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## **PREFACE**

This distance learning module is based on the notes for the tutored course module that has been offered for several years by the Institute of Materials Finishing.

Changes and additions have been made to the original notes to take into account the various technical innovations that have taken place in more recent years and, in particular, the changes in environmental, health & safety practices and general changes in industrial working.

One major change has been to ensure that study by distance learning mirrors the course offered by the tutored route. The Objective Syllabus for both paths is now identical and the courses are examined in the same way, both leading to the same qualification and certification.

The Institute appreciates the hard work in carrying out this revision by Clive Barnes and Trevor Crichton. Further, thanks are expressed to all those other members of the Institute who have contributed by way of offering advice, reading of revised lessons etc.

# INTRODUCTION TO DISTANCE LEARNING AND THIS MODULE

Distance Learning differs from the traditional method of learning that you will have used at school or college, where you work at a fixed rate that is determined by your teacher or lecturer. Their rate of teaching may be too fast or too slow for different students, so you either get bored or cannot keep up. Furthermore, if you miss a lesson, you will have to catch up before the next lesson, or you will quickly fall behind.

Distance Learning is not a new concept and has been around for several decades and it allows you to work at your own pace and in your own time. The Institute of Materials Finishing has been offering their courses for many years and after listening to our students, we realised that the preferred method of teaching was by offering scripted lecture notes.

Although you will be often working alone in your studies, the Institute makes sure that you have enough support if and when you have any problems.

In this latest revision of our courses, each lesson is a self contained and complete unit. This 2010 revision has also reviewed the course content to make it more applicable to the modern surface finishing and surface engineering industry and has allowed us to include new and recently introduced technologies.

As you are aware, you have been allocated an 'Industrial Counsellor' who, hopefully, is a member of your company. One of the roles of the Industrial Counsellor is to help you understand what you are being taught. We fully accept that non-one will fully understand every part of their course the first time they see it. Every person is different and has different skills and attributes, so they will find different parts of the course either easy or more difficult. When you meet a difficulty, you should ask the Industrial Counsellor to help you; it is their role to help you to understand the content of the lessons. If a suitable person is not immediately available within your company then the Institute will have made arrangements for you to be linked to a suitable local member of the Institute who has agreed to be available to assist you. Even if this person cannot immediately answer your problem, he or she will know someone who can. Most importantly, do not become disheartened in your studies. If, on any occasion, your Counsellor is unable to help, you should contact the education Manager at The IMF's Head Office who will arrange for a Professional Member to contact and assist you.

You will find it very useful to have a pencil or pen and paper with you when you are studying, as you can quickly write down any extra notes or explanations; these can be very useful when you come to revising or are seeking further help.

This module is made up from a set of lessons of various lengths that are composed of written text with some illustrations where relevant. You may need to read the text several times to fully understand it and before moving on to the next lesson.

There is a series of different tasks set throughout the text; these are headed SAQs, SMAs and

MAs.

## **SAOs - Self Answered Questions**

SAQ's are questions relating to what you have just studied. Their purpose is to check that you have understood the lesson so far. Firstly, you should try to answer the question without checking back through your notes and then check your answer with the model answer provided at the end of the Lesson. If your answer is correct, you should continue with the next part of the lesson. If, however, you are unable to answer the question or have incorrectly answered the question, we suggest you go over the section again and get a better understanding of the lesson.

## **SMA – Self Marked Assessment**

SMA's are usually found at the end of a lesson, but by no means every lesson. They are a series of questions that you should try to answer. The questions will be relevant to the lessons that you have just studied and there will be four or five possible answers for each question. You should identify which one you think is correct and when you have completed the series of questions, you should check your answers against those given at the end of the lesson. You will also find a short explanation explaining why each answer is correct or incorrect.

These SMAs, as both questions and answers, are also included in Appendix 1 and can be a useful source of revision prior to your examination.

## **MA –Marked Assignment**

You will be expected to carry out a series of 4 assignments during your studies. These will cover some of the Module's objectives and are designed to test your understanding of the study material and that you can use the knowledge gained to suggest answers to specific problems or situations. In the traditional system of learning, this may have been called 'homework'.

You will find detailed instructions on how to carry out the assignments in Appendix 2. Please pay particular attention to the information regarding **plagiarism** and make sure you fully understand it and the consequences of plagiarism

After completing each assignment, it should be sent to the Institute to be externally marked. (NOTE Students on tutored courses will have their assignments marked by their tutor.) Once marked, it will be returned to you. The total marks you receive for the four assignments contribute up to a maximum of 20% towards your final examination mark, so you are rewarded for your efforts.

