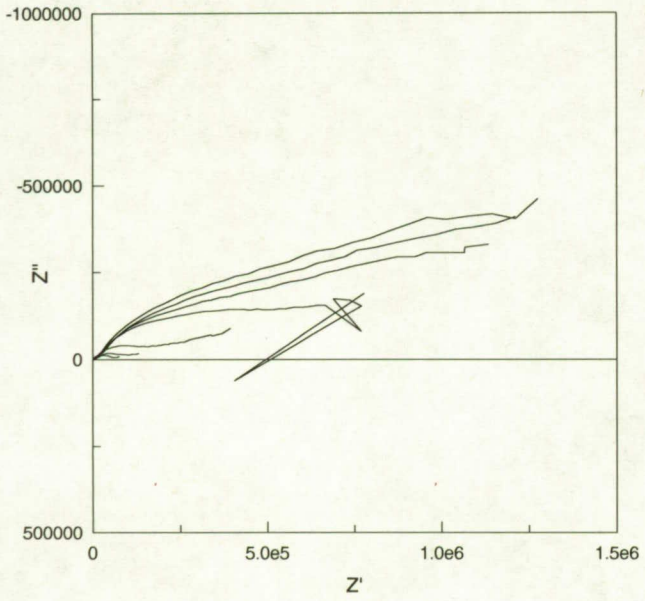

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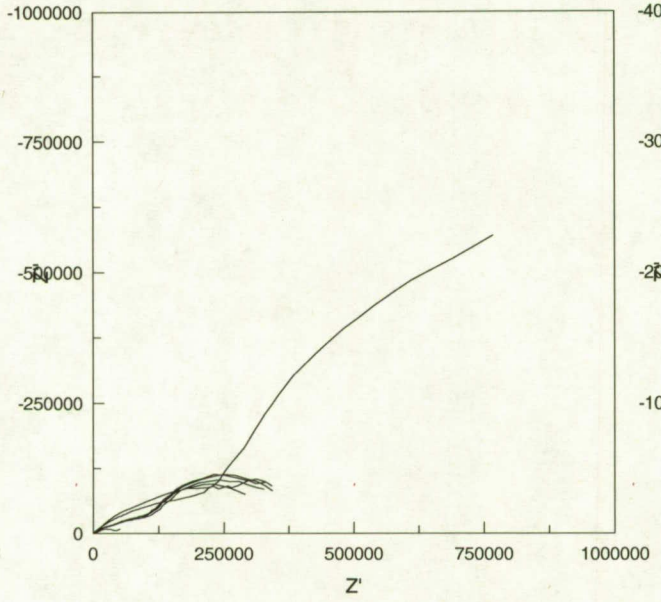

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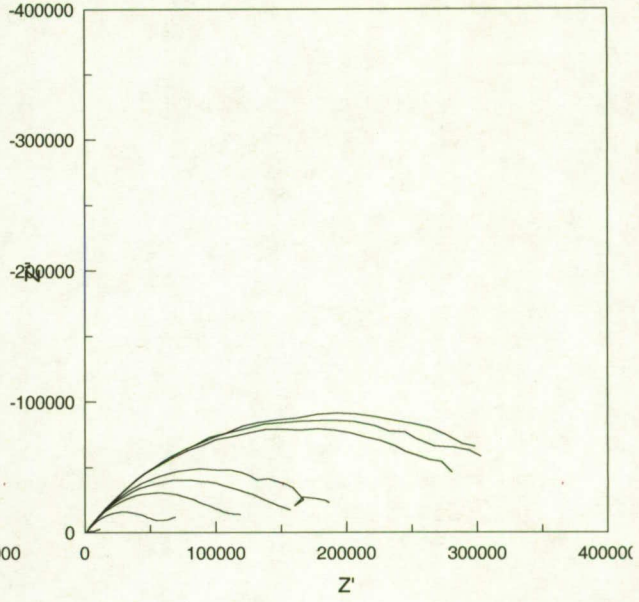

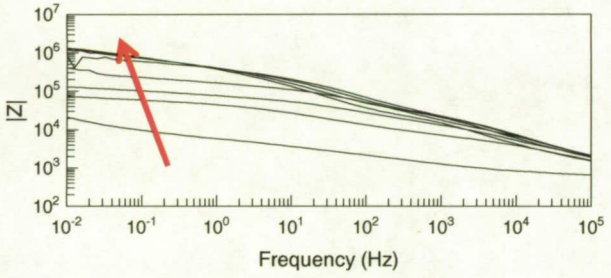

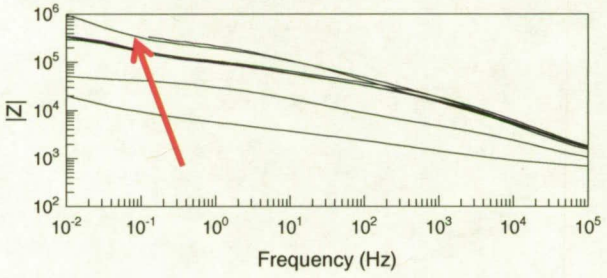

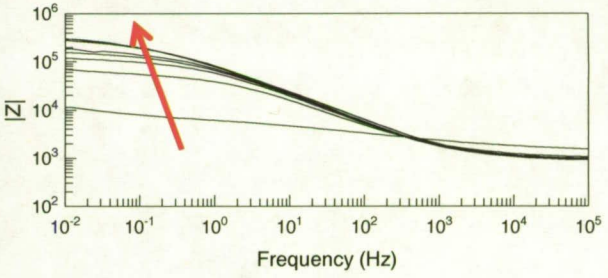

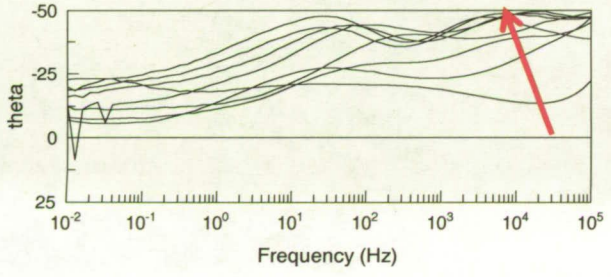

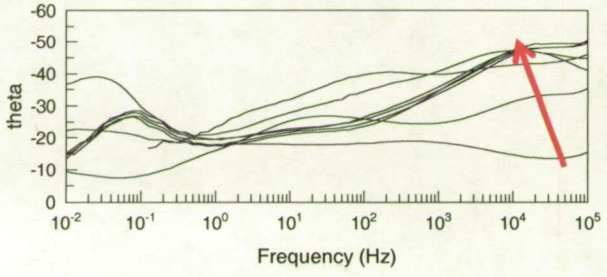

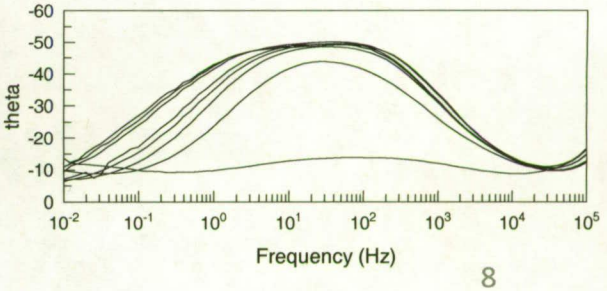

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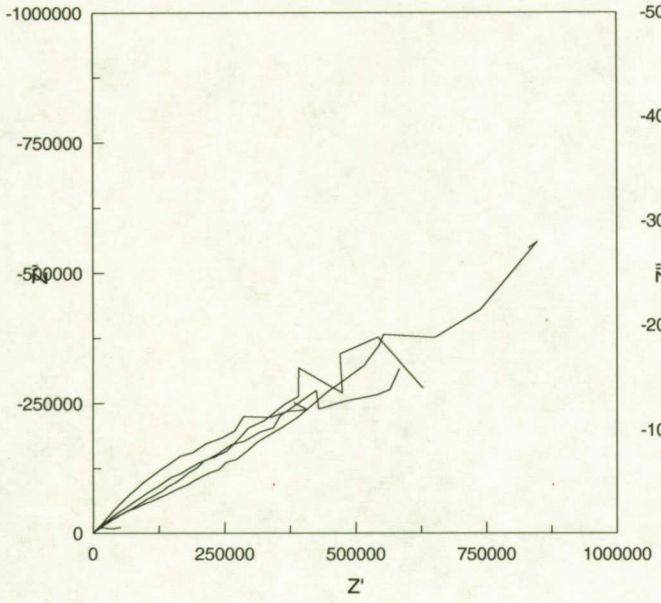

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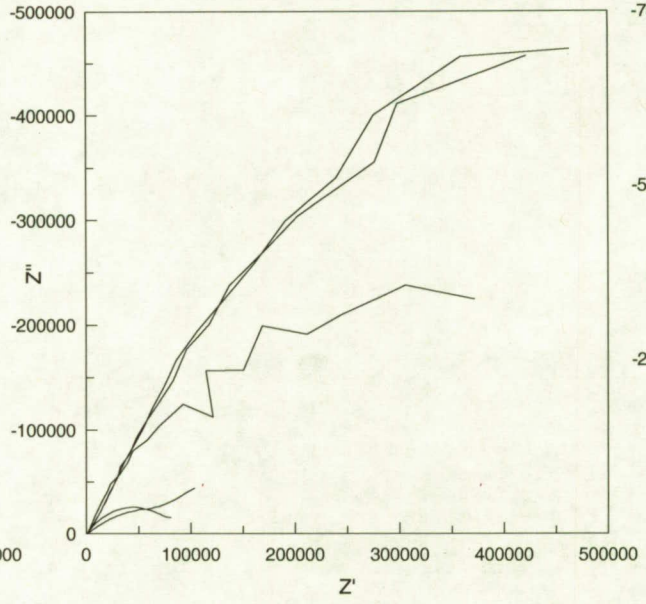

