

EWF Guideline THERMAL SPRAYING PRACTITIONER



Minimum Requirements for the Education, Examination and Qualification



EWF – 592-01

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Section I: Minimum Requirements for the Education and Training of the European Thermal Spraying Practitioner

The use of this guideline is restricted to organisations approved by the Authorized National Body (ANB). The section II of this guideline covers the examination and qualification (EWF) of Thermal Spraying Practitioners.

Issued May 2001

1. Introduction

This guideline for the education, training and examination of Thermal Spraying Practitioners has been prepared, evaluated and formulated by Members of the Subcommittee Thermal Spraying of the Committee for Education and Training of the EWF. It is designed to provide a harmonized scheme for a comprehensive education and training of Thermal Spraying Practitioners being active in job functions such as foreman, instruction, technical sales etc. It serves for quality assurance for a specific job, but does not provide an education program based on experience in which steps and sequence a high skill in thermal spraying can be acquired.

An European Thermal Spraying Practitioner is a qualified thermal sprayer in at least one process and he has industrial experience. He is able to read technical drawings and is well informed about production methods concerning thermal sprayed products. An European Thermal Spraying Practitioner is a highly qualified expert, who is responsible for the realisation of given spray technologies, for setting up spraying equipment and related periphery, and for instruction and guidance of the "European Thermal Sprayer". The European Thermal Spraying Practitioner's duties are servicing and maintenance of the spraying system as well as of other equipment and installations, appropriate handling and storage of spray consumables and the realisation of safety precautions, occupational hygiene and accident prevention regulations. He can supervise and instruct thermal sprayers and be a responsible Thermal Spraying Coordinator for standard quality requirements of thermal sprayed structures according EN ISO 14922 part 3.

An European Thermal Spraying Practitioner will normally hold a position of foreman or supervisor within the manufacturing industry. He may also fit the requirements of the standard EN 13214 "Thermal spray coordination: tasks and responsibilities".

The guideline covers the minimum requirements for the education, training and examination, agreed upon by all national welding societies within the EWF to which thermal spraying is related, in terms of training pieces and theoretical lessons in terms of themes, keywords and times devoted to the theoretical education and basical practical training. The section II of this guideline covers the examination procedures. It is to be noted that EWF-diplomas of the European Thermal Spraying Practitioners - Flame, Arc, Plasma or HVOF are valid for the whole life.

This guideline will be revised periodically by the EWF-Subcommittee "Thermal Spraying" 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 being capable of applying thermal spraying technology as covered in this guideline.

2. Access

For entry to the Module A(p) the minimum requirements are:

- Qualification as a professional worker in metalworking professions and a minimum of 3 years experience in thermal spraying, and a minimum age of 22 years, national definitions are given in appendix 1.

or

- Thermal Sprayer and five years experience

or

- ETS Qualification (European Thermal Sprayer) and a minimum of 2 years experience in at least one thermal spraying process.

Appendix 1

National definitions of the minimum requirements for the access to the Thermal Spraying Practitioner's education and examination:

Austria :

Professional worker in a metal working profession.

Belgium :

Holders of a B.S.O. (Beroeps Secundair Onderwijs) or a E.S.P. (Enseignement Secondaire Professionnel) qualification plus demonstrated practical skill in two processes + three years of practical experience

Denmark :

Craftsman (diploma of skill) in metalworking professions (Faglaert med svendebrev)

Finland :

3 years at institute of vocational education or equivalent, mechanical line, and 3 years of practical welding work in industry

France :

Germany :

Certificate of a professional worker in metalworking professions (Facharbeiterbrief), obtained 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 recognized by the district education authorities ("Regioni" or "Provincie Autonome")

Luxembourg :

Certificate of a professional worker in metalworking professions (CATP = certificat d'aptitude technique et professionnel), obtained after successful examination by the chambers of trade

Netherlands :

Profession qualification level 2/3

Norway :

Qualification as skilled worker - letter of skill - in:

Plate/welding, mechanical process or electro-mechanical processes - according Norwegian education system (Grunnskole, GK Mekaniske fag, VK1 plate/sveise-fag, fagprøve). Min. 2 years experience in thermal spraying

Portugal :

Second cycle of basic education, or

First cycle of basic education plus two years in a Professional Training Center of the metalworking area (Professional Qualificado)

Spain :

Professional worker in metalworking professions

Sweden :

Access is possible via three routes:

- a)
- b)
- c)

Switzerland :

Certificate of a professional worker in metalworking professions, got after successful examination by the craft organisation (Eidg. Fähigkeitsausweis)

United Kingdom :

Approved craft certificates in engineering subjects issued by, for example, City & Guilds of London Institute.

or

Approved Level 2/3 National Vocational Qualifications or other nationally recognized vocational qualifications in engineering subjects.

3. Instruction program

The full EWF course consists of Modules A(p), A1-4, B(p), B1-4 (see fig. 1). The Modules themselves break down into theoretical education - A(p), A1-4 - and practical training - B(p), B1-4 -. The modules A1-4, and B1-4 of the ETSP (European Thermal Spraying Practitioner) education and training are identical to the modules A1-4, and B1-4 of the ETS (European Thermal Sprayer) education and training.

The practical training - practice and production related thermal spraying - is based on the relevant instruction and exercise schedules (see B1-4). The type of base material will usually be unalloyed or low alloyed steel. In addition, other types of materials may be chosen.

