EWF Guideline
EUROPEAN ADHESIVE SPECIALIST

Minimum Requirements for the Education, Examination and Qualification

EWF-516r1-10

Published by: EWF
C/o: ISQ
Av. Prof. Dr. Cavaco Silva, 33
Taguspark – Apartado 012
P-2780-994 Oeiras
PORTUGAL

Tel: +351 21 4211351
Fax: +351 21 4228122
E-Mail: ewf@isq.pt

Table of Contents

Section I: Minimum Requirements for the Education of European Adhesive Specialist

Adhesive Specialist Course - Syllabus

SECTION I: Minimum Requirements for the Education of European Adhesive Specialists

The use of this guideline is restricted to organisations approved by the Authorised National Body (ANB). The section II of this guideline covers the examination and qualification of European Adhesive Specialists.

Introduction

This guideline for the European education and training of European Adhesive Specialists has been prepared, evaluated and formulated by Members of the Committee for Education and Training of the EWF. It is designed to provide the basic core education in adhesive technology required for a number of adhesive personnel being active in job functions such as inspection, supervision, foremanship, instruction, technical sales etc. It is possible, that additional training and/or experience may be required by the adhesive personnel beyond the basic core education to lead to qualification in the applicable job functions. Additional training programmes will be established as required. The comprehensive work has been funded by the EU in the frame of the Leonardo Da Vinci programme.

The specialist will write and explain working instructions for the bonder in theory and practice. He will instruct and supervise practitioners. He will control process parameters, with responsibility for inspection and identification of problems.

The guideline covers the minimum requirements for education and training, agreed upon by all national welding and joining societies within the EWF, in terms of themes, keywords and times devoted to them. It will be revised periodically by the Committee to take into account any changes which may effect the "state of the art". Students having successfully completed this course of education will be expected of being capable of applying adhesive technology as covered by this guideline. A subsequent document covers the examination and certification.

The contents are given in the following structure:

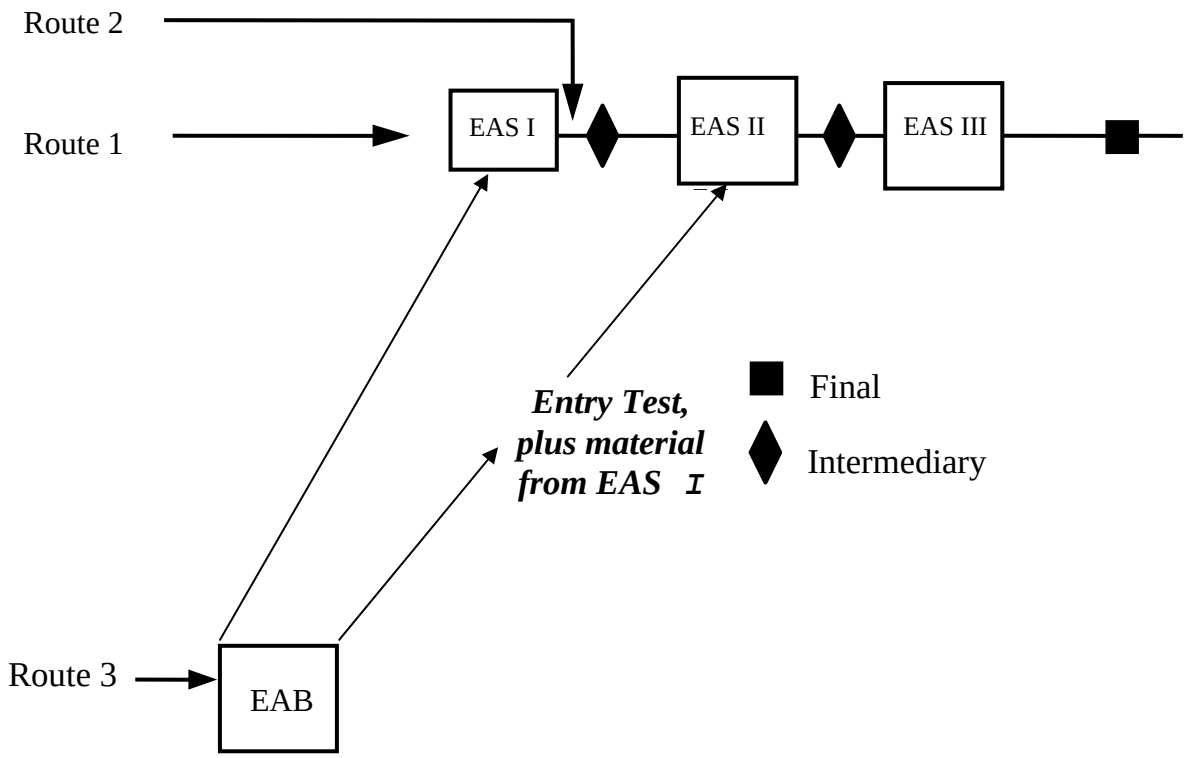
Theoretical Education	Teaching Hours
1. Adhesion and Adhesives	14
2. Materials as Adherends	14
3. Construction and Design	12
4. Durability	8
5. Bonding Process	11
6. Testing and Analysis	12
7. Health and Safety	4
8. Quality Management	7
9. Manufacturing Case Studies	8
10. Practical Skills Training	22
11. Examination	8
Total	**120**

A teaching hour will contain at least 50 minutes of direct teaching time. It is not obligatory to follow exactly the order of the topics given in this guideline and choice in the arrangement of the syllabus is permitted.

It is not obligatory to follow exactly the order of the topics given in this guideline and choice in the arrangement of the syllabus is permitted. The depth to which each topic is dealt with is indicated by the

number of hours allocated to it in the guideline. This will be reflected in the scope and depth of the examination.

For entry to the programme 3 routes are available



Route 1 and 2:

For the access to the module EAS part I, the minimum requirements are:

specific technical qualification, the national definitions are given in Appendix 1 and a minimum age of 20 years including 2 years of job related experience.

In case of cooperation arrangements eg. with technical colleges, according to which basic parts of the course EAS part I are given under careful control of the ANB, before the participant complies with the access conditions, the access may be according to the route 2 indicated in the graph.