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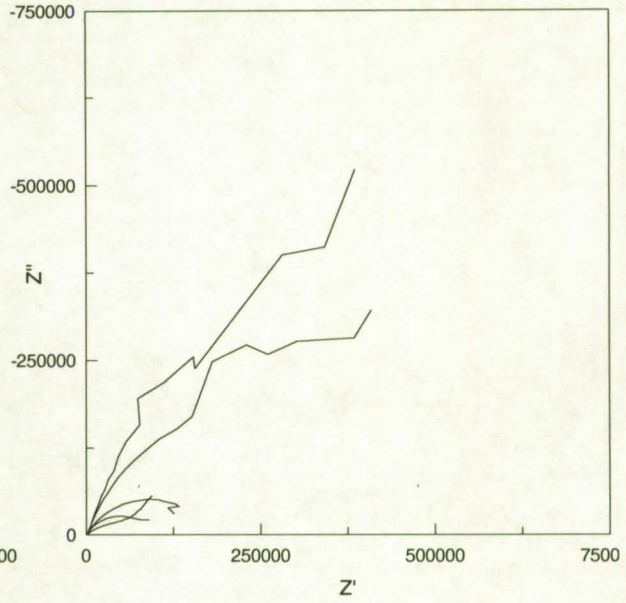

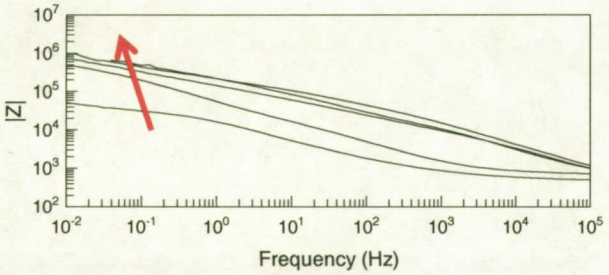

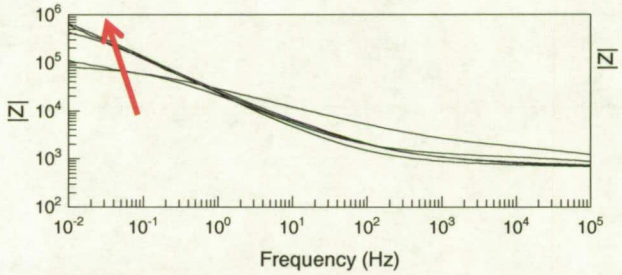

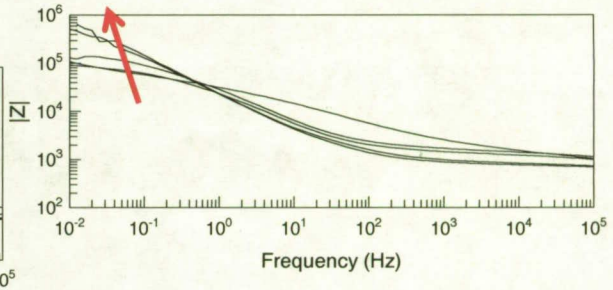

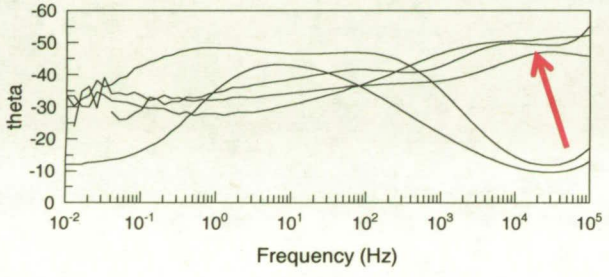

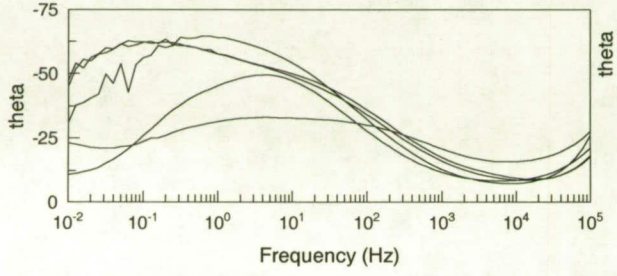

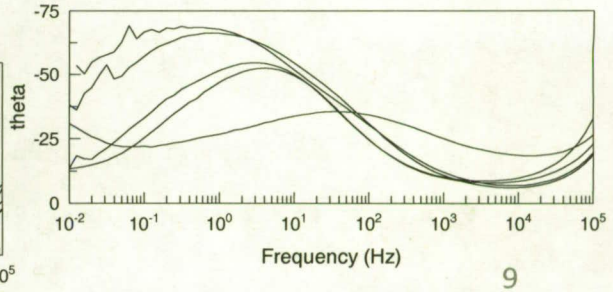

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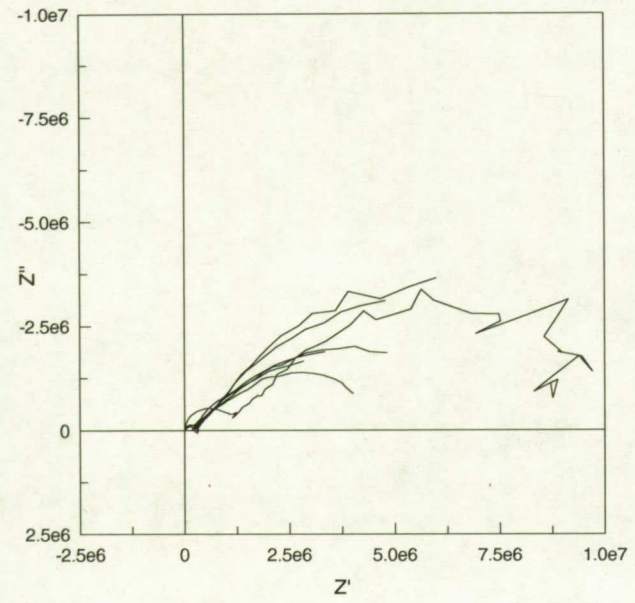

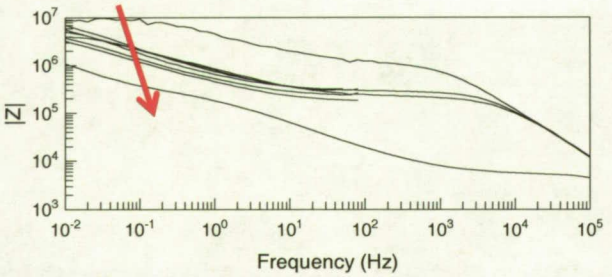

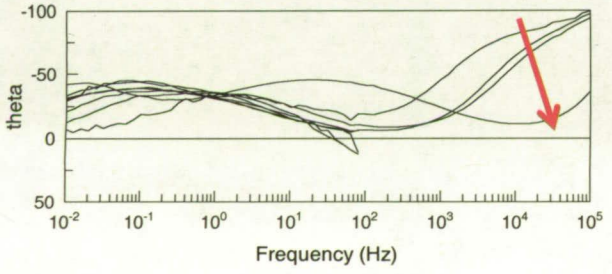

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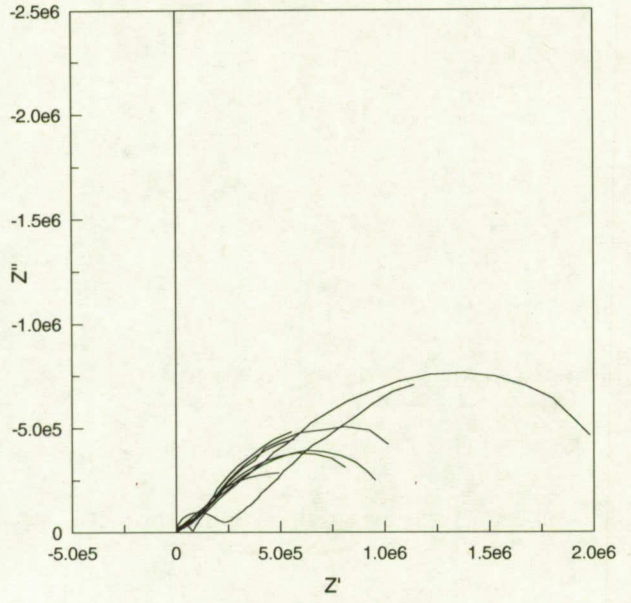

