**MSE312 Materials Laboratory, Experiments and Experimental Design of “Electrochemical Insights into Corrosion Behaviour and Risk Management: A Potentiostat Approach” INformative notes and Main guide**

“MSE312 Materials Laboratory” lecture aims to provide our undergraduate students skills of using effective analysis method and tools, conducting experiments, designing experimental procedures, obtaining data, analysing and reporting the results to examine complex engineering problems. 3 weeks of the semester will involve corrosion experiment and its risk analysis observation studies.

The experimental design of corrosion analysis and its risk analysis, data collecting and reporting will be carried out in the form of 2 work day/lecture at the end of the semester courses. The impact of experiment design process on the total grade has been determined as %10 of the final exam

**Experimental Design Information key notes and Major steps:**

Experimental design is a connected process of determining and planning experimental process steps, effectively evaluating the impact of multiple parameters and conditions on output values, and carrying out systematic performance measurements effectively, and conducting validation and verification studies with minimum error.

Experimental design steps will be followed as below;

Step 1;

Designing a corrosion experiment using a potentiostat involves several key steps and considerations. Here’s a structured approach:

1. Objective of the Experiment

1. Define the specific corrosion mechanism you want to study (e.g., pitting, uniform corrosion, galvanic corrosion).
2. Determine the materials involved (e.g., metals, alloys).

2. Materials and Equipment

1. Potentiostat/Galvanostat: Essential for controlling and measuring the electrochemical potential.
2. Electrodes:
   1. Working Electrode (WE): The metal sample you want to study.
   2. Reference Electrode (RE): A stable reference point (e.g., Ag/AgCl).
   3. Counter Electrode (CE): Often made of inert materials like platinum.
3. Electrolyte: Choose a solution that simulates the environment (e.g., NaCl solution for saltwater corrosion).

3. Experimental Setup

1. Cell Design: Use a corrosion cell that accommodates the electrodes and electrolyte. Ensure proper sealing to prevent contamination.
2. Temperature Control: If necessary, maintain a constant temperature using a water bath or temperature-controlled chamber.

4. Procedure

1. Preparation of Electrodes: Clean the working electrode surface to remove any oxides or contaminants.
2. Electrolyte Preparation: Prepare the electrolyte solution with precise concentrations.
3. Assembly: Assemble the electrochemical cell, ensuring proper connections to the potentiostat.
4. Calibration: Calibrate the potentiostat and check the reference electrode potential.

5. Types of Experiments

1. Open Circuit Potential (OCP): Measure the spontaneous potential of the working electrode over time.
2. Polarization Curves: Conduct linear sweep voltammetry to understand the corrosion rate and mechanism.
3. Impedance Spectroscopy (EIS): Analyse the impedance response to gain insights into corrosion processes.

6. Data Analysis

1. Analyse the data collected from the potentiostat using appropriate software.
2. Interpret the polarization curves, OCP trends, and EIS data to determine corrosion rates and mechanisms.
3. 7. Safety Considerations
4. Follow safety protocols when handling chemicals and operating electrical equipment.
5. Ensure proper disposal of waste materials.

8. Documentation

1. Keep detailed records of all experimental conditions, observations, and results for future reference.

Step 2;

### Risk Analysis for Corrosion Experiment Using Potentiostat;

### All risks should be indicated as risk column and table should filled according to step 1 experiment. Columns and number can be increased and new factors could determine into report of experiment results.

| **Risk** | **Description** | **Likelihood** | **Impact** | **Mitigation Measures** |
| --- | --- | --- | --- | --- |
| **Chemical Exposure** |  |  |  |  |
| **Electrical Hazards** |  |  |  |  |
| **Spillages** |  |  |  |  |
| **Equipment Failure** |  |  |  |  |
| **Heat Generation** |  |  |  |  |
| **Waste Disposal** |  |  |  |  |
| **Injury from Glassware** |  |  |  |  |
| **Inhalation of Fumes** |  |  |  |  |
| **……………………** |  |  |  |  |

By identifying potential risks and implementing mitigation measures, you can enhance safety during your corrosion experiment. Regular training and awareness of safety protocols can further reduce the likelihood of incidents. Always ensure that emergency procedures are in place and accessible to all personnel involved in the experiment.