Route 3

For access to the module EAS part O the minimum requirements are

EAB qualification

or

qualification of a professional worker (with certificate after examination) in material processing profession and a minimum of three years experience in adhesive related activities, and a minimum age of 22 years, national definitions are given in Appendix 0.

Students who enter from the Bonder or professional worker (Route 3) must pass an entry test. Those who feel they lack the necessary basic technical education may take the preparatory EAS part 0 course before the test. If a student fails in the entry test he must take the full EAS part 0 course before the next test.

The amount of lecture hours which are recommended to be included in EAS are given in the following definition of the theoretical education. The definition of the precise syllabus of Part I is the responsibility of the ANB.

The rules for the conduct of the final examination by the ANB are prescribed under Examination and Qualification in this guideline. The intermediate examination is mandatory and it is the responsibility of the training school to ensure that all participants have achieved the required knowledge. Failure in the intermediate examination will require the student to repeat the examination.

Applicants not fulfilling the access conditions may follow the course as guests, but entry to EAS examination is not permitted.

In addition, the lectures of the EAS Part I are suitable for being taught as long distance learning programmes.

Theoretical Education EAS 0 **24 hours + Exam**

1. Introduction **1 Hour**

Survey on the contents of this module
repeat of basic knowledge
information on the EWF and its education and training system
job function of the EAS in relation to EN standards

2. Units **1 hour**

units for length and area
time and time dependant units

3. Technical Calculation **4 hours**

percentage calculation
equations
rearranging of equations
calculation of length, area and volume
angular units
trigonometric functions

4. Technical Drawing **4 hours**

formats, lines, fonts, scales, drawing aids
sketch of flat pieces
drawings
projections, cross sections
planar development of shapes
pieces with hidden lines, hatching
symbols, size lines
drawing of diagrams

5. Basics of Chemistry **4 hours**

chemical elements
simple reactions

6. Basics of Materials **3 hours**

properties of materials

7. Mechanical Engineering **3 hours**

basics of statics
forces, main axes
moments, supports
conditions for stability
static systems
calculation of forces, stresses, and moments in cross sections

8. Calculation of strength **3 hours**

stresses, elongations, deflections
behaviour of structural shapes
stability of constructions

9. Joining **1 hour**

screws, rivets, bolts, shrinkage
adhesive bonding, brazing, soldering, welding
mechanical fasteners

Appendix 0

National definitions for the minimum requirements for access to the Adhesive Specialist education and examination via route 3 defined before:

Austria

Professional worker in a materials processing profession with a minimum of three years job related experience.

Belgium

Holders of a B.S.O. (Beroeps Secondair Onderwijs) or a E.S.P (Ensignement Secondaire Professionel) qualification plus three years of practical experience.

Denmark

Craftsman (diploma of skill) in materials processing professions (Faglaert med svendebrev).

Finland

3 years at institute of vocational education or equivalent, materials processing and three years of practical adhesive work in industry.

France

Professional bonders, qualified or certified according to EWF standards, or specifications, got in training centres or in industry and having elementary theoretical knowledge.

Germany

Certificate of a profession worker in materials processing professions got after successful examination by the chambers of industry or craft organisations.

Italy

National certificate (diploma) of professional worker obtained at public or private professional school recognised by the district education authorities ("Regioni" or "Provincie Autonome").

Luxembourg

Certificate of a professional worker in materials processing (CATP = certificat d'aptitude technique et professionel), got after successful examination by the chambers of trade.

Netherlands

Primary professional education "PBO" in the discipline of assembly/maintenance.

Norway

Craftsmen in materials processing (with letter of skill) (Fagarbeider med nasjonalt fagbrev).

Portugal

Second cycle of basic education.

Spain

Professional worker in materials processing.

Sweden

Professional worker in material processing profession with a minimum of three years job related experience.

Switzerland

Certificate of a professional worker in materials processing, got after successful examination by the craft organisation (Eidg. Fahigkeitsausweis),

United Kingdom

Approved craft certificates in materials subjects issued by, for example, City & Guilds of London Institute or
Approved Level 2/3 National Vocational Qualifications or other nationally recognised vocational qualifications in materials subjects.

1. ADHESION AND ADHESIVES 14 Hours

Objective: Understand the separate stages of the bonding process

1.1 INTRODUCTION

The purpose of this section is to act as a scene-setter for the remaining topics covered by the proposed qualifications for both a European Adhesive Engineer and a Specialist. This section should be common for both levels. It sets adhesive bonding within the context of other joining technologies. The links between the various topics contributing to the qualifications are outlined so that the overall objectives of the two qualifications, as an Engineer or a Technologist can be seen in context.

The place of the qualified Adhesive Engineer in industry - his/her role in a company, relationship with other professional joining staff etc.

The need to produce a rounded individual with a broad sweep of knowledge, not someone who is very focused towards one sector only.

How adhesive technology can fit into industrial manufacturing. The need to look at the use of adhesives from concept design through to final component production.

1.1.1 Historical Background

The use of adhesives (in their broadest sense) before 1900.

Industrial adoption of adhesive bonding and its increasing use in the aircraft industry.

Expanding opportunities for adhesives (and sealants) as the fabrication market becomes more diffuse.

1.1.2 Benefits and Limitations of Adhesive Bonding

The benefits and opportunities arising from the adoption of adhesive bonding by manufacturing companies, eg. reductions in cost, improved quality, greater design freedom.

The downside of adhesive bonding.

- The need to pay greater attention to health and safety.
- Cost implications in terms of new equipment, staff training etc.
- The lack of credibility in industry.

The need to look at adhesive bonding in a holistic manner, taking all factors into account: this includes design, production and cost implications.

1.1.3 Principles of Adhesion

A general overview of the theories of adhesion. Areas of agreement and areas of conflict.

The importance of surface energy and how its influences the ability to produce a good quality adhesive bond.

How pre-treatment affects surface energy and hence the degree of adhesion
Environmental effects on adhesive performance.

1.1.4 Glossary of Terms

The principle terminologies used within the adhesive technology field will be introduced. This will occur on an ad-hoc basis throughout the introductory phase. However, a brief systematic examination of terms used and their meanings (eg. as defined in pr EU 923) will be included.

Common misinterpretations of specific terms will also be highlighted, so that people are aware of potential differences of opinion concerning the use of some phrases etc.

