UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session of 2003/2004

September/October 2003

EBB 522/3 - Corrosions and Protection

Time : 3 hours

Please ensure that this paper consists of TEN printed pages before you proceed with the examination.

This paper contains SIX questions.

Answer any FIVE questions. If a candidate answer more than five questions, only the first five answered will be examined and awarded marks.

Answer to any question must start on a new page.

All questions must be answered in English.

...2/-

1. [a] Demonstrate that the CPR is related to the corrosion current density, i (A/cm) through expression

$$CPR = KAi/n\rho$$

where K is a constant, A is the atomic weight of the metal experiencing corrosion, n is the number of electrons associated with the ionization of each metal atom, and ρ is the density of the metal.

(35 marks)

[b] Calculate the value of the constant K for the CPR in mpy and i in $\mu A/cm^2$ (10^{-6} A/cm^2)

(35 marks)

[c] Compute the corrosion penetration rate, in mpy, for the corrosion of iron in HCl (to form Fe^{2+} ions) if the corrosion current density is 8×10^{-5} A/cm^2.

(30 marks)

2. The corrosion rate is to be determined for some divalent metal M in a solution containing hydrogen ions. The following corrosion data are known about the metal and solution :

For the Metal M	For Hydrogen
$V_{(M/M2+)} = -0.90$ V	$V_{(H+/H2)} = 0$ V
$i_o = 10^{-12}$ A/cm^2	$i_o = 10^{-10}$ A/cm^2
$\beta = +0.10$	$\beta = -0.15$

(a) Assuming that activation polarization controls both oxidation and reduction reactions, determine the rate of corrosion of metal M (in mol/cm^2 -s).

(50 marks)

(b) Compute the corrosion potential for this reaction.

(50 marks)

...3/-

3. [a] For each metals listed in the table, compute the pilling –Bedworth ratio. Also, on the basis of this value, specify whether or not you would expect the oxide scale that forms on the surface to be protective, and then justify your decision. Density data for both the metal and its oxide are also tabulated.

Metal	Metal density gcm^{-3}	Metal oxide	Oxide density gcm^{-3}
Mg	1.74	MgO	3.58
V	6.11	V_2O_5	3.36
Zn	7.13	ZnO	5.61

(50 marks)

[b] (1) Cite the major differences between activation and concentration polarizations.

(2) Under what conditions is activation polarization rate controlling?

(3) Under what conditions is concentration polarization rate controlling?

(50 marks)

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4. [a] In the table, weight gain-time data for the oxidation of some metal at an elevated temperature are tabulated.

W, mg/cm^2	Time (min)
6.16	100
8.59	250
12.72	1000

(i) Determine whether the oxidation kinetics obey a linear, parabolic, or logarithmic rate expression.

(30 marks)

(ii) Now compute W after a time of 1200 min.

(30 marks)

[b] For each form of corrosion, other than uniform, do the following : (a) Describe briefly why, where and the conditions under which the corrosion occurs. (b) Cite three measures that may be taken to prevent or control it.

(40 marks)

...5/-

5. For each of the following corrosion case state the cause and remedy to prevent it

Case 1 :
Materials : Duplex stainless steel (W.-Nr. 1.4462).
System : Pipeline system.
Part : Field weld
Phenomenon : Weld defect

Appearance : Selective attack inside the weld zone (left) leading to leakage and external attack to the pipe (right).
Time to Failure : Less than 6 months.
Environment : Stagnant aerated water used for hydro testing.

Cause : .....

Remedy : .....