The periods of time given in table 1 represent the average time required to attain the theoretical knowledge. The time for the specific practical part (B 1-4) needed is individual according to the capability and the skill of the student.

The theoretical instruction given to the trainees aims at a basic understanding of the process and the material including standards and safety regulations. The themes and keywords are given under the Modules description A, A 1-4.

Reference to appropriate CEN standards, directives and regulations may be made throughout the course. A "teaching hour" will contain at least 50 minutes of direct teaching time.

4. Tests and examinations

After Modules A(p) and B(p) the participant has to pass an intermediate examination. The general rules for examination are given in section II of this guideline.

Within a period of three years after this intermediate examination, the participant may attend all Modules A1-4 and B1-4 to finish the education and training in the different thermal spray processes.

After the period of three years, it is at the discretion of the ANB to decide, whether the participant can continue with further education (A1/2/3/4//B1/2/3/4), because of his experience and practice, or if he has to pass a professional interview or an entrance test covering the contents of Module A and B.

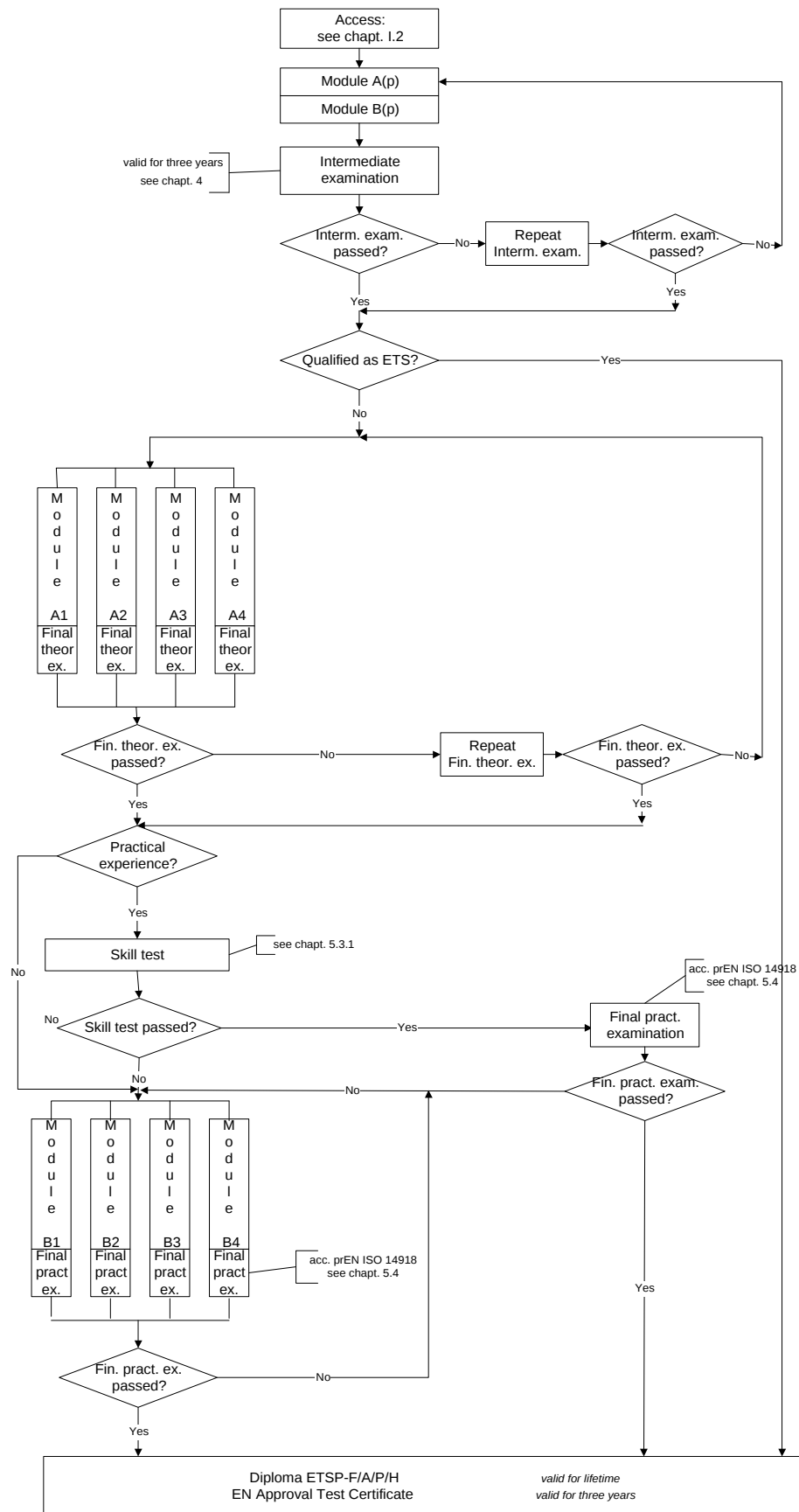


Fig. 1: Scheme of the education and training of the European Thermal Spraying Practitioner - ETSP

5. Training modules

The full EWF course for thermal spraying consists of the Modules A(p), A1-4, B(p) and B1-4:

ETSP Education and Training			
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Module A(p)	(common part)	Part 0 -Basics	16 h
	BASIC THEORETICAL EDUCATION	Part 1-3: all spray processes	51 h
Module B(p)	(common part)		
	BASIC PRACTICAL TRAINING	all spray processes	28 h
Module A(p)+B(p)	Intermediate examination	all spray processes	2h

Module A1	Specific theoretical education	Flame spraying	7h
Module A2	Specific theoretical education	Arc spraying	7h
Module A3	Specific theoretical education	Plasma spraying	9h
Module A4	Specific theoretical education	HVOF-spraying	7h
Mod. A1/2/3/4	Final theoretical examination		

Module B1	Skill test	Specific practical training	Flame spraying	*
Module B2	Skill test	Specific practical training	Arc spraying	*
Module B3	Skill test	Specific practical training	Plasma spraying	*
Module B4	Skill test	Specific practical training	HVOF-spraying	*
Mod. B1/2/3/4		Final practical test		

* Duration of the specific practical training depends on the experience and result of the skill test of the candidate, and may be fixed individually in the responsibility of the training organisation. Without practical experience, approximately 3 days (24 h) will be expected to be necessary for the specific practical training.

Table 1: ETSP - Education and training

5.1 Module A(p): Basic theoretical education

The Module provides deep and comprehensive education in thermal spraying, covering all processes.

The themes and keywords to be dealt with and the minimum times devoted to them are listed below.

<u>Part 0. Basics</u>		<u>hours</u>
0.1	Technical calculation Units - length and area Time and time dependent units Addition, subtraction, multiplication, division Percentages calculation, rule of three Use of pocket calculators Equations Rearranging equations Calculation of length, area and volume Angular units Trigonometric functions	8
0.2	Technical drawing Formats, lines, fonts, scales, drawing aids Sketch of flat pieces Drawings, projections, cross sections Pieces with hidden lines Symbols, size lines Drawing of diagrams	3
0.3	Basics of Electrotechnology and Chemistry Direct current Alternating current Circuits, connection diagrams Chemical elements Simple reactions	3
0.4	Properties of Materials and Metal Products Basics of metals, non metals Metal products: plates, profiles, bars, Castings, forgings, extrusions	2
0.	Basics	16 h

Part 1. Fundamentals of thermal spraying

		<u>hours</u>						
1.1	General introduction Wear problems Methods to protect surfaces (thermal spraying, painting, welding and others) Thermal spraying - definition and general aspects Coating properties Application possibilities and limits - overview (no details)	1						
1.2	Principles of thermal spraying Including build up of coatings (in general) Heat, particle velocities (in principle)	1						
1.3	Overview of the different thermal spraying processes and health and safety <table border="0" style="display: inline-table; vertical-align: middle;"> <tr> <td>Flame</td><td rowspan="4" style="font-size: 3em; vertical-align: middle;">}</td><td rowspan="4" style="vertical-align: middle;">equipment, peripheral equipment</td></tr> <tr><td>Arc</td></tr> <tr><td>Plasma</td></tr> <tr><td>HVOF</td></tr> </table> and other processes (e.g. D-gun)	Flame	}	equipment, peripheral equipment	Arc	Plasma	HVOF	4
Flame	}	equipment, peripheral equipment						
Arc								
Plasma								
HVOF								
1.4	Overview of properties of coatings and bonding mechanisms Porosity - types, orientation, alignment Structure Adhesion Oxide content - hardness Inclusions Imperfection and defects in general (cracks etc.) Intermediate layers/bond coatings Basic information about metallographical preparation and failures	2						
1.5	Materials Base materials Spray materials: powder, wire, rods etc. Handling and storage	2						

1. Fundamentals of thermal spraying

10 hours

Part 2. Procedural knowledge of thermal spraying

		<u>hours</u>
2.1	Prespray conditions and preparation	2
	Degreasing	
	Cleaning	
	Activating - mechanical, chemical (detailed)	
	Blasting	
	Masking	
2.2	Spraying	4
	Cold/hot spraying, fusing	
	Calculating passes	
	Mounting test samples on/beside the part to be sprayed	
	Geometrical effects (radius, corners, roundings, oversize/overmeasure spraying being machined)	
	Cooling devices, ways of cooling surfaces, CO ₂ -cooling	
	Temperatures of parts	
	Influence of parameters in general	
	Spraying on site	
	Working according TSPS (thermal spraying procedure specification)	
2.3	Overview of maintenance and calibration	2
2.4	Post-treatment	2
	General information	
	Machining (detailed)	
	Sealing	
2.5	Measuring and testing	4
	Measuring before, during and after thermal spraying	
	Testing: hardness, adhesion strength	
2.6	Workpiece handling, storage and transportation	1
	Before, meanwhile and after spraying	
2.7	Health and safety, environmental aspects	2
	Basics: including safe assembly, setting up and closing down procedures	
	Personal protection	
	Fire hazards, dust explosions, electrical hazard, flash backs	
	Leak detection, radiation, noise - specific to the process to be qualified in	
	Gases: physical properties, safety rules	

2.	Procedural knowledge of thermal spraying	17 hours
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Part 3. Procedural knowledge of thermal spraying