The aim is to ensure consistency of approach across Europe in the first instance and, on a worldwide basis later.

1.2 ADHESIVES & SEALANTS — 10 HOURS

1.2.1 Classification

By chemical family (epoxy, silicone...)
By setting made (chemical curing, solvent evaporation, melting/cooling...)
By origin (natural, synthetic, mineral, organic...)
By end-use (wood adhesives...)
By functional types (structural, hot-melt, pressure-sensitive...)
By physical form (one or multiple components, films, tapes, pastes, liquids...).

1.2.2 Constitution of Adhesives and Sealants

Different types of polymers and their basic properties
Adhesive modifiers: Fillers, adhesion promoters, tackifiers, toughgeners.
Primers
Solvents

1.2.3 Types of Adhesives and Sealants

For each of the following chemical families:

Resin chemistry

Cure chemistry
Functional types - commercial forms
Markets and applications - major suppliers

Properties:

Handling and storage
Physical (prior to cure)
Process (metering, mixing, dispensing, application)
Mechanical, chemical, thermal, electrical (after cure)
Health and safety

Chemical families:

Epoxies
Phenolics
Urethanes
Anaerobics
Acrylics
Cyanoacrylates
Silicones
Polysulphides
Elastomeric adhesives
Sealants

1.2.4 Selection Requirements of Bonded Assembly

Use
Application
Materials to be joined (surfaces)
Type of joint
Process limitations
Mechanical requirements
Service conditions

1.2.5 Selection Criteria

Compatibility with the substrates
Process (number of components, physical form, pot-life, curing, viscosity/rheology, gap-filling)
Mechanical and thermal properties
Durability

1.2.6 Applications

Working examples of selection of adhesives or sealants:
Inventory of the requirement of the bonded assembly.
Determination of the selection criteria of adhesives or sealants
Selection of adhesives
This work could be made with the aid of computerised-based systems or not

Expected Result for EAS:

1. Outline the characteristics of each adhesive and typical applications for each type.
2. Compare the characteristics of each adhesive type.
3. Recognise and define in general the potential hazards and methods of safe handling, storage and working practices.
4. Outline the selection criteria
5. Basic knowledge on how to use appropriate standards.
1. Identify the limitations and the range of applications associated with each adhesive type.

2. MATERIALS AS ADHERENDS 14 Hours

Objective: Understand the purpose of surface pre-treatment and establish the link with adhesion theories.

2.1 IMPORTANT ADHEREND PROPERTIES

The different types of substrates (plastics, metals, wood, fibres, glass, composites, ceramics) show a wide variety of properties, conditioning the type of surface treatment and the choice of adhesive. These properties are:

Mechanical properties (modulus, strength, fracture)
Stiffness
Porosity/permeability
Roughness
Corrosion
Water absorption

2.2 PURPOSE OF THE SURFACE TREATMENT (KEY SURFACE FEATURES)

There are two types of adherends, depending on their surface energy:

Low-energy surface substrates. The surfaces of plastics, rubbers and fibre composites have low surface free energies (typically less than about 50 mJ/m^2). The low level of the surface energy is critical for substrates like polyolefins and cured butyl rubber.

High-energy surface substrates

The other key surface features are:

Roughness, stability, contamination, soundness, uniformity, compatibility.

The purpose of any particular surface pre-treatment may be manifold but the main aims are usually one or more of the following:

1. To remove or prevent the subsequent formation of any weak surface boundary layer on the substrate.

2. To maximise the degree of intimate molecular contact that is attained between the adhesive and the substrate during the bonding operation.

3. To ensure that the level of intrinsic adhesion forces which are established across the interface are sufficient for obtaining both the initial joint strength and subsequent service life that is required.

4. To generate a specific surface topography on the substrate.

5. To assist in the hardening/curing of the adhesive (eg. cyanoacrylate).

6. To protect the surface of the substrate prior to the bonding operation (frequent for high energy substrate such as metals).

2.3 TYPES OF SURFACE PRETREATMENT

The surface pretreatment depends on the type of adherend.

For high energy substrates

1. Solvent cleaning

Substrate surfaces are frequently contaminated with oils, greases etc, and a common pretreatment is degreasing either with steam, or by wiping the surface with solvent dipped clean cloths, or most effectively in liquid and vapour degreasing bath.

2. Mechanical abrasion

The methods available include wire brushes, sand and emery papers, abrasive pads and grit or shot blasting.

3. Primers

Primers have two different purposes:

To improve the performance of the bonded component by chemically altering the surface (e.g. silane coupling agents, chromate conversion coatings).

To increase production flexibility on the bonding operation. After pre-treating a high-energy substrate, the active surface will readily absorb atmospheric contamination, and after a certain "surface exposure time" this may lead to inferior joint performance especially with respect to durability.

4. Chemical treatments

With nearly all high-energy substrates the maximum durability to aqueous environments is achieved when a chemical pre-treatment and/or primer is employed.

Case of steels

Steels are frequently bonded with no, or a minimum of, pretreatment being employed and good, reproducible initial joint strengths are readily obtained using a combination of degreasing/mechanical abrasion techniques, as shown above.

However, to obtain the longest service life, surface treatments are recommended, like chemical treatments or primers.

Case of titanium and its alloys

Case of aluminium and its alloys

For low-energy substrates

1. Abrasion

Simple abrasion is usually a very poor surface treatment for plastic substrates.

2. Etching treatments

Many chemical treatments have been reported for plastics but the most usual is etching acid for polyolefins, alkali metal in liquid ammonia for polytetrafluorpethylene, iodine treatment for nylon's surface etc.

3. Physico-chemical treatments

All these treatments have the same effect on the surface's substrates in order to increase bondability of the materials.

All these techniques are the only solution to increase surface tension (or wettability of the materials.

Corona discharge
Plasma
Flame treatment
Others (UV radiation, laser pretreatment)

4. Primers

Primers are associated with the adhesive for thermoplastic substrates.

The structure of these primers are similar to coupling agents such as silane, titanate, zirconate and aluminate.

For other materials

Wood, leather, glass.....

2.4 SELECTION OF SURFACE PRETREATMENT AND SURFACE PRETREATMENT FACILITIES

The pre-treatment is chosen by the user bearing in mind:

- The specifications of the assembly in terms of performance and durability
- Cost
- The productivity required (duration of the operations, storage time)
- The equipment already available
- Health and Safety considerations.