**Please note: marked assignments are compulsory and must be submitted by the due date for you to be eligible for the final examination. This is fully explained in Appendix 2 and Appendix 5.**

## **The Examination**

Your examination will last for 2 hours and the examination paper consists of two sections:

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**Section A** 5 short essay questions, all of which should be attempted, for which it is suggested you should allow about 30 minutes in total for your 5 answers.

**Section B** consists of 8 longer essay questions, of which you should attempt five; it is suggested that you allow about 15 minutes for each answer.

Section A gives a maximum of 25% of your total marks and Section B gives 75% of your total marks for the examination. Your answer papers will be marked by an external examiner of the Institute and the examiner's mark will be moderated by the Institute's Examination and Qualifications Board (EQB).

The pass mark is 40%. This is made up from both your marks for your MA's as well as the marks you obtain in the final examination.

A mark of 60% and over gives a '**Pass with Merit**' whilst a mark of over 75% gives a '**Pass with Distinction**'. If you achieve these marks, the credit will be shown on your certificate. (An average mark of at least 40% must be obtained for the 4 assignments for a merit or distinction to be awarded)

**NOTE:** Candidates whose first language is not english may use a dictionary book during the examination, other types of dictionary, e.g. electronic ones and technical dictionaries, are not permitted. The examination's invigilator will check that the dictionary is suitable before the start of the examination. (Examples of suitable dictionaries are standard english dictionaries and dictionaries providing translation from english to another language and vice versa.)

## **Additional Distance Learning Modules**

There are additional modules of a similar academic standard. These are:

- Principles of Electroplating
- Powder Coating
- Environmental, Health and Safety
- Paint, Lacquer & Varnish OR Automotive Surface Finishing
- Materials Science
- Electroforming

Any one of the above, combined with the module you have just completed, can lead to the award of a '**Technician Certificate**'. The benefit here is that you can apply for the professional qualification '**Technician of the Institute of Materials Finishing**' and the **insignia TechIMF**, with which you can apply for the international award from the UK Engineering Council of '**Engineering Technician**' and the insignia **EngTech**, which is internationally recognised across all industries.

# **OBJECTIVE SYLLABUS FOR ELECTROPLATING PRACTICE MODULE**

## **SECTION A - Introduction to Surface Finishing Technologies**

### **Lesson 1 - Surface Finishing Technologies**

**At the end of Lesson 1 you should be able to:**

- 1.1 Know the range of surface finishing processes
- 1.2 Know the applications for the different surface finishing technologies

## **SECTION B - Basic Science for Electroplating**

### **Lesson 2 - Basic Electroplating Circuits and Calculations**

**At the end of lesson 2 you should be able to:**

- 2.1 List the main components of an electroplating electrical circuit and draw the associated circuit diagram.
- 2.2 Know the parameters and their units for the control of the electrical supply to an electroplating tank
- 2.3 Calculate the operating parameters associated with the electrical supply to an electroplating tank.

### **Lesson 3 - Chemical Symbols and Chemical Equations**

**At the end of lesson 3 you should be able to:**

- 3.1 Write the chemical symbols for the chemicals used most often in electroplating
- 3.2 Write chemical equations for simple chemical reactions.
- 3.3 Understand how atoms join together by ionic, covalent and metallic bonds.

## **SECTION C - Substrate Preparation and Pretreatment**

### **Lesson 4 – Substrates and their Cleaning**

**At the end of Lesson 4 you should be able to:**

- 4.1 Understand why metals require cleaning and pretreatment before electroplating.
- 4.2 Classify, according to the properties and likely contaminants of their surfaces, the metal and non-metal substances that are commonly electroplated.
- 4.3 Understand the advantages and disadvantages of solvent degreasing.

## **Lesson 5 – Final Preparation of Substrates before plating**

**At the end of Lesson 5 you should be able to:**

- 5.1 Clean common metals using alkaline solutions.
- 5.2 Remove oxides from the surfaces of common metals using acid solutions.
- 5.3 Discuss the causes of hydrogen embrittlement of steel and know how to prevent and alleviate it.

## **Lesson 6 - How to Prepare Difficult Substrates for Plating**

**At the end of Lesson 6 you should be able to:**

- 6.1 Plate onto zinc alloy die-castings.
- 6.2 Plate onto aluminium and its alloys.
- 6.3 Plate onto stainless steel and iron.

## **Lesson 7 - How to Prepare Plastic Mouldings for Plating**

**At the end of Lesson 7 you should be able to:**

- 7.1 Understand why ABS is a popular moulding material for plastics that are to be electroplated.
- 7.2 Know how mouldings should be designed for ease of plating.
- 7.3 Know how to test the suitability of plastic mouldings for plating.
- 7.4 Know the processing sequence for ABS plastic mouldings.