	<u>hours</u>
3.1 Economics Analysis of coating process and spray costs: Deposition efficiency and rate, Costs of labour, quality control/inspection, consumables, Equipment, energy Spray time, preparation time, finishing costs etc. Waste, disposal costs	4
3.2 Quality management / Standards (ISO 9000) basic information, EN ISO 14922 part 1-4, EN 13214 and EN ISO 14918: Standards Quality manual Quality system elements Certification Material certificates, consumable certificate Spraying procedure specification Sprayer approval certificates, heat treatment records NDT and DT procedures and reports, dimensional reports	4
3.3 Mechanization, automation Handling of the gun, handling of the workpiece Def. of mechanization, automation and of industrial robots Types of mechanization/automation: - Manual control handling systems - Pick and place units - Variable control mechanism - Learning mechanism/robot - Numerical control mechanism/robot - Intelligent mechanism/robot (equipped with sensors) Robots: translation and rotation, degrees of freedom, common systems (TTT, RTT, RRT, RRR), cartesian, cylindrical, polar, arm articulation, gantry, pneumatic, electrical, hydraulical; TCP Software: 1. Programming (teach in, on-line, off-line) 2. Programming languages: typical TS programming procedures 3. PC and storing 4. Numerical control (point-to-point, continuous path - linear or circular interpolation) Hardware: Measuring systems for robots (incremental, absolut, overload) Accuracy and repeatability Fixtures Alarm, diagnosis, trouble shooting Safety, maintenance QM: controlling, monitoring, recording	8

3.4	Typical applications and case studies	8
	Typical applications according to coating functions	
	Case studies	
	Technical point of view	
	Economical point of view	
3.	Procedural knowledge of thermal spraying	24 hours

5.1.1 Module A1: Specific theoretical education

Module A1 is identical to Module A1 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - Flame spraying according EFW Guideline do not have to participate in this module, if they want to become ETSP-Flame (European Thermal Spraying Practitioner - Flame spraying).

<u>Module A1: Specific theoretical education - Flame spraying</u>		<u>hours</u>
1.	Principles of process Gases, compressed air Flame temperatures, mixtures Consumables Sprayable materials Identification (acc. EN-standard, company spec.) Powder/wire delivery form, reels, drums Self fluxing powders, metals and alloys, ceramics Plastics	1
2.	Equipment Gun, control unit, powder/wire feeder, straighteners Maintenance - spare parts exchange	1
3.	Spraying Setting up and closing down procedure Specific spray parameters, controlling parameters Relation between as-sprayed coating thickness and fused coating up to 1,5 mm thickness, limits Limits due to the base material Dimensional changes, shrinkage Wet glance, temperature, colour Fusing in detail: manual, oven, induction, laser Heat input and control Health, safety and personal protection Noise, fumes, dust	2
4.	Coating properties Bond strength values, porosity, voids, Permissible thickness, roughness	1
5.	Areas of use Engineering application Electrical application Chemical application (anticorrosion) Thermal application Typical consumables related to application	2
		7 h

5.1.2 Module A2: Specific theoretical education

Module A2 is identical to Module A2 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - Arc spraying according EWF Guideline do not have to participate in this module, if they want to become ETSP-Arc (European Thermal Spraying Practitioner - Arc spraying).

<u>Module A2: Specific theoretical chapters - Arc spraying</u>		<u>hours</u>
1.	Principles of process Power: electricity, open arc and closed arc systems Compressed air, secondary air Gases Sprayable materials Identification (acc. EN-standard: En 1274 etc., company spec.) Consumables - wires: Delivery form (reels, drums), dimensions Solid wires, cored wires, compositions	1
2.	Equipment Power source Torch/gun Feeding system Cables, hoses	1
3.	Spraying Setting up and closing down procedure Influence of spray parameters Health, safety and personal protection Environment: - Noise - Fumes and dust - UV-radiation (arc) - Electrical risks	2
4.	Coating properties Bondstrength values, porosity, voids, Thickness limitations, surface structure	1
5.	Areas of use Engineering application Electrical application Chemical application (anticorrosion) Mouldmaking	2
		7 h

5.1.3 Module A3: Specific theoretical education

Module A3 is identical to Module A3 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - Plasma spraying according EWF Guideline do not have to participate in this module, if they want to become ETSP-Plasma (European Thermal Spraying Practitioner - Plasma spraying).

<u>Module A3: Specific theoretical chapters - Plasma spraying</u>		<u>hours</u>
1.	Principles of process Power: electricity Gases - mixtures (explaining plasma) Sprayable materials Powder - identification(EN-standard: EN 1274, company spec.) Ceramics, metals and alloys, cermets, Carbides, carbon material compositions, plastics	2
2.	Equipment Power source Torch/gun Cooling, Nozzle lifetime Feeding system Cables, hoses Equipment of LPPS - low pressure plasma spraying, APS - atmospheric plasma spraying, WPS - waterstabilized plasma spraying, CAPS - controlled atmosphere plasma spraying	2
3.	Spraying Setting up and closing down procedure Influence of spray parameters Health, safety and personal protection Environment: Noise, fumes and dust, UV-radiation (arc) Electrical hazards	2
4.	Coating properties Bondstrength values, porosity, voids, Thickness limitations, surface structure Graduated coatings	1
5.	Areas of use Engineering application Electrical application Chemical application (anticorrosion) Thermal application Biochemical application	2
		9 h

5.1.4 Module A4: Specific theoretical education

Module A4 is identical to Module A4 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - HVOF spraying according EWF Guideline do not have to participate in this module, if they want to become ETSP-HVOF (European Thermal Spraying Practitioner - HVOF spraying).