2.5 SURFACE PRE-TREATMENT FACILITIES

Equipment required
Chemical products and consumables
Peripheral equipment (for Health and Safety problems, for instance)

2.6 WETTABILITY

Expected Result for EAS:

1. Describe and compare the principles of each pre-treatment and their applications.
2. Explain the selection of appropriate pre-treatment, according to the application and/or material.
3. Identify the range of application, appropriate joint preparations and potential problems to be overcome.
4. Explain the purpose and functions of step, the equipment and accessories.
5. Interpret the use of appropriate standards.
6. Describe potential hazards and methods of safe handling and working.

3. CONSTRUCTION & DESIGN 12 Hours

Objective: Understand the effect of external loads on structures, the types of structural systems and the relationship between external loads and internal forces.

3.1 FUNDAMENTALS OF THE STRENGTH OF MATERIALS

Different behaviours (elastic, elastic-plastic, plastic, viscoelastic, viscoplastic, elastomeric)
Behaviours of materials under different conditions of temperature and load
Types of fracture

3.2 BASICS OF ADHESIVE BONDING DESIGN

Design principles (calculation of stress)
Conditions of equilibrium
Stiffness
Moments of inertia
Types of stresses (tensile, shear, peel...multiaxial stresses and combined stresses)
Stresses induced by differential straining (heterogeneous joints)
Measurement of stresses in bonded joints

3.3 JOINT DESIGN

Basics of adhesive bonding design
Different types of bonded joints
Classifications (lap joints, cylindrical and tubular joints...)
Tolerance requirements
Influencing factors (experimentally constated)

- Overlap length
- Stiffness of adherends (thickness and moduli)
- Adhesive layer thickness
- Shape of the adhesive "fillet"
- Adhesive behaviour (modulus, strength)
- Coefficient of thermal expansion of adherends and adhesive

Design proof testing.

3.4 HYBRID JOINTS

Adhesive bonding associated with:

Riveting
Spot welding
Screwing
Clinching
Setting, crimping
Shrinking

Advantages and limits of these assembly methods.
Rules for design of such joints
Comparison of performances of these joints compared to bonded joints and mechanically fastened joints
Influence of factors
Practical examples in industry

3.5 DESIGN CONSIDERATIONS FOR DURABILITY OF JOINTS (LONG TERM PERFORMANCE)

Creep
Fatigue
Thermal effects
Environmental effects (moisture, water, chemicals)
Combined effects
Fracture mechanics

This different behaviour will be discussed in depth in sections 1, 2, 3, and 7. In this section, only design recommendations will be given for reducing or overcoming these effects in order to suit the specifications of the assembly.

Working examples and applications will be given.

3.6 MANUFACTURING CONSIDERATIONS

Ease of assembly
Value analysis
Automation

Expected Result for EAS:

1. Explain the performance and strength of materials
2. Understand the design principles of bonded structures
3. Describe the basics of joint design for bonded structures
4. Undertake calculation of stresses in bonded joints using analytical methods and numerical analysis
5. Give an explanation of hybrid joints
6. Account for the important design considerations with respect to durability of bonded joints
7. Rationalise the design for manufacturing considerations
8. Interpret the use of appropriate standards.

4. DURABILITY 8 Hours

Objective: Understand the effects of external factors on the bonded joint.

4.1 INTRODUCTION

4.2 THERMAL EFFECTS ON ADHESIVE JOINTS

Differential thermal expansion
Thermal transition in adhesives
Thermal degradation of adhesives
Thermal conductivity of adhesives
Temperature limits of adhesives

4.3 MOISTURE EFFECTS ON ADHESIVE JOINTS

Migration of water in adhesive joints
- Water diffusion in adhesives
- Critical water concentration

Strength degradation and failure mode

Mechanism of strength loss
- Displacement of adhesive by water
- Hydration of oxide layers

Improvement of Joint Durability
- Increasing barrier to water diffusion
- Hydration inhibition or retardation
- Application of primer

4.4 CHEMICAL EFFECTS ON ADHESIVE JOINTS

Often encountered chemical agents.
Chemical resistance of adhesives by chemical family
Chemical resistance of common adherends
Methods of bonded joint protection
- Paints and coatings
- Water displacing materials
- Elastomeric sealants

Chemical resistance test methods.

4.5 MECHANICAL STRESS EFFECTS ON ADHESIVE JOINT DURABILITY

Creep (permanent loading) - definition.
Fatigue (cyclic or dynamic loading) - definition.

Specimens for creep and fatigue testing of adhesive joints.
Allowable stresses (or strains) in adhesives for creep and fatigue.

4.6 COMBINED TEMPERATURE - MOISTURE - MECHANICAL STRESS EFFECTS ON ADHESIVE JOINTS

Evaluation parameters
Accelerated service life testing

4.7 WEATHERING AND AGEING EFFECTS ON ADHESIVE JOINTS

Definition of an environment
Short term testing
Long term testing
Comparison of short and long term testing

4.8 DURABILITY ASSESSMENT AND LIFE PREDICTION FOR ADHESIVE JOINTS

Durability test techniques
Diffusion dominated durability: spring loaded share specimens
Adhesion dominated durability: wedge, test, wet peel test
Corrosion dominated durability: salt spray test.

Expected Result for EAS:

1. Understand the effects of heat and moisture on bonded joints
2. Recognize the chemical, electrochemical and corrosion effects on bonded joints
3. Understand the effects of radiation and vacuum bonded joints
4. Explain the effect of mechanical stress durability
5. Explain the effects of combined temperature - moisture – mechanicals stress on joints
6. Explain the effect of weathering and ageing joints
7. Undertake durability assessment for joints
8. Interpret the use of appropriate standards.

5. THE BONDING PROCESS 11 Hours

Objective: Understand the developments in the bonding process including accepted terminology, standards and abbreviations.