## **SECTION D - Electroplating of Metal Coatings**

### **Lesson 8 - Applications of Electroplated Coatings and Formulation of Electroplating solutions**

**At the end of Lesson 8 you should be able to:**

- 8.1 List the main metals that are electrodeposited and describe plating processes in a clear manner.
- 8.2 State the main reasons for using these popular electrodeposited coatings and relate these to the most common substrates.
- 8.3 Understand the differences between simple salt and complex salt plating solutions.

### **Lesson 9 - Solutions and Anodes Used for Copper Electrodeposition**

**At the end of Lesson 9 you should be able to:**

- 9.1 List uses of electroplated copper coatings
- 9.2 Describe and compare the three most important plating solutions that are used for the electrodeposition of copper.
- 9.3 Make up these plating solutions.

9.4 Electrodeposit copper from these plating solutions.

## **Lesson 10 - Solutions and Anodes Used for Nickel Electrodeposition**

**At the end of Lesson 10 you should be able to:**

- 10.1 List uses of electroplated nickel coatings.
- 10.2 Describe and compare the most important plating solutions that are used for the electrodeposition of nickel.
- 10.3 Make up these nickel plating solutions and electrodeposit nickel from them.
- 10.4 State how improved electrodeposited nickel coatings can be obtained.
- 10.5 Describe high speed nickel deposition solutions.

## **Lesson 11 - Solutions and Anodes Used for Chromium Electrodeposition**

**At the end of Lesson 11 you should be able to:**

- 11.1 List uses of electroplated chromium coatings
- 11.2 Describe the common types of plating solutions used for the electrodeposition of chromium and explain the importance of their operating conditions.
- 11.3 Make up typical chromium plating solutions and electrodeposit chromium from them.

## **Lesson 12 – Solutions and Anodes used for the Electrodeposition of Zinc and Cadmium**

**At the end of Lesson 12, you should be able to:**

- 12.1 Describe the benefits and uses of electroplated zinc coatings.
- 12.2 Describe the types of plating solutions used for the electrodeposition of zinc.
- 12.3 Make up and operate these zinc plating solutions.
- 12.4 List and describe the different anode systems used to replenish zinc plating solutions.
- 12.5 Understand when and why cadmium coatings may be used.
- 12.6 Make up and operate a cadmium cyanide plating solution.

## **Lesson13 – Solutions and Anodes for the Electrodeposition of Tin**

**At the end of Lesson 13, you should be able to:**

- 13.1 Describe and compare the most important types of plating solutions used for the electrodeposition of tin.
- 13.2 Make up and operate acid stannous sulphate and alkaline stannate tin plating solutions.
- 13.3 Understand the problems associated with tin whisker growth.

## **Lesson 14 - Electrodeposition of Precious Metals : Silver and Gold**

**At the end of Lesson 14 you should be able to:**

- 14.1 List and know the uses of the various types of silver cyanide plating solutions.

- 14.2 Make up and operate these plating solutions.
- 14.3 List and describe the different types of plating solutions used for the electrodeposition of gold and gold alloys.
- 14.4 Describe the main uses of the coatings deposited from these different gold plating solutions.

## **Lesson 15 - Electrodeposition of Alloys and Composite Coatings**

**At the end of Lesson 15 you should be able to:**

- 15.1 Understand how the electrodeposition of alloys occurs.
- 15.2 Understand how plating parameters influence the composition of the deposited alloy.
- 15.3 Know the main benefits of electroplated zinc alloys and how to deposit these alloys.
- 15.4 Know the benefits of electroplated copper alloys and tin alloys.
- 15.5 Know the difference between an alloy deposit and a composite coating.
- 15.6 Understand how the codeposition of particles can enhance the properties of electroplated metal coatings.
- 15.7 List some of the applications of composite coatings.

## **Lesson 16 - Producing Conversion Coatings on Electroplated Components**

**At the end of Lesson 16 you should be able to:**

- 16.1 Explain what is meant by conversion coatings and list their different types.
- 16.2 List and compare the different types of chromate coatings used on zinc and cadmium.
- 16.3 Make up and use a simple chromating solution for zinc coatings.
- 16.4 Test chromated and unchromated zinc coatings for their corrosion resistance.

## **SECTION E - Plating Metal Coatings without Electricity**

### **Lesson 17 – Mechanisms for the Deposition of Metal Coatings Without Electricity**

**At the end of Lesson 17 you should be able to:**

- 17.1 Discuss the meaning of the terms ‘Immersion Coating’, ‘Displacement Reaction’ and ‘Exchange Reaction’.
- 17.2 Explain the significance of the Galvanic Series
- 17.3 Discuss how the behaviour of dissimilar metals in contact with one another is governed by the Galvanic Series.