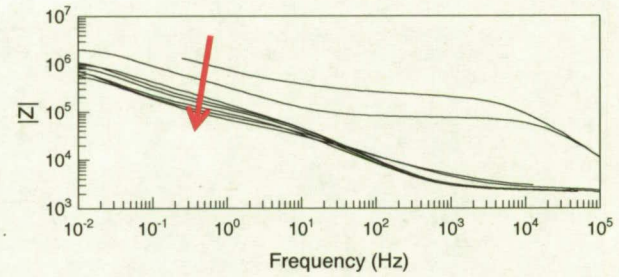

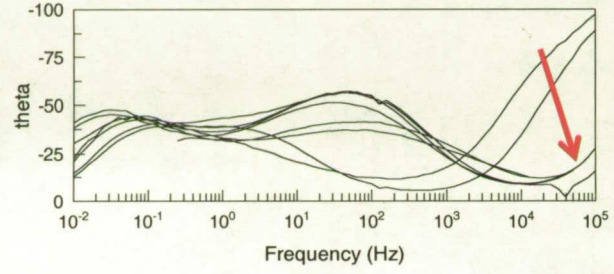

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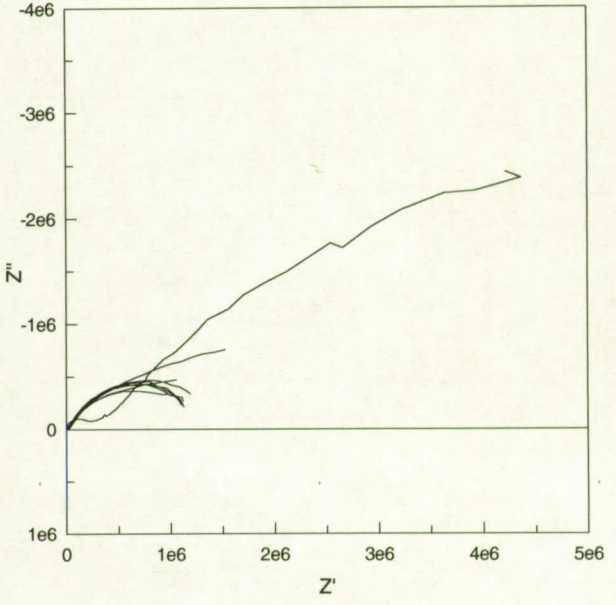

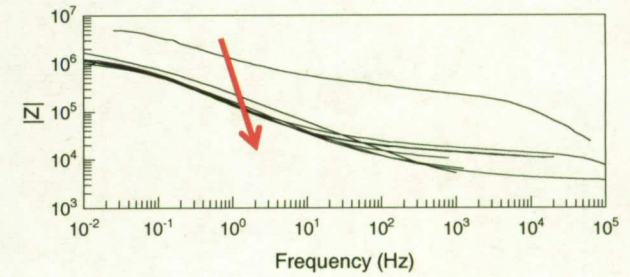

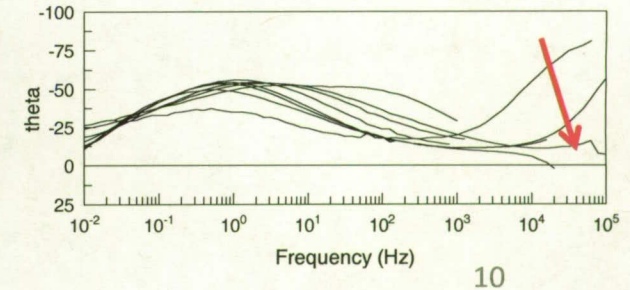

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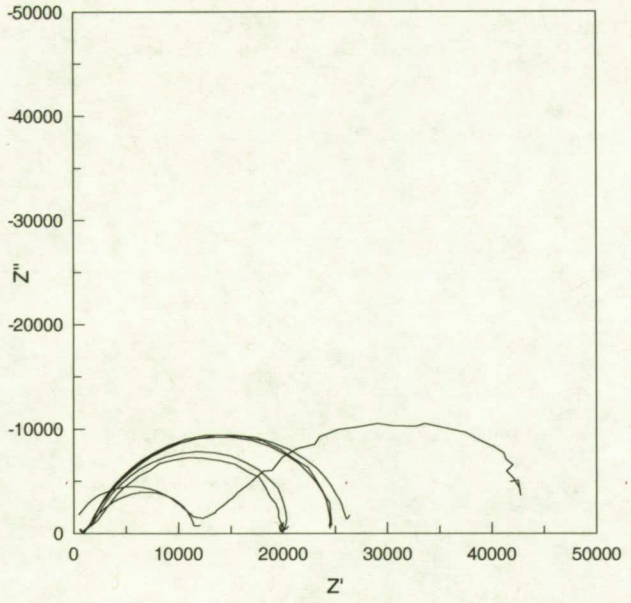

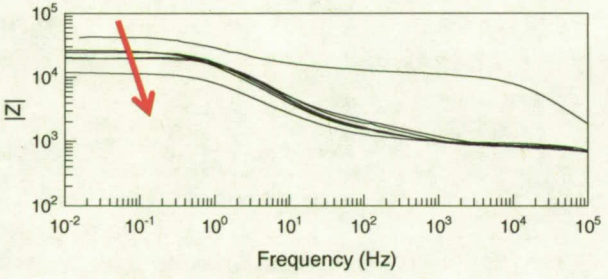

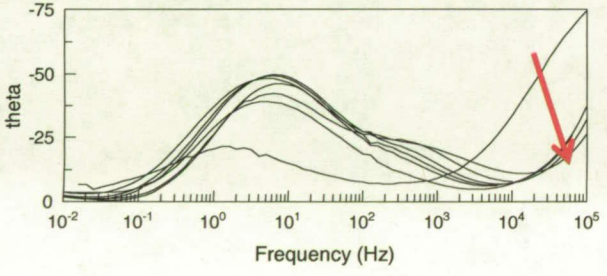

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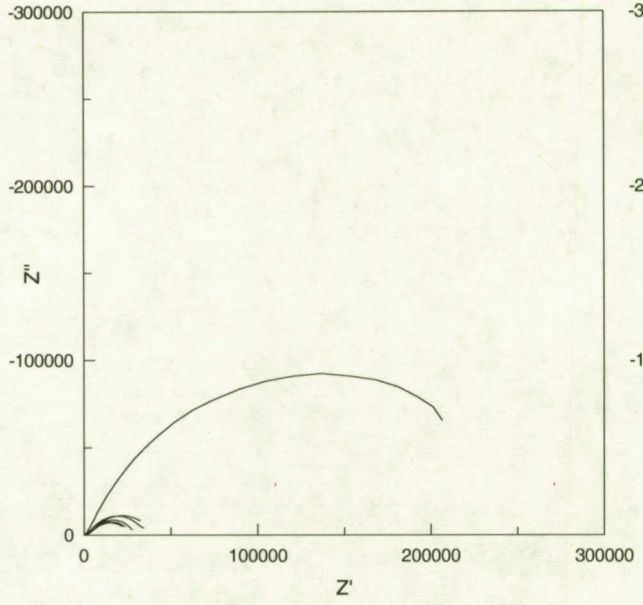

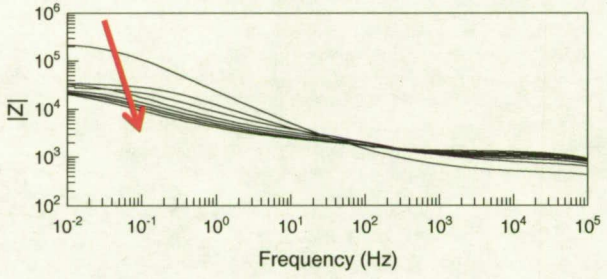

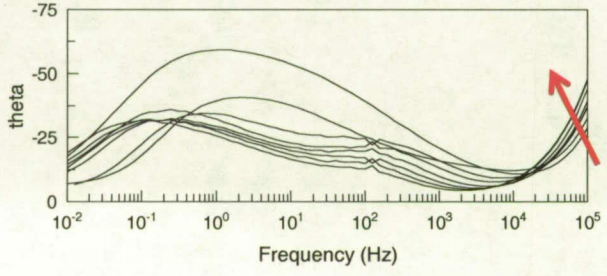

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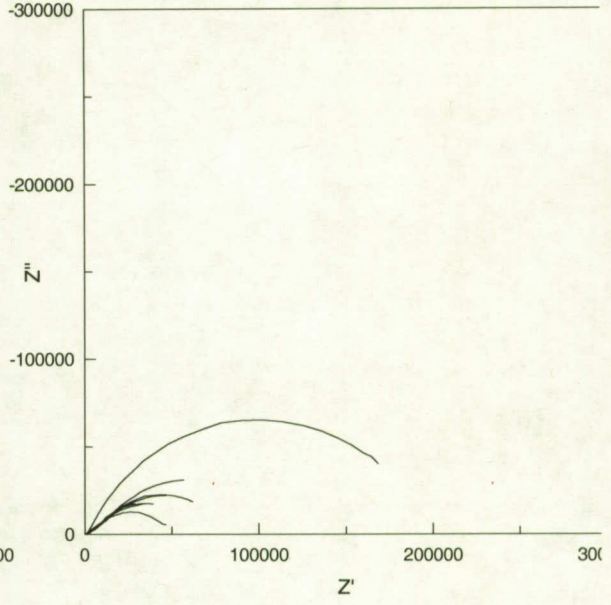