<u>Module A4: Specific theoretical chapters - HVOF-spraying</u>		<u>hours</u>
1.	Principles of process Explaining differences between flamespraying and HVOF-spraying (velocity of gases and particles) Fuels: gases and liquid fuels Oxygen Sprayable materials Powder identification (EN-standard: EN 1274, company spec.) Metals and alloys, metal matrix carbides, (ceramics)	1
2.	Equipment Gun Expansion nozzle, barrel (loading, built up problems) Cooling system Design: air cooled, water cooled, hybrid Gas supply / fuel supply - heating Tanks, bottles Control unit Powder feeder / powder injection Maintenance - spare parts exchange	2
3.	Spraying Setting up and closing down procedure Influence of spray parameters Heat into part - cooling during spraying Health, safety and personal protection Noise, fumes, dust	1
4.	Coating properties Coating quality, permissible thickness Porosity, voids, bondstrength values Visual appearance, porosity values	1
5.	Areas of use Engineering application Electrical application Chemical application (anticorrosion) Thermal application Biomedical application	2
		7 h

5.2 Module B(p): Basic practical training

The module provides demonstration and basic practical training in all 4 thermal spraying processes.

The themes and keywords to be dealt with in practice and the minimum times devoted to them are listed below.

<u>Module B(p): Basic practical training</u>		<u>hours</u>
0.	Practical demonstration Entire equipment Changing wear parts All processes Automated processes	7
1.	Surface preparation Cleaning Degreasing Mechanical surface roughening different base and different blast materials Storage between roughening and spraying Dimensions, geometrical measurements Masking Material storage and handling	3
2.	Spraying in all four TS processes Different base and spray materials Parameter setting Set up and closing down of the equipment Handling gases, pressure regulators, connecting hoses etc. Fixing the work piece Fixing the gun Starting up and closing down the spray gun Preheating Calculating traversing speed of the gun and number of passes Measurements during spraying Thickness test, temperature, cooling Oversize/overmeasure spraying (to be machined) Different blast materials Calibrating, testing, recording Trouble shooting Maintenance	14
3.	Testing of the sprayed coating Final thickness test Spray quality: visual inspection Machining test Tests to be done in workshops: bend test	1

4.	Post treatment Demonstration of fusing Sealing Cooling after spraying Taking off masking, machining, grinding Handling and storage of the part	2
5.	Personal health and safety Dust, noise, gases, electricity, heat Environmental responsibility: waste, where to store etc.	1

<u>Module B(p): Basic practical training</u>	28 h
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5.2.1 Module B1: Specific practical training

Module B1 is identical to Module B1 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - Flame spraying according EWF Guideline do not have to participate in this module, if they want to become ETSP-Flame (European Thermal Spraying Practitioner - Flame spraying).

The student has to go through the whole procedure from preparing to testing of a practical training piece, supported and controlled by the trainer.

The practical training pieces and the skill test pieces have to include flat, round and internal spraying, oversize/overmeasure spraying, see as an example (fig. 2a and b) the drawing, showing the level of difficulty to be mastered.

Test pieces for final practical test are according EN ISO 14918.

Module B1: Specific practical training - Flame spraying

- 1. Surface preparation**
 Cleaning
 Degreasing
 Mechanical surface roughening
 Geometrical measurements
 Masking
- 2. Spraying**
 Spraying the learning piece according to instructions
 Spraying with fusing according to instructions
 Measuring and testing meanwhile spraying
- 3. Testing of the sprayed coating**
 Final thickness test
 Spray quality: visual inspection
 Choice of test methods related to the piece and spray material
- 4. Post treatment**
 Choice of test methods related to the piece and spray material
- 5. Personal health and safety**
- 6. Maintenance of the equipment**
 Powder feeder, calibration

5.2.2 Module B2: Specific practical training

Module B2 is identical to Module B2 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - Arc spraying according EWF Guideline do not have to participate in this module, if they want to become ETSP-Arc (European Thermal Spraying Practitioner - Arc spraying).

The student has to go through the whole procedure from preparing to testing of a practical training piece, supported and controlled by the trainer.

The practical training pieces, the skill test pieces and final practical test pieces have to include flat, round and internal spraying, oversize/overmeasure spraying, see as an example (fig. 2a and b) the drawing, showing the level of difficulty to be mastered.

Test pieces for final practical test are according EN ISO 14918.

Module B2: Specific practical training - Arc spraying

- 1. Surface preparation**
 - Cleaning
 - Degreasing
 - Mechanical surface roughening
 - Geometrical measurements
 - Masking
- 2. Spraying**
 - Spraying the learning piece according to instructions
 - Preheating
 - Wire feeding - feed rates
 - Limitations to coating thickness
 - Measuring and testing meanwhile spraying
- 3. Testing of the sprayed coating**
 - Final thickness test
 - Spray quality: visual inspection
 - Choice of test methods related to the piece and spray material
- 4. Post treatment**
 - Choice of test methods related to the piece and spray material
- 5. Personal health and safety**
- 6. Maintenance of the equipment**
 - Calibration

5.2.3 Module B3: Specific practical training

Module B3 is identical to Module B3 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - Plasma spraying according EWF Guideline do not have to participate in this module, if they want to become ETSP-Plasma (European Thermal Spraying Practitioner - Plasma spraying).