### **Lesson 18 - Electroless Deposition of Nickel and Copper**

**At the end of Lesson 18 you should be able to:**

- 18.1 State the basic chemistry underlying the electroless deposition processes.
- 18.2 List the main types of electroless deposition coatings in commercial use.
- 18.3 State the effects on the rate of an electroless deposition of change of pH, temperature

- and reactant concentration.
- 18.4 Discuss the underlying causes of 'runaway' conditions in electroless deposition systems.
- 18.5 Describe the recommended procedures for day-to-day operation of electroless baths.
- 18.6 Describe the properties and applications of an electroless nickel-phosphorus coating.
- 18.7 Know how to activate a plastics surface for electroless deposition.

## **SECTION F - Plant and Equipment used for Electroplating**

### **Lesson 19 – Governing Laws, Workflow and Plating Tanks**

**At the end of Lesson 19 you should be able to:**

- 19.1 State the law governing siting of industrial premises.
- 19.2 State the laws affecting the operation of a Surface Finishing plant.
- 19.3 Explain the concept of 'work flow' through a Surface Finishing installation.
- 19.4 Describe how plating tanks are constructed and heated.
- 19.5 Explain how a pump should be connected to a plating tank.
- 19.6 Explain how to filter a solution.
- 19.7 Describe techniques for agitating a solution.

### **Lesson 20 – Jigs, Jigging and Barrel Plating**

**At the end of Lesson 20 you should be able to:**

- 20.1 State the function of a jig.
- 20.2 Describe and compare the different types of anodes.
- 20.3 Appreciate the use of barrel plating.
- 20.4 Recognise the need for special plating techniques.

## **SECTION G – SERVICES**

### **Lesson 21 - Water chemistry, utilities and prime services**

**At the end of Lesson 21 you should be able to:**

- 21.1 Appreciate the meaning and purpose of utilities and prime services in the Finishing Shop.
- 21.2 Realise the importance of water and know what it is.
- 21.3 Be aware of the properties of water.
- 21.4 Know about the treatment of water.
- 21.5 Be aware of the quality of deionised water.
- 21.6 Appreciate the value of water as a heat transfer fluid for cooling and heating.
- 21.7 Understand the key properties of utilities and services.
- 21.8 Be knowledgeable of the Factory Coding System.

## **SECTION H - HEALTH, SAFETY AND ENVIRONMENTAL ISSUES IN SURFACE FINISHING**

### **Lesson 22 – Health, Safety and Environmental Legislation**

**At the end of Lesson 22 you should be able to:**

- 22.1 Understand what is required of an employer under the Health & Safety at Work Act (1974).
- 22.2 Understand what is required of an employee under the Health & Safety at Work Act (1974).
- 22.3 Be aware of the requirements of the Control of Substances Hazardous to Health Regulations (COSHH).
- 22.4 Understand the need for and principles of risk assessments and their relevance to COSHH and the Health and Safety at Work Act.
- 22.5 Be aware of the use of Pictograms and Hazard and Precautionary phrases for identifying the hazards of Hazardous Substances.
- 22.6 Be aware of REACH.
- 22.7 Be aware of the main environmental legislation concerning permits, waste and pollution of water.
- 22.8 Be aware of other legislation that may affect the processes used in surface finishing.

### **Lesson 23 – Health and Safety Hazards and Precautions**

**At the end of Lesson 23 you should be able to:**

- 23.1 List and identify the most important items of safety equipment in a surface finishing department.
- 23.2 Identify the most common hazards to be found in the workplace.
- 23.3 Be aware of the most common chemical hazards.
- 23.4 Identify the principal hazards in the electroplating shop.
- 23.5 Be aware of specialist hazards to be found in other types of surface finishing areas.
- 23.6 Know how to avoid any short and long term effects of these hazards.
- 23.7 Discuss the importance and role of training in the prevention of accidents.
- 23.8 Know how to avoid a fire and to mitigate its effects.

## **Lesson 24 – The Treatment and Disposal of Metal Finishing Wastes**

**At the end of Lesson 24 you should be able to:**

- 24.1 Discuss how the discharge of hazardous effluents can cause danger, damage or loss.
- 24.2 List the main hazardous wastes from Surface Finishing.
- 24.3 Explain how heavy metal ions can be removed by alkaline precipitation and flocculation.
- 24.4 List the main methods for disposal of cyanides.
- 24.5 Discuss how to minimise the amounts of waste produced.
- 24.6 Explain the principles of ion-exchange and its application to effluent treatment.
- 24.7 Discuss the concept that valuable materials can be recovered from effluent streams.
- 24.8 List alternatives to precipitation for recovery or removal of metal ions from effluent streams.
- 24.9 Discuss methods for reducing water usage.
- 24.10 Identify how energy is wasted.