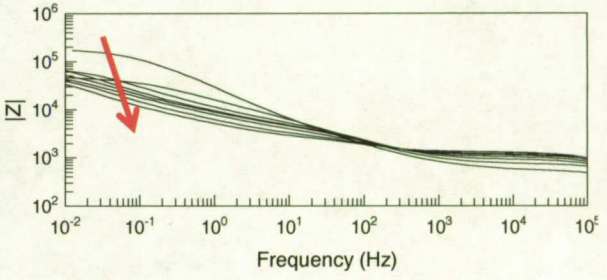

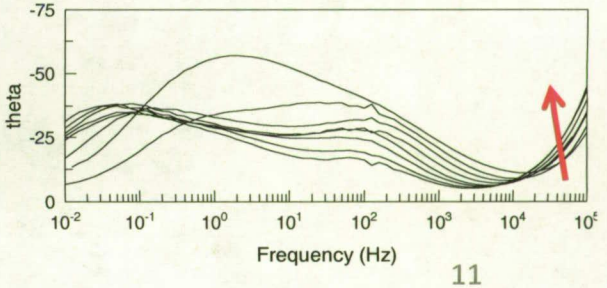

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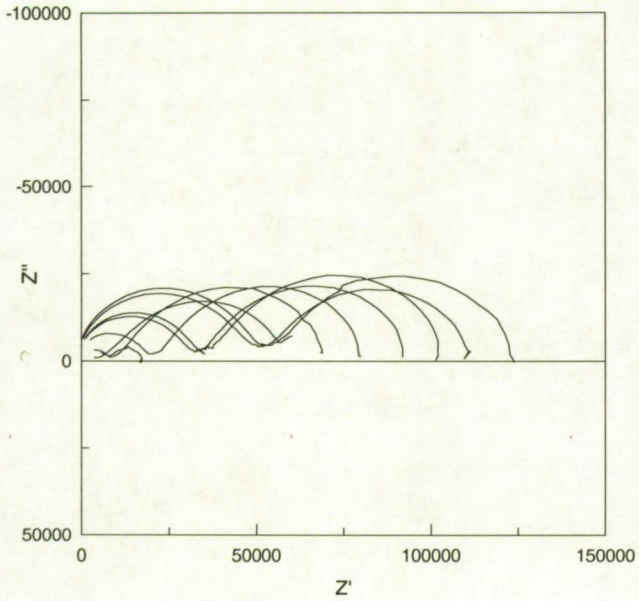

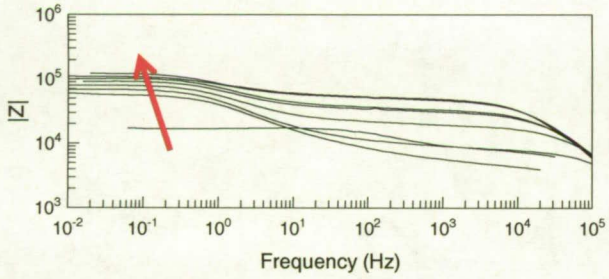

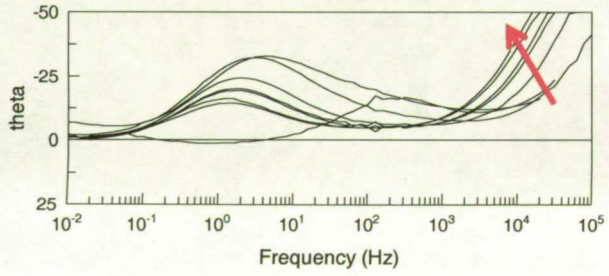

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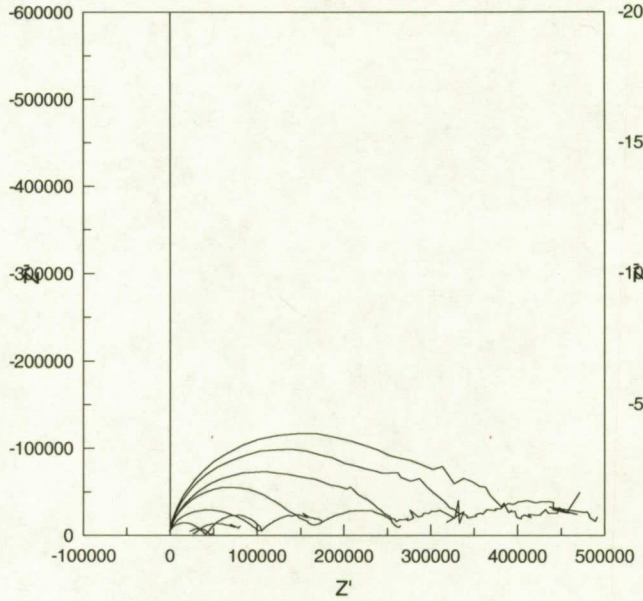
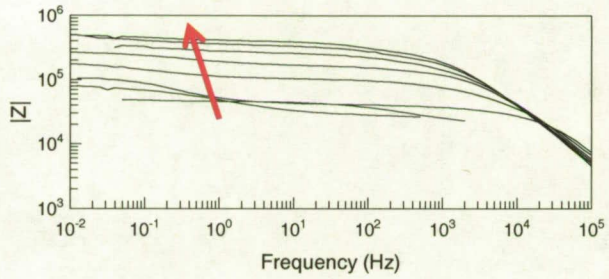
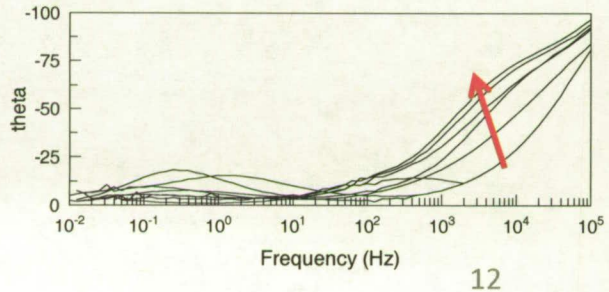
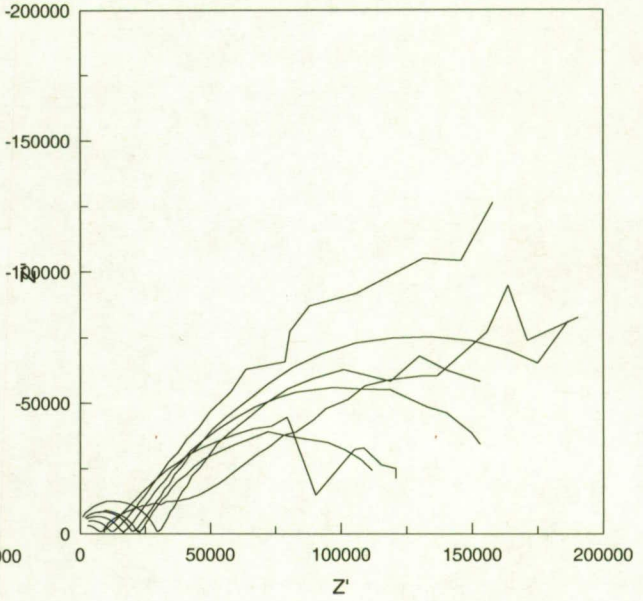
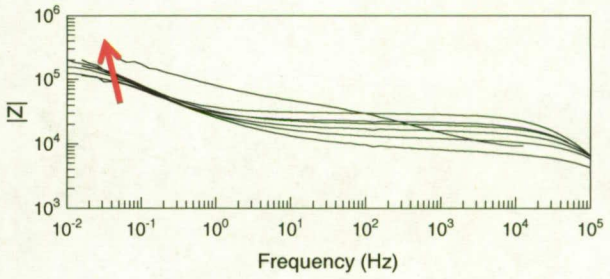