Step 3;

Here's a quantitative risk matrix for assessing the risks associated with conducting a corrosion experiment using a potentiostat. The matrix uses a numerical scale to quantify the likelihood and impact of each risk.

### Quantitative Risk Matrix

| **Likelihood (L)** | **1 - Rare (0-10%)** | **2 - Unlikely (11-30%)** | **3 - Possible (31-60%)** | **4 - Likely (61-90%)** | **5 - Almost Certain (91-100%)** |
| --- | --- | --- | --- | --- | --- |
| **Impact (I)** |  |  |  |  |  |
| **5 - Catastrophic (16-25)** | 5 (5) | 10 (10) | 15 (15) | 20 (20) | 25 (25) |
| **4 - Major (11-15)** | 4 (4) | 8 (8) | 12 (12) | 16 (16) | 20 (20) |
| **3 - Moderate (6-10)** | 3 (3) | 6 (6) | 9 (9) | 12 (12) | 15 (15) |
| **2 - Minor (1-5)** | 2 (2) | 4 (4) | 6 (6) | 8 (8) | 10 (10) |
| **1 - Insignificant (0)** | 1 (1) | 2 (2) | 3 (3) | 4 (4) | 5 (5) |

### Risk Scoring

* **Risk Score (R)** = Likelihood (L) × Impact (I)
* **Risk Levels:**
  + **1-5**: Low Risk (Acceptable)
  + **6-12**: Moderate Risk (Monitor)
  + **13-20**: High Risk (Mitigate)
  + **21-25**: Critical Risk (Immediate Action Required)

### Example Risk Assessment

This matrix allows you to quantitatively assess and prioritize risks associated with your corrosion experiment, facilitating better decision-making regarding safety measures and resource allocation.

**When writing a final report about experiment data must be included following main titles:**

### 1. **Title Page**

* Title of the Report
* Author(s)
* Date
* Institution/Organization

### 2. **Abstract**

* A brief summary of the objectives, methods, key findings, and conclusions.

### 3. **Introduction**

* Background information on corrosion.
* Importance of the study.
* Objectives of the experiment.

### 4. **Literature Review**

* Overview of previous research on corrosion.
* Relevant theories and concepts.

### 5*.* **Materials and Methods**

* Description of materials used (metals, electrolytes, etc.).
* Detailed experimental setup (potentiostat configuration, electrode arrangement).
* Procedure followed during the experiment.

### 6. **Results**

* Presentation of experimental data (graphs, tables, charts).
* Key observations from the experiments.

### 7. **Discussion**

* Interpretation of results.
* Comparison with literature values or previous studies.
* Analysis of corrosion mechanisms observed.
* Implications of findings.

### 8. **Risk Analysis**

* Summary of identified risks.
* Mitigation measures taken during the experiment.

### 9. **Conclusion**

* Summary of key findings.
* Relevance of the study.
* Suggestions for future research.

### 10. References

* List of all sources cited in the report.

**Final Report evaluation criteria;**

### 1. **Clarity and Organization (10p)**

* Is the report well-structured with clear headings and subheadings?
* Are the sections logically ordered, making it easy to follow the flow of information?

### 2. **Methodology (20p)**

* Are the materials and methods described in sufficient detail for reproducibility?
* Is the experimental setup clearly explained, including the use of the potentiostat and electrode configurations?

### 3. **Data Presentation (20p)**

* Are the results presented clearly, using appropriate tables, graphs, and charts?
* Is the data accurately interpreted and discussed in relation to the objectives of the study?

### 4. **Analysis and Discussion (40p)**

* Does the discussion adequately analyse the results and relate them to existing literature?
* Are the implications of the findings clearly articulated, and are limitations acknowledged?

### 5. **References and Citations (10p)**

* Are all sources properly cited and referenced according to a consistent format?
* Is there a sufficient number of relevant references to support the research and conclusions?