5.1 INTRODUCTION TO THE BONDING PROCESS

5.2 SOURCING AND STORING ADHESIVES

5.3 PREPARATION OF THE ADHESIVE

(Focusing each type of adhesive)

5.4 ADHESIVE APPLICATION

5.4.1 Methods of Adhesive Application

Brushing
Flowing
Spraying
Roll coating

Knife coating
Silk screening
Melting
Other

5.4.2 Metering

Procedure and equipment

5.4.3 Mixing

Procedure and equipment

5.4.4 Dispensing

Procedure and equipment

5.4.5 Control

Procedure and equipment

5.5 ASSEMBLY

5.5.1 Order of Assembly

5.5.2 Methods of Adhesive Bonding

Wet bonding
Reactivation bonding
Pressure sensitive bonding
Curing
Other methods of bonding

5.5.3 Environmental Aspects

Thermal effects
Moisture effects

5.5.4 Tooling

5.5.5 Inadequate Bonding

5.6 PRESSURE

5.7 JIGS AND FIXTURES

5.8 ADHESIVE CURING

Room temperature
Direct heat curing
Radiation curing
UV curing
    Visible light curing
    Infrared curing
Microwave curing
Moisture curing

Electric heaters
High frequency dielectric heating
Induction heating
Low-voltage electric heating
Ultrasonic activation

5.9 REPAIR

Repair concepts
Surface preparation for adhesive bonded repair
Surface contamination considerations
Examples for several applications

Repair on automotive applications
Repair on aerospace applications (aluminium structures, advanced composite structure etc)
Repair on industrial applications

5.10 AUTOMATION AND ROBOTICS

Dispensing equipment for robotic applications
Advancements in dispensing technology
Other levels of automation
Applications
Developing a robotic system

5.11 FACTORY LAYOUT (INCLUDING ECONOMIC ASPECTS)

5.12 BONDING COORDINATION (EQUIVALENT TO EN ISO 14731)

Expected Result for EAS:

1. Outline the bonding process type of adhesive.
2. Define the potential hazards and methods of safe handling, storage and working practices.
3. Outline the purpose and working principle of each component.
4. Basic knowledge on how to use appropriate standards.
5. Identify the limitations and the range of application of the process and recognise how to overcome the potential problems associated with this process.

6. TESTING AND ANALYSIS 12 Hours

Objective: Understand and name the fundamental aspects of testing materials with particular reference to adhesively bonded test pieces.

6.1 STANDARD TEST METHODS AND OTHERS

National or ISO Standards shall apply throughout

Specifications from industry:

- Military Industry
- Aerospace
- Automotive
- Electronic

6.2 PROPERTY DETERMINATION FOR ADHESIVE, ADHEREND OR JOINT

To deduce the nature and magnitude of the stresses in an adhesive joint requires the basic mechanical properties of the adhesive and substrate to be known and a mathematical analysis of the joint geometry to be available.

6.2.1 Adhesive

To analyse the stresses in adhesive joints requires a knowledge of the basic engineering properties of the adhesive. Typically, the main properties required are the tensile, or Young's modulus, the shear modulus and the yield stresses and the fracture stresses and strains in uniaxial tension and in pure shear. Most of the common standard joint tests do not enable theses properties to be deduced due to the complex state of stress induced in the adhesive layer by the specimen geometry.

Two different approaches have been adopted in an effort to overcome these problems:

- One is to measure these properties by preparing bulk specimens of the adhesive (static testing, dynamic testing, rheological characterisation)

- The second is to measure these properties by using especially designed joint geometries to measure the failure strength and to analyse the fracture and failure behaviours.

6.2.2 Adherend or Substrate

Surface energy

Roughness
Mechanical properties
Chemical properties (resistance to corrosion, compatibility with chemicals)
Thermal properties
Other properties (electrical, optical...)

6.2.3 Joint

Study of the geometry of the joint.

There are several important general aspects to bear in mind when designing adhesive joints.

The designer should not only attempt to keep stress concentrations to a minimum but also attempt to distribute the imposed loads within the adhesive layer as a combination of compressive and shear stresses; avoiding tensile, cleavage and peel stresses as much as possible.

6.3 CHARACTERISATION OF RAW MATERIAL

Viscosity
Reaction time for different adhesives (epoxy, acrylic, polyurethane etc)

6.4 CHARACTERISATION OF CURED ADHESIVE

Mechanical characterisation as other materials
Electrical and optical properties

6.5 MECHANICAL PROPERTIES OF THE ASSEMBLY

Destructive testing of the assembly:

Failure strength measurements
Fracture testing and failure analysis
Thermal properties and temperature effects
Fatigue testing and failure analysis

6.6 PERFORMANCE IN SERVICE

Tests for the durability of the assembly:

Thermal constraints
Moisture
Chemical environment
Mechanical constraints (dynamic behaviour)
UV
Combined effects

6.7 NON-DESTRUCTIVE TESTING

The basic aim of any non-destructive test of an adhesive joint must be in direct correlation of some parameter measurable by the test with the failure property to be measured or predicted, without impairing the effectiveness of the bonded part for its intended application.

Expected Result for EAS:

1. Discuss the objectives of each destructive test and the limitations of the data generated
2. Describe in detail each of the major testing methods and the parameters to be measured
3. Predict when and why special testing should be specified
4. Show competence in carrying out testing to a given schedule.

7. HEALTH & SAFETY 4 Hours

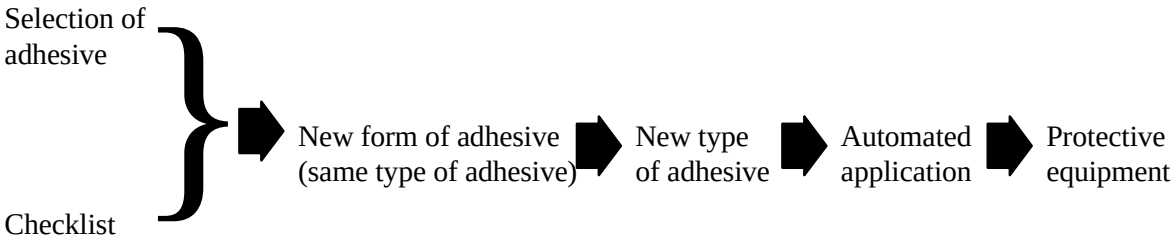
Objective: Understand detail/get a complete knowledge/explain the health and safety hazards associated with adhesive bonding and fabrication processes, including techniques to minimise them.