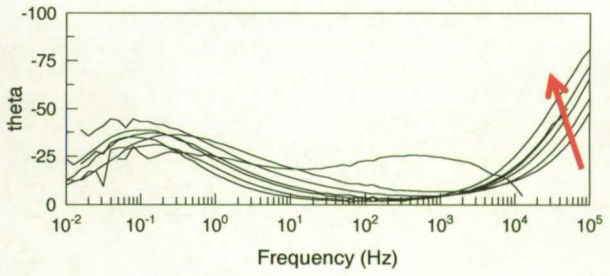




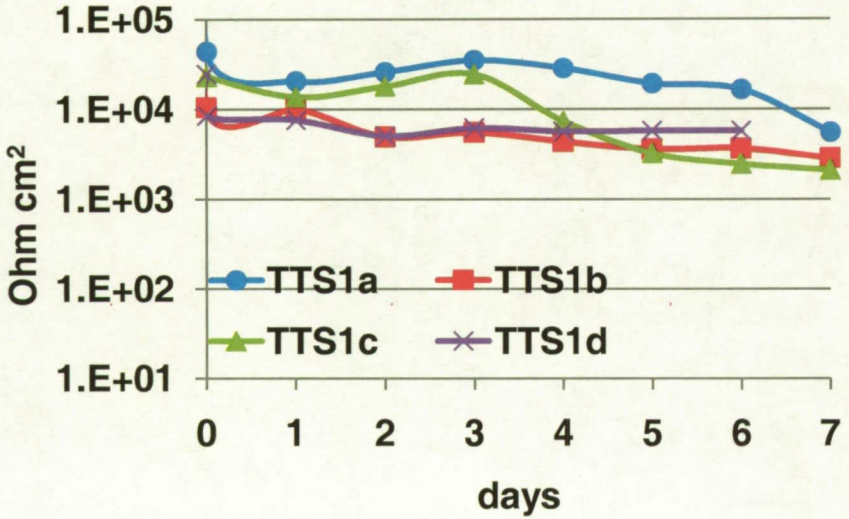
TTS2d

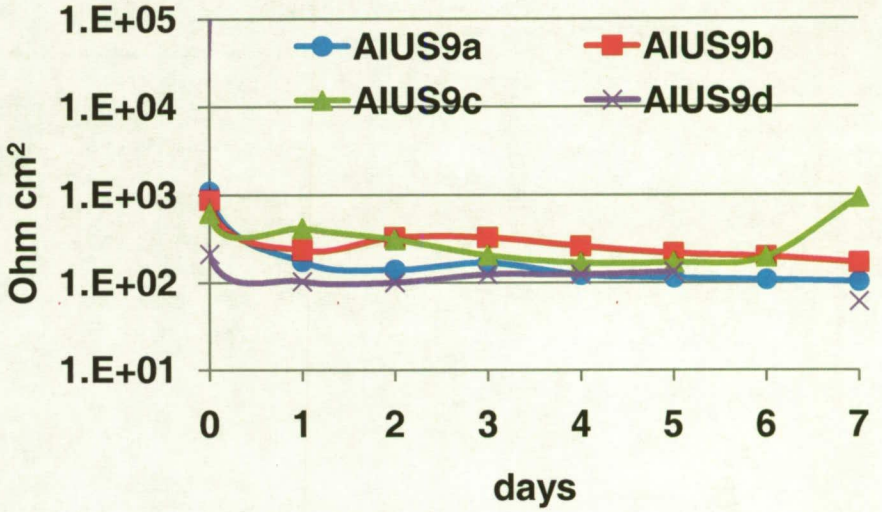






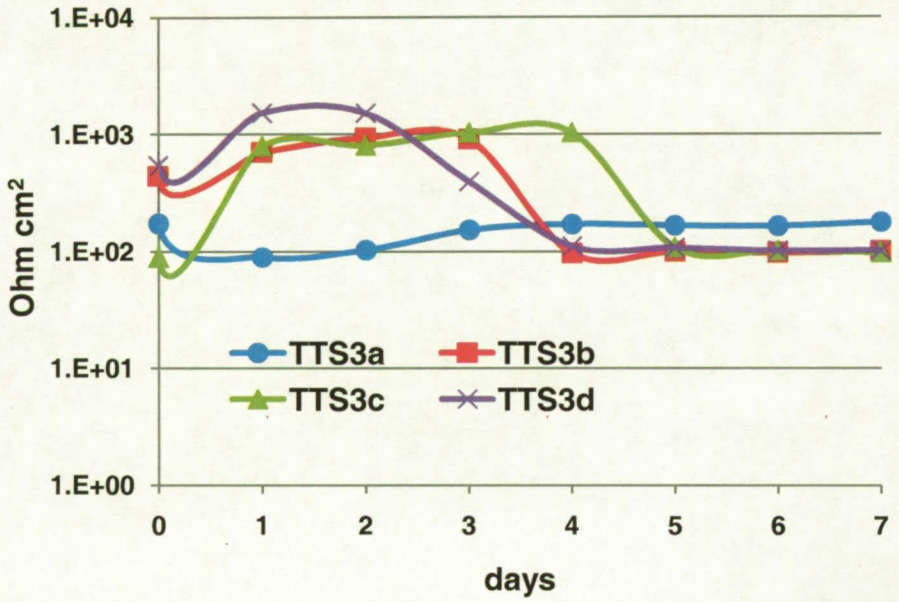
Low frequency magnitude as a function of immersion time

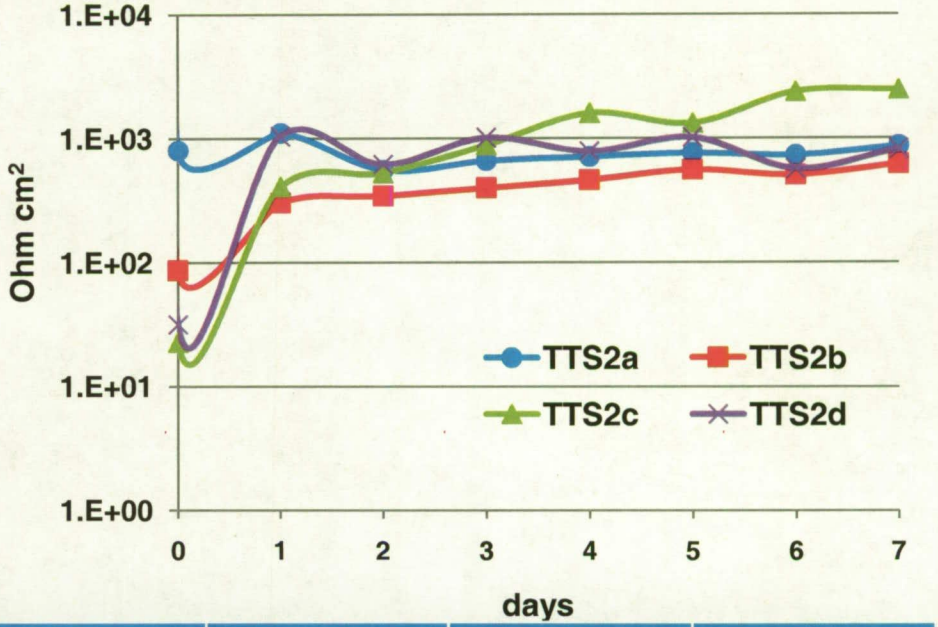


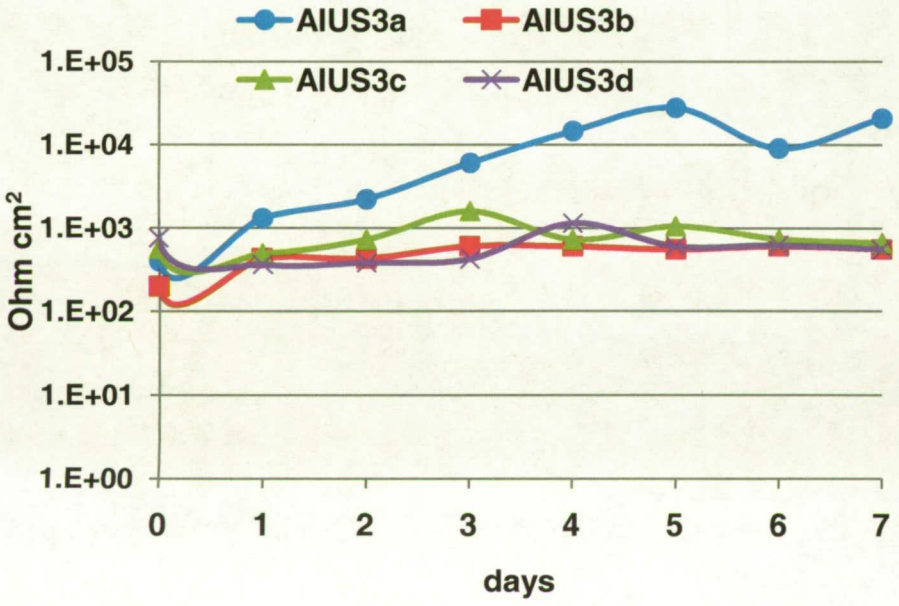


Z_7 (Wcm^2)	4000 ± 1000	300 ± 200
$\%\Delta Z_{7\text{-}0}$	-82 ± 4	-50 ± 30
ASTM D 610-01 Rating Scale	7.5	1.0