(20 marks)

...6/-

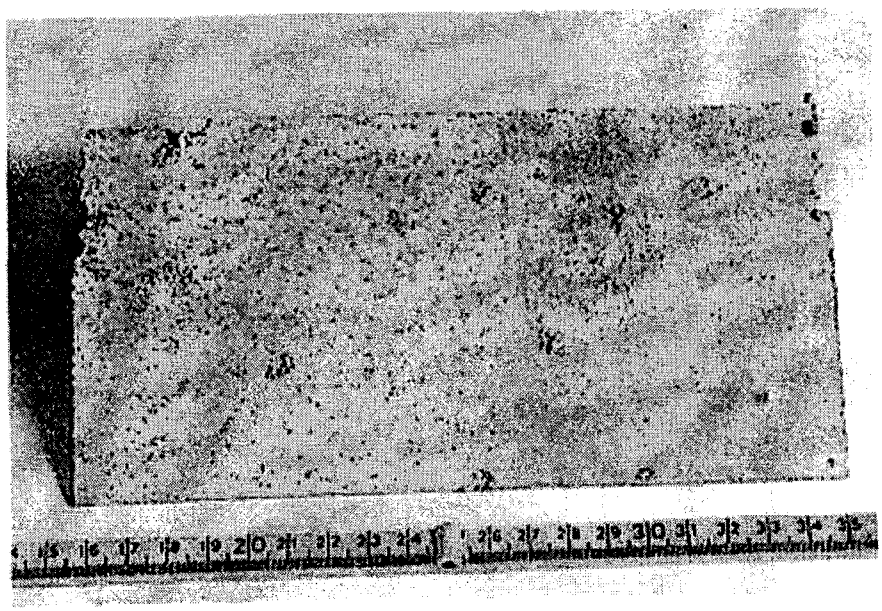
Case 2 :

Materials : Aluminum.

System : Air conditioning plant.

Part : Part of an aluminum air duct.

Phenomenon : Salt corrosion.



Appearance : Corrosion attack.

Time to Failure : Unknown.

Environment : Evaporated mains water.

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Cause : .....

Remedy : .....

(20 marks)

...7/-

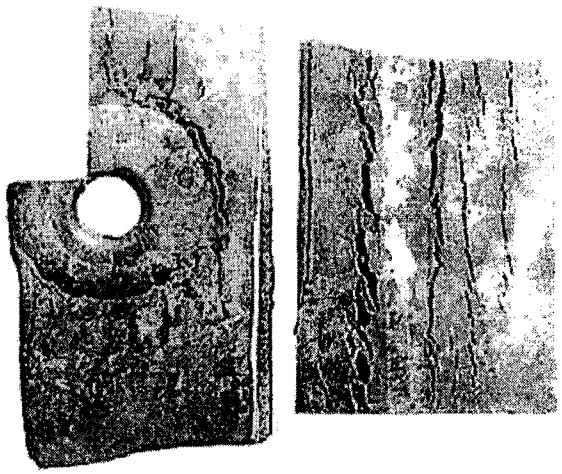
Case 3 :

Materials : Inconel 625.

System : Oxidation reactor.

Part : Branch pipes of heat exchanger feed rundown.

Phenomenon : Inter granular attack.



Appearance : Cracks.

Time to Failure : About 3 months.

Environment : Aerated disposal water; temperature approx. 350°C; pressure approx. 20 MPa.

Cause : .....

Remedy : .....

(20 marks)

...8/-

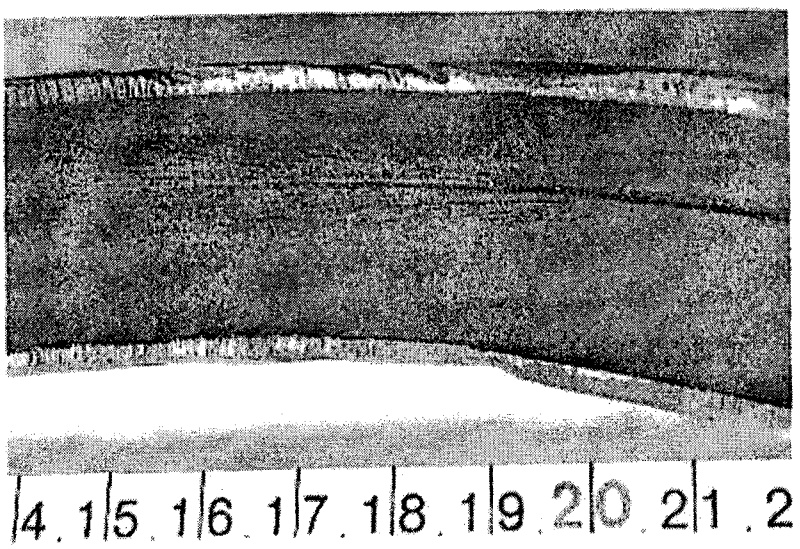
Case 4 :