Adhesives and the work environment

Introduction

Structural adhesive bonding of load-bearing parts has become increasingly widely used in recent years. Bonding has replaced other methods of joining parts, and is even used successfully in applications with very high requirements in respect of structural integrity, such as aircraft parts. An advantage of structural adhesives is their excellent technical performance, but a drawback can be their effects on the work environment and on the wider environment.

The objective of training in this module is to present the working procedure as follows:



When considering the use of structural adhesives, such as epoxy and polyurethane adhesives, it is important also to consider the method by which the adhesives will be applied. It may be possible, for example, to apply an adhesive which is a health hazard in such a way as to reduce the overall risk. The converse applies for a relatively non-hazardous adhesive: applying it manually can make it more hazardous. What we want to show here is that the choice of adhesive cannot be made on its own: it is necessary also to consider how it is to be applied.

The contents of the training material

This material comprises the following elements:

7.1. Selection of adhesive/Selection tables and performance specifications for selection of the appropriate adhesive.

7.2. A data section, including information such as the design of bonded joints, pretreatment, preparation and application of adhesives, summaries of health risks associated with constituents of adhesives.

7.3. National rules and regulations.

7.1 SELECTION TABLES AND PERFORMANCE SPECIFICATIONS

Technical performance specifications.

Adhesive/adherend cross scheme (adjusted regarding to the adhesive type health risk).

Regardless of how good an adhesive may be from a work environment or external environment viewpoint, there is no point in using it if it cannot provide the necessary technical performance for the particular bond concerned.

The performance specification may reveal that unnecessarily high demands are being made on the adhesive by designing the joint so that it is exposed to extremely high loads. In such cases, the first line of attack could be to redesign the joint: a well-designed joint can reduce the performance requirements of the adhesive itself.

When the design of the joint has been settled, and the necessary performance of the adhesive been decided on, it will probably be found that there are several adhesives that meet the requirements. An adhesive can then be selected that represents as little risk as possible. Risks associated with the use of an adhesive are due to such factors as the constituents of the adhesive and how hazardous they are. A very simple guide for selection of an appropriate adhesive should be given in a table of adhesives.

7.2 DATA SECTION

Health hazards for different types of adhesives

Synonymous chemical name list

Health hazards for different forms of adhesives

Design aspects

Surface treatment aspects
- Surface treatment methods for different adherends and applications
- Alternative surface treatment/cleaning methods

Aids for preparation, measuring and mixing adhesives

Equipment for dispensing/application of different adhesive forms

Equipment for various automation levels of dispensing application of:
- Adhesives in fluid state
- Adhesives in solid state

Health hazards for different ways of curing/solidification

Health hazards for equipment used for curing/solidification

This section contains information on various stages of the bonding process. Much of this information is concerned with the inherent risks associated with particular adhesives and how the adhesives can be applied.

No adhesives represent health hazards before users or others come into contact with them in some way. Factors that have a bearing on such contact, such as the form in which the adhesive is encountered or applied, or the method of handling, therefore also affect the health hazard.

Adhesives can be supplied in various forms, such as thick liquids, viscous pastes, powders, films, tape, granulates or blocks that must be melted prior to application. Some adhesives are single-component types, while others are of two-component form.

The most commonly encountered form of adhesive today is the liquid form. Two-component adhesives usually have to be prepared before application. This involves measuring and mixing, with resulting risks of skin contact and inhalation of fumes. The use of single-component adhesives involves less preparation and is therefore to be preferred, unless the single-component adhesives suitable for the particular application are very health-hazardous.

Adhesives in solid form are usually of the single-component type, which means that there is no measuring or mixing. Adhesives in film form, which have a defined thickness, are easy to apply in the correct quantity, and there is no need to add a little more adhesive in order to err on the side of safety, which must subsequently be removed. Adhesives in solid form are heated at some point in the bonding process in order to melt them: fumes can be released at this stage.

The form in which the adhesive is encountered also affects the choice of equipment for use with it. Appropriate choice of measuring, mixing and application equipment, together with proper ventilation, can reduce the work environment risks associated with the use of adhesives.

The way of and the equipment for curing / solidification is also important. Is the heat curing equipment, UV lamp safe etc?

Simplified, the application of adhesive can be divided into different independent elements: the adhesive itself, measuring/mixing equipment, application equipment and the curing / solidification stage.

7.3 NATIONAL RULES AND REGULATIONS

This section should include general rules for people and aspects such as:
Importers/manufacturers
Employers
Marking for use on packaging
Hazard symbols as used on packaging
Data sheets
Details of hazard substances
Applications
Exceptions
Lists of types
Written hazard and protection information
Marking
Product inspection at the place of use
Measuring equipment for different substances
Protection equipment (clothes, gloves etc).

In order to be able safely to handle a hazardous substance, it is necessary first to know the risks associated with the substance and the characteristics of the substance in general that can influence the risk picture. For example who will be exposed and for how long time? It is also necessary to know what protective measures are needed in order to ensure that the material is handled correctly, and the rules for this can vary from country to country.

Expected Result for EAS:

1. Explain the risk factors associated with adhesive bonding
2. Interpret Health and Safety regulations with respect to the hazards.
3. Select the appropriate methods to reduce each type of risk factors.
4. Perform measurements of bonding hazards.

8. QUALITY MANAGEMENT 7 Hours

Objective: Understand in detail/get a complete knowledge/explain the principles of quality assurance and quality control and recognise the related standards and their application to adhesive fabrication as a special process.

8.1 INTRODUCTION - THE ADHESIVE BONDING PROCESS

Adhesive bonding fits into ISO 9000 as a special process, the results of which cannot be fully verified by subsequent inspections and testing. The problem of assuring the quality and reliability of an adhesive joint is in the absence of suitable non-destructive examination methods, in all but a few special cases. Therefore, inspection of adhesive bonds is not a feasible way of assuring quality and in modern manufacturing philosophy, is after the event an unnecessary activity in a well-controlled process. The only way to provide assurance is to systematically manage and control the whole operation from design of the joint through to final assembly. In this way, the possibility of poor quality joints being produced is reduced to the minimum because proven procedures are being followed at all times.

8.2 RAW MATERIALS CONTROL

Supplier certification - Status of all suppliers of any materials in the bonding process (adherends, consumables, adhesive, fixed equipment).