Low frequency magnitude as a function of immersion time

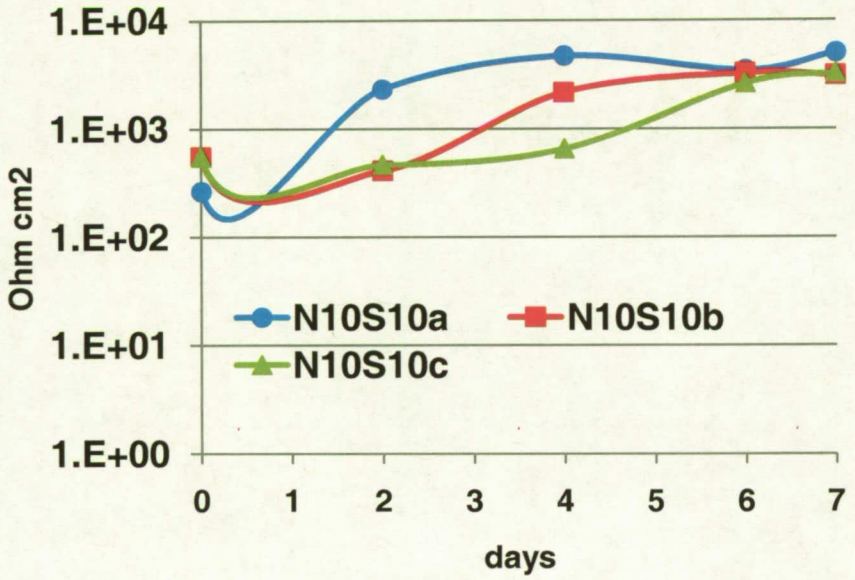


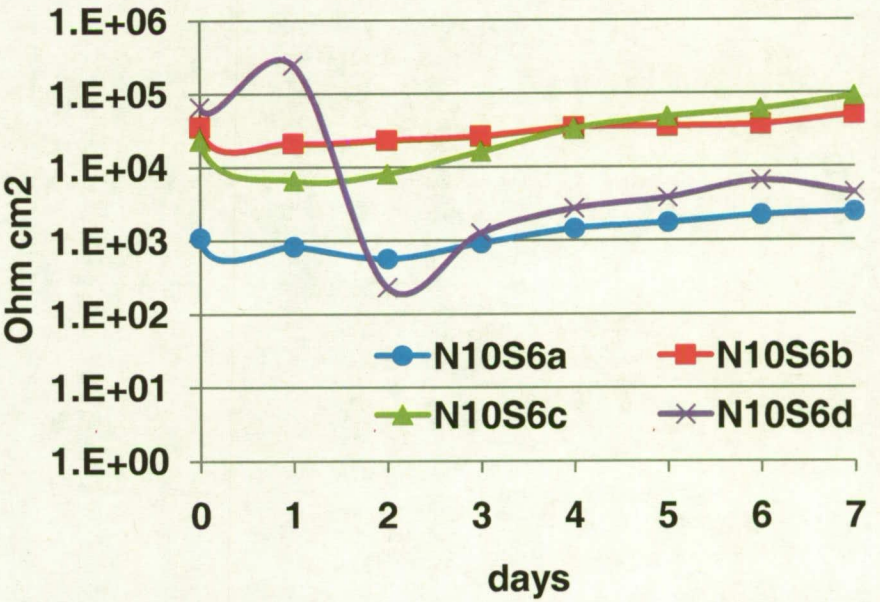


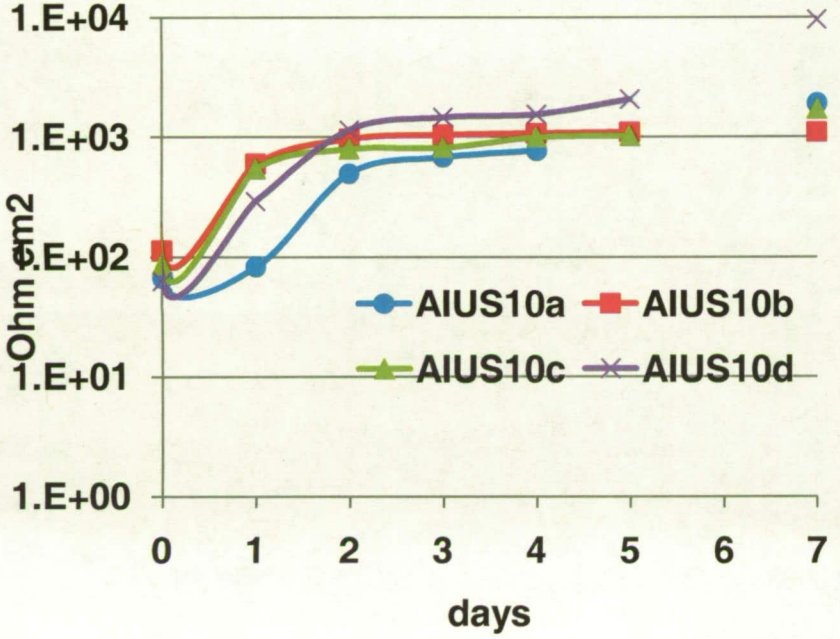


	AlUS3	TTS3	TTS2
Z_7(Wcm²) (Mean)	5500 ±5000	120±20	1200 ±400
$\%\Delta Z_{7-0}$	1300 ± 1000	-40 ± 20	3500 ± 2000
ASTM D 610-01 Rating Scale	8.0	8.5	8.3