The student has to go through the whole procedure from preparing to testing of a practical training piece, supported and controlled by the trainer.

The practical training pieces, the skill test pieces and final practical test pieces have to include flat, round and internal spraying, oversize/overmeasure spraying, see as an example (fig. 2a and b) the drawing, showing the level of difficulty to be mastered.

Test pieces for final practical test are according EN ISO 14918.

Module B3: Specific practical training - Plasma spraying

- 1. Surface preparation**
 - Cleaning
 - Degreasing
 - Mechanical surface roughening
 - Geometrical measurements
 - Masking
- 2. Spraying**
 - Spraying the learning piece according to instructions
 - Preheating
 - Powder injection (inside, outside, angles)/ checking and control
 - Limitations to coating thickness
 - Changing nozzles and electrodes (nozzle lifetime)
 - Measuring and testing meanwhile spraying
- 3. Testing of the sprayed coating**
 - Final thickness test
 - Spray quality: visual inspection
 - Choice of test methods related to the piece and spray material
- 4. Post treatment**
 - Choice of test methods related to the piece and spray material
- 5. Personal health and safety**
- 6. Maintenance of the equipment**
 - Powder feeder, calibration
 - Calibration test
 - Leakage test of powder feeder
 - Wear control of nozzles and electrodes, nozzle lifetime
 - Adjusting distance between electrode and nozzle
 - Type of cooling water

5.2.4 Module B4: Specific practical training

Module B4 is identical to Module B4 of the education and training of the European Thermal Sprayer. Therefore thermal sprayers already qualified as European Thermal Sprayer - HVOF spraying according EWF Guideline do not have to participate in this module, if they want to become ETSP-HVOF (European Thermal Spraying Practitioner - HVOF spraying).

The student has to go through the whole procedure from preparing to testing of a practical training piece, supported and controlled by the trainer.

The practical training pieces, the skill test pieces and final practical test pieces have to include flat, round and internal spraying, oversize/overmeasure spraying, see as an example (fig. 2a and b) the drawing, showing the level of difficulty to be mastered.

Test pieces for final practical test are according EN ISO 14918.

Module B4: Specific practical training - HVOF-spraying

- 1. Surface preparation**
Cleaning
Degreasing
Mechanical surface roughening
Geometrical measurements
- 2. Spraying**
Preheating - in most cases no preheating
Stock material
Limitations to coating thickness
Changing nozzles (nozzle lifetime)
Spraying the learning piece according to instructions
Measuring and testing meanwhile spraying
- 3. Testing of the sprayed coating**
Final thickness test
Spray quality: visual inspection
Choice of test methods related to the piece and spray material
- 4. Post treatment**
Choice of test methods related to the piece and spray material
- 5. Personal health and safety**
- 6. Maintenance of the equipment**
Powder feeder, calibration
Powder injection, checking and control
Calibration test
Leakage test of powder feeder
Wear control of nozzles
Type of cooling water

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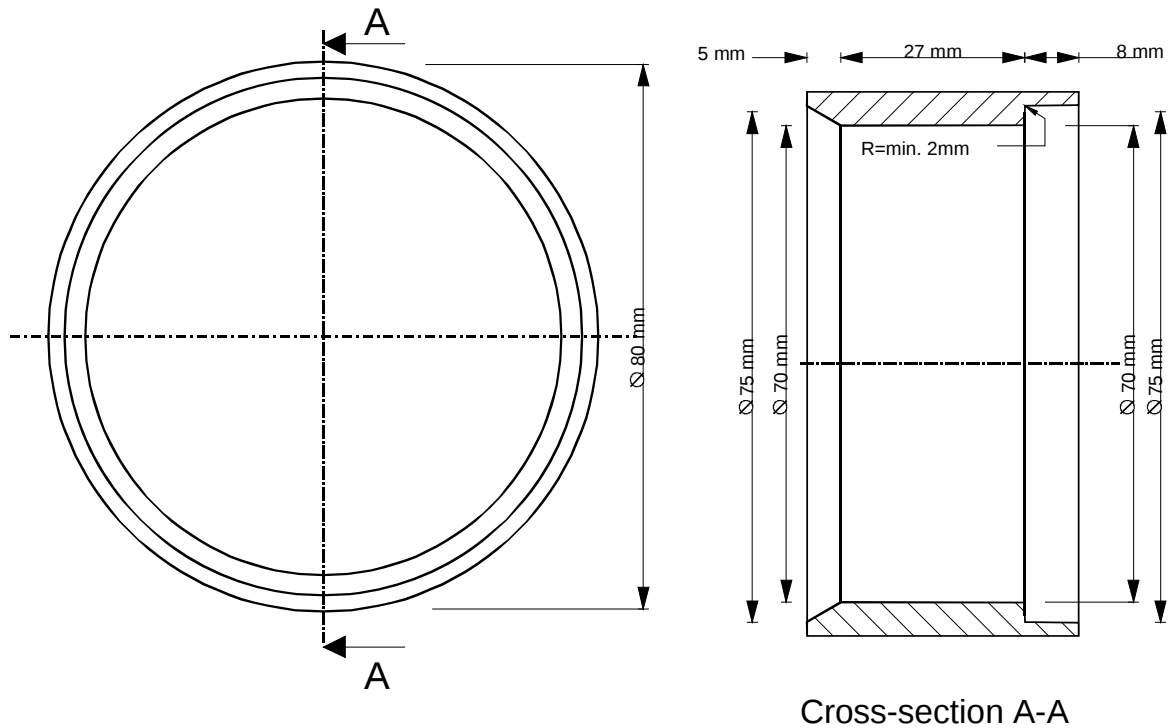
5.3 Skill test pieces/ practical training pieces and evaluation