Manufacturing system qualifications.

Incoming specifications - Defined by the final customer or the manufacturer.

Testing - The testing that is required on any incoming materials, to prove conformance to incoming specification. Tests appropriate to the process, eg. viscosity, lap shear strength. Or reliance on a specification and the supplier's quality system.

Correct storage of all materials in the bonding process, eg. control of temperature, humidity, airborne dust, shelf life.

8.3 PROCESS CONTROL

Procedure specifications - documentation of all the process steps (adhesive storage and application, surface treatment, assembly, cure). Bonding coordination, the equivalent of EN 719 (Welding Coordination), should be considered here and also in Section 6 (the Bonding Process).

Staff training - Documentation of skill, experience of staff, and training where required to achieve product reliability and to conform with the company's quality system.

Statistical monitoring methods - Measurements made during the process (flow rate, optical detection of adhesive bead, laminate thickness), then data analysis and presentation of results (eg. SPC charts), for the purpose of continuous process improvement. Methods of feedback and problem solving.

8.4 END-PRODUCT CONTROL

Visual - simple ways to check process is correct, eg. joint appearance, alignment, visible excess adhesive.

Physical - measurement of a useful feature, to detect correctly made product, eg. Tg of cured adhesive fillet, flexural test of a laminate, proof loading of finished product.

NDT - non-destructive tests that are available to detect flaws or failed product, eg. ultrasonic C-scan, electrical measurement, gas leak test.

Destructive - parallel test pieces (witness samples) tested to destruction. Tear-down of complete product, with an agreed frequency or in the event of a dispute.

Sampling and statistics - Procedures for sampling, eg. BS 6001 level S3. Frequency and cost of sampling to ensure process capability. Statistical techniques.

Limitations of end-product control - after the joint has been made.

8.5 AVAILABLE QUALITY TOOLS AND TECHNIQUES

Overview of main quality tools and techniques, what they can do and when they should be used. The seven basic tools, then advanced tools eg. QFD, Taguchi, FMEA, Ishikawa diagrams, Poka-yoke.

Expected Result for EAS:

1. Explain the main differences between quality assurance, quality control and inspection systems and their usage for adhesive fabrication.
2. Be capable of writing quality control procedures.
3. Interpret appropriate standards (e.g. ISO 9000, and ISO 3834 series).
4. Know the basic factors related to personnel and equipment, which influence the quality in a bonded fabrication.
5. Explain the role of the Bonding Specialist in the fabrication industry.

9. MANUFACTURING CASE STUDIES 8 Hours

Objective: The purpose of this topic is to give students an opportunity to look at a number of adhesively bonded applications in their entirety. This provides a chance to see how all the different topics interrelate.

9.1 INDUSTRIAL CASE STUDIES

Applications from a range of industrial sectors, eg. automotive, construction, marine, packaging, etc., will be examined to demonstrate the methods used in take a product from concept to final production.

Emphasis will be given to the importance of factors such as design, surface preparation, choice of application method, quality management, costing, health and safety considerations etc.

Where possible, these applications will be presented by industrial experts who have actual experience of the case studies they describe.

9.2 GROUP EXERCISES

Groups of students will work together as a team to provide a manufacturing solution for an adhesively bonded product. Their assessment of the problem will be discussed with industrial experts and others who will provide feedback on the actual solution employed in practice and the reasons why certain approaches were adopted.

Some exercises will incorporate analysis of failed components from which examples of insufficient detail at the design stage, poor workmanship, inadequate quality assurance etc. will be highlighted. Consideration of these factors will lead to the development of revised manufacturing schemes, including additional quality checks etc.

The aim of these exercises is to demonstrate that joining must be considered at every stage of the design and manufacturing cycle.

Expected Result for EAS:

Not applicable

10. PRACTICAL SKILLS EXERCISES 22 Hours

The objectives of this section are to give experience and appreciation to the Engineer, of processes he or she will specify, and to the Technologist, of tasks he or she will be asking others to perform.

10.1 SURFACE PREPARATION OF ADHERENDS

Practical experience of each main surface pre-treatment type, [as defined in section 3.3, Materials as Adherends, Types of Surface treatment], i.e. cleaning and degreasing, surface roughening, chemical treatments including anodising, physical treatments including at least one from plasma, corona, flame or UV/ozone, primers including coupling agents, conversion coatings and protective coatings. Measurement and assessment of treated surface, related to key surface features, eg. wettability by contact angle or surface tension inks.

10.2 USE OF DIFFERENT ADHESIVES

Manual dispensing of liquid, paste and film adhesives, in order to appreciate viscosity, cure speed, plus safe and efficient handling

10.3 USE OF ADHESIVE APPLICATION EQUIPMENT

Simple and complex dispensing equipment. Automatic dispensing, using demonstration equipment.

10.4 JOINT TYPES

Lap joints, coaxial joints, lamination of multilayers and skin - core (foam, honeycomb)

10.5 MANUFACTURE OF BONDED JOINTS WITH DIFFERENT MATERIALS

Metals - mild steel, aluminium; Plastics - thermoplastic (eg. polypropylene), thermoset composite (eg. GRP); Others - rubber, concrete, fabric.

10.6 EXAMINATION AND TESTING OF BONDED JOINTS

Mechanical testing of bonded joints in shear, peel and tensile mode. Microscopic examination of fracture surfaces.

10.7 PRACTICAL INSPECTION TECHNIQUES

Visual assessment and physical measurement of joint features, eg. Tg of cured adhesive fillet, to detect correct assembly. NDT methods including ultrasonics, acoustic (eg. coin-tap) or electrical tests.

11. EXAMINATION 3(1 + 1½) + ½ hours

There shall be an examination at the end of each module, which controls the learning curve of the candidate. The examination shall consist of a written portion that is 1 hour and a practical portion that is 1½ hour.

If the candidate achieves less than 60% at the end of the first module, experience has shown that there is a high probability of failure at the end or the course. This is documented through a discussion with the candidate and a recommendation for extra tuition is given, to increase the likelihood of a successful outcome. The candidate is not allowed to carry on without counselling and complete the course, only to fail, which is costly and ineffectual.