Materials : Carbon steel (ASTM A 106, grade B).

System : Sulphuric acid transport system.

Part : Pipe bend curving from the vertical to the horizontal, with electrical tracing at the outside of the bend.

Phenomenon : Acid corrosion (hydrogen grooving).



Appearance : A long sharp groove 1.5 mm wide, becoming increasingly deep until it penetrates the 5 mm thick pipe wall, then fanning out in several dozen small grooves.

Time to Failure : Several years.

Environment : 95-96% sulphuric acid, temperature 25°C, max. wall temperature 40°C. Pressure 0.35 MPa, flow rate 1 m/s. Regular stagnant conditions.

Cause : .....

Remedy : .....

(20 marks)

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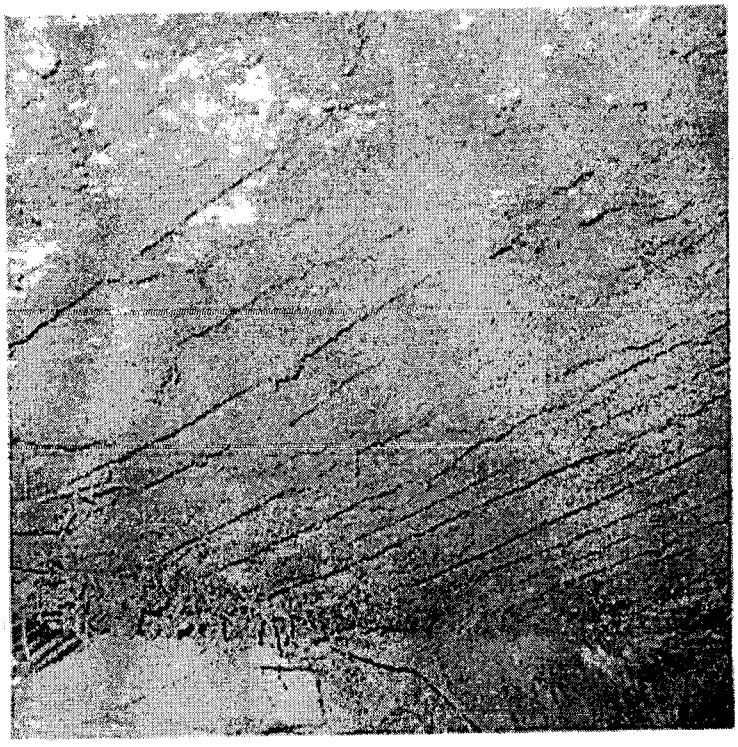
Case 5 :

Materials : Reinforced concrete.

System : Poultry manure storage pit.

Part : Ceiling.

Phenomenon : Biogenic sulphuric acid attack.



Appearance : Concrete cover dissolved, reinforcement severely attacked.

Time to Failure : 18 years.

Environment : Closed manure environment.

Cause : .....

Remedy : .....

(20 marks)

...10/-

6. State the description, illustration and view of field installation for the following :

(1) Cathodic Protection by IMPRESSED CURRENT

(35 marks)

(2) Cathodic Protection by SACRIFICIAL ANODES

(35 marks)

(3) Drainage of STRAY CURRENTS

(30 marks)

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