Fig. 2 a and b: Skill test/practical training pieces

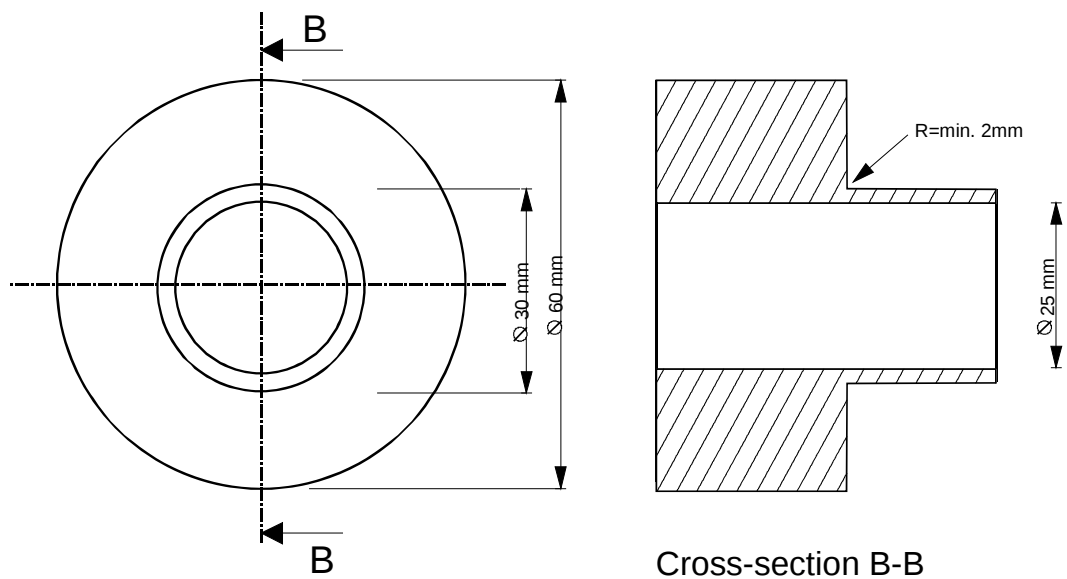
2a: Testpiece for inside diameter (I.D.) spraying

2b: Testpiece for outside diameter (O.D.) spraying

Testpiece A for I.D. spraying:



Testpiece B for O.D. spraying:



5.3.1 Skill test

The testpiece(s) must be treated and checked according to the TSPS (thermal spraying procedure specification – see 5.3.3 Description of the skill test/practical test pieces).

The following treatments and checks must be done:

- Check for corrosion
- Degrease the testpiece(s)
- Mask the testpiece according the TSPS
- Check grit material (size, contamination, etc.)
- Gritblast the testpiece according the TSPS and check the result
- Adjust and calibrate the equipment (e.g. leaktest, calibration of powderfeeders)
- Check powder or wire
- Determine the coating thickness or final spray dimensions
- Preheat the part
- Spray the part
- Check the coating thickness and temperature
- Perform all necessary tests (visual appearance, brushtest, bendtest - if necessary)

5.3.2 Evaluation of the skill test

The candidate will be evaluated on:

- workmanship of the process,
- handling of the equipment,
- theoretical knowledge,
- personal safety,
- general impression (process control).

Special attention will be addressed to:

- use of correct parameters,
- treatment of contaminated parts,
- thickness measurements

Evaluation of the test samples after spraying (see also EN ISO 14918):

- Dimensions:
 - a. Uniformity (parallelity, perpendicularity)
 - b. coating thickness
- Visual appearance

The coating shall be checked for complete coverage, uniform structure, cracks, voids, spalling, chipping, flaking or other indications of poor adhesion
- Additionally the following tests can be performed:
 - Adherence

The quality of adherence of the coating to the substrate can be tested by:

 - tensile test: bond strength test acc. EN 582
 - wire brush test
 - bend test

- machinability
- Other methods:
 - hardness test
 - metallographical investigation

5.3.3 Description of the skill test/practical test pieces

There are two different testpieces: A and B, A will be used for testing the skill of the candidate on inside diameter spraying, B for outside diameter spraying. Each testpiece can be treated in an other way, according to the TSPS made by the examiner.

The following items can be different for each individual examination:

- the surface to be sprayed,
- the coatings,
- the spraying parameters.

Example of a TSPS:

- Gritblasting :
 - blasting pressure: 5 bar
 - blasting distance: 15 cm
 - blasting angle: 80°
- Spraymaterial: bondcoat: Ni/Al, topcoat: Al₂O₃
- Thickness topcoat: 0.3 mm
- preheat to: 60 °C
- surface to be sprayed:
-
- Overspray permitted on:
-
- Spray parameter:
-
-
-
-

5.4 Final practical test

Test pieces for final practical test are according EN ISO 14918 equivalent to the application technique (manual/mechanised spraying) and to the spray process, for which the candidate has chosen the training modules.