The examination procedures described below are designed to simulate the different situations of an adhesive specialist active in industry. The examinations shall include the following subjects:

Adhesion and Adhesives
Materials as Adherends
Construction and Design
Durability
Bonding Process
Testing and Analysis
Health and Safety
Quality Management

Practical Examination

Written Examination

At the discretion of the Board of Examiners the examination shall consist of:

	a)	a series of essay questions covering the whole field of the subject
or	b)	a series of multiple choice questions covering the whole field of the subject
or	c)	a combination o a) and b) with equal marks allocated to each type.

The time devoted to the written examination shall be a minimum of 1 hour per module.

Oral Examination **½Hour**

The oral examination is mandatory.

Appendix 1

National definitions for the minimum requirements for the access to the Adhesive Specialist's education via the route 1 defined before:

Austria

High craft or industry qualification in materials processing (Meister im Gewerbe oder in der Industrie).

Belgium

Holders of B.S.O. (Beroeps Secondair Onderwijs) or a E.S.P. (Enseignement Secondaire Professionel) qualification plus the certificate of a "seventh" year of professional education plus two years of practical experience.

Denmark

Master craftsman in materials processing eg. exam og autoriseret gas, vand og sanitestmester.

Finland

France

Holders of CAP (Certificat d'Aptitude Professionelle), BEP (Brevet d'Etudes Professionelles), Baccalaureat, BP (Brevet Professional), BT (Brevet Technicien), Technicien AFPA, C.Q.T (Certificat de Qualification Technique UIMM), or equivalent.

Germany

Craft or industry qualification in materials processing

Italy

Diploma of technical professional school (at least 3 years after middle school), recognised by the Minister of Education.

Luxembourg

Master craftsman in materials processing (Inhaber einer Meisterprufung im metallverarbeitenden Handwerk).

Netherlands

Extended secondary professional education "VBO" in the disciplines of assembling/maintenance.

Norway

%

Portugal

Third cycle of basic education or the second cycle of basic education plus three years in a Professional Training Centre in the materials processing area (Professional Qualificado).

Spain

High Technician, upper grade vocational studies (Técnico Superior, Ciclos Formativos de Grado Superior) in Mechanics, Foundry, Mechanical Manufacturing, Metallic Structure, Industrial Chemistry.

Sweden

Access if possible via three routes:

a) 2 years at Gymnasieskolans verkstadstekniska linke (practical, upper secondary school). Prior to 1993.

or

b) 3 years at Gymnasieskolan Industrieprogrammet (practical, upper secondary school). After 1993.

or

c) Older equivalent educations with at least two years of technical education after the compulsory school leading to at least the same competence as alternatives a) and b) above.

Switzerland

High craft qualification in material processing professions (dipl. Meister oder Betriebsfachmann mit eidg. Fachausweis).

United Kingdom

BTec/Scotvec, National Certificate in Engineering,
or
Approved City and Guilds of London Institute Part 3 Certificate in Engineering subjects,
or
Approved Level 3 National Vocational Qualifications in engineering subjects.

SECTION II: EXAMINATION AND QUALIFICATION

1 Introduction

This guideline seeks to achieve harmonisation and common standards in examination and Certification of professional adhesive specialists in Europe. The national welding and joining organisations, being members of the EWF, mutually acknowledge the Certification awarded in any Member State to European Adhesive Specialist following examination conducted in accordance with this Guideline.

Education must have followed this EWF guideline "European Adhesive Specialist" Part I, and the examination must have been conducted by the national Body authorised by EWF for this purpose.

This "Authorised National Body" will normally be the National Welding and Joining Organisation, but may be another organisation with the agreement of the EWF Member.

2. Approval of the Training Course

Any training course leading to the EWF examination must be approved by the Authorised National Body. The number of teachers required to give the course shall be sufficient to ensure, that the expert knowledge and industrial experience to cover the syllabus, is adequately represented in the team of teachers and visiting lecturers.

3. Board of Examiners

The Chairman and members of the Board of Examiners shall be nominated by the Authorised National Body. The examining board shall consist of:

a) the Chairman, who shall be a representative of the Authorised National Body, and shall be independent from the training school.

b) Main teachers of the subject.

c) Experts from industry or other organisations.

The responsibilities of the Board of Examiners are given in the Doc EWF-416, Latest Edition.

4. Admission to the Examination

Admission to the examination leading to the award of the European Adhesive Specialist certificate will be restricted to those:

a) who comply with the access conditions defined before

and

b) who have attended the course, according to this guideline and approved by the Authorised National Body, for at least 90%. Exceptions are at the discretion of the ANB.

There shall be an examination at the end of each module, which controls the learning curve of the candidate. The examination shall consist of a written portion that is 1 hour and a practical portion that is 1½ hour.
If the candidate achieves less than 60% at the end of the first module, experience has shown that there is a high probability of failure at the end or the course. This is documented through a

discussion with the candidate and a recommendation for extra tuition is given, to increase the likelihood of a successful outcome. The candidate is not allowed to carry on without counselling and complete the course, only to fail, which is costly and ineffectual.

The examination procedures described below are designed to simulate the different situations of an adhesive specialist active in industry. The examinations shall include the following subjects:

Adhesion and Adhesives
Materials as Adherends
Construction and Design
Durability
Bonding Process
Testing and Analysis
Health and Safety
Quality Management

Practical Examination

Written Examination

At the discretion of the Board of Examiners the examination shall consist of:

a) a series of essay questions covering the whole field of the subject
or b) a series of multiple choice questions covering the whole field of the subject
or c) a combination o a) and b) with equal marks allocated to each type.

The time devoted to the written examination shall be a minimum of 1 hour per module.

Oral Examination **½Hour**

The oral examination is mandatory.

6. Evaluation of Performance

In order to pass the examination candidates must achieve at least

60% of the maximum possible mark in each subject.

Successfully completed individual parts of the examination remain valid for a period of three years. The examination in all sections shall be completed within a period of three years from start of the course.

7. Re-examination and Appeals Procedure are covered by Doc EWF-416, Latest Edition

8. European Adhesive Specialist Diploma

After successful examination a Diploma is awarded to the candidate by the Authorised National Body.
Those qualified as "European Adhesive Specialist" may be called European Adhesive Specialist in the national language and use the professional designation "EAS" (invariable in all member countries).