Low frequency magnitude as a function of immersion time

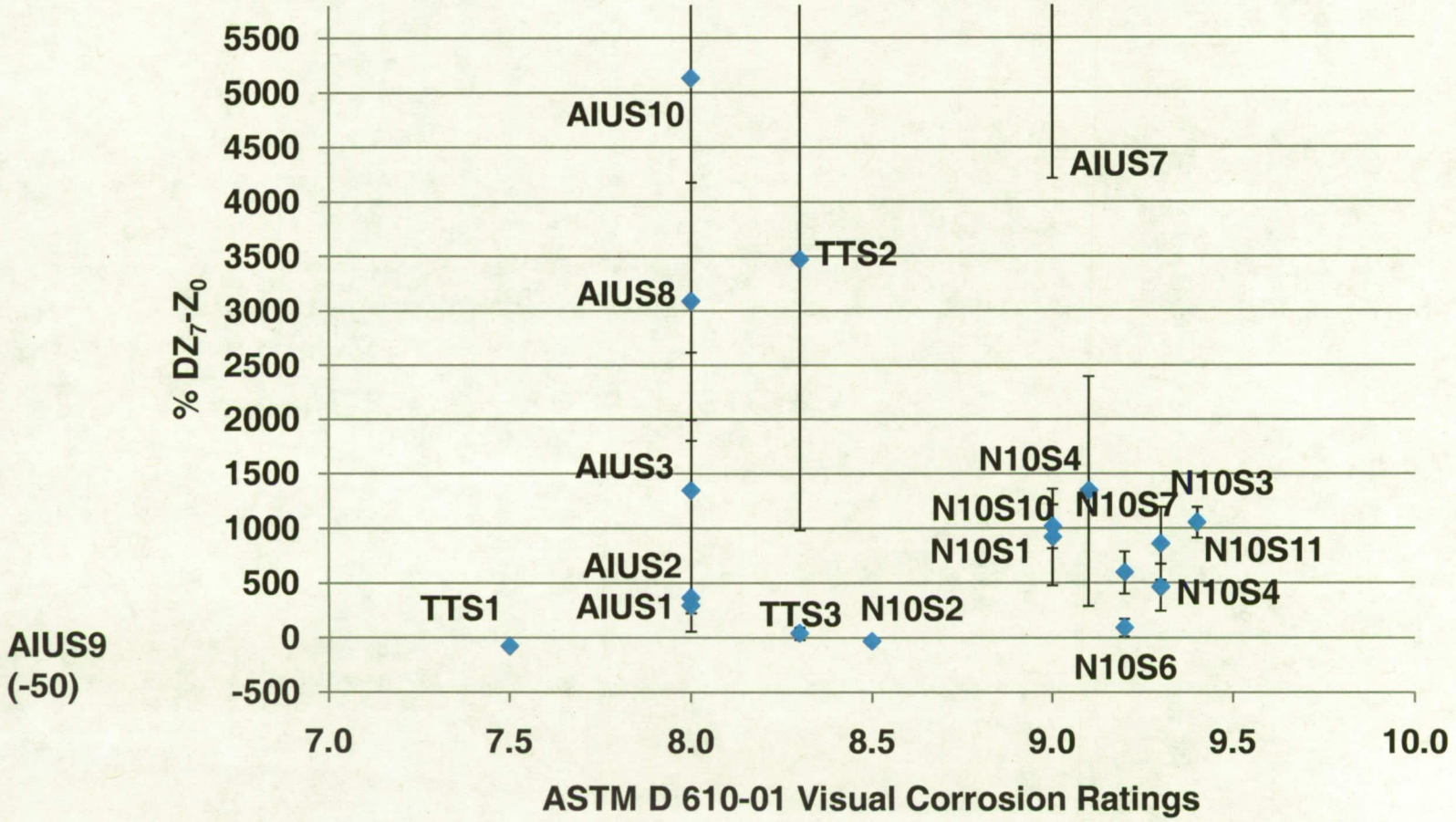




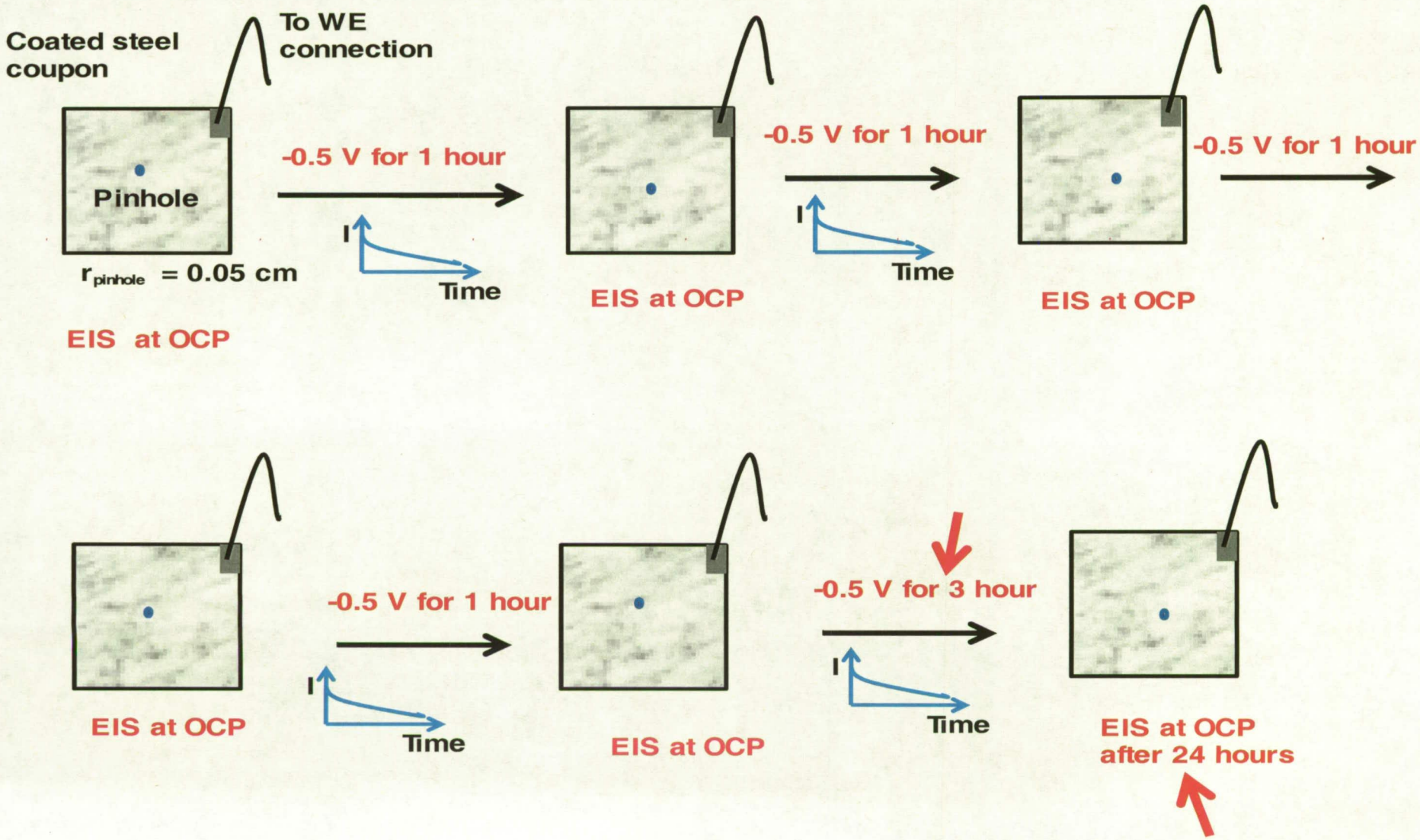


	N10S10	N10S6	A14S10
Z_7 (Wcm^2) (Mean)	3800 ±600	37000 ±20000	3600 ±2000
$\%\Delta Z_{7-0}$	900 ± 400	90 ± 80	5000 ± 3000
ASTM D 610-01 Rating Scale	9.3	9.0	8.0

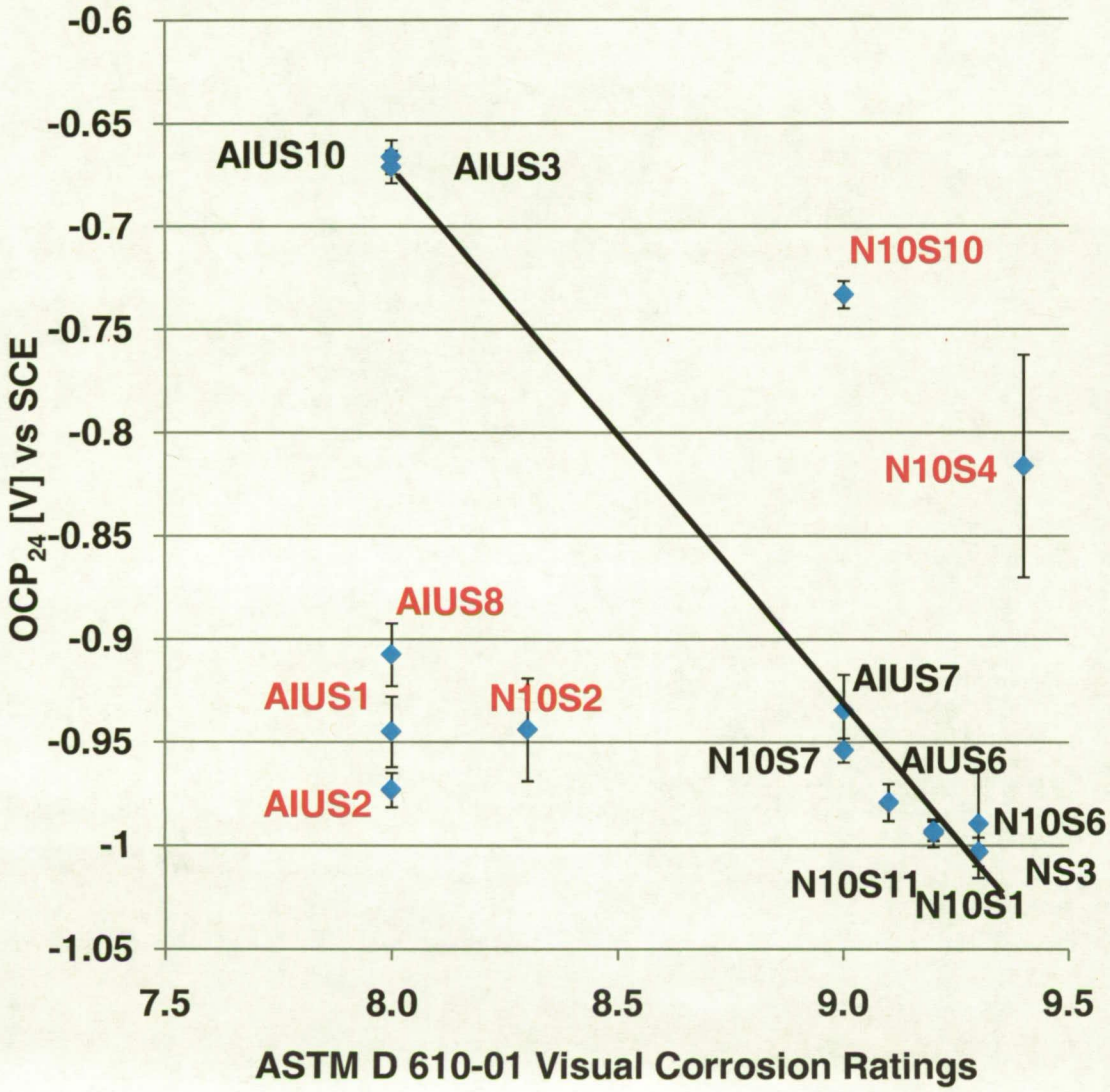
Correlation between the ASTM D 610-01 corrosion ranking at 18 months and the percentage change in the impedance magnitude from day 0 to day 7



Second Round of Experiments

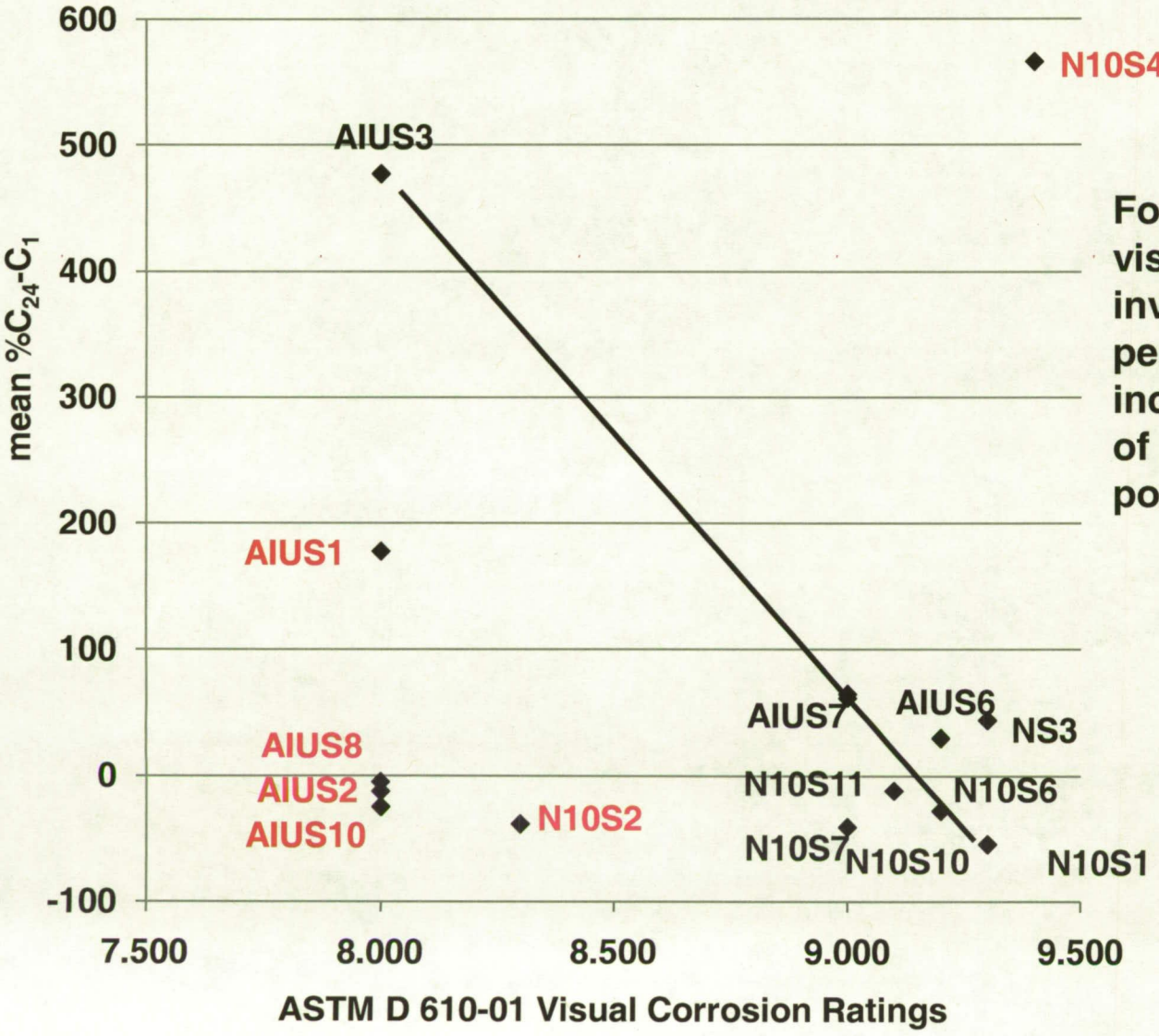


Correlation between the ASTM D 610-01 corrosion ranking at 18 months and the OCP observed 24 hours after the anodic polarization cycles