- Evaluation

Evaluation will be done adequately to EN ISO 14918 "Approval testing of thermal sprayers" taking also into account chapter 5.3.2 and 5.3.3.

Section II: Examination and Qualification

1. Introduction

The guideline seeks to achieve harmonisation and common rules in the examination and approval testing of thermal spraying practitioners. It provides for the assessment of both theoretical knowledge and practical skills.

The national welding organisations to which in most cases thermal spraying is allied, being members of the EWF, mutually acknowledge the Diploma of the European Thermal Spraying Practitioner awarded in any Member State following the education, examination and testing conducted in accordance with this guideline.

Education must have followed the instructional units specified in Section I of this Guideline, and have been given at a training establishment approved by the ANB.

For the practical training, the test pieces, given in fig 2a and b, have to be sprayed by the candidate and assessed by the training organisation.

During the final practical test, the participant has to spray testpieces in accordance with EN ISO 14918 to pass the approval test of thermal sprayers.

Qualification of the European Thermal Spraying Practitioner - Flame, Arc, Plasma or HVOF - involves full examination of the test pieces following the EN ISO 14918 "Approval testing of Thermal Sprayers".

The final theoretical examination and practical tests must be carried out at a training establishment approved by the ANB in accordance with the requirements of this guideline. An Authorized Examiner shall witness the examination and tests, and approve the test results.

2. Requirements for Training Centres

Requirements for thermal spraying teachers, training organisations and courses are documented in Doc No EOTC/AG-15/97/001/416.

3. Theoretical examination

3.1 Intermediate test

Participants who have passed Module A(p) "Theoretical training" and Module B(p) "Practical training" have to pass an intermediate test based on these modules. Having passed this intermediate test successfully, a "Intermediate examination confirmation" is handed out to the participant. The "Intermediate examination confirmation" is valid for three years, in case a participant, who did not attend all modules of specific theoretical and practical training, want to continue his education and training of further spray processes (module) at later times.

3.2 Final theoretical examination

The final theoretical examination papers for Modules A 1-4 can be multiple-choice and will be set under the authority of the Board of Examiners of the ANB, sealed, and opened in the presence of the candidates and the Authorized Examiner immediately before the examination begins. The Authorized Examiner must sign all completed papers to confirm that the examination has been conducted in a proper manner. The theoretical examination pass mark is 60 %. Failure require re-examination, see fig. 1 of this guideline.

4. Practical tests

4.1 Skill test

Thermal spraying practitioners having practical experience, who want to get the ETSP-certificate without attending Modules B1/2/3/4 have to prove their practical skill by doing the skill test. The test pieces have to meet the requirements and level of the final practical training test pieces shown in fig. 2 a and b.

If the candidate fails the skill test, he has to participate at Modules B1/2/3/4.

4.2 Final practical test

Final practical training test pieces have to be performed according EN ISO 14918 for meeting the level of the course. The sprayer has to spray manually and mechanised.

Failure requires re-examination, see fig. 1 of this guideline.

5. Surveillance during testspraying

Final practical test, on completion of Modules B1 - B4 shall be conducted following the requirements of EN ISO 14918 and shall be witnessed by an Authorized Examiner on behalf of the ANB. The candidate must be provided with clear unambiguous instructions and a Thermal Spraying Procedure Specification (TSPS). All test materials and consumables must be properly identified. Calibrated equipment shall be used according to industrial needs.

6. Destructive and non-destructive examination

Test pieces and specimens shall be clearly identified and the test specimens submitted for destructive and/or non-destructive examination (such as visual examination or dye check) – see also EN ISO 14918 - to a laboratory approved under the national testing laboratory certification scheme.

7. Evaluation of results

The test results shall be evaluated by a Authorized Examiner in accordance with the guideline and EN ISO 14918. The test certificate shall be countersigned by the Authorized Examiner or third party.

8. Transition arrangements

Up to the end of 2006 the following transition arrangement will apply:

Practising thermal spraying practitioners having followed a structured training programme* and having practised** in thermal spraying in one of the methods*** for at least 2 years, may be awarded the diploma of European Thermal Spraying Practitioner following assessment by the ANB, if the following requirements are fulfilled:

* The training programme must have been according to national guidelines or supplier courses, which must have been controllable by the ANB. The national ANB has to make sure about the contents and time duration and how many years backwards the contents of the course was constant

** An authential curriculum vitae would be considered to fulfill the requirements for documented evidence.

*** One of the following methods:

1. Flame spraying - powder
 - wire
2. Arc spraying
3. Plasma spraying
4. HVOF-spraying

Two additional rules must be observed when applying the transition arrangements:

1. Only the country from which the applicant received his thermal spraying qualification or in which he currently is practising, can award the qualification certificate under the transition arrangement.
2. The thermal spraying qualification from countries outside the EWF-member states cannot be used to justify the award of a qualification certificate under the transition arrangements.

For each country specific transition arrangements will be approved by the Committee for Education and Training, and may be obtained from the ANB.

9. Re-examination

Re-examination and appeals are covered by Doc No EOTC/AG-15/97/001/416.