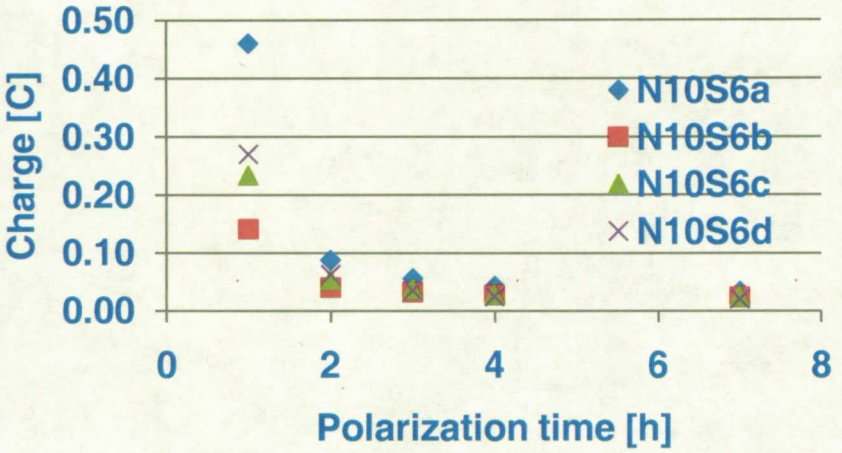
For 60 % of the samples the visual corrosion ranking at inversely correlates with the steady state OCP observed after a cycle of anodic potentiostatic polarizations

Correlation between the ASTM D 610-01 corrosion ranking at 18 months and the percentage capacitance change caused by the anodic polarization

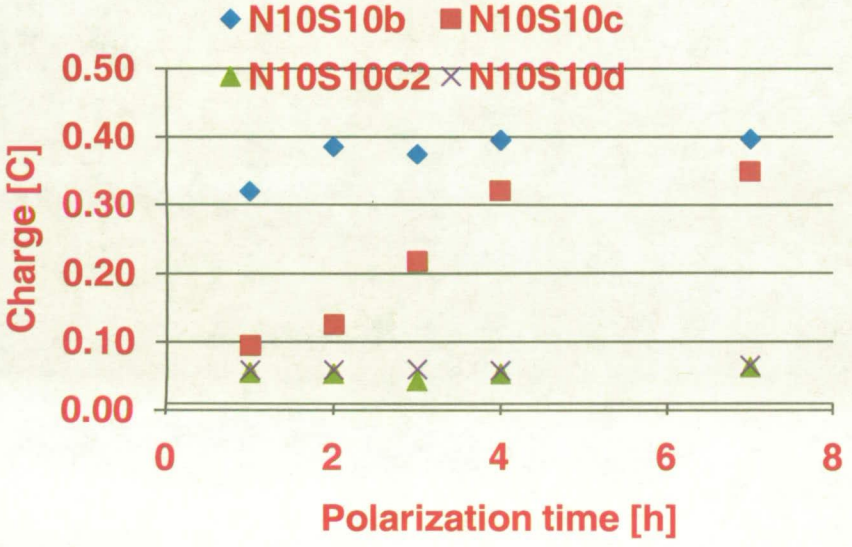


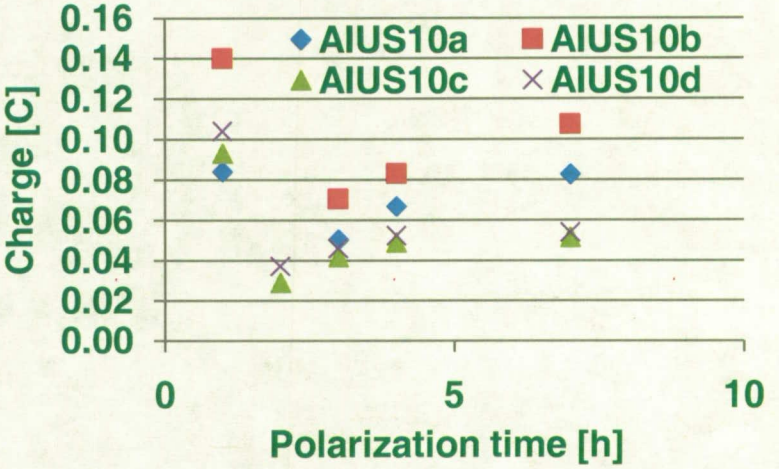
For 60 % of the samples the visual corrosion ranking inversely correlates with the percentage capacitance increase observed after a cycle of anodic potentiostatic polarizations

Variation of the charge measured during potentiostatic anodic polarization at -0.5 V



decrease in the charge as a function of the polarization time

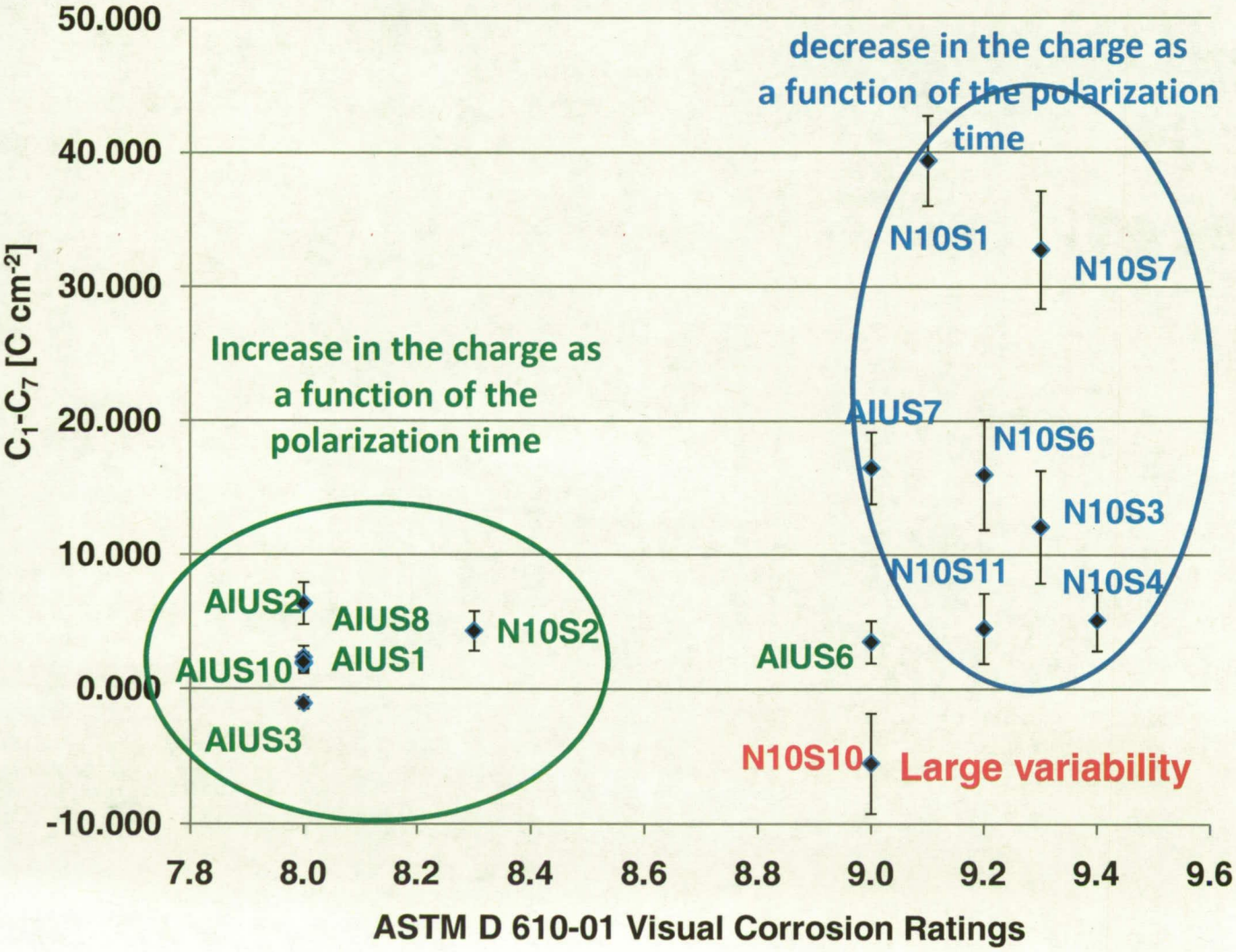




Increase in the charge as a function of the polarization time

Large variability in the charge as a function of the polarization time

Correlation between the ASTM D 610-01 corrosion ranking at 18 months and difference between the charge observed after 1 hours of anodic potentiostatic polarization and 7 hours.



For 87 % of the samples, a decrease in the charge correlated with ranking of 9 or above , whereas an increase in the charges correlates with a ranking lower than 9

Summary

1) 79 % correlation existed between the ASTM 610-01 visual corrosion ranking and the delta ocp observed over 4 days of immersion time in 0.5 M NaCl

2) 60% correlation existed between the ASTM 610-01 visual corrosion ranking and the steady state OCP observed after a total anodic potentistatic polarization time of 7 hours

3) 60% correlation existed between the ASTM 610-01 visual corrosion ranking and the interfacial capacitance increase observed after a total anodic potentistatic polarization time of 7 hours

4) 87% orrelation existed between the ASTM 610-01 visual corrosion ranking and the change incharge measured during 7 hours of anodic potentiostatic polarization